Perception of Public Transport Quality of Service among Regular Private Vehicle Users in Madrid, Spain

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ABSTRACT
Urban traffic levels can be reduced by drawing travellers away from private vehicles (PV) over to using public transport (PT). This modal change can be achieved by either introducing restrictions on PVs or by introducing measures which increase people's satisfaction with PT. Many studies have shown that quality of service affects customer satisfaction which, in turn, influences the behavioural intentions towards the service; however, these studies have mainly concentrated on PT-users. This paper intends to identify the main attributes which influence the perception PV-users have about the PT services provided in Madrid (Spain). Ordinal logit models have been applied to an online panel survey with a sample size of 500 regular PV-users. In order to achieve a comprehensive analysis and to deal with heterogeneity in perceptions, 15 models have been developed for the entire sample and for 14 user segments. The results indicate that the inhabitants are satisfied with PT in Madrid and that the most important PT service attributes for PV-users are frequency, speed and intermodality. Frequency is an important attribute for all the segments, while speed and intermodality are important for most of the segments. An analysis by segments has identified attributes which, although not important in most cases, are relevant for specific segments. Another interesting finding was that there are two attributes (accessibility and individual space) that were not found to be important in any segment. Findings from this study can be used to develop policies and recommendations for persuading more PV-users to use the PT services.

Keywords: Service quality, Satisfaction, Public transportation, Private vehicle users, Car users, Segmentation, Ordered logit

INTRODUCTION

Faced with the traffic externalities generated by the extensive and intensive use of private vehicles (PV) political agendas need to include strategies to encourage and increase the use of public transport (PT) for society to move towards a more sustainable transport system. Appropriate improvements are needed, so that commuters start perceiving PT as a more attractive mode of transport (*1*).

Various studies (eg., *2-5*) have shown that improving the image and quality of PT not only retains existing users but also attracts new users to the service. Lai and Chen (*4*) stated that satisfaction has a direct and important effect on behaviour. For Zhao et al. (*5*) satisfaction has a significant positive influence on making the choice to use public transport. Jen et al. (*3*) pointed out that satisfaction is the connection between service quality, loyalty and behavioural intentions, adding that this relationship can be effective for both the regular customer and the potential customer, although the behaviour of car users is more difficult to change (*2*). Generally, these studies concentrate on evaluating the satisfaction levels of PT users, less research exists looking at the perception of non PT users (e.g. *6-9*). Understanding the satisfaction of regular PV users is of great interest if we are to comprehend their needs and preferences with regard to PT to convince them to make the modal switch. PV user satisfaction shows a high degree of heterogeneity, given the socio-demographic characteristics of the users, their mobility patterns, their tastes and preferences, or the subjectivity they feel to certain aspects of the PT service, as also occurs with the PT users themselves (*10*).

The aim of this study centres on analysing how PV users feel about public transport by identifying the attributes with the greatest influence on their overall perception of the service. Furthermore, the study also aims to identify the presence of heterogeneity in perception according to specific market segments of PV users. The methodology followed involves an analysis of user groups with specific socio-demographic characteristics and according to specific mobility conditions. This will be the first time that a study has been specifically performed on PT quality which concentrates on PV user perceptions whilst controlling heterogeneity through sample stratification.

The paper is organized as follows: the Literature review section presents the existing research on this area; the Data collection section briefly describes the survey, the data collection process and some descriptive statistics; the section on Discrete choice models presents the methodology followed; the Results and Discussion sections summarize and highlight the main outcomes obtained with the analysis; and finally, some of the conclusions drawn and policy implications are offered in the last section.

LITERATURE REVIEW

PV user satisfaction with public transport

The ample bibliography addressing perceived quality in public transport highlights the huge interest in the importance of customers' opinions in the evaluation of service performance. However, there are much fewer studies that address the point of view of non-users in analysing PT service quality (e.g., *6-9*). Abenoza et al. (*6*) analysed data provided by the Swedish Public Transport Barometer, which asked both current users and non-users (or rarely users) of public transport about how satisfied they were with the service being provided according to certain service attributes. Krizek and El-Genedy (*7*) analysed the data collected from two surveys asked about a metro system, one interviewed PT users and the other asked non-users. The latter survey covered the following topics: the reasons for not using transit, the perceptions of non-users about safety and comfort whilst using transit, and their concerns about driver attitude,

amenities, commute characteristics and service reliability. Li et al. (*8*), surveyed commuters who drive to work (car users) to assess which factors had the most bearing on their willingness to travel by PT. They explained that PT comfort, reliability and economics played a significant role in attracting PV users over to PT, while timeliness and freedom were not significant. Two other factors (convenience and safety) were not included in the final model because they were not found to be significant in a previous paired sample T-test. Woods and Masthoff (*9*) asked the public for their perceptions of different service aspects regarding their car driving, public transport and cycling experiences in three European cities (eg., comfort, flexibility, speed, good value for money, etc.). This sample of users was defined as car users, PT users, cyclists and those who used various modes of transport based on their most frequent journey.

