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How does private vehicle users perceive the public transport service quality in large metropolitan areas? A European comparison

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ABSTRACT

Most studies on public transport service quality focus on the perspective of the public transport user, overlooking potential users, that is, private vehicle users. This paper explores the perception of private vehicle users about the quality of public transport. The objective is to identify the attributes that bear the greatest influence on the general satisfaction of the private vehicle user with respect to public transport in five major European cities: Berlin, Lisbon, London, Madrid and Rome. The analysis estimates the effect of 14 quality of service attributes on general satisfaction using Ordinal Logit Models (OLM), using data from an online survey sent to private vehicle users, with a similar sample size for each city (N > 500 per city). To analyse the heterogeneity of the perceptions, 20 models were calibrated: 15 models were calibrated controlling for location; and five models (one per city) were calibrated controlling for sociodemographic and mobility characteristics. Frequency, punctuality, intermodality, cost and cleanliness were identified as attributes exerting a significant effect on satisfaction in practically all the models, meaning they could be considered core attributes for private vehicle users. On a second level, a group of attributes were significant in a substantial number of models (service hours, proximity, speed, temperature and safety). Finally, the remaining attributes were only significant for specific cities or segments. The last two groups of attributes allowed to detect differences between cities and market segments.

1. Introduction

A decline in the use of private vehicles is thought to be the most effective means of remedying the negative outputs of traffic, but it must be accompanied by the availability of a public transport service that is attractive, competitive and sustainable. The transport sector is addressed in three of the 17 Sustainable Development Goals (UN, 2015) with strategies oriented towards sustainable mobility, resilient infrastructures, a reduction of fossil fuel consumption, and improvements in road safety and public transport. The latter improvements are intended to ensure a higher quality in public transport, which would make the user more loyal and would attract new users (Bamberg et al., 2003; Lai and Chen, 2011; Zhao et al., 2013; Suman and Bolia, 2019).

Previous research has made manifest that satisfaction with service affects behavioural intentions, loyalty and mode choice (Lai and Chen, 2011; Zhao et al., 2013) both for public transport users and non-users, although the behaviour of car users is more difficult to change (Bamberg et al., 2003) as their preferences are more attitudinal and emotional than instrumental (Steg, 2005). Studies of the perception of quality in service have focused on the customer, whereas studies approaching the satisfaction with service of non-public transport users are scarce (Krizek and El-Genedy, 2007; Abenoza et al., 2017; Woods and Masthoff, 2017; Li et al., 2019; Bellizi et al., 2020; De Oña, 2021). The present study is centred on this perspective, of great interest for public transport operators, as it provides information about their needs, preferences and attitudes as relevant information for future strategies of attracting users. In addition, it hopes to identify the heterogeneity of their perceptions, just as previous studies deal with the opinion of the public transport user (De Oña et al., 2015; Tyrinopoulos and Antoniou, 2008) by means of the identification of market segments based on mobility patterns and sociodemographic, contextual and geographic conditioners. Therefore, the main aim of this endeavour is to analyse how private vehicle users in Europe assess the different service quality attributes of urban and metropolitan public transport, and how this perception affects their general satisfaction. To this end, we used information on perceptions of private vehicle users about the public transport services offered in five European cities (Madrid, Rome, Berlin, Lisbon and London). With this information two types of analysis were undertaken: an analysis by

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market segments with specific socio-demographic characteristics and according to specific mobility conditions, controlling for the city of residence; and an analysis by city, controlling for the sociodemographic and mobility characteristics. The first analysis is meant to identify patterns of behaviour at the European level, as well as differences among market segments. The second analysis attempts to identify differences and similarities among the five cities analysed. This will be the first time that a study has been specifically performed on public transport quality from the point of view of private vehicle users while controlling heterogeneity through sample stratification and analysing differences among five large European cities.

The rest of the paper is organized as follows. Section 2 presents a literature review of four topics: (i) previous studies about public transport service quality from the point of view of private vehicle users; (ii) main quality of service attributes considered in public transport studies; (iii) market segmentation for dealing with heterogeneity; and (iv) cross-country analysis in public transportation. Section 3 provides a general view of the benchmark survey used, followed by the samples and main survey results. Section 4 presents the methodology used, based on ordered logit models, and the market segments considered for analysis. Section 5 presents the results, starting with the general model and the market segments, followed by the specific models for each city, and finishing with the priority areas identified. Section 6 offers a discussion highlighting the main findings derived from the analysis, and Section 7 summarizes the most important conclusions.

2. Literature review

2.1. Private vehicle users and satisfaction with public transport

The paradigm for measuring quality in public transport mainly focus on the user perspective, with analysis of customer satisfaction as an operational construct based on which the attributes of service, perception of them, and their importance can be identified in terms of overall satisfaction with the service. Analysing the quality of service, considering public transport users as key informants, has generated an extensive bibliography, though with some lack of consensus about identifying the attributes of service quality (De Oña and De Oña, 2015b). Nonetheless, certain authors agree in underlining that the information supplied by non-users is always valuable if they are empowered by knowledge about or experience with public transport (Zhao et al., 2013). Thus, measuring satisfaction with public transport service calls for overlooking the exclusive car drivers (no familiarity with public transport) and the exclusive public transport users (with a possible captive bias regarding public transport) (Diana, 2012). Including both collectives, Bellizi et al. (2020) used a stated preferences survey and identified the most important service attributes for public transport users and private vehicle users. These authors calibrated models to discern the preferences between those who knew the service well and the potential users who did not have such a complete perception of it. Bus users were found to pay more attention to journey time and comfort, while potential users emphasized time and fare.

Research exclusively focused on the satisfaction of the private vehicle user with public transport service is scarce, and tends to be included with the perception of the public transport users for comparative purposes (Abenoza et al., 2017; Al-Ayyash and Abou-Zeid, 2019; de Oña, 2021; de Oña et al., 2021; Krizek and El-Genedy, 2007; Woods and Masthoff, 2017). Abenoza et al. (2017) analysed the opinion of current users and non-users (or rare users) of public transport, to determine levels of satisfaction and the relative importance of the quality of service attributes, finding that stakeholders should prioritize customer interface, operation, network and length of the trip. Al-Ayyash and Abou-Zeid (2019) investigated car users and public transport users' satisfaction when commuting by comparing three measures: car users' satisfaction when commuting by car, car users' remembered satisfaction with public transport (for a past trip they made) and car users' satisfaction with public transport predicted as if they were regular public transport commuters. They found that remembered satisfaction of car users with public transport (infrequent users) was lower than public transport satisfaction of car users predicted as regular users. In addition, they highlighted the importance of formulating marketing campaigns in order to correct the misperceptions car users could have about the public transport service and in this way to attract non-regular public transport users to try public transport more regularly. Besides that, by approaching two European cities, de Oña (2021) gathered the point of view of a sample of regular private vehicle users respect the latent constructs that comprise the service quality–satisfaction-behavioural intentions paradigm with regards to transit service. They used a multigroup analysis and a multiple-indicator and multiple-causes model, and determined that punctuality, frequency, information and intermodality were the key service aspects most influencing their overall quality perception. De Oña et al. (2021) explored the perceptions of service quality, satisfaction and attitudes toward public transport across a sample of private vehicle users and a sample of public transport users, both of them from Madrid (Spain). They calibrated 350 models for controlling the heterogeneity of data and determined some indicators that did not show differences between the market segments analysed. These indicators were punctuality, information and low-income. On the contrary, they derived other indicators that exhibited significant differences in all the segments, such as proximity, intermodality, save time and money, and lifestyle. Krizek and El-Genedy (2007) conducted two surveys, a face-to-face one for metro users and a telephone survey for non-metro users. Their aim was to understand the preferences of users/non-users to establish market segments. They found that just a few attributes (e.g., driver's attitude, comfort and value of time) influenced the demand of irregular choice users, whereas the number of attributes was higher for regular choice riders.

The perspective of the non-user is attractive for researchers in that their motivation, attitudes and travel behaviour are of interest for subsequent development of strategies oriented toward modal changes (Bamberg, 2003; Kang et al., 2019) or travel intentions (Li et al., 2019). Hine and Scott (2000) employed qualitative techniques to register such attitudes with respect to the perception of interchange and its influence in attracting/retaining both types of public transport users. They indicate that car users conceive as a good service that which offers a frequency of every 15–20 min, with a bus stop near their home, and available buses running at regular intervals.

To summarize, there are still very few studies that have investigated the private vehicle users' perceptions towards the service quality of public transport. Hence much effort should be performed in order to explore the needs and requirements private vehicle users have about the public transport services, thus understanding the motivations that could promote a modal shift. Although some research works have interviewed non-users that do not use transit services at all, by using stated preference experiments for ascertaining their preferences (Bellizi et al., 2020), other authors have approached non-users that know the transit services, as they are rare or irregular transit users (Abenoza et al., 2017; Al-Ayyash and Abou-Zeid, 2019; De Oña, 2021; De Oña et al., 2021; Krizek and El-Genedy, 2007; Woods and Masthoff, 2017). We retain that it is necessary that non-users have certain knowledge about the public transport service in order to be able to evaluate it and derive the most important attributes influencing their overall satisfaction. In fact, car users could have an inaccurate perception of the public transport performance due to their scarce or inexistent use of the transit system, so promoting a more frequent use of public transport through specific actions, could help private vehicle users to become more accustomed to it, and they could become more satisfied with it over time (Al-Ayyash and Abou-Zeid, 2019). In this line, Al-Ayyash and Abou-Zeid (2019) and de Oña et al. (2021) determined that public transport users were more satisfied with the service than private vehicle users with sporadic use. However, it is expected that this group of non-users is more prone to a modal shift than those that never have used the public transport mode,

and they could be considered by public transport operators and administrators as a key target group to persuade towards the public transport. In fact, people that are not captive to a mode of transport tend to be more satisfied with this mode of transport (Susilo and Cats, 2014), then, we can expect higher satisfaction rates from the private vehicle users if they finally decide to perform this long-awaited modal shift.

2.2. Main quality of service attributes in public transportation

Further work has been undertaken to identify those aspects of service that are most attractive for both the public transport user and the non-user, so that improvement would imply greater use of the service. These aspects are known as the set of quality of service attributes, and validated as an analytical tool to measure the complexity of quality (Parasuraman et al., 1985), although at present there is no unanimous consensus as to the elements that should configure the set. Parasuraman et al. (1985) proposed a generic, standardized list, while other authors have stressed the difficulties in homogenizing characteristics for different services and contexts (De Oña and de Oña, 2015b). Considering the particularities of the service (i.e., type, mode, context, operator, etc.), one can attain greater specificity in measurements of perception and in the projection of strategies for improvement, though at the same time the capacity of standardizing the procedure is limited.

Diverse researchers, in a literature review, have tried to identify the most common quality of service attributes to categorize them in functional groups. Redman et al. (2013) took 12 and grouped them as either physical or perceived. Reliability, frequency, speed and price were considered "physical", exerting a greater force of attraction for car users. The relative importance of the quality of service attributes affecting demand was reportedly influenced by sociodemographic characteristics, personal situations and experiences with public transport. Mouwen (2015) grouped 15 quality of service attributes into three categories (core attributes, peripheral interactional and peripheral physical attributes) to explore the perceptions of public transport users regarding several modes of the Dutch public transport system (bus, tram, metro and regional train). Public transport users lent greater importance to on-time performance, travel speed and service frequency (core attributes). Suman and Boila (2019) pointed out the attributes that might inhibit use of public transport (safety, security, accessibility, punctuality, directly and comfort) and connected them to possible interventions for improvement. Similarly, Abenoza et al. (2017) worked with 15 public transport service attributes in the context of Sweden, concluding that customer interface, length of the trip in time, and freedom from crime were the most influential attributes in the satisfaction of current and potential public transport users. Li et al. (2019) found that the factors most convincing car users to travel by public transport were comfort, reliability and economics. Finally, Bellizzi et al. (2020) found that potential users valued above all time and fare, whereas bus users valued journey time, comfort and fare. Despite the numerous lists of quality of service attributes existing in the literature, a careful look shows them to be fairly similar.

