



Users' perception for innovation and sustainability management: evidence from public transport

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Abstract

No one doubts the importance of public transport services in the economic backbone of any country. In recent decades, there has been a growing interest in the contribution to Sustainable Development Goals on the part of governments, companies, and stakeholders. In this sense, transport can contribute to the sustainability of cities and facilitate other social objectives, such as universal accessibility, with innovation being a key pillar for this. Thus, the main objective of this study is to analyze users' perceptions of the innovation and sustainability of public transport in Spain.

To analyze the user's perception of public transport, a questionnaire was developed following Bitner's Servicescape Model. A total of 1,354 responses were collected in different Spanish cities. The main results show that the policies implemented in both innovation and sustainability are perceived positively but do not seem to have much impact on the service user. Public transport users prioritize the speed, frequency, and safety of the service received. In addition, it should be noted that the gender of the user influences the preferences of the objectives, i.e., men value technological development in public transport more. At the same time, women give higher priority to sustainability. The age of users is another variable that conditions public transport users' perceptions of innovation and sustainability. The results also show users' preferences for different types of public transport.

The study's main contribution is that it shows to what extent the innovation and sustainability policies applied in the public transport service are valued and motivate citizens to use the service. The political and management decisions may be disconnected from the reality perceived by users. These decisions may be more linked to regulatory pressures and involve a high implementation cost, so it is necessary to consider the valuation of users' service so that the benefit or social return of these investments is high, encouraging the use of the service.

Keywords Public transport users · Public transport sustainability · Public transport innovation · Innovation management · Sustainability management

Extended author information available on the last page of the article

1 Introduction

Since the emergence of the concept of sustainability (Brundtland 1987), many public or private companies have made great strides toward achieving the ambitious goals proposed by the United Nations (Cai and Choi 2020; Georgeson and Maslin 2018; Paletta and Bonoli 2019). Therefore, companies have participated in sustainable development by taking into account separately or jointly the three dimensions of sustainability, which are economic sustainability, social sustainability, and environmental sustainability (Buerke et al. 2017; Purvis et al. 2019; Tipu 2022). Each of the dimensions of sustainability has had a significant impact on society and has been studied in academic literature over the years (Anand and Se 2000; Duić et al. 2015; Eizenberg and Jabareen 2017; Goodland 1995; Hansmann et al. 2012; Liboni et al. 2022; Malak-Rawlikowska et al. 2019; Málovics et al. 2008). However, environmental sustainability is the pillar that has attracted the most attention from the outset (Moldan et al. 2012; Morelli 2011). According to several studies (Ao et al. 2022; Owen et al. 2018; Yi et al. 2018), the governments of many countries have invested heavily in and promoted environmental sustainability actions to raise awareness of the importance of environmental sustainability in business and society.

Among the companies that have committed themselves to sustainable development are public transport companies (Cruz and Katz-Gerro 2016; Miller et al. 2016). Nowadays, public transport is one of the essential services for the proper development of any country, considered a fundamental tool for achieving sustainable mobility (European Commission 2017). The reasons that attribute this role to public transport are that it promotes a sustainable or social economy, minimizes air and noise pollution, reduces congestion and accidents, and facilitates processes of social and territorial inclusion (Halvorsen et al. 2020; Moslem et al. 2020). In Spain, public transport comprises public and private companies committed to sustainability and technological innovation to offer a quality service (De Oña et al. 2020; Lopez-Carreiro et al. 2021; Pitarch-Garrido et al. 2018). Continuous investment in public transport services makes the Spanish transportation system one of the best at the European level regarding technological innovation, which is directly related to environmental sustainability.

According to the Web of Science (WOS), the last five years (2018–2022) have seen an exponential growth in the academic literature in research on the implementation of smart innovations in the public transport system (Brakewood and Watkins 2019, Drabick et al. 2021, Ingvardson et al. 2018, Lopez et al. 2019) and the development of techniques and policies aimed at improving transport sustainability (Alonso et al. 2018; Alkharabsheh et al. 2021; Awasthi et al. 2018, Gutierrez et al. 2021, Shekhovtsov et al. 2020, Solano et al. 2021). The present study contributes to the literature and to this recent interest by providing the user's assessment of these innovative and sustainable practices, using the Spanish case study. In doing so, it contributes to making the management decisions of the service operating companies more user-oriented.

There are studies from the perspective of costs and revenues (Awad-Núñez et al. 2021; Delgado Jalon et al. 2019); other studies analyze the efficiency of the service (Alonso et al. 2018; Wang et al. 2015). However, not many studies have been found that complement these studies with the perceived social value of the service provided (De Oña et al. 2021; Delgado Jalon et al. 2019; Solano et al. 2021). Because of the above, it seems interesting to undertake a study that analyzes the social value perceived by the public transport user, specifically for policies and management decisions on innovation and sustainability.

The main contribution of the study is that it shows to what extent the innovation and sustainability policies applied in the public transport service are valued and contribute to motivating citizens to use the service. On occasion, the operating companies' political and management decisions may be disconnected from the reality perceived by citizens. These decisions may be more linked to regulatory pressures and involve a high implementation cost. According to Roukoni et al. (2018), an implemented transport policy's effectiveness depends on the agreement between its stakeholders. To ensure that the benefit or social return on these investments is substantial and that service use is encouraged, the citizen and service user must be valued while designing these policies.

Taking all this into account, the main objective of this study is to analyze users' perceptions of the technological innovation and sustainability of public transport in Spain. To this end, we study the relationship between technological development and sustainability with variables such as accessibility, safety, and quality. Furthermore, it is analyzed whether the new policies of technological development and sustainability influence the motivation of users to use public transport instead of other modes of transport.