Other research has addressed which aspects of the PT service encourage people to make the modal switch (*11*), or has looked at which aspects of the PT service need to be improved to make it more attractive to car users (*12*). Redman et al. (*11*) reviewed 74 studies where improvements had been made to certain service attributes in different PT services and evaluated the effect the changes had on encouraging people to make the switch from the private vehicle to public transport. The fare was identified as the attribute that had the biggest influence on modal change, whether that was by offering a completely free service or by introducing fare reductions. In fact, Fujii and Kitamura (*13*), Thøgersen (*14*) and Thøgersen and Møller (*15*) all found that free PT use has an initial effect in attracting car users to PT, but that other quality attributes are important for sustaining this modal switch over time. This needs to be followed up by finding the individual motivations and values of these PV users, what would attract them to using public transport. Hine and Scott (*12*) used the qualitative analysis (focus groups and in-depth interviews) of car users and PT users to determine the service attributes that could be improved to make the PT interchanges and journeys more attractive.

One of the criticisms made regarding the measurement of non-user satisfaction with PT is that in order to obtain specific judgements about different service attributes the interviewee must have some information or experience about using the service or at least some knowledge about it (*5*).

Main quality of service attributes in public transportation

Quality of service as a multidimensional construct (*16-17*) is usually measured by users scoring a series of quality of service attributes (QoSA).

There is no unanimous consensus about which QoSAs should be considered in researching service quality perception. Nevertheless, supported by Parasuraman et al. (*17*), many works propose a generic list for any kind of service while other authors state that each service being analysed needs its own particular list which is adjusted to the type of service and the specific context (*10*). The argument being that the more the QoSA suits the characteristics of the service being studied in a specific context and with its own particularities, then the greater will be the probability of obtaining valid and trustworthy results to determine the most suitable strategies for improving the service.

Redman et al. (*11*) reviewed the literature to identify which were the most widely used QoSAs in studies about quality in PT. They were able to categorise these attributes into Physical attributes (reliability, frequency, speed, accessibility, price, information provision, ease of transfer/interchanges, and vehicle condition) and Perceived attributes (comfort, safety, convenience and aesthetics). These QoSAs are replicated in different work with greater or lesser desegregation (e.g., *6;18*). For example, Mowen (*18*) used 15 QoSA for an analysis of the Dutch PT market (bus, tram, metro and regional train) by grouping into core attributes (on-time performance, speed,

frequency, price), interactional attributes (personnel and driver behaviour) and physical attributes (on-board information, information at stops, safety at stops and on-board, ticket accessibility, cleanliness of vehicle, ease of boarding, seat availability and noise). Similarly, Abenoza et al. (*6*) analysed the PT service in Sweden using 15 attributes, among which were customer interface, safety, information (general, planned and unplanned changes), speed, convenience, cleanliness of vehicle, frequency, seat availability, personnel and driver behaviour, ticket accessibility, reliability, station maintenance and proximity. Although specific to each of the studies the QoSAs being used are generally quite similar.

Market segmentation for heterogeneity analysis

When analysing satisfaction, it must be remembered that the researcher is working with highly heterogeneous subjective data and segmentation techniques need to be applied to allow for a more in-depth analysis (*10;19*). The research can then identify the relevant aspects for each segment and specific improvement strategies can be designed (*20*).

Many authors (eg., *6-7;20-21*) have analysed PT user satisfaction using different approaches to segmentation to analyse perception heterogeneity. Segmentation based on sociodemographic characteristics (eg., geographical area of residence, income, occupation, standard of education, gender, age, etc.) is the most widely used procedure; although it is also interesting to set the differences based on mobility patterns (*19*), frequency of using PT (*8;22*) or attitudes towards PT (*23-24*).

Although more recently there has been an increase in the use of cluster analysis to address heterogeneity (eg., *6;21;25*), most studies continue to use a traditional market segmentation based on a population's socioeconomic and demographic characteristics (eg., *26-28*).

DATA COLLECTION

The aim of this paper is to analyse the perception of quality that PV users in Madrid have of the public transport services on offer. These users are defined as people who use a motorised vehicle (i.e. car, motorcycle or scooter) for their daily journeys. However, for them to be able to suitably evaluate the PT service and take part in this research they must have a minimal knowledge about the services available in the study area (*5*), therefore, the regular PV users being asked must be at least occasional PT users.

Table 1 here

The quality of public transport was collected through an online panel survey in the Madrid metropolitan area during May and June 2019. The questionnaire, with an average duration of 7 minutes, consisted of several parts: questions to identify the study's target population; PV usage habits; experience and satisfaction with use of the PV; reasons for hardly ever using PT; perceived quality, satisfaction, attitudes and intention to use PT; knowledge about the PT service; and sociodemographic and mobility questions. Table 1 displays the 22 variables that were considered for this study: overall satisfaction with the PT service (1 item), quality of service attributes (14 items), and sociodemographic and mobility attributes (7 items). The PV users were asked to score their perception about overall satisfaction with the PT service and with its QoSAs on a 5 point Likert scale ranging from 1 to 5 (where 1 meant "very unsatisfied" and 5

meant "very satisfied"). In total, 500 regular PV users, who were also at least occasional PT users (less than one trip per week), completed the survey.

Table 1 shows that the regular PV users in Madrid are mainly males (59.8%), residents in the city centre (54.6%), between 25 and 44 years old (45.8%) and between 45 and 64 years old (30.4%), with university degrees (59.2%), with a household monthly family income below 2,700€/month (43.8%) and with no dependent members in the family (66.2%) (i.e. children or other dependent relatives). Regarding their mobility patterns, 57.0% are occasional PT users (less than one trip per week) and 43.0% are frequent PT users (one or more trips per week). These are normal rates of PT usage in large metropolitan areas with highly used public transport networks mainly in the city centre, even by regular PV users. Occasional PT users (N=285) were also asked about the three main reasons for such a low frequency of use. The main reasons were the unsuitability of the service for their routes (53.0%), their personal preferences for the car (37.9%), the length of the trip in time using public transport (36.8%) and the distance to the stops at origin or destination (35.1%). We highlight that the reason "I don't know the service" was only pointed out by three people (1.1%).