2.3. Market segmentation for heterogeneity analysis

The analytical concept of "overall satisfaction with the service" is subjected to a high degree of subjectivity, given the personal, structural and systemic contexts underlying the service to be evaluated. Therefore, carrying out a thorough analysis requires taking into account the influence of this heterogeneity by means of data segmentation techniques (Zhao et al., 2013; De Oña and De Oña, 2015a). In this way the market segment can be related with the level of importance or the appraisal assigned to specific characteristics of the service, so that policymakers can focus public transport improvement campaigns on those aspects underlined by the groups of interest (Beirão and Cabral, 2008).

The literature describes different approaches to segmentation in order to register perception heterogeneity (Krizek and El-Genedy, 2007; Beirão and Cabral, 2008; Abenoza et al., 2017; Machado et al., 2018). The most usual one is the approach based on pre-defined key sociodemographic characteristics (geographical area of residence, income, occupation, standard of education, gender, age, etc.) (de Oña and de Oña, 2015a; De Oña et al., 2015). Often included are mobility patterns (Fellesson and Friman, 2008), frequency of using public transport (Li et al., 2019), service operator or modal alternatives (Tyrinopoulos and Antoniou, 2008; Mouwen, 2015), attitudes towards public transport (Şimşekoğlu et al., 2015) or behaviour intention (Anable, 2005; Li et al., 2019).

Furthermore, the segmentation analysis attempts to elucidate differences between groups of users traditionally established in the literature as captive/choice users or public transport users/non-users, according to the frequency in using the system, the possibility of using different modes, the personal conditions and one's perceptions of the public transport service to identify the factors that would produce the modal change toward it. Laques et al. (2013) went into greater detail, and distinguished two intermediate groups in the taxonomy of the transport industry deserving attention. "Utilitarism" refers to individuals who walk not because they enjoy it, but because they acknowledge it is better for them, while "dedication" takes in those individuals who use public transport because they choose not to use the car. These two segments are associated with trip satisfaction and trip practicality (relationship between the travel time of the modal alternative and the time of travel of the mode actually taken). The authors conclude that to improve trip satisfaction for any mode (walking, cycling, public transport, or car) it is essential to enhance comfort, aesthetic quality of the trip route, and safety, measures that will have a greater effect among captives (with low ratio trip practicality and low level of preference for their trip) and utilitarianism segments; and that to increase trip practicality it is necessary to focus on speed, efficiency and connectivity, thereby attracting captives and dedicated travellers. Krizek and El-Geneidy (2007), through cluster analysis, distinguished four groups of individuals: system users (captive and choice riders) versus non-users (auto-captive and potential riders). They highlight choice users and potential users as the market segment of interest for policymakers, and evoked strategies for improving reliability (punctuality), travel time, type of service (service hours, intermodality) and comfort as the most effective means of attracting these groups to public transport usage. Both the above studies are relevant in that they address the choice/captive distinction not only for public transport users, as usual, but also for private vehicle users.

While cluster analysis is a procedure extended to address heterogeneity (Abenoza et al., 2017; de Oña et al., 2016; Machado et al., 2018; Beirão and Cabral, 2008), it is more frequent to encounter classic sociodemographic segmentation.

To sum up, there is a complete agreement among the research community that public transport users' opinions about the quality of the service are heterogenous, because of the sociodemographic characteristics, the mobility patterns, the cultural or operational context, and their preferences and tastes (de Oña and de Oña, 2015a). Henceforth, it is expected that this heterogeneity also exists among the private vehicle users when public transport service is evaluated. The bibliography on this topic is scarce, however. We hold that a classic segmentation of the sample by using different sociodemographic variables and mobility patterns is adequate as it has been applied in numerous research works dealing with public transport users.

2.4. Contextual heterogeneity

Together with the variables mentioned above, the place of operation of the service is also considered in the analysis of quality heterogeneity. Previous studies put the accent on the operational context (Woods and Masthoff, 2017) as influencing differential satisfaction with service. Variables such as large cities (Felleson and Friman, 2008), population density (Abenoza et al., 2017; Mouwen, 2015) or level of urbanization

(Diana, 2012; Tyrinopoulos and Antoniou, 2008; Krizek and El-Geneidy, 2007) may be included in analyses to account for such differences.

Felleson and Friman (2008) analysed perceptions of the quality of transport systems in nine European cities (Stockholm, Barcelona, Copenhagen, Geneva, Helsinki, Vienna, Berlin, Manchester and Oslo). They identified two dimensions that were common to all nine cities: safety (stations and on-board security) and system factor (travel waiting time, number of departures, reliability, and accessibility to stops). Mouwen (2015) conducted a study to determine satisfaction among Dutch public transport users, estimating the importance of the quality of service attributes in that satisfaction according to the public transport modes. Among their segmentation variables was the level of urbanization (low/high density). It was concluded that public transport users residing in smaller cities were more satisfied with the service than people in metropolitan areas. Diana (2012) likewise concluded that multi-travellers living in smaller municipalities outside metropolitan areas were more satisfied with service. Woods and Masthoff (2017) asked the residents of three European cities (Barcelona, Helsinki and Milan) about their perceptions of different service aspects (comfort, flexibility, speed, good value for money, etc.) regarding their car driving, public transport and cycling experiences. Public transport was appraised more positively than the car in value for money and safety, and more negatively in flexibility, reliability, comfort, effort and speed, among other aspects. Moreover, they compared the cities and found that Helsinki and Milan showed similar patterns, but Barcelona expressed different preferences for cycling. Susilo and Cats (2014) queried car users, public transport users, cyclists and pedestrians in eight European cities (Bucharest, Coventry, Dublin, Rome, Stockholm, Turin, Valencia and Vilnius). They built cross-correlation matrices and estimated multiple regression models to learn which were the main determinants of satisfaction with the public transport service. They identified ease of transfer, station environment and on-board comfort as the most important attributes.

Then, based on the previous research works, the contextual heterogeneity should be looked into by determining the similarities and differences among the attributes of the public transport services in the case of considering different geographic locations.

3. Survey, samples and main survey statistics

The aim of this paper is to analyse the perception of quality that private vehicle users have about the public transport services in five European cities: Madrid, Rome, Lisbon, Berlin and London. These users are defined as people who use a motorised private vehicle (i.e., car, motorcycle or scooter) for their daily journeys. In order to be able to evaluate the public transport system and take part in this research, they needed a minimal knowledge about the services available in the study area (Zhao et al., 2013). Therefore, the regular private vehicle users surveyed had to be also occasional public transport users.

3.1. Survey description

The data was collected through an online survey at the metropolitan areas of Madrid, Rome, Lisbon, Berlin and London from May to July 2019. The questionnaire, with an average duration of 7 min, was translated into the local language. It was divided into eight sections, as it was part of a broader research project, involving both public transport users and private vehicle users. This paper relies on just the following parts of the complete survey: background questions to identify the study's target population and sociodemographic and mobility questions, private vehicle usage habits, experience and satisfaction with public transport, main reasons which explain a low user frequency of public transport, and perceived satisfaction.

Table 1 displays the 22 variables that were considered for this study: overall satisfaction with the public transport service (1 item), quality of service attributes (14 items), and sociodemographic and mobility attributes (7 items). The private vehicle users rated their perception about overall satisfaction with the public transport service and with its quality of service attributes on a 5-point scale ranging from 1 ("very unsatisfied") to 5 ("very satisfied"). The questionnaire was tested on 8% of the sample and verified in form and content. A total of 2531 regular private vehicle users, using public transport at least once a week, over 18 years old, were interviewed in the five cities (see Table 1). A sampling stratified by gender and age was designed, with assignment proportional to the real size of the strata for each city (EUROSTAT, 2011). The margin error for Madrid, Rome, Berlin and London samples was ±4.38% for $p = q = 0.5$ and a confidence level of 95%, and in the case of Lisbon the margin error was ±4.26%, being all of them under the maximum ±5% recommended (Selltiz et al., 1980).

3.2. Sample and main survey statistics

Table 1 shows that the regular private vehicle user resides mainly in the metropolitan area of Madrid, London, Lisbon (around 78%) and Rome (68%), whereas respondents in Berlin reside mainly in the city centre (59%). They are mostly males (ranging from 51% to 60%), with the exception of Berlin, where females represent 53%. The largest age group is between 25 and 44 in Madrid (46%), Lisbon and London (44%) and between 45 and 64 in Rome (41%) and Berlin (37%). Respondents tend to have university degrees (ranging from 52% in Rome to 66% in London), with the exception of Berlin, where 57% have no university studies. This could be associated with the net incomes: Berlin shows a greater percentage of net income below three times the minimum wage (76%). Most of private vehicle users (over 69%) do not have dependent household members (i.e., children or other dependent relatives). Most private vehicle users surveyed use public transport occasionally (less than one trip per week). This is particular true in Lisbon (71%), followed by Madrid and Rome (around 57%) and Berlin (52%). In contrast, private vehicle users in London are more regular public transport users (55% with one or more trips per week). These are usual rates of public transport usage in large metropolitan areas with highly used public transport networks mainly in the city centre, involving even regular private vehicle users.

Private vehicle users evoke three main reasons to explain their low frequency of public transport use in the five cities, but their order varies: "The unsuitability of the service for their routes" is the most frequent reason in Madrid and Lisbon, and in Rome takes the second position, where there is greater consensus as to the use of public transport entailing a greater investment of time for regular trips. This reason appears among the three most frequent ones for all the cities. It is the second one in Berlin, Lisbon and London, and the third in Madrid. In Berlin and London, the main reason is "personal preference for the car", which is the second reason in Madrid. We highlight that the reason "I don't know the service" is only pointed out by a residual percentage in each city. Furthermore, in Berlin the private vehicle user attributes his/her scanty use of public transport to the price (31%) as opposed to just 13% on average for all the other cities, with the exception of Rome where only 3% of users highlight a negative perception of price.

Private vehicle users in London (3.68) and Madrid (3.51) showed a high level of satisfaction with the public transport system along with Berlin (3.41). The service in Rome (2.38) and Lisbon (2.94) does not meet with approval according to the private vehicle users (below 3 points), however. For all the cities, safety is foremost among the three most appraised attributes. It obtains the highest average scores in Berlin (3.86) and Madrid (3.74), second place in London (3.89) and Rome (3.22), and third place in Lisbon (3.21). Accessibility is also highly relevant among the top three, with the exception of Rome and London. Intermodality records a noteworthy assessment in Madrid and Lisbon (3.53 and 3.22, respectively) and proximity is highly valued in Rome (3.15) and in Berlin (3.75). The most appreciated service quality attribute in Rome is cost (3.37), while in London it is service hours (3.98). Interestingly, punctuality got the lowest average scores in Rome (2.37)

Table 1
Satisfaction's survey data and descriptive statistics.

