Railway transit services in Algiers: priority improvement actions based on users perceptions

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ABSTRACT

The Algerian Government has recently promoted transportation projects such as the Algiers metro and tramway services that represent a key part of its political and financial effort to improve mobility in the country. However, public transport systems' profitability requires a thorough diagnosis of the services provided based on users' perceptions and expectations. That is, to invest money according to users' requirements. A methodological approach, which combines an Importance-Performance Analysis and a decision tree model, is proposed as means of analyzing rail services performance in Algiers and identifying the aspects that should be prioritized for improvement actions.. Three railway transit services were analyzed in Algiers: the tramway, the metro and the commuter rail. More than 450 surveys were collected per mode. After applying the proposed methodology, results show that there are lines of action common to the three services, and specific strategies that may improve customer satisfaction and customer loyalty with the three railway transit services in Algiers. This is the first full experience analysis about service quality in Algiers' railways transit modes. The proposed two-step methodology is, for the first time, applied for analyzing service quality in public transport.

Keywords: tramway; metro; commuter rail; customer satisfaction survey; derived importance;importance-performance analysis; decision trees

1. Introduction

The mobility context of developing countries is very different from the situation found in other developed ones. In most of these developing countries the private car is the dominant mode of transport and a tough opponent to public transport (PT) modes. The situation is even worse in countries, like Algeria, that are oil producers and where the price of oil is very low. In these cases, measures for improving the PT service quality

becomes necessary for attracting users towards the use of these more sustainable transport modes.

The governments of developing countries should focus on elaborating specific analysis on this area, since PT services represent an essential element for the economic and social development of a nation. Moreover, a sustainable growth of the urban agglomerations will be conditioned to the quality of the PT system. In the North of Africa there are various countries (e.g., Algeria, Morocco) that have started to build metros and light rail transit systems. Particularly, Algeria is developing a wide construction program on guided modes of transport (i.e., metro, light rail transit) to promote a sustainable mobility in its main cities (e.g., Algiers, Oran, Constantine, Batna, Setif, Tlemcen, Blida, Bejaia, Djelfa, etc.) (de Oña et al., 2013).

In the case of Algiers, it is estimated that the population of the province, more than 2.8 million inhabitants, generated 6.5 million trips everyday in 2014 that showed the following modal share: 53% of walking, 30.2% of public transit, 13.6% of private vehicle, 2.2% of taxi and 1% of other modes (Baouni, 2015). Walking is the mode most frequently used by Algerians, who also walk long distances mostly between 600 to 1,000m and 1,000 to 1,400m (Baouni et al., 2014). However, the preference for traveling by foot could be due to the lack of a homogeneous offer of public transit and intermodality throughout the city of Algiers (Ait Aoudia, 2013). Furthermore, the private vehicle is experiencing a notable increased use that is exemplified by an 4.77% average annual increase in car ownership between 2004 and 2008 (Safar Zitoun and Tabti Talamali, 2009).

After the 90s, private operators have increasingly dominated the offer of urban transit in Algiers due to the deregulation of the sector after an urban transport crisis in the 80s, and the difficulties experienced by the country during the Algerian Civil War (1991-

2002) (Ait Aoudia, 2013; Safar Zitoun and Tabti Talamali, 2009; Chabane, 2013). In 2013, there were 4,439 private operators that accounted for 85.2% of the bus seating capacity offered, whereas two public operators provided the remaining capacity (DTW, 2014). The large number of small private operators and the common handcrafted nature of its services (i.e., lack of timetables and fixed routes) contributes to the lack of service quality and the problematic situation of the urban transportation network, frequently congested and so called "anarchic" (Ait Aoudia, 2013; Safar Zitoun and Tabti Talamali, 2009).

It is worth highlighting the political and financial efforts of the government to launch sustainable transportation projects in the last years, which have the metro and tramway services of Algiers as key parts of the solution and major structural axes in the city (Ait Aoudia, 2013). The metro service was first operated in November 2011 and was, at that time, the first underground metro service in Maghreb and the second one in North Africa (after the metro service in Cairo, Egypt) (de Oña et al., 2013). Currently, the metro consist of a 1-line underground rail transit of 9.5 km and 10 stations, and it transported approximately 13 million passengers in its first year of operation (de Oña et al., 2013). The tramway service started operations in May 2011 and it currently consists of a 16.2 km line with 28 stations that transported almost 9 million passengers in 2014 (EMA, 2015). The beginning of the metro itinerary is located in downtown Algiers and goes in the South-East direction across the city. At the metro station Les Fusillés, there is intermodality between one of the four cable cars of the city and the tramway service. The latter serves as a prolongation of the mass transit service in East direction that provides 6 more "communes" (neighborhoods) with access to the city center. Both the metro and tramway service are part of larger projects that consider the extension of the

metro network up to three lines and 62 km (Baouni, 2009), and 23 km in the case of the tramway network (RATPDEV. SETRAM, 2015).

Last, the rail transit system in Algiers is complemented by the commuter rail system, a heavy rail transit service that communicates residential, university and industrial areas of the metropolitan area and the city center, and that transported more than 28.7 millions of passengers in 2012 (SNTF, 2014). The commuter rail network consists of two parts: i) a common triple-track railway of 10.3 km and 6 stations that goes southeast across Algiers from the city center until the Harrach train station; ii) the commuter rail continues with a 2-leg railway that communicates the southwestern and eastern parts of the urban agglomeration with double-track railways of 68 km and 42 km respectively.

In this context, it is evident that rail PT is gaining a high presence in the day-to-day citizens' life. Guaranteeing attractive PT services that operate with high level of quality ensures the systems' profitability at a prospect of financial development and social integration. It requires a thorough diagnosis of the services provided based on users' perceptions and expectations. That is, the improvement of service quality does not only mean to invest money in advanced technologies, but also to prioritize actions that influence the level of quality perceived by customers (Freitas, 2013).

In this line, this paper presents a methodological approach to assess the quality of three railway transit services in Algiers: the tramway, the metro and the commuter rail. An Importance–Performance Analysis (IPA) combined with a decision tree model identified the aspects that should be prioritized for improvement actions. By means of an ad-hoc Customer Satisfaction Survey (CSS), users' perceptions were collected concerning a list of attributes describing each local service. The importance of these attributes was derived from users' perceptions by calibrating a decision tree model. The Classification and Regression Trees (CART) algorithm was applied due to its well-

known reputation and its advantages over other parametric models (de Oña et al., 2012; de Oña and de Oña, 2015b; de Oña et al., 2015a). Parametric models have to comply with some model assumptions and pre-defined underlying relationships between dependent and independent variables, such as normal data, linear relationships between dependent and independent variables, low multi-colinearity, and so on. According to Garver (2003), these assumptions are almost always violated in customer satisfaction research. If these assumptions are violated, the model could lead to erroneous estimations of the likelihood of service quality. CART is able to overcome the above-mentioned limitations due to it is a non-parametric model with non-predefined underlying relationships between variables. In addition, IPA approach is applied, as it is one of the preferred methodologies of transport company managers due to its simplicity and graphic results (Foote and Stuart, 1998; Christopher et al., 1999; Figler et al., 2011; TRB, 2013).