PV users scored the general satisfaction with the PT service (3.51) above the scale's central value which was above the average of the QoSAs scores (3.36). Safety and accessibility presented the highest average scores (3.74 and 3.67), followed by intermodality (3.53) and information (3.48). Interestingly, individual space and security had the lowest average scores (3.02 and 3.03).

DISCRETE CHOICE MODELS

In order to investigate the main determinants of transit satisfaction among the different segments of PV users, several ordered regression models were specified and estimated. The ordered regression models used here were for the following categories of users:

- General: i.e. considering all PV 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 PV users into two age groups, from 18 to 44 years old and 45 years old or older ($S_{<44}$ vs. S_{45+}).
- Public transport use frequency: dividing into occasional PT users (less than one trip per week) and frequent PT users (one or more trips per week) (S_{occ} vs. S_{freq}).
- Standard of education: differentiating between with or without a university degree. (S_{ud} vs. S_{nud})
- Dependent persons in the family: distinguishing PV users with or without dependent persons in the family (S_{dep} vs. S_{ndep}).
- Net income: dividing into two groups, incomes below 2,700€/month and incomes above 2,700€/month (S_{low} vs. S_{high}).

In total, 15 models were specified and estimated (a general model for the entire sample, and two models for each one of the variables considered for segmentation). The models contained overall satisfaction with PT as their dependent variable and 14 quality of service attributes as independent variables. In all the models the socio-demographic variables were not considered as they were used for segmentation purposes.

In agreement with previous studies (e.g. *6;29-30*) the independent variables are treated as if they were continuous variables. 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

produces an average incremental change that shows the general trend which could be relevant for policy implications (*6*). However, although this approach has been frequently used in the satisfaction literature, some caution is needed since the previous assumption may not hold if the distance between the QoSAs' categories is not the same.

Ordered logit models were used because the dependent variable is ordinal in nature in this case and to perform a simple regression would produce biased results. In order to be able to compare different ordered logit models, the marginal effects on the expected value of the dependent variable were derived from the parameter estimates. In ordered logit models, the marginal change is represented by the β parameters and the marginal effects is the fully standardized coefficient for the independent variable (*31*).

All statistical analysis was performed using STATA/MP-15.

RESULTS

Estimated models

Table 2 shows the results of the estimated coefficients (Estim.) and the marginal effects (M.Eff.) for each QoSA that was significant at the 95% confidence level. The marginal effects coefficient can be interpreted as "for a standard deviation increase in the independent variable, the dependent variable is expected to increase by the value of the coefficient times standard deviations, holding all other variables constant". Therefore, the higher the marginal effect of an attribute is the greater will be the impact or importance of that attribute on overall satisfaction.

The adjusted R^2 (pseudo) values ranging from 0.234 to 0.344 can be considered a good fit for satisfaction 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 (see Table 2).

Accessibility and individual space were not found to be significant for any of the segments. Service hours were only found to be significant for S_{ud}. Proximity of stops to origin-destination was only significant for S_{fem} and S_{45+}. Similarly, cleanliness was significant for S_{city} and S_{ndep}, and safety was found to be significant for S_{all} and S_{ndep}. The three significant attributes in a greater number of segments were frequency (all models), speed (11 models) and intermodality (10). Frequency had the largest impact on 13 out of 15 segments, with the highest value (0.32) for S_{high}. The only exceptions are punctuality that had the largest impact for S_{freq}, and temperature for S_{low}. Speed had the second largest impact on three of the segments (general model, S_{city} and S_{high}) and the third largest effect on five segments (S_{male}, S_{fem}, S_{freq}, S_{ud} and S_{dep}). Intermodality occupies the second position for six segments (S_{ma}, $S_{<45}$, S_{occ}, S_{nud}, S_{ndep} and S_{low}) and the third position in the general model (S_{all}).

Frequency, speed and intermodality are the most important attributes for the general model. Safety, temperature and cost were the other three significant QoSAs with a lower impact. All the other QoSAs were not found to be significant. Table 2 shows that, with the exception of frequency, most of the significant attributes were different between the segments.

Table 2 here

Most segments generally presented from four to six significant QoSAs, but there were still some segments with very few significant attributes (S_{nud} and S_{high} with only two, and S_{freq} with three attributes). However, there is one segment (S_{ud}) with seven significant QoSAs. Variability in importance is high for some attributes and low for others. Safety presents the highest variability (205%), calculated as the relationship

between the largest (S_{dep}: 0.241) and the smallest (S_{all}: 0.079) M.Eff. coefficient. Temperature (104%) and frequency (102%) also provide high values. Cleanliness shows the lowest variability (25%), followed by information (41%) and proximity (54%).