		Madrid	Rome	Berlin	Lisbon	London	All
Sample size (N)		500	501	500	530	500	2,531
	Dependent variable: Mean (Standard Deviation)						
Overall satisfaction	In general, I am satisfied with the public transport service in "*zone*"	3.51 (1.06)	2.38 (1.27)	3.41 (1.14)	2.94 (1.03)	3.68 (1.07)	3.18 (1.21)
	Independent variables (quality of service attributes): Mean (Standard Deviation)						
1. Service hours	Service hours	3.39 (1.15)	2.76 (1.28)	3.68 (1.00)	2.91 (1.06)	3.98 (0.90)	3.34 (1.18)
2. Proximity	Proximity of stops to starting point or destination of the trip	3.41 (1.12)	3.15 (1.24)	3.75 (1.05)	3.12 (1.05)	3.75 (1.00)	3.43 (1.13)
3. Frequency	Frequency or number of daily services	3.30 (1.12)	2.65 (1.25)	3.64 (1.05)	2.87 (1.05)	3.88 (0.93)	3.26 (1.18)
4. Punctuality	Punctuality	3.36 (1.08)	2.37 (1.29)	3.21 (1.14)	2.62 (1.05)	3.64 (1.03)	3.03 (1.22)
5. Speed	Speed	3.35 (1.10)	2.75 (1.21)	3.54 (0.99)	2.99 (0.99)	3.67 (0.93)	3.26 (1.10)
6. Cost	Cost	3.10 (1.19)	3.37 (1.12)	3.07 (1.20)	3.07 (1.13)	3.47 (1.23)	3.21 (1.19)
7. Accessibility	Ease of entrance and exit from the vehicle and/or stations	3.67 (0.98)	3.10 (1.22)	3.74 (0.98)	3.37 (0.94)	3.85 (0.97)	3.54 (1.06)
8. Intermodality	Ease of transfers/good connection with other modes of transport	3.53 (1.07)	2.74 (1.25)	3.47 (1.08)	3.22 (1.00)	3.74 (0.95)	3.33 (1.12)
9. Individual space	Individual space available inside the vehicle	3.02 (1.10)	2.65 (1.28)	3.18 (1.06)	2.77 (1.02)	3.33 (1.12)	2.99 (1.15)
10. Temperature	Temperature inside the vehicle	3.28 (1.09)	2.69 (1.23)	3.16 (1.14)	2.93 (1.02)	3.36 (1.12)	3.08 (1.15)
11. Cleanliness	Cleanliness of the vehicle and stations	3.43 (0.98)	2.53 (1.29)	3.22 (1.06)	2.97 (0.97)	3.41 (1.06)	3.11 (1.13)
12. Safety	Safety on board (regarding accidents)	3.74 (0.99)	3.22 (1.14)	3.86 (0.96)	3.21 (1.01)	3.89 (0.94)	3.58 (1.06)
13. Security	Safety regarding robbery and violence	3.03 (1.05)	2.62 (1.24)	3.33 (1.09)	2.84 (1.04)	3.50 (1.08)	3.06 (1.15)
14. Information	Information provided	3.48 (1.03)	2.86 (1.19)	3.40 (1.05)	3.00 (1.07)	3.88 (0.92)	3.32 (1.12)
	Sociodemographic and mobility characteristics: percentage (sample)						
Geographical area	City centre	22.4 (112)	32.1 (161)	58.6 (293)	22.5 (119)	22.4 (112)	31.5 (797)
	Metropolitan area	77.6 (388)	67.9 (340)	41.4 (207)	77.5 (411)	77.6 (388)	68.5 (1734)
Gender	Male	59.8 (299)	56.1 (281)	47.4 (237)	51.3 (272)	51.6 (258)	53.2 (1347)
	Female	40.2 (201)	43.9 (220)	52.6 (263)	48.7 (258)	48.4 (242)	46.8 (1184)
Age	18–24	7.8 (39)	6.2 (31)	8.2 (41)	6.6 (35)	7.6 (38)	7.3 (184)
	25–44	45.8 (229)	38.5 (193)	35.6 (178)	44.3 (235)	43.8 (219)	41.6 (1054)
	45–64	30.4 (152)	41.3 (207)	37.2 (186)	40.0 (212)	32.2 (161)	36.3 (918)
	65+	16.0 (80)	14.0 (70)	19.0 (95)	9.1 (48)	16.4 (82)	14.8 (375)
Transit use frequency	Frequent (one or more trips per week)	43.0 (215)	42.1 (211)	47.8 (239)	29.4 (156)	55.0 (275)	43.3 (1096)
	Occasional (less than one trip per week)	57.0 (285)	57.9 (290)	52.2 (261)	70.6 (374)	45.0 (225)	56.7 (1435)
University degree	Without university degree	40.2 (201)	47.9 (240)	57.4 (287)	36.2 (192)	33.0 (165)	42.9 (1085)
	With university degree	59.2 (296)	51.9 (260)	42.0 (210)	63.8 (338)	66.0 (330)	56.7 (1434)
Dependent members in the family	No	66.2 (331)	65.2 (313)	79.0 (395)	61.3 (325)	75.6 (378)	68.8 (1742)
	Yes (i.e., children or other dependent relatives)	32.6 (163)	36.7 (184)	17.8 (89)	37.4 (198)	22.4 (112)	29.5 (746)
Net income	Low income	43.8 (219)	59.7 (299)	76.2 (381)	53.4 (283)	50.8 (254)	56.7 (1436)
	High income	40.2 (201)	29.1 (146)	17.0 (85)	35.5 (188)	34.0 (170)	31.2 (790)
	Main reasons which explain a low user frequency of public transport: percentage (sample)						
Takes a long time to get there		36.8 (105)	50.3 (146)	36.4 (95)	46.5 (174)	37.3 (84)	42.1 (604)
There is no adequate service for my route (many stops, route length, etc.)		53.0 (151)	35.5 (103)	16.5 (43)	57.0 (213)	21.3 (48)	38.9 (558)
I prefer to use the car		37.9 (108)	27.6 (80)	46.7 (122)	30.2 (113)	52.4 (118)	37.7 (541)
It's uncomfortable, it's dirty, too much noise, lack of space, inadequate temperature, etc.		18.6 (53)	31.7 (92)	35.2 (92)	26.2 (98)	28.4 (64)	27.8 (399)
I need the car to run my errands, take the children to school, etc.		20.0 (57)	23.4 (68)	29.9 (78)	31.8 (119)	22.2 (50)	25.9 (372)
The stops are far from my starting point or destination		35.1 (100)	19.7 (57)	12.3 (32)	30.2 (113)	20.9 (47)	24.3 (349)

(*continued on next page*)

Table 1 (*continued*)

	Madrid	Rome	Berlin	Lisbon	London	All
The transfers don't work well	8.8 (25)	27.9 (81)	20.7 (54)	18.7 (70)	13.3 (30)	18.1 (260)
Expensive	17.5 (50)	3.1 (9)	31.0 (81)	11.8 (44)	19.6 (44)	15.9 (228)
I don't like public transport	8.1 (23)	15.5 (45)	13.0 (34)	5.6 (21)	17.3 (39)	11.3 (162)
Other	8.8 (25)	4.5 (13)	10.3 (27)	4.8 (18)	13.8 (31)	7.9 (114)
It's unsafe	1.4 (4)	3.8 (11)	14.9 (39)	3.5 (13)	5.8 (13)	5.6 (80)
There is no public transport	3.9 (11)	4.1 (12)	1.1 (3)	5.6 (21)	3.1 (7)	3.8 (54)
I don't know the service	1.1 (3)	1.7 (5)	0.8 (2)	2.7 (10)	1.3 (3)	1.6 (23)
Doesn't know/Doesn't answer	0.0 (0)	0.3 (1)	0.4 (1)	0.0 (0)	1.8 (4)	0.4 (6)

and Lisbon (2.62). Even though the mean value of satisfaction for the different attributes presents little variability over the five cities surveyed, for some of them the differences are greater. For more detail, you can see the distribution of scores in Fig. A.1 in Appendix. This figure evidences that, in general terms, neither overall satisfaction, nor the appraisals of the different attributes, present normal distributions.

In order to detect significant differences among the scores of the attributes in the five cities under study, the non-parametric Kruskal-Wallis test for k independent samples was applied to those cases with valid responses for each one of the variables. The cities presented significant differences respect overall satisfaction ($p = 0.000$) and regarding specific attributes. The Holm procedure was also used to identify attributes with similar behaviours among cities (see Table A.1 in Appendix). The distributions of Rome and Lisbon are seen to be similar in terms of proximity, safety and information. Madrid and Berlin present even more similarities (punctuality, cost, accessibility, intermodality, temperature, safety, information and overall satisfaction). In some cases, the values are similar to those of other cities (Madrid and Lisbon about cost; Madrid and London regarding temperature and cleanliness). Appraisal of safety draws a distinctive pattern, as three similar pairs are detected: Madrid-Berlin, Berlin-London, and Rome-Lisbon.

4. Methodology

In order to investigate the main determinants of transit satisfaction, two analyses were undertaken. The first aimed to identify the effect of the service quality attributes on global satisfaction, using the pooled sample, distinguishing private vehicle users by market segment, and controlling for the city of residence. The objective of this analysis was to obtain conclusions that could be generalized for other European cities, according to market segments. For this purpose, an Ordered Logit Model (OLM) was specified and estimated for the pooled sample and 14 models were implemented for different segments of private vehicle users. The OLMs considered the following categories of users:

- General: i.e. considering all private vehicle users (S_{all})
- Geographical area: differentiating between resident in the city centre and in the metropolitan area (S_{city} vs. S_{ma})
- Gender: distinguishing between male and female (S_{male} vs. S_{fem}).
- Age: dividing the private vehicle users into two age groups, from 18 to 44 years old and 45 years or older ($S_{\leq 44}$ vs. S_{45+}).
- Public transport use frequency: dividing into occasional public transport users (less than one trip per week) and frequent public transport users (one or more trips per week) (S_{occ} vs. S_{freq}).
- Education level: differentiating between with or without a university degree (S_{ud} vs. S_{nud})
- Dependent persons in the family: distinguishing private vehicle users with or without dependent persons in the family (S_{dep} vs. S_{ndep}).
- Net income: dividing into two groups, incomes below three times the minimum wage and incomes above (S_{low} vs. S_{high}).

In total, 15 models were specified and estimated (a general model for the pooled sample, and two models for each one of the variables considered for segmentation). The models considered overall satisfaction with public transport as their dependent variable and 14 quality of service attributes as independent variables, together with four dummy variables related to the city (Madrid was adopted as reference). Sociodemographic variables were not considered in any model, as they were used for segmentation purposes.

The second analysis was intended to identify the most important attributes for each city. In this case, the models analysed the influence upon general satisfaction of the quality of service attributes, using the sociodemographic and mobility characteristics of the respondents as control factors. To this end, five OLMs were specified and estimated, one for each city. General satisfaction was the dependent variable, and the independent variables were the 14 service quality attributes and seven dummy variables related to sociodemographic and mobility characteristics. The reference cases for the dummy variables were metropolitan area, female, younger than 45, occasional user, no university degree, no dependent family members, and low net income.

In agreement with previous studies (e.g. Abenoza et al., 2017; De Oña et al., 2018; Quddus et al., 2019), the independent variables were treated as if they were continuous. This approach assumes that the independent variables have a linear impact across their increment (i.e., the incremental changes between categories would be the same from 1 to 2 and from 4 to 5) and produce an average incremental change that reflects the general trend, which could prove relevant for policy modifications (Abenoza et al., 2017). Although this approach is frequently used in satisfaction literature, it calls for some caution, since the previous assumption may not hold if the distance between the quality of service attributes' categories is not the same.

OLMs were used because the dependent variable (satisfaction) is ordinal in nature, implying that simple regression could produce biased results. In general, an OLM is expressed as a latent-variable model. Defining y^* as a latent variable, the structural model is:

$$y_i^* = \boldsymbol{\beta} \cdot \boldsymbol{x_i} + \varepsilon_i \quad (1)$$

where i is the observation and ε is a random error. In this case, y_i^* is the dependent variable (satisfaction); $\boldsymbol{x_i}$ is the set of independent variables for individual i (quality of service perceptions and other dummy variables for sociodemographic characteristics or location); $\boldsymbol{\beta}$ are the parameter estimates to be calculated; and ε_i is the error term. Because y^* is latent, its value depends on the identification assumption we make about the variance of the errors (in OLM, the assumption is $\mathrm{Var}(\varepsilon) = \pi^2/3$), and the $\boldsymbol{\beta}$ coefficients, other than the sign, do not offer any useful interpretation.