After this introduction, the paper is organized as follows: a Literature review section provides an overview on current studies on quality and customer satisfaction related to the perception of transit, the Methodology section presents the CART and IPA methodologies; the Data section briefly describes the designed survey, data collection and some descriptive statistics about the three samples; the Results and Discussion part summarizes the main results obtained with the analysis; and finally, in the last section it can be found the main conclusions of the study.

2. Literature review

In recent years, transit service quality has emerged as a very popular topic among researchers, not only in developed countries, where it became a trending topic few years ago (dell' Olio et al., 2010; de Oña et al., 2012; 2014; 2015a; Eboli and Mazzulla, 2011; Hassan et al., 2013; Harvey et al., 2014; Hensher et al., 2010; Liekendael et al., 2006;

Nathanail, 2008), but also in developing ones, where studies in the quality field are being booted since the beginning of this decade. Some of these investigations were developed in Pakistan (Irfan et al., 2012), Iran (Mahmoudi et al., 2010), India (Geetika, 2010; Prasad and Shekhar, 2010a; Prasad and Shekhar, 2010b), Turkey (Alpu, 2015; Aydin et al., 2015; Celik et al., 2014), and Ghana (Ojo et al., 2014).

As a result, some differences are found concerning the approach that, at the present time, is used for service quality evaluation in both contexts. At developed countries, more sophisticated models are implemented (de Oña and de Oña, 2015a) such as discrete choice models (dell'Olio et al., 2010; Hensher et al., 2010), structural equation models (de Oña et al., 2013) and data mining algorithms (de Oña et al., 2012; de Oña et al., 2014; de Oña and de Oña, 2015a). Likewise, sample stratification with advance techniques such as cluster analysis (Wen and Lai, 2010; Wen, et al, 2008; de Oña et al., 2015b) is used for reducing the heterogeneity of users' perceptions; or complex models with random parameters are used for accounting for this heterogeneity (Hensher et al., 2010). Furthermore, combining objective data (technical data) and subjective data (customers' opinions) to evaluate the global quality of public transport emerges as a useful and reliable measurement tool of transit service quality (Liekendael et al., 2006; Nathanail, 2008; Eboli and Mazzulla, 2011; Hassan et al., 2013; Barabino and Di Francesco, 2016). In fact, not only data collected from customer satisfaction surveys is used for service quality evaluation, but also data gathered with stated preference surveys (Eboli and Mazzulla, 2008; Gatta and Marcucci, 2007). In this regard, Barabino and Di Francesco (2016) further developed the SERVQUAL model to integrate objective and subjective data of service quality at different temporal levels (e.g. strategic, tactical and operational). Furthermore, they proposed a service quality gap analysis quantified in terms of percentage of passengers in a category relevant to the gap calculation such as

percentage of passengers who perceived a service *in conformity* and *targeted* passengers.

Finally, some studies investigate the complete framework concerning passengers' attitudes towards the transit service. That is, evaluating transit service quality, and the existing relationship with other constructs connected with it: passengers' satisfaction, loyalty, involvement, perceived costs and so on (de Oña et al., 2016; Jen et al., 2011; Lai and Chen, 2011). Nevertheless, many transit operators at developed countries use simple methodological approaches (such as SERVQUAL model or some modified versions of it) for evaluating their services provided.

At developing countries, it is more common to employ simple measurement tools of transit service quality, based on the SERVQUAL scale (Irfan et al., 2012; Mahmoudi et al., 2010; Prasad and Shekhar, 2010a; 2010b; Ojo et al., 2014), factor and/or regression analysis (Alpu, 2015; Geetika, 2010), or simple Structural Equation Models (Irfan et al., 2012). For example, Irfan et al. (2012) investigated passengers' perceptions about the service quality of the rail transport system in Pakistan by employing a modified SERVQUAL instrument. The proposed instrument considered eight service quality dimensions and by using a Structural Equation Model, it was determined the relationship among the service quality attributes and passenger satisfaction. Mahmoudi et al. (2010) explored customer satisfaction at a Bus Rapid Transit in Tehran (Iran) based on the SERVQUAL scale and using a Pearson correlation. Likewise, on the basis of SERVQUAL and rail transport quality, Prasad and Shekhar (2010a) developed the RAILQUAL instrument for analyzing the Indian railways. They added three new transport dimensions (comfort, security and convenience) to the original five SERVQUAL dimensions. Ojo et al. (2014) used SERVQUAL methodology to assess passengers' perspective of intercity bus service quality on Cape Coast - Accra route in

Ghana. The High Speed Rail of Istanbul was investigated by Alpu (2015). Factor analysis and a regression model were conducted to determine the relevant factors affecting passengers overall satisfaction towards the service. Geetika (2010) analyzed service quality in Indian railways. For this purpose, factor analysis was used to identify the most important factors of customer satisfaction.

Furthermore, conventional stratification is carried out based on socioeconomic and demographic factors. For example, Ojo et al. (2014) stratified the sample of passengers according to their socioeconomic characteristics (sex, age, level of education and income) and used an ANOVA analysis to identify significant differences among passengers' perceptions at these groups.

Sometimes, SERVQUAL approach has been combined with other more complex techniques such as the fuzzy logic theory and multi criteria decision analysis (Prasad and Shekhar, 2010b; Celik et al., 2014; Aydin, 2015). Prasad and Shekhar (2010b) applied the fuzzy set theory to the RAILQUAL instrument in order to reduce subjectivity and ambiguity of passengers' judgments, obtaining more expressive results, and a better means to avoid misleading results and their wrong interpretation than in Prasad and Shekhar (2010a). Celik et al. (2014) analyzed the quality of the rail transit network in Istanbul, Turkey. They examined the metro, tram, light rail and funicular services through an approach that integrated statistical analysis, SERVQUAL, interval type-2 fuzzy sets and VIKOR. Likewise, Aydin et al. (2015) also evaluated customer satisfaction levels at Istanbul railways services; by proposing a novel Multicriteria decision making that combined trapezoidal fuzzy sets and fuzzy-Choquet integral.

However, SERVQUAL model presents some disadvantages over other methodologies (de Oña and de Oña, 2015a), as it uses passengers' expectations and perceptions at the same time (which may be confusing for passengers) and, for collecting this information,

it is necessary to increase surveys' length (this can depress the overall response rate and accuracy of the survey). This could be the main reason why this methodology is less used at developed countries over the last few years, although transit operators still use it.

3. Methodology

The proposed methodological approach combines the use of attributes importance and service perceptions rates for ascertaining which service attributes a firm should devote more attention, and which will need a lower priority. In a first step, CART algorithm is used for attributes importance extraction and subsequently, IPA is used for information organization. Both together offer a useful and practice-ready tool for operators to better allocate their resources in accordance with users requirements.