Table 2 allows comparisons to be made with the following results:

- Geographical area: frequency and speed are important attributes for both segments. However, S_{ma}'s PV users consider intermodality and security to be very important, while these attributes are not significant for S_{city}. S_{city}'s respondents identify cleanliness, information and temperature as significant.
- Gender: frequency, speed and intermodality are important attributes for both groups. In the case of females, cost and proximity are also important, while temperature and punctuality are important for males.
- Age: frequency is the only important attribute for both segments. Proximity, cost and speed are important for the older PV users, whereas intermodality, punctuality, information and security are important attributes for the youngest age groups.
- Frequency of using public transport: frequency and speed are important attributes for both segments. For frequent PT users the other important attribute is punctuality, while for the occasional PT users the other important attributes are intermodality, security, cost and information.
- Standard of education: frequency and intermodality are important attributes for both segments. These are the only important attributes for S_{nud}, while cost, speed, service hours, security and temperature are also important for S_{ud}.
- Dependent person in the family: frequency is commonly an important attribute for both segments. S_{dep}'s PV users consider speed and safety to be very important, while S_{ndep} identifies intermodality, cost and cleanliness as important.
- Net income: frequency is an important attribute for both groups. PV users with high incomes only add speed to the list, while PV users with lower incomes identify temperature, intermodality, information and cost as important attributes.

Priority areas

In order to attract more PV users to using public transport, planners must know how each segment of PV users perceive quality and the importance they place on the different QoSAs. A two-fold figure (Figure 1) is used to visualize the importance and satisfaction with QoSAs for each segment.

Figure 1(a) shows the importance attached to each of the QoSAs. This importance is represented by the marginal effect obtained for each QoSA from the models' output (Table 2). Only those attributes that were significant for three or more segments have been included in this figure. In addition, Figure 1(b) shows the satisfaction across all QoSAs obtained from the descriptive statistics (Table 1 displayed the average values for S_{all}, while this figure displays the values for each market segment).

Figure 1 here

Figure 1(a) is divided into two areas. The vertical line distinguishes the most important QoSAs for the PV users (frequency, intermodality, punctuality and speed),

which should receive the most attention, from the others, which although significant are shown to be of average importance to PV users in their consideration of overall satisfaction (information, temperature, cost and security). The remaining attributes have not been included in this figure either because they are not significant, or they are but only in two or less market segments, which means they are of minor importance.

Frequency is the most important service characteristic for most of the segments that were analysed. The segments with the highest values were S_{high}, S_{fem} y S_{ud}. The only market segment found below the average value (0.16) is S_{nud}. Other segments which also show low importance values for this attribute are S_{freq} and S_{male}. Intermodality is the second most important attribute. There are several market segments above the average value: S_{ma}, $S_{<44}$, S_{low}, S_{ndep} and S_{occ}. However, although intermodality is significant for ten market segments, its importance is below the average value for S_{all}, S_{male}, S_{fem}, S_{nud} and S_{ud}. Punctuality is important only for S_{freq} (above the average), S_{male} and $S_{<44}$. Finally, speed presents the highest values of importance for S_{dep} and S_{high}. Although the importance values were not so high, speed also shows the second highest impact on S_{all} and S_{city}, and the third highest impact on S_{male}, S_{fem}, S_{freq} and S_{ud}.

The attributes with middling importance are information, temperature, cost and security. Security is important to only four market segments, with values under the average for $S_{<44}$, S_{occ} and S_{ud}, and above average for S_{ma}. Cost is important for seven market segments, although only S_{fem} presents a marginal effect above the average value. All the other six segments (S_{all}, S_{45+}, S_{occ}, S_{ud}, S_{ndep}, and S_{low}) had below average values. Temperature is important for five market segments, with above average values for two segments (S_{low} and S_{male}) and below average values for the other three (S_{all}, S_{city} and S_{ud}). And, finally, information is important for four segments, with values under the average for S_{all}, $S_{<44}$ and S_{occ}, and above the average for S_{low}.

Figure 1(b) shows a lower variability for the QoSAs' perceptions, if compared with Figure 1(a). The red line represents the stated satisfaction average (3.37) and the blue line notes the central point of the scale (3.00). Table 1 shows that satisfaction with the QoSAs varies from 3.02 (individual space) to 3.74 (safety) for the entire sample. The variability shown by the different segments with respect to the overall population is narrow.

Two of the segments showed greater variability than the overall model because of their high positive scores: S_{freq} with high values for proximity (3.66), safety (3.85), frequency (3.43) and cleanliness (3.56); and S_{45+} with high values for temperature (3.50), service hours (3.54), and safety (3.83). On the other hand, S_{ma} presents the lowest values for cost (2.90), frequency (3.19) and information (3.33). However, most of the QoSAs' rates are around the average satisfaction levels, with values between 3.20 and 3.60.

The attributes that are most appreciated by most of the segments are safety and accessibility with average values close to 3.70. Intermodality is also seen with favourable eyes by all the segments, although its scores are a little on the low side (from 3.43 for S_{low} to 3.67 for S_{high}). Meanwhile, individual space, security, cost, temperature and frequency are the attributes with the lowest rates, below average for most of the segments. In the case of frequency, only S_{city} (3.40), S_{freq} (3.43) and S_{high} (3.37) score above average; and for temperature, only S_{45+} (3.50), S_{nud} (3.42) and S_{dep} (3.40) are above average.

Finally, some attributes can be seen to be unsatisfactory for certain segments as they are located below the central point on the scale (blue line). The most unsatisfactory is individual space in segments S_{city} (2.95), S_{ndep} (2.97) and S_{low} (2.97). Similarly, S_{fem}

(2.96) and S_{occ} (2.96) are not satisfied with security, while S_{ma} (2.90), S_{low} (2.98) and S_{occ} (2.99) are unsatisfied with cost.