In order to interpret and compare the results from different OLMs this paper uses an approach based on transforming the coefficients into more meaningful quantities (Long and Freese, 2014). In OLM, the marginal change is represented by the β parameters, following Eq. (2).

$$\frac{\partial y^*}{\partial x_i} = \beta_i \quad (2)$$

However, the marginal change cannot be interpreted without standardizing (using the standard deviation of y^*) because of the identification problems highlighted above. Then, the y^*-standardized coefficient for x_i is:

$$\beta_i^{Sy^*} = \frac{\beta_i}{\sigma_{y^*}} \quad (3)$$

which, in our case, could be interpreted as "for a unit increase in variable x, satisfaction is expected to increase by $\beta_i^{Sy^*}$ standard deviations, holding all other variables constant". This is an appropriated interpretation for dummy or categorical variables (e.g., sociodemographic characteristics or location). However, for continuous independent variables (that are affected by the variable's units) it is more meaningful to use the fully standardized coefficient (Long and Freese, 2014) following Eq. (4), which means that "for a standard deviation increase in variable x, satisfaction is expected to increase β_i^S standard deviations, holding all other variables constant".

$$\beta_i^S = \frac{\sigma_i \cdot \beta_i}{\sigma_{y^*}} \quad (4)$$

Using the standardized marginal changes, it is possible to compare not only the direction but also the magnitude of the effect of different variables over the dependent variable (Long and Freese, 2014). All statistical analyses were done using Stata/MP 16.1.

5. Results

5.1. General model and market segment models

Table 2 presents the models for the pooled sample and the 14 market segments, providing the parameter estimates (β) and the standardized marginal changes (SMC) for each independent variable (quality of service attributes and city) that were significant ($p < 0.05$). The following interpretation is based on the SMC for the quality of service attributes, as the city variables (dummy) were introduced in the models to control for possible heterogeneity based on location (including possible differences in public transport performance at each location).

For the quality of service attributes, the SMC can be interpreted as "for a standard deviation increase in the independent variable (e.g., perception about frequency), the dependent variable (overall satisfaction) is expected to increase by the value of the coefficient SMC times the standard deviation, holding all other variables constant". Therefore, the higher the SMC of an independent variable, the greater the impact or importance of that variable on overall satisfaction.

The adjusted R^2 (pseudo) values, ranging from 0.284 to 0.333, can be considered a good fit for this kind of data. For the general model and for each market segment, the proposed models are superior to the intercept-only models according to the log-likelihood ratio test, meaning that both the quality of service attributes and the city are significant variables that influence satisfaction in all cases. All the models indicate, through the likelihood ratio, based on χ^2, that a significant relationship exists between the dependent variable and the set of independent variables.

Of the 14 quality of service attributes analysed, six had a significant influence on the general satisfaction for a considerable number of segments: frequency, punctuality and intermodality were significant in all the models; cost and cleanliness in 14 models (not being significant for S_{high}), service hours in 11 (not significant in S_{city}, S_{freq}, S_{nud} and S_{high}) and speed in 10 (not significant in S_{city}, S_{fem}, S_{freq}, S_{dep} and S_{low}). Proximity, temperature, safety and information were identified as influential in less models; accessibility, individual space and security were significant in three or less market segments.

Frequency had the largest impact on six segments, with the highest SMC value (0.22) for S_{high}, and had the second largest impact on seven segments. Similarly, punctuality presented the greatest significant effect on ten segments, the highest case being S_{freq} (0.23); and had the second largest impact on three segments. Intermodality presented the second largest effect (0.14) on three segments (S_{ma}, S_{fem} and $S \leq 44$), and the third largest effect on eight segments. Cleanliness also had the third largest effect on two segments (S_{city} and $S \leq 44$) and the second position for segment S_{low}.

Punctuality, frequency and intermodality were the most important attributes for the general model. Cleanliness was ranked in fourth place, while service hours, speed, and cost were significant to a similar degree (0.07 on average). Proximity, temperature, safety and information were other significant quality of service attributes, with a lower impact (0.05 in average).

Most segments generally presented from eight to ten significant quality of service attributes. Only S_{city} presented six significant attributes, and there were two segments (without university degree and high incomes) with seven significant quality of service attributes. Variability in importance was high for some attributes and low for others. Security presented the highest variability (162%), calculated as the relationship between the largest SMC (high income: 0.144) and the lowest one (with university degree: 0.055). Proximity (156%) and frequency (128%) also provided high values. Accessibility showed the lowest variability (40%), followed by service hours (68%).

Table 2 also allows for comparisons with the following results:

- Geographical area (city centre versus metropolitan area): frequency and punctuality are important attributes for both segments. Frequency is the most important for residents in the city centre, while for those residing in metropolitan areas, punctuality is more important. Intermodality takes second place for residents of the metropolitan area. Cleanliness is the third most important aspect for residents of the city centre. Other significant attributes for city centre residents are proximity, cost and intermodality; whereas the metropolitan area adds service hours, speed, cost, cleanliness and safety.
- Gender (male versus females): For males, punctuality, frequency, and speed are the main attributes, in this order; but for females, frequency, intermodality and punctuality are the main attributes. Other significant attributes for males are intermodality, cleanliness, temperature, service hours, safety, cost and information. Females give a lower number of significant attributes. Apart from the three most important ones, females put emphasis on cleanliness, service hours, cost, proximity and accessibility.
- Age (from 18 to 44 years old versus more than 44 years old): Punctuality, intermodality and cleanliness are important attributes for the youngest age group, whereas the most important attributes for the older group are frequency, punctuality and intermodality. Frequency and cleanliness are important for both, in the fourth position. Young users significantly appraise temperature, safety and information, yet the older users do not, preferring proximity and individual space. Service hours, speed, and cost are important for both age groups.
- Frequency of using public transport (frequent versus occasional user): frequency, punctuality and intermodality are the three most important attributes for both segments. Cleanliness is in fourth position for both users. Occasional users present more significant attributes: service hours, proximity, speed, cost, and security. Cost, accessibility, temperature and safety are relevant for frequent users.
- Education level (with versus without university degree): frequency and punctuality are the most important attributes for both segments. Users not holding a degree also highly appraise cleanliness and intermodality, while those with a degree appreciate intermodality and service hours. The group with a university degree presents more significant attributes (11) than the other group (7). Speed, cost and temperature are further attributes considered significant by those with fewer years of education; users with a high education level also identified as important proximity, speed, cost, cleanliness, safety, security and information.
- Dependent member in the family (with versus without dependent members in the family): punctuality and frequency are upheld as the most important by both groups. Those not having dependent members in the family value intermodality in third place, while users with dependent family members place safety in third place. Intermodality

Table 2
Modelling results: pooled sample and market segments.

	Pooled sample (S_{all})		City centre (S_{city})		Metropolitan area (S_{ma})		Male (S_{male})		Female (S_{fem})	
	β	SMC	β	SMC	β	SMC	β	SMC	β	SMC
1.Service hours	0.203	0.078	ns	ns	0.254	0.099	0.185	0.068	0.224	0.088
2.Proximity	0.132	0.049	0.224	0.077	ns	ns	ns	ns	0.182	0.069
3.Frequency	0.365	0.140	0.511	0.187	0.310	0.120	0.372	0.137	0.372	0.146
4.Punctuality	0.440	0.175	0.450	0.175	0.444	0.177	0.530	0.209	0.334	0.132
5.Speed	0.190	0.069	ns	ns	0.213	0.076	0.313	0.111	ns	ns
6.Cost	0.168	0.065	0.226	0.085	0.143	0.055	0.153	0.058	0.185	0.072
7.Accesibility	ns	ns	ns	ns	ns	ns	ns	ns	0.187	0.068
8.Intermodality	0.324	0.119	0.212	0.076	0.376	0.139	0.285	0.100	0.367	0.140
9.Individual space	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
10.Temperature	0.123	0.046	ns	ns	ns	ns	0.190	0.069	ns	ns
11.Cleanliness	0.271	0.100	0.405	0.151	0.216	0.079	0.265	0.094	0.261	0.099
12.Safety	0.163	0.057	ns	ns	0.189	0.065	0.202	0.067	ns	ns
13.Security	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
14.Information	0.128	0.046	ns	ns	ns	ns	0.156	0.056	ns	ns
Rome	-1.140	-0.372	-0.961	-0.301	-1.241	-0.411	-0.883	-0.287	-1.596	-0.518
Berlin	-0.347	-0.113	ns	ns	-0.469	-0.155	ns	ns	-0.546	-0.177
Lisbon	-0.304	-0.099	-0.687	-0.215	ns	ns	ns	ns	-0.563	-0.183
London	-0.331	-0.108	-0.653	-0.204	ns	ns	ns	ns	-0.438	-0.142
N	2306		738		1568		1236		1070	
LL-zero	-3543.98		-1145.69		-2387.53		-1879.66		-1657.54	
LL-final	-2460.40		-773.67		-1671.27		-1295.77		-1148.72	
Pseudo R^2	0.306		0.325		0.300		0.311		0.307	

	18-44 years ($S_{\leq 44}$)		45 years or more (S_{45+})		Occasional user (S_{occ})		Frequent user (S_{freq})		No university degree (S_{nud})	
	β	SMC	β	SMC	β	SMC	β	SMC	β	SMC
1.Service hours	0.187	0.072	0.218	0.083	0.288	0.114	ns	ns	ns	ns
2.Proximity	ns	ns	0.172	0.061	0.134	0.051	ns	ns	ns	ns
3.Frequency	0.248	0.097	0.507	0.188	0.338	0.132	0.389	0.148	0.368	0.145
4.Punctuality	0.456	0.186	0.402	0.153	0.334	0.131	0.581	0.233	0.414	0.166
5.Speed	0.166	0.061	0.224	0.078	0.194	0.069	ns	ns	0.220	0.081
6.Cost	0.195	0.077	0.130	0.048	0.150	0.059	0.171	0.067	0.138	0.054
7.Accesibility	ns	ns	ns	ns	ns	ns	0.178	0.061	ns	ns
8.Intermodality	0.378	0.140	0.275	0.099	0.344	0.129	0.289	0.104	0.339	0.129
9.Individual space	ns	ns	0.177	0.061	ns	ns	ns	ns	ns	ns
10.Temperature	0.134	0.052	ns	ns	ns	ns	0.164	0.063	0.221	0.087
11.Cleanliness	0.292	0.110	0.243	0.086	0.275	0.099	0.220	0.084	0.314	0.118
12.Safety	0.202	0.071	ns	ns	ns	ns	0.230	0.079	ns	ns
13.Security	ns	ns	ns	ns	0.165	0.061	ns	ns	ns	ns
14.Information	0.199	0.073	ns	ns	ns	ns	ns	ns	ns	ns
Rome	-0.986	-0.332	-1.322	-0.417	-1.406	-0.482	-0.789	-0.257	-1.175	-0.393
Berlin	ns	ns	-0.756	-0.239	-0.615	-0.211	ns	ns	-0.406	-0.136
Lisbon	ns	ns	ns	ns	-0.494	-0.169	ns	ns	ns	ns
London	-0.419	-0.141	ns	ns	-0.401	-0.137	ns	ns	ns	ns
N	1134		1172		1279		1027		979	
LL-zero	-1712.50		-1820.08		-1925.71		-1538.00		-1505.00	
LL-final	-1210.31		-1233.99		-1379.72		-1060.64		-1066.09	
Pseudo R^2	0.293		0.322		0.284		0.310		0.292	