Therefore, a previously validated survey was developed and distributed nationwide. In the end, the sample consisted of 1,354 responses. The methodology of the study is divided into two parts. The first part analyzes transport users' perception through Bitner's Servicescape Model (Bitner 1992). The second part of the statistical analysis is to see the relationship between the variables studied. A table of correlations between the dependent and independent variables was drawn up, and then regression analysis was carried out to confirm the results of the correlations.

The results obtained have shown that public transport in Spain is related to sustainability and innovation according to the answers to the survey carried out by the users. Also, the results show that the policies implemented in both innovation and sustainability are perceived positively but do not seem to have much impact on the service user. The results of the second part of the analysis have concluded that users attach importance to sustainability and innovation objectives but prioritize quality (speed, frequency) and safety objectives.

This study is organized as follows. The first part of the manuscript is the introduction, and the second is the literature on the importance of sustainability and technological innovation in public transport. The third part describes the variables, methodology, and sample. After that, the results are analyzed, and the conclusions are presented.

2 Literature background

Sustainable development is considered one of the priority objectives in the policies of the European Union based on the 2030 Agenda adopted by the United Nations (United Nations General Assembly 2015). This Agenda includes 17 Sustainable Development Goals (SDGs) that can be grouped into three pillars: environmental, economic, and social sustainability (Purvis et al. 2019; Tipu 2022).

Within these objectives, the transport sector is essential as one of sustainability's significant challenges. Although steps have been taken to lessen this sector's impact, it still contributes significantly to climate change, accounting for 45% of nitrogen oxide emissions, being the most common source of environmental noise that affects more than 100 million people, and being the primary source of sulfur oxide emissions and NO_x emissions (EEA 2020). Because of its direct consequences, EU countries are still trying to put in place measures to mitigate its impact. Within these measures, implementing cleaner vehicles, digital solutions, and services, traffic mitigation policies, and the development of urban public transport are considered necessary tools to improve sustainable mobility (European Commission 2017; Paulsson 2018).

Urban public transport is the most sustainable mode of motorized transport (Banister 2008). Therefore, its promotion is necessary to improve the quality of life in cities characterized by excessive private transport use and a high population concentration. It is estimated that in 2050, 68% of the population will live in urban areas (López et al. 2019).

Sustainable transport is understood as a system that enables (Estrategia Española de Movilidad Sostenible 2009) the development of the three pillars of sustainability. From an economic point of view, to efficiently meet the mobility needs arising from economic activities, thus promoting development and competitiveness; social: providing good accessibility conditions for citizens to labor markets, goods, and services, favoring social and territorial equity; and the healthiest modes of transport; environmental: to contribute to the protection of the environment and the health of citizens, reducing the environmental impacts of transport, contributing to the reduction of greenhouse gas emissions and optimizing the use of non-renewable resources, especially energy. Efficient and sustainable urban mobility in large cities is so essential that innovative approaches to new modes of transport and vehicles have been considered (Nehk et al. 2021).

In most European cities, urban public transport is provided by private operators through public tenders (Aldenius et al. 2021). A similar situation occurs in Spain, where municipal trading companies are the most commonly used in large cities (De Rus 1990). Whereas, in small cities, the service is usually offered by private companies on a concession basis (De Rus 1990), with the majority of the private companies being.

And when it comes to transportation options, urban surface public transportation (buses) is the one that the responsible authorities utilize more, as opposed to suburban (metro and tram), which are less common in Spanish cities, while offering mobility services in their cities (Observatorio de la Movilidad Metropolitana 2020).

Public transport impacts the environmental dimension of sustainability by minimizing air and noise pollution. But also on the social and economic side, reducing

congestion and accidents and facilitating the processes of social and territorial inclusion (Anguita et al. 2014; Halvorsen et al. 2020; Moslem et al. 2020; Susniene 2012; Schmöcker et al. 2004, Saif et al. 2017). Following Saif et al. (2017), the transport system has to be accessible to everyone, i.e., the service is not based on its performance but on its status as a public service.

In the case of buses, taking into account that their fleet's fuel type has an impact on the environment (Romero-Ania et al. 2021), the majority of them are made up of natural gas and hybrid vehicles, with e-vehicles making up a smaller portion of their fleet (Observatorio de Costes y Financiación del Transporte Urbano Colectivo 2021). This result in more efficient and environmentally friendly fleets.

From an economic and social point of view, public transport fares have a high social content (Holmgren 2013) with lines and frequencies that are not economically justified (Pina and Torres 2001), which guarantees the accessibility of the service to the entire population.

In terms of measures to improve sustainability in transport, the literature review indicates a growing interest in transport innovation and intelligent ICT solutions. Recent studies analyse the incorporation of card payment methods, the way in which stations interact with passengers, interactive service information screens and access points, among others (Brakewood and Watkins 2019, Drabick et al. 2021, Ingvardson et al. 2018, Lopez et al. 2019). Other studies analyse innovation linked to the improvement of factors that can be considered subjective (Duleba and Moslem 2019), along with the development of techniques and policies based on the planning, design and operation of transport systems (Alkharabsheh et al. 2021; Alonso et al. 2018; Awasthi et al. 2018; Gutiérrez et al. 2021; Solano et al. 2021; Shekhovtsov et al. 2020).