DISCUSSION

If PV users are to be attracted to using PT it will be essential to improve our comprehension about their perception of the PT QoSAs and which of them has the greatest impact on their overall satisfaction. In general, this study has identified that the three most important attributes for the whole sample are frequency, speed and intermodality, particularly frequency. Similarly, Redman et al. (*11*) found that an increase in bus frequency and speed in Dublin produced a car use reduction rate from 34% to 22%. Other studies which analysed both PT users (eg., *18-19*) and non-users (*32*) also found these attributes to be relevant.

The chosen market segmentation strategy was based on socio-demographic and mobility characteristics and has proven to be very useful for identifying QoSAs that are important to specific segments and to find differences and similarities among the segments (eg., male vs. female, etc.). Among the different strata that were analysed frequency, speed and intermodality were also identified as the most important attributes in most cases. This process of segmentation has highlighted that there are also other attributes (i.e., punctuality, information, temperature, cost and security) that are important for the whole sample or for a significant number of specific segments, but which are found on a secondary level of importance. Although these attributes may be of secondary importance they must not be forgotten as recently Li et al. (*8*) identified reliability (associated to information and punctuality in their study), comfort (associated to temperature) and economics (associated to travel cost) as significantly influential factors on PT travel intentions.

Another interesting finding is the identification of attributes that are not significant for PV users (accessibility and individual space) or those that are significant in only one or two segments (service hours, proximity, cleanliness and safety). Li et al. (*8*) also found convenience (associated to service hours) and safety as non-significant in their study of commuter car users in Shanghai.

The analysis of these market segments has also led to the identification of high heterogeneity among the opinions of private vehicle users. On the one hand, segments with a reduced number of significant attributes can be seen (e.g. S_{high} with only two attributes) while other segments consider a much greater number to be significant (e.g. S_{ud} with seven attributes). This allows the researchers to draw specific conclusions per segment (e.g. people with higher income levels fundamentally value frequency and speed; people with higher standards of education consider a greater number of attributes in order to form their overall opinion about the service; etc.). On the other hand, although the most important attributes are repeated in most of the segments (speed and intermodality) or in all of them (frequency), the attributes on the secondary level of importance are specific for certain segments.

The stated level of satisfaction of the private vehicle users with the public transport QoSAs is located above the central point of the scale for all the attributes in the case of the entire sample, indicating that the PV users are satisfied with the PT service in Madrid. This situation is repeated for most of the segments and attributes, although some specific cases are found below the cut off point for the attributes cost, security and individual space. We must highlight that individual space is one of the attributes with the lowest satisfaction for all segments and was not found to be important for any market segment. A comparison between the levels of satisfaction shown by different groups (Figure 1) shows the PV user segments that are most critical

with public transport in Madrid (S_{occ}, S_{low}, S_{ma} and $S_{<44}$), as well as those that are the most satisfied (S_{high}, S_{city}, S_{45+} and S_{freq}). Some of these results are found to agree with previous work. For example, Abenoza et al (*6*) concluded that the segments that most use public transport were the ones that were most satisfied with the service whereas the residents in peripheral areas much less so.

This study has some limitations. The most important limitation is that the dataset is based on a survey in the metropolitan area of Madrid which has a very good transport system. The specific results should not be generalized to other areas without further research as the context may have an important influence on the results. Another limitation is that this study does not discuss different PT modes (i.e. bus, metro, rail, etc.). It would be interesting to subdivide the market to identify more specific results for different PT modes. Finally, another limitation is that this study quantifies the impact of satisfaction ratings with individual QoSAs on overall satisfaction but does not explain them, which makes it difficult to quantify the benefits of policies aimed at improving the perceived quality of the PT service. Although, this is a common limitation in most studies analysing satisfaction in PT, this could be crucial when trying to attract more PV users to using PT. Further research should focus on this issue.

CONCLUSIONS AND POLICY IMPLICATIONS

From a sustainable transport perspective, both the policy makers and the PT operators need to realise that in order to reduce private vehicle usage and attract those users over to using public transport they need to focus their efforts on the PV users. Increasing the cost of using PV (eg., introducing congestion pricing, eliminating free parking, removing policies/subsidies favouring cars, etc.) could be the most effective measures for pushing PV users towards the PT service, particularly where transit is already of high quality. However, from the point of view of PT supply, making improvements to the PT service is considered to be one of the best ways of attracting more users and to keep existing users. Therefore, it is a basic requirement to know how PV users perceive the main attributes making up the quality of service being provided and which attributes they consider to be of greater importance. This study has tried to contribute to the overall knowledge about how private vehicle users view public transport.

This paper analysed regular PV user satisfaction with PT using a survey with a sample size of 500 and identified important factors impacting on overall satisfaction for formulating policies and recommendations. Firstly, it must be highlighted that the PV users are satisfied with the PT service in the metropolitan area of Madrid. However, we must be wary of generalising the results of this study to other areas where the users are not so satisfied with the PT services being provided.

Secondly, whereas in the majority of PT user satisfaction studies all the QoSAs are identified as important contributions to overall satisfaction (eg., 6;29), this research has found that PV users concentrate their attention on a limited number of attributes. More specifically, frequency was the only attribute that was found to be significant in all the models, although speed and intermodality were also found to be important in most of the strata. Therefore, if more PV users are to be attracted to using public transport, the providers need to offer higher frequencies, a faster service and better connections.

Thirdly, two attributes failed to be identified as significant in any of the models (accessibility and individual space), despite individual space being the worst valued in all the strata and accessibility being one of the most highly valued. This shows that the improvement of certain attributes will not attract any more PV users to using public

transport, irrespectively whether they are found to be valued as good or bad. It would be beneficial to correctly identify these attributes in order not to waste valuable resources and effort towards improving them.