3.1. **CART algorithm**

The Classification and Regression Trees (CART) algorithm (Breiman et al., 1984) constitutes a data mining technique without model assumptions and pre-defined underlying relationships between dependent and independent variables. CART is a particular methodology used for building binary decision trees in which the Gini Index (a measure of purity) can be applied as the splitting criterion. CART model is built recursively, following a descending strategy, starting with the full data set (made by the root node) and subsequently splitting into even smaller subsets. Then, this process begins with all the data concentrated on the root node, and a set of candidate split rules is created, which consist of all possible splits for all variables included in the analysis. The variable used as splitter is the one that creates the best homogeneity in the child nodes based on the Gini reduction criterion. This criterion is applied recursively to the

descendants to achieve child nodes having maximum "worth" in terms of its contribution toward maximizing the homogeneity through the resulting split.

Then, the Gini reduction criterion measures the worth of each split as follows:

$$Worth = I\ (P) - \sum_{b=1}^{B} P(b) * I(b) \quad (1)$$

Where *I(P)* denotes the impurity measure of the parent node, *P(b)* denotes the proportion of observations in the node assigned to a branch *b* and *I(b)* denotes the impurity of the node *b*.

Then, the impurity of a node *t* according to Gini measure, *I (t)*, may be defined as follows:

$$I(t) = 1 - \sum_{i=1}^{J} \left(\frac{n_i}{n}\right)^2 \quad (2)$$

in which *J* is the number of classes in the target variable, n_i is the number of cases belonging to the class *i*, and *n* is the total number of cases. If a node is "pure", all the observations in the node belong to one class, and *I(t)* will be equal to zero.

When developing a CART, this criterion is applied recursively to the descendants to achieve child nodes having maximum worth which, in turn, become the parents for successive splits, and so on. The splitting process ceases only when there is no (or less than a pre-specified minimum) reduction in impurity and/or the minimum limit for number of observations in a leaf is reached. This process gives rise to a saturated tree that provides the best fit for the data set it was derived from, though it overfits the information contained within the data set and such overfitting does not help in accurately classifying another data set. Therefore, in developing a CART model the data are usually divided into two subsets, one for learning (or training) and the other for testing (or validation). The learning sample is used to split nodes, while the testing

sample is used to compare the misclassification. The saturated tree is then constructed from the learning data.

Overly large trees could result in higher misclassification when applied to classify new data sets. To decrease its complexity, the tree is pruned in the second step according to a cost-complexity algorithm based on removing the branches that add little to the predictive value of the tree. The cost-complexity measure combines precision criteria (as opposed to complexity in the number of nodes and processing speed) by searching for the tree that obtains the lowest value for this parameter. Thus, with the last step, the optimal tree is obtained. A more detailed description of the CART method can be found in Breiman et al. (1984).

One of the most valuable outcomes provided by CART analysis is the value of the importance of independent variables, which reflects the impact of such predictor variables on the model. Breiman et al. (1984).devised the variable importance measure (VIM) for classification trees based on the weighted average of the reduction in the Gini impurity measure (Eq. 2) achieved by all splits using a variable *xj* across all internal nodes of the tree, where the weight is the node size. The information is obtained for all the independent variables, making it easy to find which ones are the most important.

In our case, CART algorithm derived the importance of each attribute of the three railway services by calibrating three different models with the users' perceptions rates collected with the CSS. That is, users' overall satisfaction at each mode of transport is considered the dependent variable, and users' perceptions about the quality of different service attributes are considered the independent variables.

3.2. IPA

IPA is a quadrant analysis that uses the importance and the performance rate of the service attributes as coordinates of a two-dimensional grid split into four quadrants

(Martilla and James, 1977). This quadrant chart quantifies the importance of each attribute from a customer´s perspective (vertical axis), and shows the customer´s average perception rating for each factor (horizontal axis). Attributes placed on the right side of the quadrant chart have relatively high performance scores, and those on the left side represent low performance values. Likewise, the quadrants on the top of the chart contain those attributes that appear to be the most important compared to those placed on the bottom of the chart, which have a relatively lower importance. Then, by conducting an average split based on importance and performance ratings, the vertical and horizontal axis are established in the quadrant chart and the attributes can be classified based on their relative urgency of improvement as follows: "Keep up the good work" (upper-average importance and performance), "Possible overkill" (upper-average performance, under-average importance), "Concentrate here" (upper-average importance, under-average performance) and "Lower priority" (under-average importance and performance).

In this paper, IPA was conducted with the users' perceptions of the attributes describing each railway service and deriving their importance from three CART models respectively.

4. Data

This paper focuses on the service quality perceptions and customer satisfaction of passengers of three different PT services in Algiers: the tramway (on-ground light rail transit), the metro (underground light rail transit) and commuter rail (on-ground heavy rail transit). Users´ perceptions, trip and socio-demographic characteristics of 1,454 PT users (495, 446 and 513 for the tramway, metro and commuter train respectively) were collected in March 2015 by using an ad-hoc CSS that consisted on three different questionnaires adapted to each of the three local transit services. The CSS was

developed based on a thorough literature review of service quality measurement and evaluation (de Oña et al., 2015b; de Oña and de Oña, 2015a), the European Standard EN 13816, and the experience of the authors in this field, specifically, their previous work on local PT services in Algiers and similar PT services in developed countries (de Oña et al., 2013; de Oña et al., 2015b). Moreover, the first version of the CSS was tested and purified by conducting a pilot survey of 347 passengers of these local PT service in November 2014 and by considering the resulting feedback of the interviewers. Both the pilot and the final CSSs were collected by face-to-face interviews at the main stops of the three transit modes. This survey mode was selected for gathering users' responses as the help of the interviewer is decisive on the quality of data. The language chosen to conduct the data collection was French. Although Arabic is the official language in Algiers, French has a significant role in its government, education, culture and media. Moreover, the country had 11.2 million French-speaking citizens in 2008 (OIF, 2010). Additionally, the interviewers were able to translate the question to Arabic in a closed form for non-French speaking respondents. Therefore, the bias in the data collection derived from the questionnaire language was considered to be negligible. The authors of this study considered the methodology used to design and conduct the CSS especially satisfying given that this is the first thorough CSS of PT users conducted in Algiers.

The survey instrument consisted of three parts that gathered information related to users' perceptions about the quality of the service and their overall level of satisfaction (Part A), users' travel habits (Part B) and their socio-demographic characteristics (Part C). Part A concerned data based on respondents' overall ridership and Part B collected information about the trip that passengers were taking when they were interviewed. Respondents' assessments of the level of quality in regards to the overall PT service and

its different attributes were measured with an 11-point scale (0-lowest quality and 10-highest quality). Moreover, the overall level of satisfaction with the PT service was measured with a 5-point Likert scale (1-lowest level of satisfaction, 5-highest level of satisfaction). Two different measurement scales were used for the following reason: overall level of satisfaction was measured with a 5-point Likert scale because it is easier for users to express a global evaluation on a 5 semantic level scale; on the contrary, an 11-point scale was used to evaluate the service attributes in order to achieve a better differentiation between attribute scores, as using a wider scale helps to this differentiation and helps users to evaluate each attribute in comparison to the other ones. This evidence was proven with a pilot survey conducted prior to the final version of our survey.