Improving the quality of public transport services encourages its use to the detriment of less sustainable modes such as the private car (Mugion et al. 2018; Susniene 2012; Vicente et al. 2020). According to the study conducted by Mugion et al. (2018) on user perception of urban transport in the city of Rome (Italy), the quality of service perceived by users has a direct effect on the intention to use public transport. Another study (Vicente et al. 2020) based on a sample of public transport users in the city of Lisbon (Portugal) has shown that there is a positive effect of public transport operators' commitment to environmental sustainability on passenger loyalty and satisfaction. In other words, if users see that public transport has a positive effect on environmental sustainability, they will use this mode of transport more often, reducing the use of less sustainable transport. To confirm that there is a demand from citizens for the use of more sustainable vehicles (Romero-Ania et al. 2021), it is essential to know whether the efforts made by authorities and transport operators have an impact on transport use.

Despite these efforts, a study by Minelgaitè et al. (2020) indicates that overall the use of urban public transport in EU countries is low, as, in addition to improving transport services, both image-enhancing and awareness-raising measures are needed.

Sustainable means of transport must exist and the population's will to use them (Lopez et al. 2019). To achieve this, transport actions must be publicized, and the importance of these actions must be argued to improve the user's perception of innovation and sustainability.

3 Hypotheses development

As seen in the literature review, the development of technology and the sustainability achieved by public transport are demanded by both users and competent authorities to achieve more sustainable mobility. No previous studies relate these policies to the motivation to use public transport.

There are studies on service quality and user satisfaction, with the understanding that customer perception and satisfaction with service quality are directly related to service utilization (Chocholac et al. 2020; de Oña and de Oña 2015; Friman et al. 2020; Minelgaitè et al. 2020; Murugesan and Moorthy 1998; Too and Earl 2010). The definition of public service quality and its attributes can have been studied during the last periods (Chocholac et al. 2020; de Oña and de Oña 2015; Friman et al. 2020; Minelgaitè et al. 2020).

It is worth noting that customer preferences for the service are differentiated according to user groups and that it is necessary to identify and promote measures according to each of them to motivate transport use (Murugesan 1998; Chocholac et al. 2020).

The studies mentioned earlier discuss how service quality impacts user satisfaction and perception. However, we have not found studies that specifically analyze the impact of technological development and sustainability on user perception. Given the importance of innovation and sustainability previously exposed in the literature, the following research question is posed to sustainability policies and technological development:

RQ1 Are users motivated to use public transport if they know about the new policies on technological development and sustainability achieved by public transport?

The technological development of urban transport companies allows for the generation of more environmentally and socially friendly modes of transport to achieve improved sustainability in cities (Lopez et al. 2019; Zhao et al. 2020). The research on technology development, system planning, and demand modeling was the most widely conducted until the 20th century (Friman et al. 2020). Studies on quality and user satisfaction began to emerge from this point onwards.

These studies have focused on analyzing quality characteristics (Chocholac et al. 2020; de Oña and de Oña 2015; Friman et al. 2020; Minelgaitè et al. 2020) and their relationship with satisfaction (Chocholac et al. 2020; de Oña and de Oña 2015; However, no research has been discovered that directly links technological advancement to the factors quality, accessibility, and safety (Friman et al. 2020; Minelgaitè et al. 2020; Murugesan and Moorthy 1998; Too and Earl 2010).

Therefore, the following hypothesis is put forward to see the relationship between the technological development of public transport and variables like sustainability, safety, and quality.

H1 The technological development of public transport has a positive relationship with sustainability, accessibility, safety, and quality.

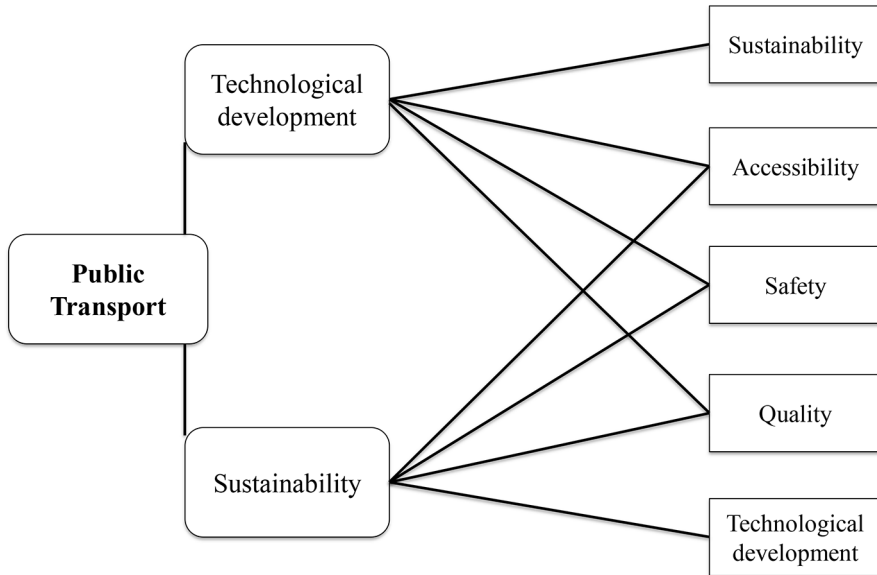


Fig. 1 Research Model
Source: own elaboration

As mentioned above, public transport significantly impacts sustainability (Anguita et al. 2014; Susniene 2012; Schmöcker et al. 2004; Saif et al. 2017). Therefore, the following hypothesis analyzes whether sustainability in public transport is positively related to the quality, accessibility, and safety of public transport. Therefore, the following hypothesis is put forward:

H2 The achieved sustainability of public transport has a positive relationship with technological development, accessibility, safety, and quality.