	With university degree (S_{ud})		No dependent members (S_{ndep})		With dependent members (S_{dep})		Low income (S_{low})		High income (S_{high})	
	β	SMC	β	SMC	β	SMC	β	SMC	β	SMC
1.Service hours	0.296	0.108	0.193	0.073	0.239	0.093	0.204	0.077	ns	ns
2.Proximity	0.224	0.079	0.136	0.049	ns	ns	ns	ns	0.356	0.125
3.Frequency	0.373	0.137	0.374	0.143	0.363	0.136	0.302	0.116	0.612	0.221
4.Punctuality	0.443	0.171	0.422	0.167	0.526	0.206	0.487	0.194	0.301	0.114
5.Speed	0.152	0.053	0.223	0.080	ns	ns	ns	ns	0.192	0.067
6.Cost	0.202	0.075	0.157	0.061	0.171	0.063	0.146	0.057	ns	ns
7.Accesibility	ns	ns	ns	ns	ns	ns	0.138	0.049	ns	ns
8.Intermodality	0.346	0.122	0.349	0.130	0.219	0.077	0.299	0.110	0.371	0.131
9.Individual space	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
10.Temperature	ns	ns	ns	ns	0.258	0.093	0.153	0.058	0.199	0.071
11.Cleanliness	0.242	0.086	0.295	0.108	0.239	0.087	0.355	0.131	ns	ns
12.Safety	0.198	0.064	ns	ns	0.347	0.120	0.195	0.069	ns	ns
13.Security	0.156	0.055	ns	ns	ns	ns	ns	ns	0.408	0.144
14.Information	0.156	0.054	0.217	0.079	ns	ns	0.230	0.085	ns	ns
Rome	-1.135	-0.358	-1.061	-0.349	-1.188	-0.375	-1.105	-0.367	-1.299	-0.402
Berlin	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Lisbon	-0.352	-0.111	ns	ns	ns	ns	ns	ns	-0.544	-0.168
London	-0.392	-0.123	ns	ns	-0.541	-0.171	-0.415	-0.138	ns	ns
Nº obs.	1319		1601		671		1312		735	

(*continued on next page*)

Table 2 (*continued*)

	With university degree (S_{ud})		No dependent members (S_{ndep})		With dependent members (S_{dep})		Low income (S_{low})		High income (S_{high})	
	β	SMC	β	SMC	β	SMC	β	SMC	β	SMC
Log-Ll zero	-2021.73		-2450.80		-1033.89		-1997.20		-1137.53	
Log- Ll final	-1364.26		-1708.50		-700.00		-1402.77		-758.63	
Pseudo R^2	0.325		0.303		0.323		0.298		0.333	

Notes: β = parameter estimates; SMC = standardized marginal change.
Significance levels: ns = Non-significant (p>0.05); otherwise 95%.
Madrid as reference value for the dummy variables (Rome, Berlin, Lisbon, London).

and temperature are also important for users with dependent members in the family. Other attributes that are significant for both groups are service hours, cost, and cleanliness. Proximity, speed and information are only significant for those who have no dependent members in the family.

- Net income (low versus high-income): There are noteworthy differences between these two groups. The top three attributes for low income users (in order of preference) are punctuality, cleanliness and frequency, whereas for the high-income group the top three are frequency, security and intermodality. Punctuality, intermodality and temperature are significant for both groups. However, service hours, cost, accessibility, cleanliness, safety and information are significant only for low-income users, and proximity only for high-income ones.

The reader should bear in mind that the effects of the quality of service attributes on general satisfaction are mediated by the cities where public transport services operate. To control for this effect, the cities were included in the OLM as dummy variables. The city effect is seen to vary depending on the segment: all the cities present significant differences with respect to Madrid (taken as reference) in the general model and for the segments of females and occasional users; meanwhile, the rest of the segments showed significant differences in three or fewer cities. Rome stands out, presenting significant differences for all the segments. Overall, the likelihood that private vehicle users express less enthusiastic satisfaction is higher if they live in a city other than Madrid. In the case of Rome, this is observed for all the segments.

5.2. Cross-country analysis

Table 3 shows the results for five OLMs, corresponding to data from Madrid, Rome, Berlin, Lisbon and London. These results allow to analyse the influence of the quality of service attributes over satisfaction specifically for each one of the cities. Seven dummy variables were introduced in the models to control for the sociodemographic and mobility characteristics of those surveyed in each city. Although, it could be tempting to compare the SMC between the cites for identifying similarities and differences, they should not be compared (or carefully compared) as they could by affected by differences in the quality of public transport in each city or other variables that have not been included in the models.

The adjusted R^2 (pseudo) values can be considered a good fit for satisfaction data, ranging from 26% to 33%. For all cities, the proposed models are superior to the intercept-only models according to the log-likelihood ratio test. The models specified for this analysis show the existence of significant relationships between the dependent variable and a set of independent variables.

Only frequency shows a significant influence over global satisfaction

Table 3
Modelling results: city models.

	Madrid		Rome		Berlin		Lisbon		London	
	β	SMC	β	SMC	β	SMC	β	SMC	β	SMC
1. Service hours	ns	ns	0.403	0.159	ns	ns	0.382	0.139	ns	ns
2. Proximity	ns	ns	ns	ns	ns	ns	0.274	0.100	ns	ns
3. Frequency	0.579	0.233	0.402	0.151	0.367	0.130	0.340	0.123	0.418	0.140
4. Punctuality	ns	ns	0.482	0.191	0.512	0.197	0.737	0.271	0.439	0.162
5. Speed	0.313	0.126	ns	ns	ns	ns	0.305	0.107	ns	ns
6. Cost	0.244	0.104	−0.232	−0.080	0.277	0.114	ns	ns	ns	ns
7. Accessibility	ns	ns	ns	ns	ns	ns	ns	ns	0.284	0.095
8. Intermodality	0.325	0.127	ns	ns	0.411	0.153	ns	ns	0.633	0.212
9. Individual space	ns	ns	ns	ns	ns	ns	ns	ns	0.290	0.114
10. Temperature	0.402	0.158	ns	ns	ns	ns	0.332	0.120	ns	ns
11. Cleanliness	ns	ns	ns	ns	0.436	0.160	0.281	0.096	ns	ns
12. Safety	ns	ns	0.421	0.147	ns	ns	ns	ns	ns	ns
13. Security	ns	ns	ns	ns	ns	ns	ns	ns	0.386	0.145
14. Information	ns	ns	0.262	0.096	ns	ns	ns	ns	ns	ns
City centre	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Male	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Age 45+	ns	ns	ns	ns	ns	ns	ns	ns	0.658	0.235
Habitual User	ns	ns	0.446	0.138	0.445	0.152	0.470	0.163	ns	ns
University degree	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Dependant mem.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
High income	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Nº obs.	394		412		418		424		371	
Log-Ll zero	−551.123		−619.692		−616.737		−614.973		−503.700	
Log-Ll final	−408.925		−413.456		−440.306		−435.764		−364.724	
Pseudo-R^2	0.258		0.333		0.286		0.291		0.276	

Notes: β = parameter estimates; SMC = standardized marginal change.
Significance levels: ns = Non-significant (p > 0.05); otherwise 95%.
Madrid as reference value for the dummy variables (Rome, Berlin, Lisbon, London).

with the public transport service in all the cities. Punctuality is significant in all but Madrid. Cost is significant in three cities (Madrid, Rome and Berlin). This variable has a positive sign in Madrid and Berlin, which could be expected, as a good perception of cost generates an improvement in general satisfaction. Interestingly, however, it has a negative sign in Rome. Though somewhat surprising, this result is coherent with the distributions shown in Figure A1 for the case of Rome. The distribution of frequencies for cost presents negative skewness, while the distribution of overall satisfaction presents positive skewness. Intermodality is also significant in three cities: in London, this is the attribute with the greatest SMC, and in Madrid and Berlin it presents the third highest value.

Although the quality of service attributes varies from model to model, some common patterns emerge in the impact they bear on overall satisfaction with public transport in the five cities under study. Punctuality shows the highest effect in Rome, Berlin and Lisbon; while in London it comes in second place. Frequency is the attribute with the greatest effect in Madrid, it comes in third place in Rome and Lisbon, and it is largely overlooked in Berlin and London. Service hours would be the second most influential attribute in Rome and Lisbon, but it is not significant for the other three cities. Intermodality, despite being significant in just three cities, manages to be placed among the top three attributes, taking first place in London and third place in Madrid and Berlin. Temperature and cleanliness are significant in both Madrid and Berlin, but its position is relevant in Madrid only (second place). In Berlin, the second position is occupied by cleanliness. Proximity, speed, accessibility, individual space, safety and information have a significant effect in a couple of cities, and a lesser effect on satisfaction. Security stands as the exception, positioned in third place for London.

In the different models, the influence of the quality of service attributes is controlled by the sociodemographic variables, although their effect is hardly significant. The likelihood of private vehicle users over 45 in London expressing positive satisfaction is greater than among the younger users. Moreover, the appraisal of frequent users is more positive than that of occasional users in Rome, Berlin and Lisbon.

5.3. Priority areas

It is relevant for policy makers to know how each segment of private vehicle users perceive quality and what importance they place on the different quality of service attributes, as this knowledge could be used to attract potential users towards the public transport in European cities and around the world. To this end, we present a ranking of attributes according to the estimated importance in each market segment, together with the mean satisfaction value expressed for each (Fig. 1). The aspects of service most appreciated by private vehicle users in each city and their level of satisfaction are also represented in Fig. 2. Fig. 1.a shows the importance attached to each of the quality of service attributes, represented by the standardized marginal change (SMC) obtained for each attribute from the models' output of each market segment (Table 2). The position of the attributes at the x-axis, from left to right, is based on the average value among the different market segments (average SMC). As much higher it is an attribute's average SMC, it is located leftmost. Similarly, Fig. 2.a. Exhibits also the importance attached to each of the quality of service attributes, based on the SMC, but in this case obtained from the models calibrated for each city (Table 3). Likewise, the attributes position on the x-axis follow the same criterion specified before. In addition, Fig. 1.b and Fig. 2.b show the satisfaction rates stated by the interviewees across all quality of service attributes, averaged for each market segment and for each city, respectively. The attributes' mean satisfaction rates for each city are reported in the descriptive statistics (Table 1). The position of the attributes at the x-axis of both figures is determined by the average value of satisfaction, as well as for the importance figures.

5.3.1. Priority quality of service attributes across market segments

Fig. 1.a is divided into two areas: on the left, the attributes with an average SMC above 0.10; and on the right, those with an average value below that threshold. The vertical line separates the attributes with the highest values (punctuality, frequency, intermodality, and cleanliness), which should receive the most attention, from the others; although the latter are significant, they are held to be of average importance for private vehicle users in their consideration of overall satisfaction. Deserving mention is the fact that cost is significant for a very high number of market segments (14), but it scarcely contributes to overall satisfaction. Some attributes (information, accessibility, security and individual space) are significant in just a few market segments.

Punctuality is the first ranked attribute for most of the segments, and it is significant in all of them. The segments with the highest values for punctuality are S_{freq} and S_{male}. In turn, S_{fem} and S_{high} present the lowest values for this attribute. Frequency is significant in all the segments and is found in the top two attributes for all the segments except $S_{\leq 44}$. It presents the highest values for S_{high} and S_{45+}, and the lowest values for $S_{\leq 44}$. and S_{low}. For punctuality and frequency, Fig. 1.a shows high dispersion for SMC. Intermodality is the third attribute in significance for all market segments, and takes third place in average SMC. Intermodality presents the highest values for S_{ma}, S_{fem} and $S_{\leq 44}$, and the lowest values for S_{city} and S_{dep}. As was seen for cleanliness, the dispersion of SMC is minor. The fourth attribute presenting high importance is cleanliness, being significant in 14 market segments, with maximal values in S_{city} and S_{low}, and minimal values in S_{ma} and S_{freq}.

Even though cost is significant in 14 market segments, its SMC are low in all the segments, which leaves it on the right side of Fig. 1.a. The dispersion of SMC is seen to be limited, with values ranging from 0.05 (for S_{45+} and S_{ndep}) to 0.09 (for S_{city}).