The number of service attributes evaluated in Part A varied between 23 and 26 depending on the questionnaire used for each PT service (i.e., metro, tramway and commuter rail), which were adapted to the specific PT service respectively as follows.

Part A of the questionnaire concerned the perceptions of PT users in regards to seven dimensions of the service quality: Availability of the service, Accessibility, Information, Time, Customer Service, Comfort and Safety. A total of 29 attributes of the different PT services were initially considered to analyze users´ assessment of the quality of the service, however, 9 of these attributes (referred as "Specific attributes", *Si*) were only included in some of the questionnaires of the three modes due to the different characteristics of the PT services. The 29 attributes and their average perceived service quality per mode are described in Table 1.

In regards to the accessibility, there were important differences between the three PT services that justified the economization of questions in some questionnaires and, consequently, the beneficial shorter length of the survey. Only users of the metro were

asked for their assessment of the operation of the escalators. Conversely, all tramway stations were on the street level and there was no need of escalators. In the case of the commuter rail, the six train stations located in the rail track common to the east and southwest bounds only had regular stairs that occasionally could represent access barriers due to the height difference between the street and platform levels. Moreover, commuter rail passengers were neither asked for their perceived ease of access to the PT service for people with disabilities, in a different manner to the other two PT services. The commuter rail showed an obvious problem of accessibility that was sufficiently well captured by the remaining items of accessibility (ease of access to stations and platforms from the street; ease of connection with other PT services). Similarly, only users of the metro and tramway services were asked for their assessment of the operation of the ticket validation machines because tickets were manually validated by a supervisor in the case of the commuter rail service.

Passengers of the three PT services were asked about attributes related to time such as waiting time at station and speed of the trip, however, only users of the commuter rail were asked for an evaluation of the punctuality of the service. This item was excluded of the other questionnaires based on the results of the survey design process (pilot survey and interviewers' feedback). These results showed that the concept of punctuality was only well understood by commuter rail passengers possibly because the time between commuter trains was much longer and this PT service did not provide users with real time information of train frequencies.

Furthermore, the tramway stations were on the street level and outdoors, therefore the questionnaire of the tramway economized on the questions related to cleanliness and lightening of the stations. Additionally, the quality evaluation of toilets, vending

machines and stores was only consider in the case of commuter rail users because this was the only transit mode that offered this type of services.

Table 1

In regards to the safety assessment, the survey instrument design process showed that it was relevant to ask passengers of the commuter rail and tramway services about their perceived level of safety against traffic accidents due to the recent incidents experienced. In the case of the tramway, there have recently been traffic accidents that involved the tram and private vehicles and consequently, it could especially be useful for the tramway operator to know the level of safety against traffic accidents perceived by its users. Similarly, the commuter rail experienced an accident in November 2014 that resulted in one death and 63 injured people and took place in the middle point of the itinerary between the train stations of Agha and Harrach in Algiers. Additionally, passengers of the commuter rail were asked for their perceived level of safety in the area of the platforms related to aspect such as protected walkways and signalization.

Table 2 summarizes the descriptive characteristics of the complete samples of the three PT services. The three surveys were collected in successive periods of time: the survey of metro users was collected on three weekdays (17-19/3/2015); tram users were interviewed on three week days and a Saturday (14-17/3/2015; note that the Islamic weekly calendar adopted in Algiers considers Friday and Saturday as the official weekend); and the users of the commuter train were interviewed on a weekday, a Friday and a Saturday (12-14/3/2015). The number of valid surveys per mode was 446, 495 and 513 for the metro, tramway and commuter train respectively, which sums a total of 1,454 PT valid responses of passengers between the three local PT services. It is worth noting that within the three samples of PT users work was the main trip purpose (41.3%, 27.9% and 36.1% for the metro, tramway and commuter rail respectively), although the

proportion of trips due to studies was also notable in the case of the commuter rail (32.6%). Additionally, trips were frequently done for studies purpose in the case of the tramway (21.6%) but even more trips, almost one forth of the sample (24.8%), were done for other reasons, in a similar manner to the sample of metro passengers (25.1%).

Furthermore, walking (>34%), and secondly the bus (>20%), were the most preferred modes to go from the trip origin location to the station by users of the three PT services. Similarly, once users drop of the PT services, they most frequently walked to their destination (>55%) or less frequently took the bus. Only in the case of the metro service, passengers more frequently preferred to get to their destination by taxi (18.1%) than by bus (15.4%) from the arrival station. In regards to access times, all PT users tended to take more time to do the trip origin-station than the trip station-destination (approximately 4.3 minutes shorter in average terms) and the distribution of access times origin-station tended to be more dispersed. The most frequent alternative to the PT services was always the bus (>36%). It is interesting to note that the private car was considered as the preferred transportation alternative by approximately 18% of respondents of the three PT services, and it was the second most preferred alternative for tramway users. However, metro and commuter rail passengers respectively preferred the taxi (26.8%) and the student bus service (Cous) (27.4%) against the private car alternative.

A higher proportion of PT users holding a High School or Professional Education diploma (≈26.6%) and Bachelor´s degree (≈42.8%) composed the samples of metro and commuter rail passengers. On the other hand, tramway users were more evenly distributed between users holding a Mandatory School diploma (21.8%), a High School or Professional Education diploma (31.9%) and a Bachelor´s degree (29.9%). Moreover, more than two thirds of the sample of commuter rail passengers consisted of

employed users (36.1%) and students (32.4%), whereas in the metro and tramway samples the proportion of students decreased (15% and 24.2%, respectively) and the proportion of users with a liberal profession doubled (≈20%). The sample of the commuter rail passengers was evenly distributed between groups of users with 18-25, 26-40 and 41-65 years of age (≈30%). In a different manner, the samples of metro and tramway passengers mainly consisted of users between 26 and 40 years old (≈39%) and, in a smaller proportion, users between 41 and 65 years old (32.7% and 25.9%, respectively). More males composed all samples (≈52% for the tramway and commuter train services) and the metro showed the greatest gender difference (57.6% of male users). Last, it is worth highlighting the amount of respondents who were not willing to state the monthly income level of their household (42.6-52.5% of missing values).

Table 2

5. Results and discussion

An IPA and CART analysis of the three railway transit systems in Algiers allowed us to prioritize various specific actions to improve the perceived service quality of the three PT services, and consequently, improve customer satisfaction and customer loyalty. The reference of service quality level and importance in the IPA was independently set for each PT service as the average of the perceived service quality and importance of its attributes respectively. Attributes' importance is displayed in Table 3, derived from CART model. Additionally, the average perceived service quality of three modes was occasionally considered to look into each PT service in the context of the overall perceived service quality of the railway transit system in Algiers.