However, no studies have been found that indicate that sustainability is a consequence of technological development. As discussed in hypothesis one, it is a technological development that directly influences sustainability. Similarly, research on public service quality is based on defining attributes and measuring customer satisfaction (Chocholac et al. 2020; de Oña and de Oña 2015; Friman et al. 2020; Minelgaitė et al. 2020), which is a crucial determinant of perceived accessibility. A study elaborated by Friman et al. (2020) directly relates perceived quality, safety, and accessibility to each other. These variables are considered to be conditioning factors for achieving the social dimension of sustainability. It is therefore expected that the hypothesis will be accepted.

Figure 1 shows the proposed research model.

Table 1 Variables used in the study

Tobjectctic	Importance of technological development in public transport.
Tobjectsustainab	Importance of sustainable (environmental) development in public transport.
Tobjectunivaccess	Importance of universal accessibility for everyone in public transport.
Tobjectsafety	Importance of feeling of safety in public transport.
Tobjectspeed	Importance of public transport speed/travel time.
Tobjectspace	Importance of comfort, space and temperature in public transport.
Sustainbpolicytpmotivation	Motivation of users to use the service when they learn about new sustainability policies applied in public transport.
Innovapolicytpmotivation	Motivation of users to use the service when they learn about new innovation policies applied in public transport.
Sitppollution	Assessment of the social impact of the service in terms of pollution reduction.
Sitpnoise	Assessment of the social impact of the service in terms of noise mitigation in the city.

Source: own elaboration

4 Methodology

4.1 Materials

The variables used in the model were divided into two parts: the descriptive variables of the sample and the specific variables to test the hypotheses. Explanatory variables include the respondents' age, gender, whether they were frequent public transport users, employment status, and place of residence. The importance of these variables have been widely used to classify the sample (Delgado et al. 2019; Dabić et al. 2021; Gelashvili et al. 2022; Martínez-Navalón et al. 2020; Trivedi and Teichert 2019). The following table (Table 1) summarizes the variables used in the study's statistical analysis.

The study's dependent variables were Tobjectctic and Tobjectsustainab, which measure the importance of sustainable development and innovation development in public transport as perceived by users. Other variables are independent variables that explain the main variables. As can be seen in Table 1,

through these variables, we can measure users' perception of public transport policies on sustainability and innovation. Likewise, the selected variables allow for measuring the safety and quality perceived by public transport users and the motivation to use public transport by the policies used to implement sustainability and innovation measures.

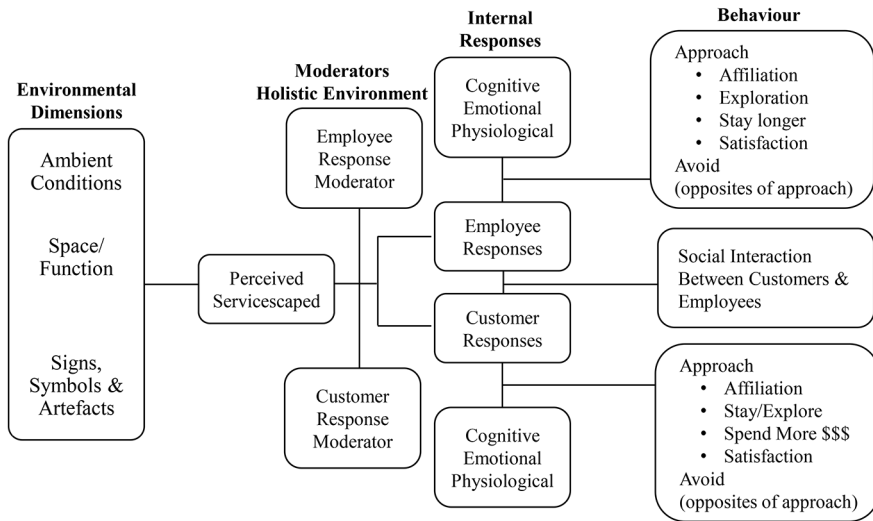


Fig. 2 Bitner's Servicescape model
 Source: Bitner (1992)

4.2 Measures

Firstly, Bitner's Servicescape Model (1992) assesses the users' social perceptions about public transport innovation and sustainability. This model considers that the elements of the environment in which a service is provided influence consumer behavior to a greater or lesser extent. The physical environment surrounding the service provided and its characteristics directly affect user perception and satisfaction (Gao 2020), and this is because the service is produced and consumed at the same time. Figure 2 shows a summary of the model, with three differentiated parts to obtain the social perception of a service: environmental dimension, internal responses, and behaviors.

Bitner's Servicescape Model is a model that has been used in different areas (Boukabiya and Outtaj 2021; Eun-Ho and Choi, 2020; Pizam and Tasci 2019; Yang and Chung 2021) to measure the relationship between the service giver and the service receiver taking into account the environment and the place where the service is provided. Therefore, it is a model that has been widely used in the area of transport to measure efficiency and users' perception of the service received (Kankaew 2020; Park and Park 2018; Taheri et al. 2020), but there are very few studies specifically on public transport in the last decade (Delgado et al. 2019).

Considering the above, in this research, the questionnaire was designed to evaluate each of the three dimensions defined by Bitner's model:

1. Environmental dimension is the physical and functional space where the service is provided, and it generates in the user what the model defines as "first impressions" of the service. In this block, questions are asked regarding the quality of the environment where the service is provided (air, temperature, noise, smell,

- space, etc.), the feeling about the contribution of public transport to the sustainable development of cities, among others.
2. Internal responses: more internalized sensations of the user, such as cognitive, emotional, and physiological responses, which arise from interacting with the service and its environment. This block of questions focuses more on the opinions of internal users, such as whether they use public transportation more often when they are aware of applied innovation and sustainability policies and whether they believe private transportation should be replaced by public transportation as a way to improve urban sustainability.
 3. Behaviors: after the experience with the service, the user may manifest approaching and avoiding behaviors which, in turn, impact social interactions. In this block, questions were included about the reasons for using public transport, the importance of specific service objectives, and the cost increase of the service to the user to improve innovation and sustainability of the service.