Fourthly, this research has once again shown the value of sample segmentation to achieve a comprehensive assessment of private vehicle user opinions because of their high heterogeneity. This segmentation has provided important and specific information about particular user groups (e.g. people with university qualifications are those who are most likely to consider more QoSAs when forming their overall point of view about satisfaction).

Finally, future research is proposed to generalise the results and broaden the study by analysing other areas with different characteristics (e.g. countries, network size, etc.). This research has analysed satisfaction levels regarding public transport in general and has not differentiated between modes of transport. By increasing the sample size and the number of questions in the survey comparisons could be made between how the public perceive different modes of transport (e.g. bus vs. rail).

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AUTHOR CONTRIBUTIONS

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

1. Suman, H., & Bolia, N. (2019). A review of service assessment attributes and improvement. Transportation in Developing Economies, 5, 1-17.
2. 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.
3. Jen, W., Tu, R., & Lu, T. (2011). Managing passenger behavioral intention: An integrated framework for service quality, satisfaction, perceived value and switching barriers. Transportation, 38, 321-342.
4. Lai, W.-T., & Chen, C.-F. (2011). Behavioral intentions of public transit passengers-The roles of service quality, perceived value, satisfaction and involvement. Transport Policy, 18, 318-325.
5. 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.
6. Abenoza, R., Cats, O., & Susilo, Y. (2017). Travel satisfaction with public transport: Determinants, user classes, regional disparities and their evolution. Transportation Research Part A, 95, 64-84.
7. Krizek, K., & El-Geneidy. (2007). Segmenting preferences and habits of transit users and non-users. Journal of Public Transportation, 10, 71-94.
8. 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.

9. Woods R., Masthoff J., (2017). A comparison of car driving, public transport and cycling experiences in three European cities. Transportation Research Part A, 103, 211-222
10. De Oña, J., & De Oña, R. (2015). Quality of service in public transport based on customer satisfaction surveys: A review and assessment of methodological approaches. Transportation Science, 49, 605-622.
11. Redman, L., Friman, M., Gärling, T., & Hartig, T. (2013). Quality attributes of public transport that attract car users: A research review. Transport Policy, 25, 119-127.
12. Hine, J., & Scott, J. (2000). Seamless, accessible travel: users' views of the public transport journey and interchange. Transport Policy, 7, 217-226.
13. Fujii, S., Kitamura, R., (2003). What does a one-month free bus ticket do to habitual drivers? An experimental analysis of habit and attitude change. Transportation, 30, 81–95
14. Thøgersen, J., 2009. Promoting public transport as a subscription service: effects of a free month travel card. Transport Policy, 16, 335–343.
15. Thøgersen, J., Møller, B., 2008. Breaking car use habits: The effectiveness of a free one-month travelcard. Transportation, 35, 329–345.
16. Oliver, R. (1997). Satisfaction. A Behavioral perspective on the consumer. New York: McGraw-Hill.
17. Parasuraman, A., Zeithaml, V., & Berry, L. (1985). A conceptual model of service quality and its implications for future research. Journal of Marketing, 49, 41-50.
18. Mouwen, A. (2015). Drivers of customer satisfaction with public transport services. Transportation Research Part A, 78, 1-20.
19. Fellesson, M., & Friman, M. (2008). Perceived satisfaction with public transport service in nine european cities. Journal of the Transportation Research Forum, 47, 93-103.
20. 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.
21. Machado, J., De Oña, R., Diez-Mesa, F., & De Oña, J. (2018). Finding service quality improvement opportunities across. Transportmetrica A: Transport Science, 14, 761-783.
22. Siddall, A., Pistik, M., & Allen, J. (2006). Transit products, services, and environments in a complex system: User-centered design research in Chicago. Transportation Research Board 85th Annual meeting, Washington D.C. 18p.
23. Jensen, M. (1999). Passion and heart in transport - a sociological analysis on transport behavior. Transport Policy, 6, 19-33.
24. 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 Policy, 42, 113-120.
25. 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.
26. 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.

27. De Oña, J., & De Oña, R. (2015). Analysis of transit quality of service through segmentation and classification tree techniques. Transportmetrica A: Transport Science, 11, 365-387.
28. Dell'Olio, L., Ibeas, A., & Cecín, P. (2010). Modelling user perception of bus transit quality. Transport Policy, 17, 388-397
29. 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.
30. Quddus, M., Rahman, F., Monsuur, F., De Oña, J., & Enoch, M. (2019). Analyzing bus passengers' satisfaction in Dhaka using discrete choice models. Transportation Research Record, Journal of the Transportation Research Board, 2673, 758-768.
31. Long, J., & Freese, J. (2014). Regression models for categorical dependent variables using STATA. Tx:US: Stata Press.
32. 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.