Table 3

The metro service showed the highest level of perceived service quality, although operators and the administration should consider important lines of action that

complement current efforts to promote this transit service to increase the likelihood of their success. It is worth noting that the availability of the metro can be considered to be a "Keep up the good work" factor because the number of operating hours, and the frequency and regularity of the service showed a relatively high level of perceived quality and importance on customer satisfaction (Figure 1 and Table 1). Only the availability attribute related to the proximity of stations to origin and destination could significantly worsen PT users´ assessment of the quality of the service, although this is expected to improve in the future due to the expected network extension. Additionally, passengers considered time, safety and comfort to have a relatively high level of service quality but these attributes were less important in their overall customer satisfaction ("Possible overkill" factor). Therefore, the metro service could profit from these dimensions by publicizing attributes such as the speed of the trip, the police presence and the good quality of tangible equipment.

On the other hand, the accessibility of the service should be carefully analyzed and improvement actions should be promoted. Despite the relevant perceived good-quality level of the operation of the elevators, escalators, and validation machines, the metro infrastructure could show significant access barriers for disabled people. This is highlighted by the poor perceived service quality and importance of the attribute S2 (SQ=1.14). Furthermore, the intermodality of the system (attribute Q5) was also considered to be a correction factor but with a lower level of priority. Additionally, improvements in Customer Service and Information provision may improve customer satisfaction. For instance, second-priority actions such as increase the effectiveness of the staff when attending customers, improve the performance of the Customer Service (e.g., offices, web site and telephone service), as well as provide updated, precise and reliable information in stations may be effective strategies.

Figure 1

Moreover, it is interesting noting that the ticket price of the metro showed the relatively best level of perceived service quality (5.42) despite its higher ticket cost when compared with the other railway transit services. The metro ticket has a fixed price of 50 DA (≈0.50 EUR), while the fixed price of the tramway service is 40 DA. The commuter rail service has a flexible price, depending on the length of the trip, between 20 and 80 DA. This result could be due to metro passengers showed a higher average household monthly income, which may lead metro users to consider it to be a more economic ticket price. However, respondents of the three PT services were frequently reticent to give information about their income and the high proportion of missing information (over 42.3%) lead us to carefully consider the implications of this result.

Figure 2

Figure 2 represents the results of the IPA with the commuter rail service, and shows that safety and customer service required high-priority improvement actions. All safety attributes were classified as "Concentrate here" factors, indicating that passengers felt a relatively and important low level of safety in regards to thief and aggression, accidents such as crash and derailment, and safety at stations (e.g., protected walkways and signalization). These results could be partly related to the recent railway accident that happened in Algiers in November 2014, and they may lead the transit owner/administration to take improvement actions to make the system safer and communicate these measures to its passengers. Additionally, the Customer Service needs improvement and strategies such as enhancing the effectiveness of the staff, improving the customer service offices, web site and phone services, and providing updated, precise and reliable information in stations were priority actions.

Moreover, second-priority actions were improvements of the accessibility and time dimensions of the service. The intermodality of the service was considered to be a "Concentrate here" factor, and the remaining accessibility attributes of the service (ease of access from the street to stations/platforms and ticket price) showed relatively low level of service quality but also a lower importance in overall customer satisfaction. Furthermore, waiting time at stations and punctuality showed a poor-quality level based on passengers perceptions, although the speed of the trip was considered to have a relatively better level of quality and higher importance. However, it is worth noting that the commuter rail showed the worst level of service quality of the three railway transit systems studied. Consequently, the speed of the trip and some availability attributes such as operating hours and frequency of the commuter rail service could be considered to be critical deficiencies when compared to the complete railway transit system of Algiers. Furthermore, the regularity of the service was specifically classified as a "Concentrate here" factor in the context of the commuter rail service and therefore, these results indicate that improvement actions of the availability of the service should be carefully considered as well.

The tramway service also showed important deficiencies in terms of Customer Service, safety and information in a similar manner to the commuter rail transit service (Figure 3). It is worth highlighting that passengers felt a low level of safety in regards to accidents (crash/derailment) that was especially important in their customer satisfaction. This result could be due to the potential traffic conflicts throughout the on-surface tramway itinerary and possible traffic accidents that involved the tramway and other vehicles.

Figure 3

On the other hand, the availability of the service can be considered to be a "Keep up the good work" factor due to the relatively better perceived level of quality and importance of attributes such as operating hours, frequency and regularity of the service. The proximity of the stations to passengers' origin/destination was the only critical availability aspect that needs priority improvement. Moreover, comfort was also mostly perceived to have a good level of quality and it was important in customer satisfaction, with the only exception of the available seating/standing up space in vehicles that was considered to be a "Concentrate here" factor. Last, the tramway service could profit from "Possible overkill" factors related to time such as waiting time at stations and speed of the trip by publicizing them and consequently, enhancing their importance in customer satisfaction.

6. Conclusions

The urban transport in Algiers have experienced a difficult situation during the last 25 years that has lead public transit projects to be an essential part of the solution, more and more urgently needed for the sustainable growth of the urban agglomeration. Currently, the last government efforts to launch sustainable transportation projects have resulted in the metro and tramway services started operations, and future developments consider the extension of the railway transit network. At this point, it is crucial that operators and the administration consider important lines of action that complement current efforts to promote the railway transit system and therefore, ensure their success and the improvement of its ridership (Bamberg et al., 2011). The proposed two-step methodology allowed identifying these important lines of action based on users' perceptions.

This study showed that there are lines of action common to the three railway transit services, and specific strategies that may improve customer satisfaction and customer

loyalty. First, our results support current plans to extend the railway transit network in the urban agglomeration of Algiers, however, this developments should explicitly analyze what physical access barriers may exist, specially in the cases of the metro and commuter rail services. A handicapped friendly design may be considered so that future developments result in a modern public transit infrastructure that welcomes and allows a wider social sector to use it.

Safety is also a crucial and priority aspect in the cases of the tramway and commuter rail services. The authors of this paper recommend the administrator and operators of these services to take and publicize preventive actions in terms of safety such as safer railway and road intersections in the case of the tramway, and strengthen the commuter rail safety system, its signalization at stations and protect walkways.

Soft transport measures, such as marketing and customized information provision, may be cost-effective actions that themselves increase ridership and allow management and operation improvements to success. Customer service improvement should be a priority in the case of the commuter rail and tramway service, but also it can be a second-priority action for the metro service. Actions such as enhancing staff effectiveness when attending passengers, improve customer service offices, web site and phone service, and providing updated, precise and reliable information in stations could significantly enhance customer satisfaction.

Last, the metro and tramway services should maintain the good quality in regards to the availability of the service (e.g., operating hours, frequency and regularity) and further profit from these attributes by publicizing aspects such as the speed of the trip. Moreover, both transit services should keep and profit from the high level of quality in terms of comfort, for instance in regards to the tangible service equipment. However, in

the case of the tramway service the adequate availability of seating/standing up space should be further analyzed.