This will better understand how the general public perceives innovation and sustainability in the public transportation system. The questionnaire includes questions to be rated on a Likert scale from 1 to 5 (1 worst rating and five highest), dichotomous questions to choose between yes or no, questions with several closed answer options, and an open question.

The second part of the analysis is based on linear regression and the correlation table to answer the hypotheses raised in this work. Linear regression and correlation tables have been used in research to measure the relationship and effects between dependent and independent variables (Gelashvili et al. 2022; Ting et al. 2021). First, the Breusch-Pagan test (Breusch and Pagan 1980) was used to detect heteroscedasticity in the models. The results of the test have shown values greater than 0.005. Therefore the existence of homoscedasticity in the models was assumed. After that, the correlation of the variables used in the model was done. The correlation table shows the relationship between the variables and the strength of the correlation. Correlation between variables has been used for the same purpose in comparable studies (Beck et al. 2021; Olsson et al. 2012; Wielechowski et al. 2020). Finally, two linear regression models have been run, one assuming *Tobjecttic* as the dependent variable and the other with *Tobjectsustainab* as the dependent variable. Considering RQ1, it is expected that the motivation variable will be significant in both models. For H1 and H2, the models with the most independent variables employed in the study are anticipated to explain the data.

4.3 Participants

The sample collected amounted to 1,354 surveys conducted in Spain during March, April, and May 2022. First, the sampling error calculates where the following Random Sampling Error Formula was used:

$$K = 2\sqrt{[(p(1-p))/n]}.$$

The size of the sample, *n*, is determined, 1,354 responses. For *p*, maximum dispersion is assumed, where all elements in the questions have the same probability of being chosen: $p = q = 0.5$. Therefore:

$p(1-p) = \text{dispersion} = 0.25$.

So, the result of the K for the questionnaire is 2.71%. On balance, the results obtained in the sample will fluctuate by $\pm 2.71\%$ at a 95% confidence level in the total population.

Among the main characteristics of the sample, it is worth noting that 47% of the respondents were male and 51% female (the rest preferred not to say). Of the total sample, 65% were aged between 16 and 30, 22% were aged between 31 and 50, and the rest were over 51. Students accounted for 52% of the responses, and 41% corresponded to active workers, with a lower percentage of unemployed, retired, or ERTE (Layoff) workers. Regarding geographical area, 48% of those surveyed live in Madrid city, 29% in other municipalities in the Madrid region, and the rest in other Spanish provinces.

5 Result of analysis

5.1 Reliability of the survey

Before starting the Serviscape Model and statistical analysis, the validity and reliability of the survey used for this study were measured. Cronbach's alpha and the KMO index were used for this purpose. Cronbach's Alpha results were 0.888, indicating an excellent internal consistency for the measurement scale as the work by Reyes-Menéndez et al. (2019) established a minimum threshold of 0.7 (in a range between 0 and 1). Meanwhile, the study by Bland and Altman (1997) considers the coefficient to be good if the value is between 0.8 and 0.9. In the case of our study, Cronbach's Alpha reliability result is valid.

In addition, the KMO index, Kaiser, Meyer, and Olkin's measure of sampling adequacy, which measures the correlation and interrelationship between variables, has been performed (Isman and Canan Gungoren 2014). For this measure, a value equal to or greater than 0.7 indicates a good interrelationship of the variables. The results of this test have shown the KMO index result of 0.872, which is within the range proposed by several researchers. Bartlett's test of Sphericity assesses the applicability of the factor analysis of the variables studied in the Sig case. (p-value) is less than 0.05, had a result of 0.000. Therefore, we proceed to analyze the results because the survey and the results are reliable.

5.2 Servicescape model

Based on users' responses, Bitner's Servicescape Model analyzes the social perception of public transport innovation and sustainability. In this first part, the study focuses on analyzing the responses exclusively recorded, taking into account the linkage of the questions with Bitner's three dimensions, explained in the methodology. This will better understand how the general public perceives innovation and sustainability in the public transportation system. The statistical analysis will be carried out in the following section, 5.3, to contrast the hypotheses.

The first question is vital to the questionnaire as it indicates to what extent the respondent may or may not consider themselves service users. The 68.2% of respondents stated that they were frequent users, which allows the results recorded to provide an accurate perception of the value of the service.

Block 1: 'Environmental dimensions.'

Concerning the quality of air, space, cleanliness, noise, and seats, 50% of the respondents rated the quality of the bus as good and very good. The remaining 50% are mainly between indifferent and poor. In the case of the metro, the situation is similar, but there is a greater tendency towards a more pessimistic assessment.

As for the perception of the contribution of public transport to the sustainable development of cities, 68% of respondents say it is delicious.

The assessment of the indications on sustainability measures implemented in the service shows differences by age. The first age bracket (between 15 and 30 years old), where the student group is located, reflects a more remarkable indifference than the rest of the age brackets above 30 years old, where there is a clear positive assessment of these indications. Generally, there is a tendency to rate these indications positively, with only 15% of respondents rating them poorly or very poorly. In the case of indications of new technology measures implemented in the service, the assessment recorded is very similar.

Block 2: 'Feelings' or 'internal responses.'