The attributes of intermediate importance are service hours, proximity, speed, temperature, safety, and security. Security is important to only three market segments, with values around 0.06 for S_{occ} and S_{ud}; but it is the second most important attribute for S_{high}. The other five attributes are significant for 8 to 11 segments, with average values between 0.07 and 0.09. The highest values for service hours are in segments S_{occ} and S_{ud}. Proximity is highly valued by S_{high}, whereas those that most appreciate speed are S_{male}. The highest SMC for the attribute temperature is seen for S_{nud} and S_{dep}. Safety's SMC are not highly significant, with the exception of the segment S_{dep}, where it is the third most important attribute.

Finally, a look at the group including information, individual space and accessibility. These three attributes are significant in a reduced number of segments, and they show the lowest average SMC, ranging from 0.06 to 0.07. Information is significant in six segments, with the highest values for S_{ndep} and S_{low}, and the lowest ones for S_{all} and S_{ud}. Accessibility, significant in three segments, shows the highest value for S_{fem} and the lowest one for S_{low}. Individual space is only significant for S_{45+}.

Fig. 1.b reflects lower variability among the perceptions about the quality of service attributes, if compared with Fig. 1.a. The red line represents the stated average satisfaction (3.26) and the blue line notes the central point of the scale (3.00). Table 1 indicates that satisfaction with the quality of service attributes varies from 3.58 (safety) to 2.99 (individual space) for the entire sample. The variability shown by the different segments with respect to the overall population is narrow; still, there are segments that stand out because of their extreme opinions, in either a positive or negative sense.

Three of the segments showed greater variability than the overall model and the rest of the market segments have remarkably high positive scores: S_{freq} is the segment expressing highest satisfaction with all the attributes, but particularly with proximity (3.73). Also deserving mention, alternating for second place in satisfaction, are S_{city} with its emphasis on safety (3.67), proximity (3.62) and frequency (3.40), and $S_{\leq 44}$ with greater appreciation for accessibility (3.62), intermodality (3.46), information (3.46), speed (3.39), cleanliness (3.22), security

(3.21) and individual space (3.14). On the other hand, S_{occ} presents the lowest values for all attributes, though individual space (2.81) and punctuality (2.82) are the attributes with the worst assessment.

The attributes most appreciated by most of the segments are safety (3.58) and accessibility (3.54). Proximity is also seen as very favourable by all the segments except S_{occ}; its score is below the average for the quality of service attributes (3.26). Meanwhile, cleanliness, temperature, security, punctuality and individual space are the attributes with the lowest rates, below average for all of the segments. Only S_{freq} expresses appraisals above the average for all attributes except individual space.

Finally, some attributes appear to be unsatisfactory for certain segments, as they are located below the central point on the scale (blue line in Fig. 1b). Individual space, punctuality, and security are not satisfactory for several market segments.

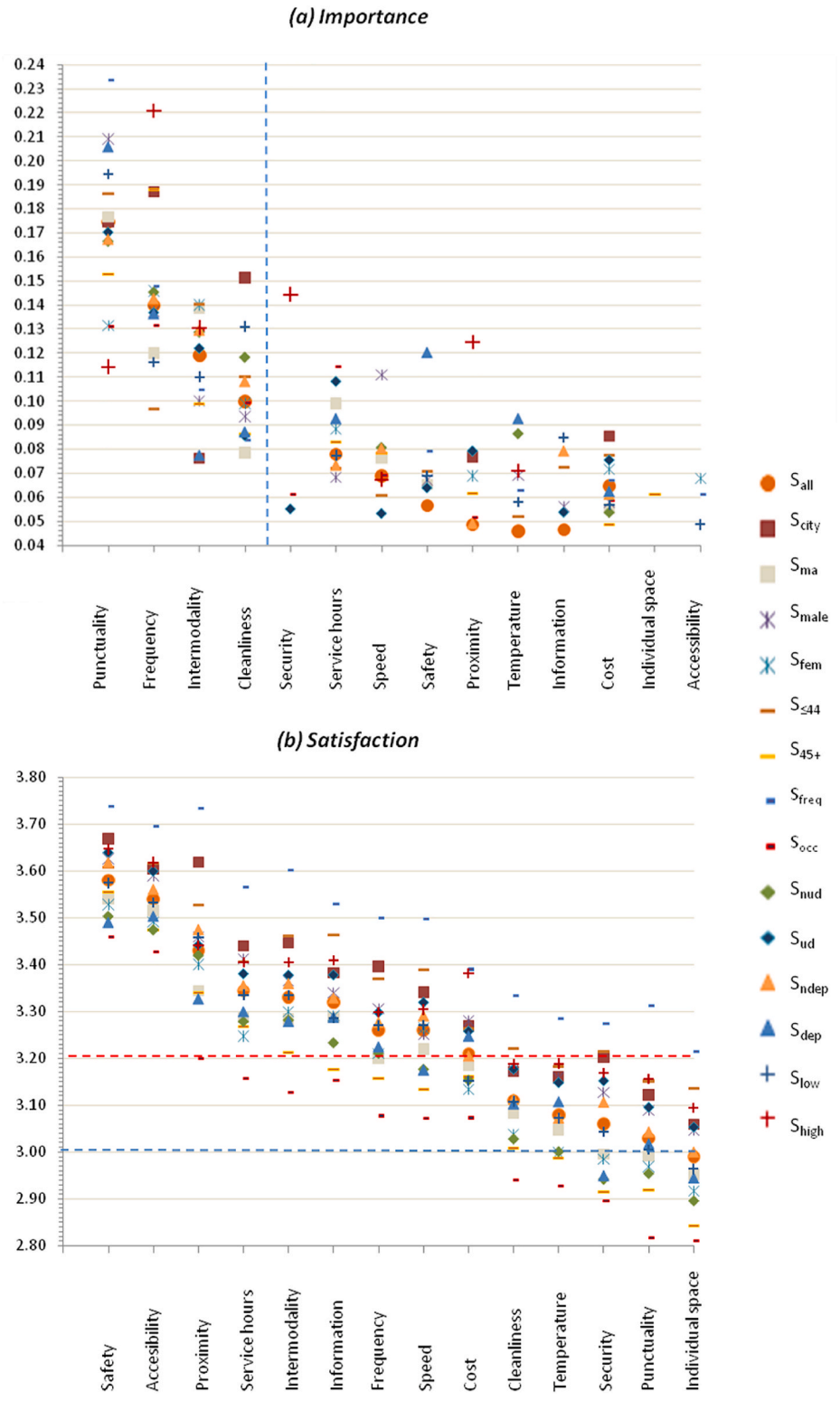

Fig. 1. Attribute importance and satisfaction across different segments of private vehicle users.

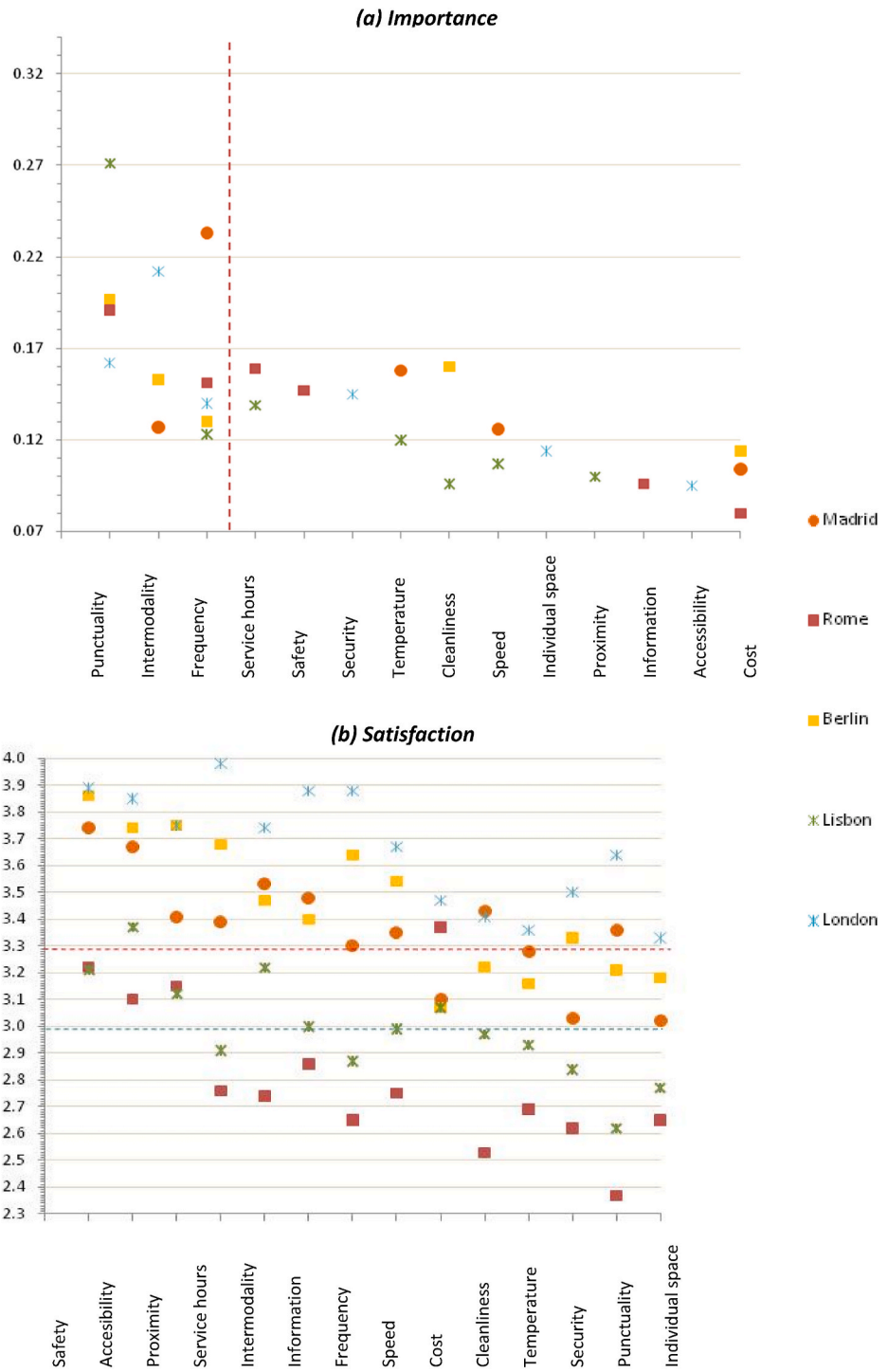

Fig. 2. Attribute importance and satisfaction of private vehicle users across different European cities.

4.4. *Priority quality of service attributes across cities*

Fig. 2.a groups the most important attributes for the private vehicle users according to their location. Punctuality, intermodality and frequency are the main attributes, both in terms of significant influence on general satisfaction in most of the cities analysed, and because of the intensity of that influence. The other 11 attributes are only significant in one or two cities. Cost is the exception. Although it is significant in three cities, it is not among the most important.

Punctuality is the most important attribute in four cities. It is the most important attribute (0.27) for private vehicles users in Lisbon; yet in Berlin, Rome and London its effect is lower. Intermodality is highly relevant in London, followed by Berlin and Madrid. Frequency is the third most important attribute. It is significant in all five cities, and it present the highest score in Madrid (0.23).

Several service quality's attributes (service hours, safety, security, temperature, cleanliness and speed) bear average impact on overall satisfaction. Still, they may be significant in only one or two cities. Service hours and safety, for instance, are relevant in Rome; security is of great interest just for Londoners; temperature is the second most essential characteristic for the users of Madrid's service, and it is also relevant in Lisbon. Lisbon presents the largest number of attributes

within this group, but with less importance compared to the other cities.

In a final stage of analysis, we grouped the attributes that appear to be of lesser relevance, significant in just one city. They are individual space and accessibility in London, proximity in Lisbon, and information in Rome. Finally, Madrid and Berlin present the lowest number of significant service quality's attributes; and the private vehicle users in Lisbon present the highest number of service quality's attributes.