This is the first full experience on transit service quality analysis in Algiers, with a systematic analysis across all the railways modes. In the future, it would be interesting to evaluate the rest of transit modes in Algiers (for example, the bus transit system), in order to help Algiers' government to formulate specific improvement actions which considers public transport as a whole, in an integrated strategic line. Moreover, further research should be carried out concerning the intermodality at the city from users' perspective, as this aspect represents an essential point for assuring a sustainable mobility at large cities. Finally, non-users' perceptions about transit system merit future investigations, as they represent a high percent of the population, and they should be considered as potential users.

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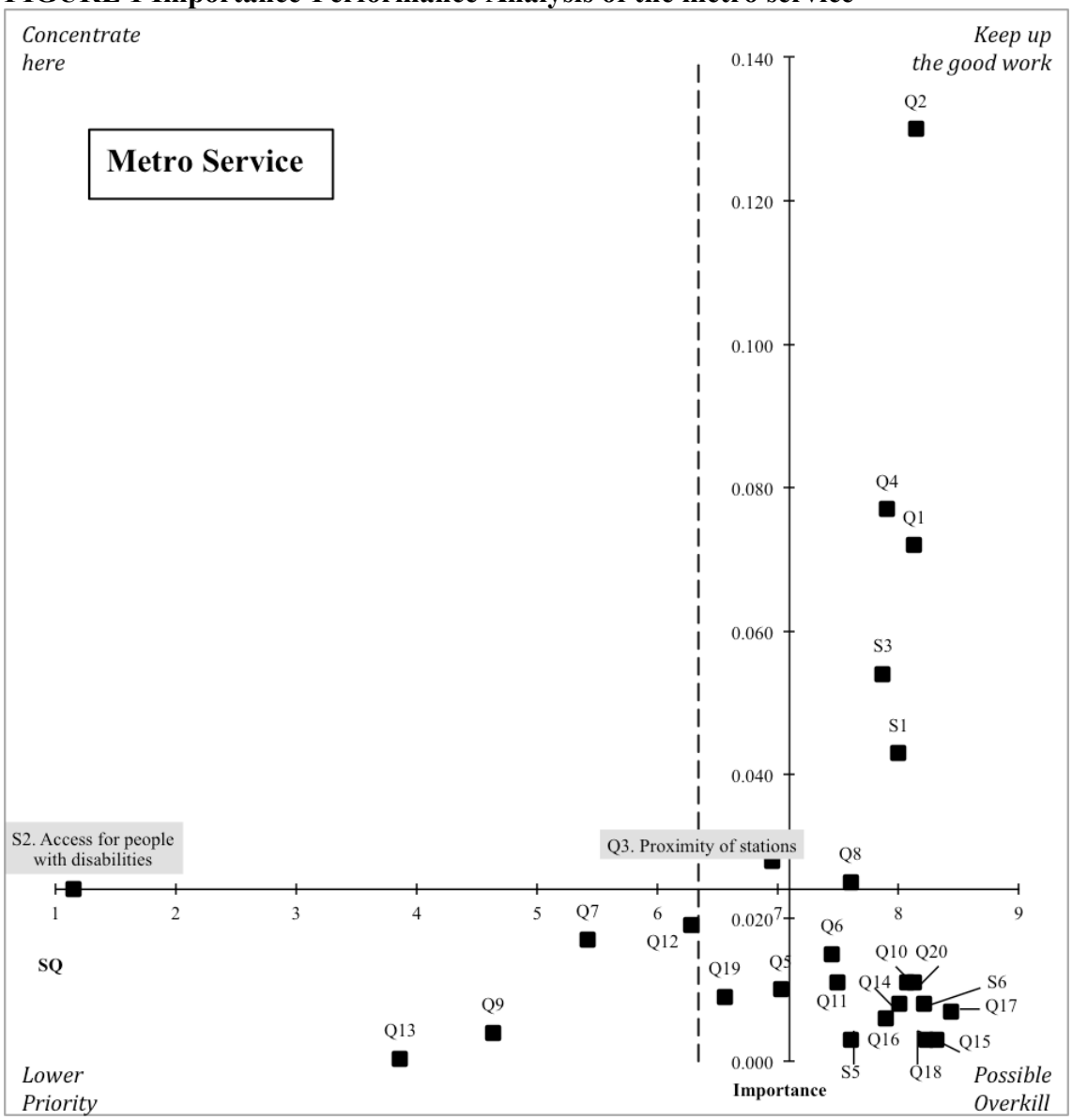
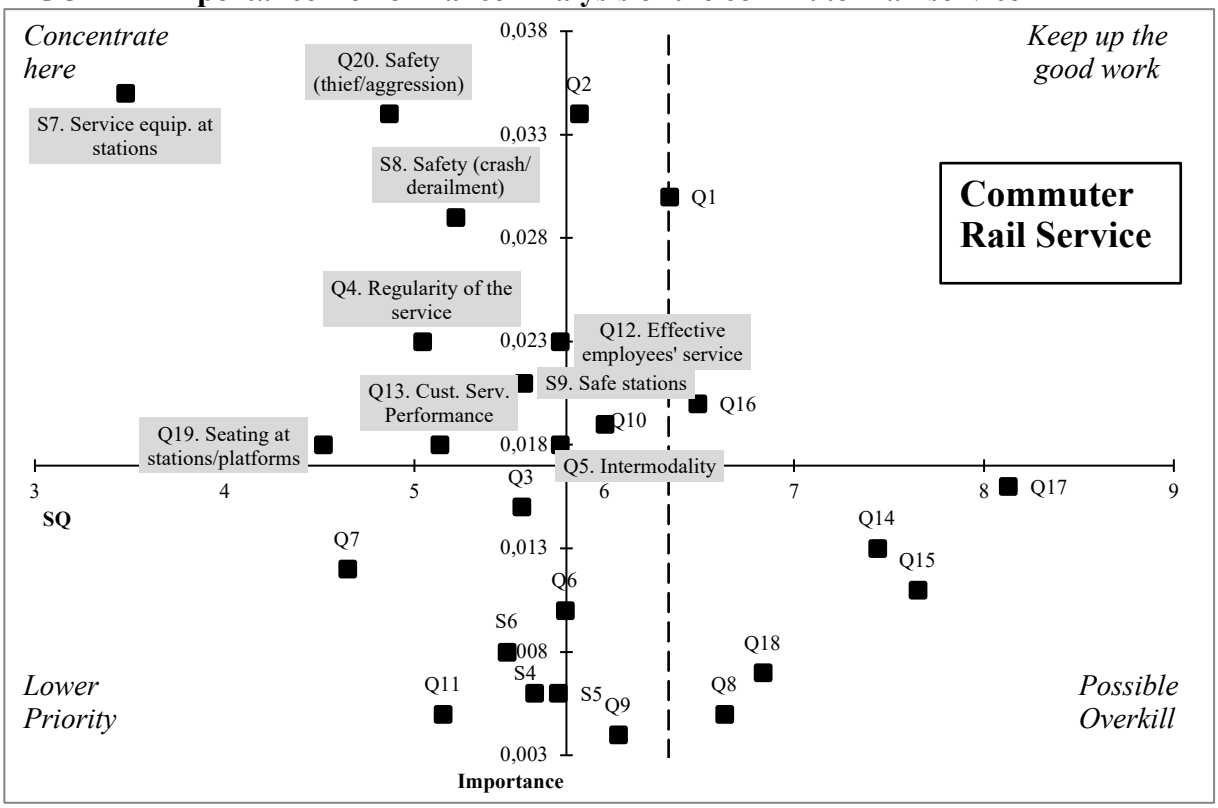
FIGURE 1 Importance-Performance Analysis of the metro service