There is a positive user response to innovations in public transport. This response is similar to user-utility-enhancing inventions and sustainability innovations that result in good for all citizens. In both cases, 67% of the respondents rated it as good or very good, with a large part of the remaining percentage at an intermediate level.

Ages 30 and up, especially those who do not belong to the group of students, show more incentive to utilize the service due to the innovation policies that have been implemented. This is probably due to the student's more obligatory behavior when using the service. However, other groups may be more impacted by learning about these policies and changing their mobility patterns. The results recorded with the motivation generated by sustainability policies are similar in motivation. Based on the above, the research question can be answered, the policies implemented in both innovation and sustainability are perceived positively but do not seem to have much impact on the service user. As for the relationship with other travelers, the user does not feel identified with other travelers. However, there is a greater tendency to say that people in the immediate environment have similar mobility habits. This could lead managers to study user profiles with similar characteristics and develop innovative policies that are differentiated from other groups. In comparing which mode is the most innovative and contributes most to sustainable development, the general response is obvious: the user considers the metro the most innovative and sustainable mode.

Concerning the open-ended question about the image with which they associate public transport, the most frequently recorded answers refer to bus and metro, and above all, to the crowds of people using the service and the stress this generates for them. Regarding sustainability and innovation, only 10% of the real answers are reached, of which 97% refer to sustainability and only 3% to innovation.

Regarding the social repercussion of the service, the user values most positively the impact on reducing pollution and the contribution to universal accessibility. Both issues are related to sustainability and innovation.

Block 3: 'behavior.'

The main reason for using the service is to save money (31.4%), followed by the lack of a private car (30.8%) and to save time (14.7%). All this indicates compulsory mobility patterns, especially in the younger age group. In fourth place comes the reason for social awareness (14.1%), which reflects an operational decision to use the service because of its contribution to the sustainability of the service.

For work purposes, there is more frequent use than for leisure purposes. However, for each age group, there is a similar weight in the frequency of use for work and leisure purposes.

Regarding the importance of service objectives for the user, technological development and environmental sustainability are perceived as the lowest priorities, behind frequency, safety, speed, and universal accessibility. However, there is a higher prioritization of these two objectives for the group of active workers than for students.

On the other hand, there is widespread support for the idea that competent authorities should invest in innovation to contribute to cities' sustainable development and improve user quality. In both cases, 75% of respondents agreed or strongly agreed. However, users disagree that this innovation translates into an increase in the service cost, although there is more excellent support if this cost is borne by all citizens (47%).

5.3 Quantitative analysis

The first step of statistical analysis was measuring the relationship between the dependent and independent variables. The result is shown in Table 2.

As we can see in the table, there are strong or less strong relationships between the analyzed variables ($r(1361) = [0.1253, 0.7852]$, $p = .000$). The range of relationships the least strong is 13%, and the most decisive is 79%. The variables that are not correlated are 'Innovapolicytpmotivation' and the gender of public transport users. This is the first indication that gender does not measure users' motivation to use public transport when innovation policies exist. There is also no correlation between gender and perception of public transport service concerning noise mitigation. But it should be borne in mind that the correlation analysis indicates the possible relationships but does not ensure the outcome.

Therefore, the second part of the statistical analysis was two regression models with two independent variables. The results of the linear regression can be seen in Table 3.

First, we will analyze the model with the dependent variable of the importance of technological development in public transport. A significant regression equation was found ($F(10, 1351) = 230.24$, $p < 0.00$) with R^2 of 0.630. The variables gender ($b = -0.081$, $p = 0.015$), *tojectsustainab* ($b = 0.322$, $p = 0.000$), *tojectunivaccess* ($b = 0.260$, $p = 0.000$), *object safety* ($b = 0.060$, $p = 0.054$), *object speed* ($b = 0.148$, $p = 0.000$), *object space* ($b = 0.060$, $p = 0.027$), *innovapolicytpmotivation* ($b = 0.064$, $p = 0.017$), *site pollution* ($b = -0.076$, $p = 0.001$) and *sitpnoise* ($b = 0.076$, $p = 0.000$)

Table 2 Correlation Matrix

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Tobjecttic	1										
2. Tobjectustainab	0.7218*	1									
	0.0000										
3. Gender	0.1253*	0.1941*	1								
	0.0000	0.0000									
4. Tobjectunivaccess	0.7245*	0.7447*	0.2105*	1							
	0.0000	0.0000	0.0000								
5. Tobjectisafety	0.6683*	0.6850*	0.1858*	0.7852*	1						
	0.0000	0.0000	0.0000	0.0000							
6. Tobjectspeed	0.6514*	0.6271*	0.1520*	0.7190*	0.7605*	1					
	0.0000	0.0000	0.0000	0.0000	0.0000						
7. Tobjectspace	0.5956*	0.5852*	0.1355*	0.6664*	0.7284	0.7416*	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
8. Sustainbpolycytpmot.	0.3570*	0.4409*	0.1250*	0.3404*	0.3179*	0.2772*	0.2471*	1			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
9. Innovapolycytpmot.	0.3437*	0.3729*	0.0928	0.3176*	0.3080*	0.2722*	0.2576*	0.7669*	1		
	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000			
10. Sittpollution	0.3130*	0.3755*	0.0630	0.3614*	0.3690*	0.3297*	0.4066*	0.3460*	0.3286*	1	
	0.0000	0.0000	0.0201	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
11. Sitpmoise	0.2843*	0.2753*	0.0037	0.2767*	0.2767*	0.2506*	0.2865*	0.2872*	0.2862*	0.6564*	1
	0.0000	0.0000	0.8919	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: own elaboration

were significant predictors of the tobjecttic. All variables positively correlate with the dependent variable except age and pollution reduction. This result indicates that pollution is reduced when technological advances are made in public transport. Thus, the importance of the technological development of public transport is higher for younger people.