Fig. 2.b shows the high dispersion existing among the five cities in terms of quality of service perception. London is the city showing the highest degree of satisfaction for nearly all the attributes evaluated, with noteworthy scores for service hours (3.98), safety (3.89), frequency, and information (both 3.88). It is followed by Berlin and Madrid, also expressing satisfaction above the average value for all the quality of service attributes (3.26, red line in Fig. 2b) with certain exceptions: in Berlin, cleanliness (3.22), temperature (3.16), punctuality (3.21) and individual space (3.18) get relatively poor evaluations, but above the line of approval (3.00); cost (3.10), security (3.03) and individual space (3.02) are similarly scored in the case of Madrid. Lisbon and Rome could be included in a different group of cities. Most of the attributes of these two cities are scored below the acceptable threshold (3.00). In Rome, the exceptions are cost (3.37), safety (3.22), proximity (3.15) and accessibility (3.10), while in Lisbon the attributes that meet with approval are accessibility (3.37), intermodality (3.22), safety (3.21) and cost (3.07).

6. Discussion

Knowing more about the perceptions of private vehicle users when it comes to the main attributes of the public transport service of major cities, and identifying their impact upon their degree of satisfaction with the service is fundamental for building strategies to attract these potential users. Both the analyses carried out here (market segments analysis controlling the location effect, and city-based analysis controlling by sociodemographic and mobility variables) have proven useful for linking the most important quality of service attributes to specific segments, as well as finding differences and similarities among market segments and cities.

This study identifies, for private vehicle users in five large European cities (Madrid, Rome, Berlin, Lisbon and London), that punctuality, frequency and intermodality are the three most important public transport service quality's attributes. Two of these attributes (frequency and punctuality) are often identified as key attributes by the users of public transport in developed countries (Quddus et al., 2019), where the top four attributes use to be punctuality, frequency, comfort, and speed. Intermodality is very important in large cities, where a journey may imply more than one mode of public transport. Frequency has a significant effect in all the strata and in all the cities. Punctuality is likewise significant in all strata and cities, except Madrid. Intermodality is significant in all the strata and for Madrid, Berlin and London. Punctuality is the most important attribute in Rome, Berlin and Lisbon, frequency is number one in Madrid, and intermodality in London. Similarly, Redman et al. (2013) found that reliability and frequency constituted the main focus for determining public transport demand and satisfaction levels. Woods and Masthoff (2017) showed that residents in large Europeans cities highlighted the car over public transport because of flexibility, reliability, comfort, effort and speed, but that some of these aspects were also important for satisfaction with public transport (e.g., safety, accessibility and proximity). Further studies of public transport users (Fellesson and Friman, 2008; Mowen, 2015) and non-users (IDAE, 2017) also found these attributes to be relevant.

In our study, the attributes cost and cleanliness were also rated as very important. Both attributes are significant in almost all market segments and in two or more cities. Cost is significant in Madrid, Rome and Berlin. Redman et al. (2013) and Bellizzi et al. (2020) highlighted the fare as an important attribute for modal change. Cleanliness is significant in Berlin and Lisbon, indeed being the second most important attribute in Berlin. Felleson and Friman (2008) likewise found this attribute to be relevant for the public transport users in Berlin, the aspect with most weight in the dimension of comfort, as well as the third most important dimension (after safety and reliability) among the satisfaction dimensions of the system.

A number of other attributes (e.g., service hours, proximity, speed, temperature and safety) were found to be important for the pooled sample and for a significant number of specific segments, but on a secondary level. Service hours, for example, is the second most important attribute for Roman users, and temperature is ranked number two in Madrid. Although these attributes may be of secondary importance, they should not be forgotten. Recently, Li et al. (2019) identified reliability (associated with information and punctuality in their study), comfort (tied to temperature) and economics (tied to travel cost) as significantly influential factors for private vehicle users in the context of modal shifts in Shanghai. Bellizzi et al. (2020) also singled out these attributes, affirming that bus users place emphasis on more attributes (waiting time, comfort and fare) than potential users (only fare).

It is interesting to note that all the attributes studied bear an impact on satisfaction with service, albeit for a minimal number of market segments or just one city. This finding is in line with previous reports of satisfaction with public transport (e.g., Abenoza et al., 2017; de Oña et al., 2018), where all the quality of service attributes are identified as significant. Accessibility, individual space, security and information are the four attributes found to be significant in fewer cases, and therefore they would occupy the lowest part of the ranking. Notwithstanding, in some cities these attributes contribute significantly to overall satisfaction, as would be the case of security in London.

This distinction of levels for the attributes of public transport in the minds of public transport users has been previously identified in the literature (de Oña and de Oña, 2015b). Philip and Hazlett (1997) proposed a model based on three classes of attributes (pivotal, core, and peripheral). This model was subsequently contrasted for the rail transportation industry by Tripp and Drea (2002). The Transit Capacity and Quality of Service Manual (Transportation Research Board, 2004) categorizes attributes under availability factors, which are more important to passengers, and comfort and convenience factors, which are less important for passengers. Eboli and Mazzulla (2008) empirically demonstrated the existence of two categories of attributes (basic and not basic).

The analysis of these market segments has also led to awareness of the heterogeneity among opinions of private vehicle users, the market segments likewise reflecting a heterogeneous number of significant attributes (ranging from six to eleven). Given, the most important attributes (punctuality, frequency, intermodality, cost and cleanliness) are repeated in most segments, but the attributes on other levels of importance are segment-specific. Hence, specific conclusions can be drawn per segment: e.g., high income private vehicle users value security; users with dependent family members value safety, male users value speed.

For the pooled data, Fig. 1.b shows that private vehicle users are satisfied with all the quality of service attributes, with the exception of individual space. The stated perceptions for the quality of service attributes are located above the central point of the scale (3.0) for all the attributes and for most of the segments. We should highlight that individual space is one of the attributes with the lowest satisfaction among all market segments, proving significant in just two (S_{45+}, S_{occ}). Fig. 1.b shows that the most critical private vehicle users in these five European cities are occasional users, aged over 45 and not having a university degree; the most satisfied are frequent users, younger than 45 and having high incomes. Nonetheless, Diana (2012) did not arrive at any clear correlation between satisfaction and the level of use of public transport in Italy.

Private vehicle users in London gave higher scores to general satisfaction, and most of the quality of service attributes (Table 1), followed by Madrid and Berlin. Yet the first analysis undertaken here led to the identification of private vehicle users in Madrid as the most generous in their appraisals of public transport (Table 2) —in all cases the marginal

change of the dummy variables for controlling the city's effect are negative or non-significant. The most critical views of the public transport system come from Rome, which presents significant differences from Madrid in all the strata. Generally speaking, the most critical opinions come from women and occasional users. Bellizzi et al. (2020) also reported that women users of public transport were more critical about service.

The analysis by cities showed that of all the quality of service attributes considered, only five to seven are significant for private vehicle users, though findings vary depending on the city. Users in Madrid and Berlin are the ones identifying the fewest significant attributes, whereas those of Lisbon identify the most. In addition to the aspects mentioned above (frequency, punctuality and intermodality), private vehicle users in Madrid appraise speed, cost and temperature as significant; in Rome they value service hours, cost, safety and information; in Berlin cost and cleanliness are most valued; in Lisbon they emphasize service hours, proximity, speed, temperature and cleanliness; and in London users identify accessibility, individual space and security. This second analysis shows that no significant differences could be detected in Madrid regarding the different market segments. In the cases of Rome, Berlin and Lisbon, significant differences were identified only in terms of the user typology, where frequent users of public transport gave higher ratings than occasional users. In London the key difference was age: private vehicle users over 45 better appraised the public transport service.

The private vehicle users of Rome and Lisbon are the most critical. They gave scores below 3.0 for all the characteristics of the service except for the three-best ranked in the entire sample (safety, accessibility and proximity), and intermodality in the case of Lisbon. Notwithstanding, the residents of London, Madrid and Berlin are satisfied with the service, and consistently score the quality of service attributes above 3.0. Susilo and Cats (2014) likewise identified the public transport service in Rome as one of the three worst in their study of eight European cities.

The different importance weights and satisfaction rates attached to the various characteristics in the five different cities probably are due to two reasons: a) the geographic context produces heterogeneity among the private vehicles users opinions (i.e., they present different needs and preferences according to their different territorial context); and b) the actual performance of the service is also different at each city. We retain that the cultural context is very similar among these five major European cities, but with some specific particularities for each location. So, it should not be expected that private vehicle users evaluate equally the public transport service in each city. In this way, Susilo and Cats (2014) found similar patterns and also differences in determining the main determinants of satisfaction with the public transport service across eight European cities; and similar results were also found by Woods and Masthoff (2017) when analysing the preferences towards car driving, public transport and cycling in Barcelona, Helsinki and Milan. So, in extrapolating these findings to other settings, one must bear in mind that the importance attributed to the various quality of service attributes could be quite influenced by the characteristics of the non-users, their patterns of mobility, their experience using public transport, and the location where the service operates.

7. Conclusions

Possible measures oriented to encourage the use of public transport among private vehicle users, and to retain existing users, should include improving the quality of service. Offering a service that the private vehicle user perceives as one of quality, representing a suitable option for regular journeys, calls for familiarity with the personal context of the user and his/her perception of the main attributes of the service that provide for general satisfaction. The present study aims to contribute to such knowledge of the perspective of private vehicle users regarding the quality of their local public transport service.

By looking into the private vehicle users' perceptions of public transport through a survey of five Europeans cities (Madrid, Rome, Berlin, Lisbon and London) and OLM, we were able to identify essential attributes of service that are determinant for the satisfaction of private vehicle users. These aspects may be the key points to be actively addressed by policymakers. In general, private vehicle users are satisfied with their public transport system in the five European cities analysed here. Nevertheless, perceptions vary from city to city: the residents of London, Madrid and Berlin are the most satisfied, while those of Rome and Lisbon express a lower level of satisfaction. In this way, it is manifested the importance of the context where the service is being performed. In fact, satisfaction is influenced by the actual service quality performance, as well as for the user requirement level about the service. This last issue is related with the user cultural and socioeconomic context. Moreover, we have to bear in mind that, in this research, private transport users have a minimum knowledge about the service (otherwise, they would not be able to evaluate it). Perhaps, evaluating private vehicle users with no use or knowledge about the public transport service would supply signals of higher dissatisfaction levels, as some authors have proved that public transport users are more delighted with the transit service than private transport users with little knowledge about the service.

Frequency, punctuality, intermodality, cost and cleanliness were identified as the five most important attributes in most of the market segments analysed for these cities, and they should be considered as core attributes for the private vehicle users. Frequency and punctuality also tend to be of foremost importance for the users of public transport in developed countries. Although all the attributes of service were identified as significant for some market segment or some city, it can be said that private vehicle users, just like public transport users, conform different levels of attributes. The top level, or core attributes, comprises the five attributes specified above. A second level would comprise service hours, proximity, speed, temperature, and safety, elements associated with comfort and convenience that could be considered with a medium importance. And the third level would take in accessibility, individual space, security and information, attributes valued only by specific groups of private vehicle users, as the less important attributes.

This research provides evidence that the perception of quality service on the part of private vehicle users is neither homogenous among population sectors nor among cities, with the exception of the core attributes specified. The sociodemographic and territorial context, along with mobility habits, bear substantial weight when identifying other attributes that contribute to satisfaction. This finding implies that caution should be used when extrapolating the results beyond the five cities actually studied here, as heterogeneity must be accounted for.

Because there are, notwithstanding, important similarities between the users of public transport and private vehicle users in terms of the perception of quality regarding diverse attributes of service (e.g., main core attributes, influence of setting, etc.), one conclusion to be drawn is that such considerations are fundamental and must be studied in depth so that the measures adopted by public transport operators can prove useful for both types of users. One of the most immediate objectives would be to enhance the level of quality perceived by both types of users, to ensure the fidelity of current users while attracting new users from the private vehicle.