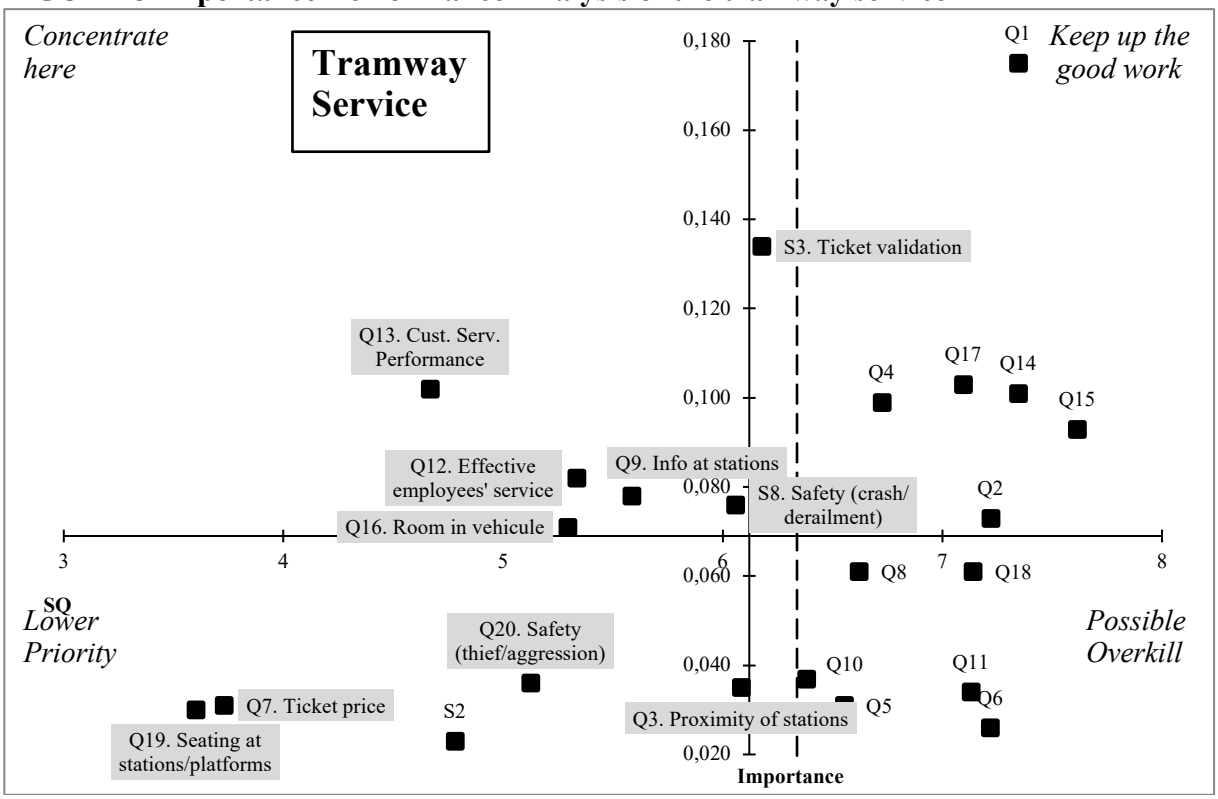
Note: Dashed line: overall average of service quality including the three railway transit services. Continuous line: reference axes only based on the average values of the specific transit service. Shaded attributes: highlighted because their low quality and relative importance.

FIGURE 2 Importance-Performance Analysis of the commuter rail service



Note: Dashed line: overall average of service quality including the three railway transit services. Continuous line: reference axes only based on the average values of the specific transit service. Shaded attributes: highlighted because their low quality and relative importance.

FIGURE 3 Importance-Performance Analysis of the tramway service



Note: Dashed line: overall average of service quality including the three railway transit services. Continuous line: reference axes only based on the average values of the specific transit service. Shaded attributes: highlighted because their low quality and relative importance.

TABLE 1 Service quality dimensions, corresponding attributes and their average perceived service quality

	Description	Metro	Commuter Rail	Tramway
	Availability of the service			
Q1	Operating hours of the service	8.13	6.34	7.34
Q2	Number of trains per day (frequency of the service)	8.14	5.87	7.22
Q3	Proximity of stations to origin/destination	6.95	5.56	6.08
Q4	Regularity of the service (absence of interruptions caused by breakdown or incidents)	7.90	5.04	6.72
	Accessibility of the service			
Q5	Easy connection with other transportation modes such as taxis, bus, tramway, metro, commuter rail, cable car, etc.	7.02	5.76	6.55
Q6	Easy access to satiations and platforms from the street	7.45	5.79	7.22
S1	Operation of elevators, escalators, etc.	8.00	-	-
S2	Ease of access for people with disabilities	1.14	-	4.78
S3	Operation of ticket validators at the entrance/exit of stations	7.87	-	6.18
Q7	Price of the ticket	5.42	4.64	3.73
	Information			
Q8	Updated, precise and reliable information on vehicles (operating hours, stops, service interruptions, etc.)	7.60	6.63	6,62
Q9	Updated, precise and reliable information in stations (price, operating hours, stops, service interruptions, etc.)	4.63	6.07	5.58
	Time			
S4	Punctuality	-	5.63	-
Q10	Speed of the trip	8.13	6.00	6.38
Q11	Waiting time on the platform	7.49	5.15	7.13
	Customer Service			
Q12	Effectiveness and speed of employees to respond, give information and deal with user´s daily problems (ticket validation problems, etc.)	6.28	5.76	5.33
Q13	Performance of the Customer Service (offices, web site, contact by phone, deal with complaints, etc.)	3.86	5.13	4.67
	Comfort			
Q14	Cleanliness of the vehicle	8.01	7.44	7.34
Q15	Lightning on vehicles	8.32	7.65	7.61
Q16	Level of comfort on vehicle (seat availability or enough room while standing up)	7.89	6.49	5.29
Q17	Temperature and ventilation system on vehicle and in stations	8.44	8.13	7.09
Q18	Appropriate driving	8.23	6.83	7.14
S5	Cleanliness of the stations	7.60	5.75	-
S6	Lightning in stations	8.21	5.48	-
Q19	Seat availability in stations and on platforms	6.56	4.52	3.60
S7	Services equipment at stations (i.e. toilets, food/drink vending machines, shops)	-	3.48	-
	Safety			
Q20	Sense of security against theft and aggression in stations and on vehicles	8.07	4.86	5.12
S8	Sense of security against accidents while traveling (crash/vehicle derailment)	-	5.22	6.06
S9	Safety at stations (protected walkways, signalization, speed limit signs, etc.)	-	5.57	-