Secondly, another regression model was created where the dependent variable was the importance of environmental sustainability development in public transport. As in the first model, a significant regression equation was found ($F(10, 1351)=266.60$, $p<0.00$) with R^2 of 0.665 in this model too. The significant variables to explain the dependent variable were gender ($b=-0.074$, $p=0.031$), tobjecttic ($b=0.335$, $p=0.000$), tobjectunivaccess ($b=0.322$, $p=0.000$), object safety ($b=0.132$, $p=0.000$), sustainbpolicytpmotivation ($b=0.200$, $p=0.000$), innovapolicytpmotivation ($b=0.048$, $p=0.079$), site pollution ($b=-0.079$, $p=0.001$) and sitpnoise ($b=-0.038$, $p=0.087$). As we can see, all the relationships explained above with the dependent variable are positive except noise mitigation. This means that when the importance of environmental sustainability development of public transport increases for users, noise mitigation in the city decreases.

Finally, we can say that the two regression models have allowed the testing of the hypotheses put forward in the study.

6 Result discussion

The results obtained through the Servicescape model are analyzed in the first case. The results have shown that the regulations implemented concerning sustainability and innovation in public transport are more highly valued and significantly impact the ages of over 30. This is probably because these are users with less obligational mobility patterns. This proves that students reflect the most mandatory mobility patterns (financial savings, lack of a private car, etc.). All of the above could lead managers to study user profiles with similar characteristics and develop innovative policies that are differentiated from other groups. Through an improvement in this type of policy, it would be necessary to try to encourage, on the one hand, a greater use of the service in those groups that can make an active change in their mobility patterns (Delgado et al. 2019). On the other side, to maintain its use in the future, the service is being valued and seen more highly by people who currently utilize it for required purposes. As seen in research conducted in different European cities (Mugion et al. 2018; Vicente et al. 2020), service quality influences the intention to use public transport, which impacts more responsible and sustainable mobility.

In addition, innovation and sustainability policies can be designed around geographical areas or urban neighborhoods, as users report finding similarities and mobility habits with their immediate surroundings. Another point to consider is that while these goals appear to be more deeply ingrained and associated with the metro by the user, the perception of innovation and sustainability should be addressed in the case of buses. However, overall, the findings indicated that people's perceptions of the viability of public transportation for city development were excellent. This result is in line with the academic literature associating public transport with sustainability

Table 3 Results of the Linear Regression

Variables	Tobjectctic		Tobject sustainab	
	Coef.	p>t	Coef.	p>t
Gender	-0.0809226	0.015	0.0736866	0.031
Tobjectctic	-	-	0.3354025	0.000
Tobject sustainab	0.3215663	0.000	-	-
Tobject univaccess	0.2602908	0.000	0.3219131	0.000
Tobject safety	0.0600667	0.054	0.1322762	0.000
Tobject speed	0.1481158	0.000	0.0319162	0.298
Tobject space	0.0602112	0.027	0.0197039	0.479
Sustainbpolicytpmoti- vation	0.0005652	0.984	0.1998422	0.000
Innovapolicytpmotiva- tion	0.0640152	0.017	0.0481507	0.079
Sitppollution	-0.0759401	0.001	0.079418	0.001
Sitpnoise	0.0759401	0.000	-0.0380609	0.087

Source: own elaboration

(Saif et al. 2017). There is a high degree of investment in innovation, the renewal of alternative energy sources, and a fleet of hybrid and electric vehicles. The bus operators and the service concessionaires must make an effort to disseminate and communicate these actions (Observatorio de Costes y Financiación del Transporte Urbano Colectivo 2021). Likewise, public transport operators in certain cities, such as Madrid, export their know-how to other countries in terms of technology development and the design of mobility plans (Gómez et al. 2014). These actions need to be publicized, and the importance of these actions needs to be argued to improve the user's perception of innovation and sustainability.

Secondly, the relationship between the dependent variables of sustainability and innovation of public transport and the independent variables of quality of service (accessibility, safety, and quality) has been statistically analyzed. In addition, gender has been used as one of the independent variables as the academic literature considers gender to influence sustainability and innovation (Dai et al. 2019; Meinzen-Dick et al. 2014; Sovacool et al. 2018). In our study, gender distinction can be seen, with men valuing technological development in public transport more highly than women. Conversely, women give higher priority to sustainability than to technological development. Our results are, therefore, in line with the academic literature on the subject.

The results of the first regression model where 'Tobjectctic' was the dependent variable showed a direct and positive relationship with other variables such as accessibility, security, and quality, so technological development policies should focus on these aspects to improve their assessment and perception. Specifically, if we analyze the results one by one, we will see a negative relationship between the dependent variable and the variable of pollution (sitppollution). This result indicates that pollution is reduced when technological advances are made in public transport. The rest of the independent variables have a positive and significant relationship with the dependent variable. Hypothesis 1 is therefore accepted as the model establishes a positive relationship between technological development and the independent variables such as accessibility, safety, and quality. Academic literature has also considered service quality, accessibility, and safety essential for public transport users (Friman et al. 2020).