TABLES

FIGURES

Table 1. Satisfaction survey data and descriptive statistics

		Mean	SD
Dependent variable:			
Overall Satisfaction	In general, I am satisfied with the public transport service in Madrid	3.51	1.06
Independent variables (quality of service attributes):			
Service hours	Service hours	3.39	1.15
Proximity	Proximity of stops to starting point or destination of the trip	3.41	1.12
Frequency	Frequency or number of daily services	3.30	1.12
Punctuality	Punctuality	3.36	1.08
Speed	Speed	3.35	1.10
Cost	Cost	3.10	1.19
Accessibility	Ease of entrance and exit from the vehicle and/or stations	3.67	0.98
Intermodality	Ease of transfers/good connections with other modes of transport	3.53	1.07
Individual space	Individual space available inside the vehicle	3.02	1.10
Temperature	Temperature inside the vehicle	3.28	1.09
Cleanliness	Cleanliness of the vehicle and stations	3.43	0.98
Safety	Safety on board (regarding accidents)	3.74	0.99
Security	Safety regarding robbery and violence	3.03	1.05
Information	Information provided	3.48	1.03
Sociodemographic and mobility characteristics:			
		Count	%
Geographical area	City center	273	54.6
	Metropolitan area	227	45.4
Gender	Male	299	59.8
	Female	201	40.2
Age	18–24	39	7.8
	25–44	229	45.8
	45–64	152	30.4
	65+	80	16.0
Standard of education	Without university degree	201	40.2
	With university degree	296	59.2
Net income	2,700€/month or less	219	43.8
	More than 2,700€/month	201	40.2
Public transport use frequency	Frequent user (one or more trips per week)	215	43.0
	Occasional user (less than one trip per week)	285	57.0
Dependent members in the family	No	331	66.2
	Yes (ie., children or other dependent relatives)	163	32.6
Main reasons which explain a low user frequency of public transport:			
There is no adequate service for my route (many stops, route length, etc.)		151	53.0
I prefer to use the car		108	37.9
Takes a long time to get there		105	36.8
The stops are far from my starting point or destination		100	35.1
I need the car to run my errands, take the children to school, etc.		57	20.0
It's uncomfortable, it's dirty, too much noise, lack of space, inadequate temperature, etc.		53	18.6
Expensive		50	17.5
The transfers don't work well		25	8.8
I don't like public transport		23	8.1
There is no public transport		11	3.9
It's unsafe		4	1.4
I don't know the service		3	1.1

Sample size (N) = 500; SD = Standard deviation.

Table 2. Modeling results

	General model (S_{all})		City center (S_{city})		Metropolitan area (S_{ma})		Male (S_{male})		Female (S_{fem})	
	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff
1. Service hours	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
2. Proximity	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	0.325	0.128
3. Frequency	0.581	0.231	0.509	0.200	0.680	0.258	0.499	0.183	0.754	0.310
4. Punctuality	ns.	ns.	ns.	ns.	ns.	ns.	0.343	0.126	ns.	ns.
5. Speed	0.369	0.144	0.431	0.166	0.386	0.145	0.391	0.145	0.428	0.166
6. Cost	0.248	0.103	ns.	ns.	ns.	ns.	ns.	ns.	0.458	0.176
7. Accessibility	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
8. Intermodality	0.366	0.139	ns.	ns.	0.623	0.225	0.368	0.128	0.363	0.144
9. Individual space	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
10. Temperature	0.262	0.101	0.306	0.119	ns.	ns.	0.470	0.170	ns.	ns.
11. Cleanliness	ns.	ns.	0.443	0.148	ns.	ns.	ns.	ns.	ns.	ns.
12. Safety	0.221	0.079	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
13. Security	ns.	ns.	ns.	ns.	0.498	0.186	ns.	ns.	ns.	ns.
14. Information	ns.	ns.	0.405	0.141	ns.	ns.	ns.	ns.	ns.	ns.
Nº obs (N)	469		253		216		284		185	
Log-Ll zero	-668.38453		-354.55905		-309.44212		-396.38307		-269.36073	
Log-Ll final	-486.69039		-250.57413		-223.05437		-280.21521		-192.93411	
Pseudo R^2	0.2718		0.2933		0.2792		0.2931		0.2837	
	18-44 years old ($S_{<44}$)		≥ 45 years old (S_{45+})		Frequent user (S_{freq})		Occasional user (S_{occ})		Without university degree (S_{nud})	
	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff
1. Service hours	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
2. Proximity	ns.	ns.	0.484	0.197	ns.	ns.	ns.	ns.	ns.	ns.
3. Frequency	0.623	0.231	0.527	0.215	0.448	0.178	0.718	0.272	0.688	0.302
4. Punctuality	0.386	0.138	ns.	ns.	0.628	0.238	ns.	ns.	ns.	ns.
5. Speed	ns.	ns.	0.350	0.143	0.402	0.158	0.359	0.132	ns.	ns.
6. Cost	ns.	ns.	0.369	0.158	ns.	ns.	0.309	0.125	ns.	ns.
7. Accessibility	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
8. Intermodality	0.630	0.219	ns.	ns.	ns.	ns.	0.466	0.171	0.370	0.158
9. Individual space	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
10. Temperature	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
11. Cleanliness	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
12. Safety	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
13. Security	0.329	0.108	ns.	ns.	ns.	ns.	0.417	0.150	ns.	ns.
14. Information	0.399	0.132	ns.	ns.	ns.	ns.	0.347	0.122	ns.	ns.
Nº obs (N)	251		218		209		260		187	
Log-Ll zero	-356.2785		-309.30309		-292.55811		-368.9976		-271.23553	
Log-Ll final	-242.4686		-231.66785		-207.18959		-265.91564		-207.86952	
Pseudo R^2	0.3194		0.251		0.2918		0.2794		0.2336	
	With university degree (S_{ud})		No dependent members in the family (S_{ndep})		With dependent members in the family (S_{dep})		2,700€/month or less (S_{low})		More than 2,700€/month (S_{high})	
	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff	Estim.	M.Eff
1. Service hours	0.320	0.115	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
2. Proximity	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
3. Frequency	0.607	0.216	0.502	0.197	0.691	0.267	0.393	0.156	0.820	0.315
4. Punctuality	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
5. Speed	0.413	0.146	ns.	ns.	0.575	0.224	ns.	ns.	0.594	0.223
6. Cost	0.400	0.149	0.336	0.139	ns.	ns.	0.307	0.129	ns.	ns.
7. Accessibility	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
8. Intermodality	0.414	0.138	0.458	0.174	ns.	ns.	0.512	0.199	ns.	ns.
9. Individual space	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
10. Temperature	0.304	0.107	ns.	ns.	ns.	ns.	0.524	0.206	ns.	ns.
11. Cleanliness	ns.	ns.	0.344	0.118	ns.	ns.	ns.	ns.	ns.	ns.
12. Safety	ns.	ns.	ns.	ns.	0.710	0.241	ns.	ns.	ns.	ns.
13. Security	0.323	0.108	ns.	ns.	ns.	ns.	ns.	ns.	ns.	ns.
14. Information	ns.	ns.	ns.	ns.	ns.	ns.	0.454	0.172	ns.	ns.
Nº obs (N)	279		311		152		206		192	
Log-Ll zero	-392.94775		-444.40414		-214.12988		-292.67114		-263.87693	
Log-Ll final	-265.58379		-321.37667		-152.24139		-212.58051		-188.9333	
Pseudo R^2	0.3241		0.2768		0.289		0.2737		0.284	