Note: Q: Average service quality; S: Average service quality specific of some questionnaires

TABLE 2 Trip and Socio-demographic characteristics

	METRO		TRAM		TRAIN	
	Cases	**%**	**Cases**	**%**	**Cases**	**%**
Sample Size	446		495		513	
Date	17-19/3/2015		14-17/3/2015		12-14/3/2015	
Times	7a.m.-6p.m.		7a.m.-5p.m.		7:30a.m.-3p.m.	
B1. Reason to do your trip by metro? (up to 3 reasons)						
My only alternative	2	0.2	66	6.5	68	5.2
Comfort	201	16.8	176	17.4	187	14.2
Congestion	111	9.3	197	19.5	163	12.4
Frequency	216	18.0	188	18.6	267	20.3
No private vehicle	48	4.0	103	10.2	91	6.9
Lack of parking	141	11.8	98	9.7	69	5.2
Price	67	5.6	4	0.4	19	1.4
Safety	110	9.2	36	3.6	186	14.1
Speed	277	23.1	112	11.1	257	19.5
Another reason	22	1.8	27	2.7	5	0.4
Missing Values	3	0.3	2	0.2	5	0.4
B2. Trip purpose						
Shopping	55	12.3	84	17.0	66	12.9
Others	112	25.1	123	24.8	64	12.5
Studies	50	11.2	107	21.6	167	32.6
Leisure	32	7.2	37	7.5	25	4.9
Work	184	41.3	138	27.9	185	36.1
Missing Values	13	2.9	6	1.2	6	1.2
B3. Mode taken to get from origin to station						
Bus	101	20.0	133	24.6	193	34.3
Students' Bus (Cous)	9	1.8	31	5.7	20	3.6
Walk	175	34.6	231	42.7	213	37.8
Metro	-	-	14	2.6	9	1.6
Motorcycle	0	0.0	1	0.2	1	0.2
Taxi	77	15.2	53	9.8	31	5.5
Cable car	11	2.2	14	2.6	6	1.1
Commuter rail	12	2.4	20	3.7	5	0.9
Tramway	57	11.3	-	-	25	4.4
Private Car	59	11.7	41	7.6	55	9.8
Missing Values	5	1.0	3	0.6	5	0.9
B4. Time trip origin-station (min)						
Average	16.8		19.0		21.6	
Standard Deviation	10.5		14.2		10.1	
Minimum	2.0		1.0		5.0	
Maximum	75.0		120.0		130.0	
Q1 (25%)	10.0		10.0		15.0	
Q2 (50%)	15.0		15.0		20.0	
Q3 (75%)	20.0		25.0		25.8	
Missing Values	5.0		15.0		1.0	
B5. Mode taken to get to destination from station						
Bus	74	15.4	86	16.8	91	17.1
Students' Bus (Cous)	5	1.0	34	6.6	39	7.3
Walk	286	59.6	305	59.5	293	55.1
Metro	-	-	7	1.4	5	0.9
Taxi	87	18.1	63	12.3	66	12.4
Tramway	13	2.7	-	-	30	5.6
Cable car	2	0.4	6	1.2	0	0.0
Commuter rail	2	0.4	4	0.8	-	-
Private Car	4	0.8	2	0.4	1	0.2
Missing Values	7	1.5	6	1.2	7	1.3
B6. Time trip station-Destination (min)						

Average	12.4		15.2		17.0	
Standard Deviation	8.4		14.0		8.0	
Minimum	0.0		2.0		5.0	
Maximum	75.0		90.0		60.0	
Q1 (25%)	8.0		8.0		10.0	
Q2 (50%)	10.0		10.0		15.0	
Q3 (75%)	15.0		15.0		20.0	
Missing Values	6.0		6.0		1.0	
B7. Frequency of use						
> 4 days/week	132	29.6	145	29.3	241	47.0
3-4 days/week	111	24.9	92	18.6	84	16.4
1-2 days/week	138	30.9	155	31.3	120	23.4
Occasionally	60	13.5	95	19.2	63	12.3
Missing Values	5	1.1	8	1.6	5	1.0
B8. Transport mode alternative to this PT service						
Bus	230	36.5	282	47.5	230	43.2
Students' Bus (Cous)	33	5.2	63	10.6	146	27.4
Walk	6	1.0	10	1.7	5	0.9
Metro	-	-	7	1.2	3	0.6
Motorcycle	0	0.0	1	0.2	0	0.0
Taxi	169	26.8	93	15.7	19	3.6
Cable car	3	0.5	4	0.7	0	0.0
Commuter rail	17	2.7	17	2.9	-	-
Tramway	49	7.8	-	-	22	4.1
Private Car	117	18.5	108	18.2	97	18.2
Missing Values	7	1.1	9	1.5	10	1.9
C1. Availability of:						
Driver license	304	68.2	343	69.3	359	70.0
Access to private vehicle	148	33.2	138	27.9	123	24.0
Access to motorcycle	3	0.7	3	0.6	6	1.2
Access to bicycle	2	0.4	9	1.8	2	0.4
None	118	26.5	132	26.7	141	27.5
C2. Level of studies completed						
Without studies	14	3.1	46	9.3	44	8.6
Mandatory school	64	14.3	108	21.8	61	11.9
High School or Professional Education	129	28.9	158	31.9	125	24.4
Bachelor's degree or higher	183	41.0	148	29.9	229	44.6
Missing Values	56	12.6	35	7.1	54	10.5
C3. Employment Status						
Employed	164	36.8	131	26.5	185	36.1
Unemployed	10	2.2	32	6.5	19	3.7
Student	67	15.0	120	24.2	166	32.4
Homemaker	23	5.2	48	9.7	44	8.6
Liberal Profession	93	20.9	97	19.6	56	10.9
Retired	30	6.7	41	8.3	23	4.5
Other	52	11.7	21	4.2	14	2.7
Missing Values	7	1.6	5	1.0	6	1.2
C4. Age (years of age)						
<18	7	1.6	19	3.8	5	1.0
18-25	78	17.5	120	24.2	166	32.4
26-40	175	39.2	197	39.8	149	29.0
41-65	146	32.7	128	25.9	162	31.6
>65	27	6.1	18	3.6	14	2.7
Missing Values	13	2.9	13	2.6	17	3.3
C5. Household monthly income						
< 36001DA	55	12.3	76	15.4	183	35.7
36,001-54,000DA	97	21.7	74	14.9	64	12.5
54,001-72,000DA	86	19.3	68	13.7	32	6.2
> 72,000DA	18	4.0	25	5.1	17	3.3
Missing Values	190	42.6	252	50.5	217	42.3

C6. Gender						
Female	181	40.6	228	46.1	243	47.4
Male	257	57.6	262	52.9	269	52.4
Missing Values	8	1.8	5	1.0	1	0.2