Hypothesis 2 analyzed the relationship between the dependent variable, the importance of environmental sustainability development in public transport, and the independent variables. It is important to note that the quality variables 'Tobjectspace' and 'Tobjectspeed' are not significant in the model. All other variables have a positive and direct relationship with the explained variable, except 'Sitnoise,' which has a negative relationship with 'Tobjectsustainab'. This means that when the importance of the development of environmental sustainability of public transport increases for users, noise mitigation in the city decreases simultaneously. This could be because most of the sample were people living outside Madrid, for whom noise mitigation is essential. Mugion et al. (2018) state that service quality affects individuals' intention toward sustainable mobility. Although in our study, this relationship has not been confirmed. Based on these results, hypothesis 2 is partially accepted, as the quality variables are not significant, but the accessibility and safety variables are.

It is also worth noting the positive and significant relationship between 'Tobjectsustainab' and 'Tobjecttic' that both models reflect, which implies that the importance that the user attaches to technological development has similar behavior to that which they attach to sustainability.

7 Conclusion

This study aimed to analyze the perception of public transport users on the technological innovation and sustainability achieved. Variables such as users' gender, age, service quality, accessibility, and safety, among others, have been used. A sample of 1,354 responses obtained in Spain was used. Generally, the main conclusion is that aspects related to innovation and sustainability in public transport services are not the most valued by users. However, certain groups of users do give them value and importance. The policies implemented in both innovation and sustainability are perceived positively but do not seem to have much impact on the service user. This shows a long way to go for the competent authorities and the operating companies. In addition, users attach importance to sustainability and innovation objectives, even if they prioritize other objectives such as speed, frequency, or safety.

7.1 Theoretical contributions

In recent years, there has been a growing interest in the academic literature on the implementation of smart innovations in the public transport system (Brakewood and Watkins 2019, Drabick et al. 2021) and the development of techniques and policies aimed at improving the sustainability of transport (Gutiérrez et al. 2021; Solano et al. 2021). Also, the literature review has shown several studies analyzing the variables in this research separately, but none have established the same model. Therefore, the theoretical contribution of our study to the academy is the following: (i) contribute and provide update literature on user's assessment of the innovative and sustainable practices in the public transport. In other words, it contributes to ensure that the management decisions of the service operators can be more user-oriented; (ii) this is the

first study that jointly analyzes public transport users' perceptions of technological advances and sustainability and the relationship between these and the variables of service quality, safety, and accessibility. For this reason, this model could be useful for measuring user perceptions of sustainability and innovation in public transport in other metropolitan cities; (iii) the gender distinction in assessing technological innovation and sustainability of public transport is shown. In particular, this study contributes to the literature on gender-distinct public transport user preferences.

This could lead to the conclusion that academia should focus on this aspect and investigate further the reasons for this distinction, trying to conclude how to transfer the importance of sustainability of the service equally to men and women.

7.2 Managerial implications

In recent years, the transport industry has been affected by numerous technological changes, which has had an impact on quality, safety, development and accessibility of public transport. Our results are based on how users have perceived all these developments and advances. This allows hospitality entrepreneurs to carefully consider all factors that are associated with the use of these technologies and that can affect the success of their business. On the basis of the results the following practical implications are proposed: (i) the three variables that users attach importance to when choosing public transport as a mode of transport are speed, safety and frequency. Public transport management must take these variables into account as they are important to maintain or increase ridership; (ii) from a management point of view, sustainable development and investment in technology has a direct effect on the intention to use public transport, so this must be a priority for public transport management; (iii) the age of users affects the perception of technological development and sustainable actions in public transport, this means that there is a need for action on the part of the management of the transport operators to reach all users; (iv) the results show that political and management decisions may be disconnected from the reality perceived by users. In other words, the decisions taken are often linked to regulatory pressures that imply a high cost of implementation, so it is necessary to consider the valuation of the service by users so that the benefit or social return on these investments is high, providing incentives for the use of the service.

Apart from these practical implications, one of the most important things is to get more frequent users. Concerning measures that could be taken to improve outreach to those who are not frequent users of the service, one measure that could be proposed is to generate an incentive for the use of the service employing an individualized or collective ranking. This ranking could be associated with obtaining discounts and advantages in leisure activities, such as restaurants, theatre and cinema tickets, etc. It also helps partner companies to include these actions in fulfilling their SDGs. An E-WOM (Electronic Word of Mouth) effect could result from this knowledge being disseminated on various platforms or profiles set up for this purpose on social media, as suggested by numerous authors (Azer and Ranaweera 2022; Bakti et al. 2020; Bastos and Moore 2021; Martínez-Navalón et al. 2021; Tran and Strutton 2020) and get an incentive in the use of public transport.

7.3 Limitations and future research directions

This study is not free of limitations. The first and most important is the sample. Although this study's sample is considered a large sample, most of the responses are received from public transport users in the city of Madrid. This limitation prevents the generalization of the results as Spain is a large country, and each autonomous community has a different mobility culture. Therefore, it is foreseen to increase and diversify the sample for future research. However, it does allow conclusions to be extrapolated to other Spanish metropolitan areas with transport systems developed to a similar degree to Madrid, for example, the metropolitan area of Barcelona, Valencia or Sevilla. Likewise, the conclusions obtained for the Madrid transport system can contribute as a guide for systems in other countries with similar characteristics. In fact, in the last decade, their mobility plans, technologies and sustainability policies are being exported as know-how to Latin American countries whose transport systems are still under development (Gómez et al. 2014).

Another limitation is not being able to analyze control variables such as training and awareness of users on the importance of sustainability actions. Therefore future lines of research could use the control variables to see the exact reason for this result. Finally, it would have been interesting to use another robustness analysis to give more reliability to the results obtained.

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Data availability The datasets generated during the analysis of the current study are available from the corresponding author on reasonable request.

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