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Appendix

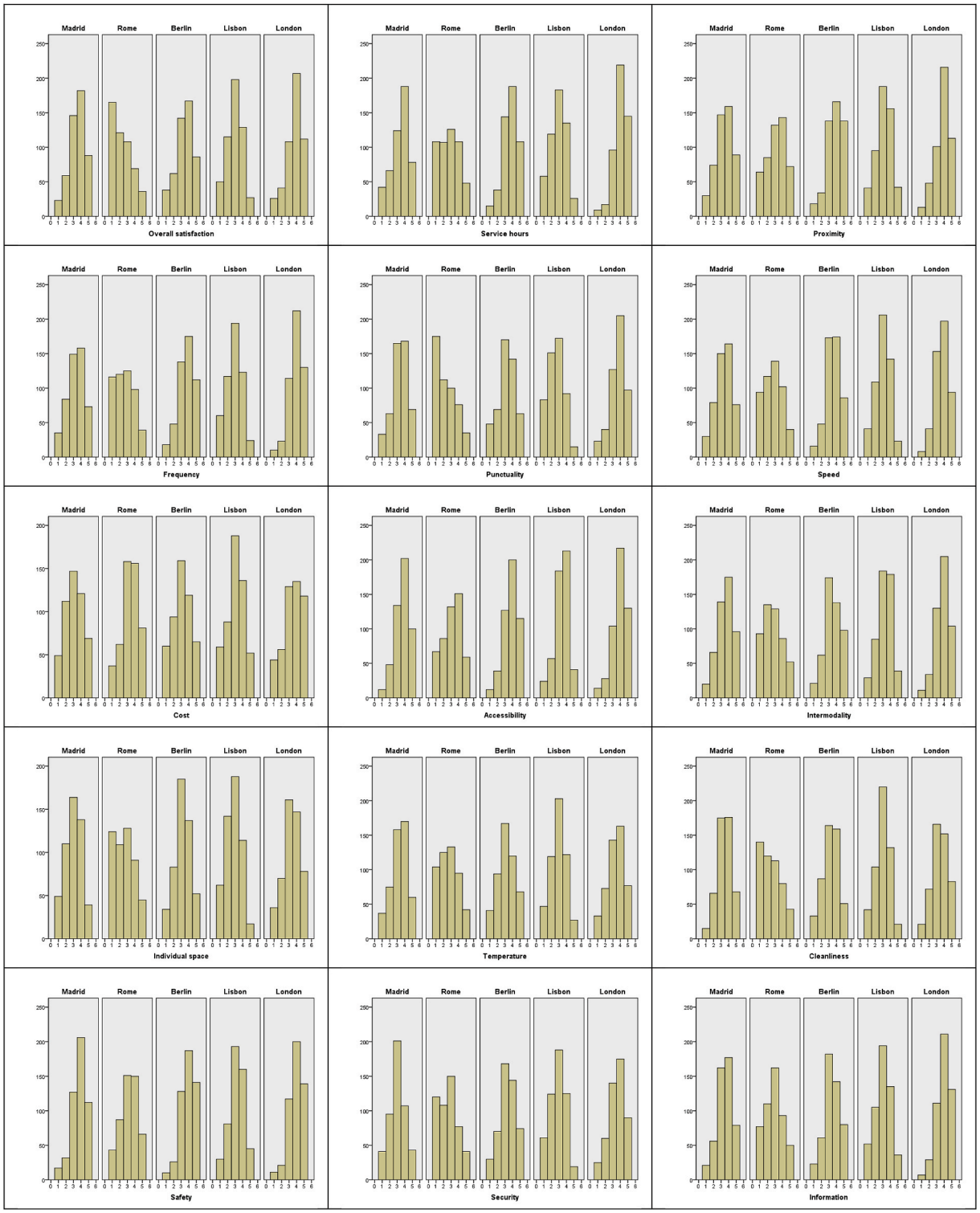

Fig. A.1. Variables' score distribution by city.

Table A.1
Kruskal-Wallis post hoc, Holm test

	Madrid	Rome	Berlin	Lisbon	London
Overall satisfaction	a		a		
1. Service hours					
2. Proximity		a	b	a	b
3. Frequency					
4. Punctuality	a		a		
5. Speed					
6. Cost	a,b		a,c	b,c	
7. Accessibility	a		a,b		b
8. Intermodality	a		a		
9. Individual space					
10. Temperature	a,b		a		b
11. Cleanliness	a				a
12. Safety	a	c	a,b	c	b
13. Security					
14. Information	a	b	a	b	

Note: a,b,c represent homogeneous groups (p-value < 0.05).

Author statement

The authors confirm contribution as follows: study conception and design, de Oña, Estevez, de Oña; data collection, de Oña and Estevez; analysis and interpretation of results, de Oña and Estevez; draft manuscript preparation, de Oña, Estevez and de Oña. All authors reviewed the results and approved the final version of the manuscript.

References

Abenoza, R., Cats, O., Susilo, Y., 2017. Travel satisfaction with public transport: determinants, user classes, regional disparities and their evolution. Transport. Res. Pol. Pract. 95, 64–84.

Al-Ayyash, Z., Abou-Zeid, M., 2019. Investigating commute satisfaction differences of private car users and public transport users in a developing country context. Transportation 46, 515–536.

Anable, J., 2005. 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. Transport Pol. 12, 65–78.

Bamberg, S., Rölle, D., Weber, C., 2003. Does habitual car use not lead to more resistance to change of travel mode? Transportation 30, 97–108.

Beirão, G., Cabral, J.A.S., 2008. Market segmentation analysis using attitudes toward transportation exploring the differences between men and women. Transportation Research Record. Journal of the Transportation Research Board 2067, 56–64.

Bellizzi, G.G., Dell'Olio, L., Eboli, L., Mazulla, G., 2020. Heterogeneity in desired bus service quality from user's and potential users' perspective. Transport. Res. Pol. Pract. 132, 365–377.

De Oña, J., De Oña, R., 2015a. Analysis of transit quality of service through segmentation and classification tree techniques. Transportmetrica: Transport. Sci. 11, 365–387.

De Oña, J., De Oña, R., 2015b. Quality of service in public transport based on customer satisfaction surveys: a review and assessment of methodological approaches. Transport. Sci. 49, 605–622.

De Oña, J., De Oña, R., Díez-Mesa, F., Eboli, L., Mazulla, G., 2016. A Composite index for evaluating transit service quality across different user profiles. Journal of Public Transportation 19, 128–153.

De Oña, J., De Oña, R., Eboli, L., Mazzulla, G., 2015. Heterogeneity in perceptions of service quality among groups of railway passengers. International Journal of Sustainable Transportation 9, 612–626.

De Oña, J., De Oña, R., Eboli, L., Forciniti, C., Mazulla, G., 2018. An ordered regression model to predict transit passengers' behavioral intentions. Case Studies on Transport Policy 6, 449–455.

De Oña, J., 2021. Service Quality, Satisfaction and Behavioral Intentions towards Public Transport from the Point of View of Private Vehicle Users. https://doi.org/10.1007/s11116-021-10175-7. Transportation.

De Oña, J., Estévez, E., De Oña, R., 2021. Public transport users versus private vehicle users: differences about quality of service, satisfaction and attitudes toward public transport in Madrid (Spain). Travel Behaviour and Society 23, 76–85.

Diana, M., 2012. Measuring the satisfaction of multimodal travelers for local transit services in different urban contexts. Transport. Res. Pol. Pract. 46, 1–11.

Eboli, L., Mazzulla, G., 2008. A stated preference experiment for measuring service quality in public transport. Transport. Plann. Technol. 31, 509–523.

EUROSTAT, European Commission, January, 2011. Dataset Population, Urban Audit Cities. https://ec.europa.eu/eurostat/web/cities/data/database.

Fellesson, M., Friman, M., 2008. Perceived satisfaction with public transport service in nine european cities. J. Transport. Res. Forum 47, 93–103.

Hine, J., Scott, J., 2000. Seamless, accessible travel: users' views of the public transport journey and interchange. Transport Pol. 7, 217–226.

IDAE, 2017. Estudio sobre hábitos y actitudes de los no usuarios habituales del transporte público urbano colectivo online: https://www.idae.es/publicaciones/estudio-sobre-habitos-y-actitudes-de-los-no-usuarios-habituales-hacia-el-transporte.

Kang, A.S., Jayaraman, K., Keng-Lin, Soh c, Wong, Wai Peng, 2019. Convenience, flexible service, and commute impedance as the predictors of drivers' intention to switch and behavioral readiness to use public transport. Transport. Res. Part F 62, 505–519.

Krizek, K., El-Geneidy, 2007. Segmenting preferences and habits of transit users and non-users. Journal of Public Transportation 10, 71–94.

Lai, W.-T., Chen, C.-F., 2011. Behavioral intentions of public transit passengers- the roles of service quality, perceived value, satisfaction and involvement. Transport Pol. 18, 318–325.

Li, L., Cao, M., Bai, Y., Song, Z., 2019. Analysis of public transportation competitiveness based on potential passenger travel intentions: case study in Shanghai, China. Transportation Research Record. Journal of the Transportation Research Board 2673, 823–832.

Long, J., Freese, J., 2014. Regression Models for Categorical Dependent Variables Using STATA. Stata Press, Tx:US.

Machado, J., De Oña, R., Diez-Mesa, F., De Oña, J., 2018. Finding service quality improvement opportunities across. Transportmetrica: Transport. Sci. 14, 761–783.

Mouwen, A., 2015. Drivers of customer satisfaction with public transport services. Transport. Res. Pol. Pract. 78, 1–20.

Parasuraman, A., Zeithaml, V., Berry, L., 1985. A conceptual model of service quality and its implications for future research. J. Market. 49, 41–50.

Philip, G., Hazlett, S.A., 1997. The measurement of service quality: a new P-C-P attributes model. Int. J. Qual. Reliab. Manag. 14, 260–286.

Quddus, M., Rahman, F., Monsuur, F., De Oña, J., Enoch, M., 2019. Analyzing bus passengers' satisfaction in Dhaka using discrete choice models. Transport. Res. Rec. 2673, 758–768.

Redman, L., Friman, M., Gärling, T., Hartig, T., 2013. Quality attributes of public transport that attract car users: a research review. Transport Pol. 25, 119–127.

Selltiz, C., Wrightsman, S.L., Cook, S.W., 1980. Métodos en investigación en las relaciones sociales, 9ª Ed. Madrid.

Şimşekoğlu, Ö., Nordfjærn, T., Rundmo, T., 2015. The role of attitudes, transport priorities, and car use habit for travel mode use and intentions to use public transportation in an urban Norwegian public. Transport Pol. 42, 113–120.

Steg, L., 2005. Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transport. Res. Pol. Pract. 39, 147–162.

Suman, H., Bolia, N., 2019. A review of service assessment attributes and improvement. Transportation in Developing Economies 5, 1–17.

Susilo, Y.O., Cats, O., 2014. Exploring key determinants of travel satisfaction for multi-modal trips by different traveler groups. Transport. Res. Pol. Pract. 67, 366–380.

Transportation Research Board, 2004. Transit capacity and quality of service manual. In: Transit Cooperative Research Program (TCRP) Report 100, second ed. Transportation Research Board, Washington, DC.

Tripp, C., Drea, J.T., 2002. Selecting and promoting service encounter elements in passenger rail transport. J. Serv. Market. 16, 432–442.

Tyrinopoulos, Y., Antoniou, C., 2008. Public transit user satisfaction: variability and policy implications. Transport Pol. 15, 260–272.

Woods, R., Masthoff, J., 2017. A comparison of car driving, public transport and cycling experiences in three European cities. Transport. Res. Pol. Pract. 103, 211–222.

Zhao, L.-n., Wang, W., Hu, X.-j., Ji, Y.-j., 2013. The importance of residents' attitude towards service quality in travel choice of public transit. Procedia Social and Behavioral Sciences 96, 218–230.