Significance levels: ns. Not significant; otherwise 95%.

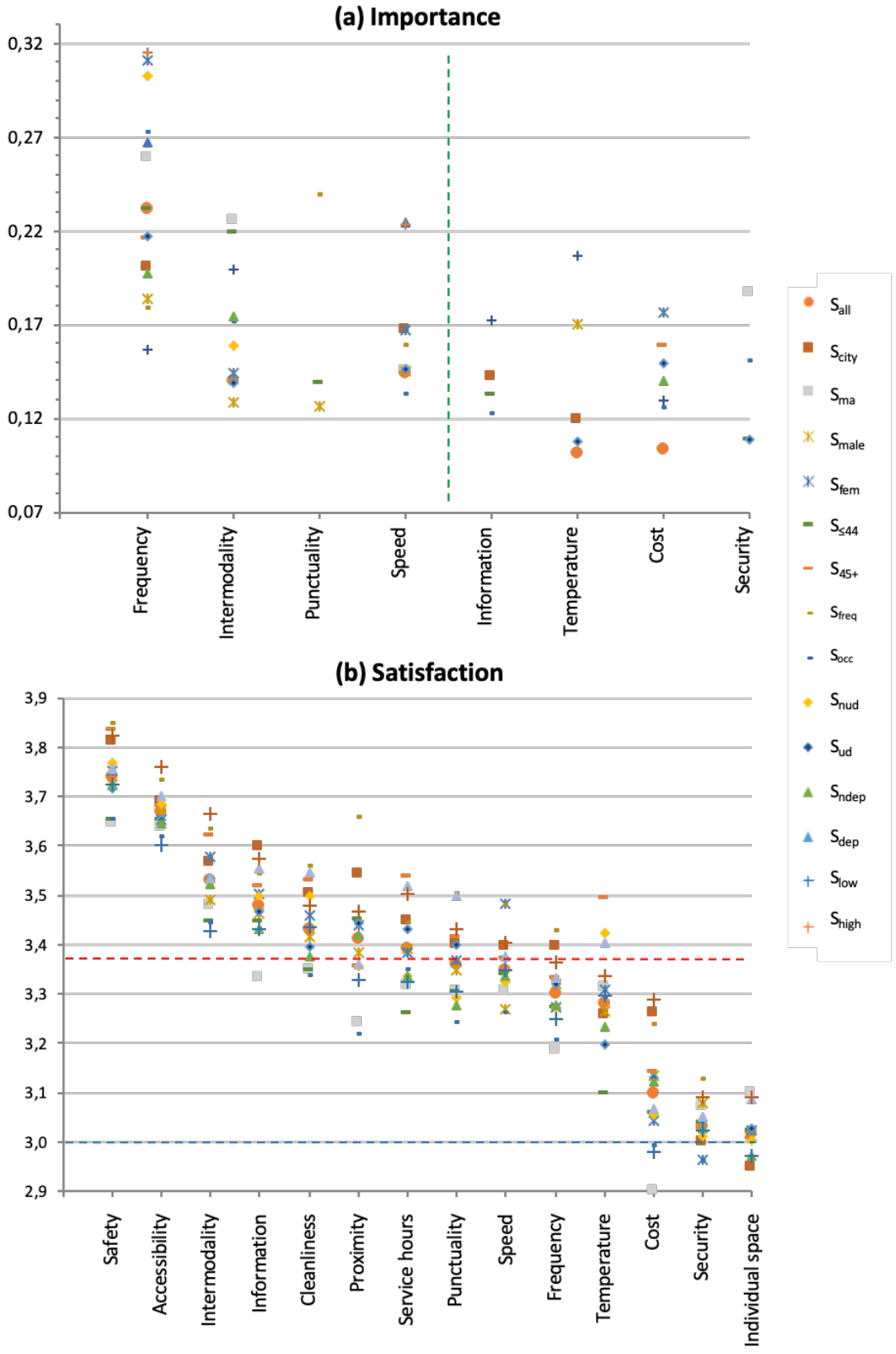

Figure 1. Attribute's importance and satisfaction across different segments of private vehicle users