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SOMMARIO

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THE EVALUATION OF PASSENGER SATISFACTION IN THE LOCAL PUBLIC TRANSPORT: A STRATEGY FOR DATA ANALYSIS

Abstract

The diffusion of ISO 9001:2000 certification and adoption of mobility charter led the companies of Local Public Transport (LPT) to carry out surveys of Passenger Satisfaction (PS). However, often, the data analysis is limited to the application of descriptive and explorative statistical techniques. In this way, the collected data are used in an inefficient way and the information that is transferred to the company management is not sufficient to make decisions.

A good analysis strategy requires the use of a combination of parametric and nonparametric techniques. In this paper we propose the combined application of Rasch Analysis and Simple Components analysis based on the RV coefficient (SCA-RV).

JEL CLASSIFICATION: C13; C14

KEYWORDS: PASSENGER SATISFACTION; RASCH ANALYSIS; RATING SCALE MODEL; SIMPLE COMPONENTS ANALYSIS; SCA-RV; LPT

1. Introduction

The diffusion of ISO 9001:2000 certification and adoption of the principles defined in the Charter of the services of Transport sector led an increasing number of LPT companies to activate procedures for assessing the quality. The concept of quality, however, over the years has been considerably modified by binding more closely to that of satisfaction. In particular, the American Society for Quality defines the quality: "*…the characteristics of a product or service that bear on its ability to satisfy*

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stated or implied needs". From that statement one can see how even in the context of LPT, objective indicators measure the purely virtual or potential quality, only the perceived service quality by the customers (passengers, citizens, stakeholders ...) is the real quality.

It is necessary to move the attention to what is perceived, rather than what is supplied. However, this leads to considerable difficulties, in particular as regards the instruments to be used for its assessment.

In fact, the objective parameters are always uniquely determined, and their measurement does not lend itself to different interpretations, while the measurement of satisfaction is more complex because of the its subjective nature and the presence of other factors that are not always easily separable from the aspect that one wants to evaluate.

Since the measurement of passenger satisfaction depends on cognitive emotional and psychological aspects (Oliver, 1993), it is a latent variable and its measurement can only be done through a set of items which change according to adopted conceptual model. Consequently, the analysis of satisfaction can only be achieved through appropriate statistical techniques to estimate these latent aspects and keeping, as far as possible, the effects attributable to such factors separate.

A further problem concerns the multivariate nature of quality (Parasuraman et al., 1988) that requires an analysis of the phenomenon using statistical techniques that consider the different dimensions and allow us to define whether a service is really able to meet the expressed and implied needs of customers.

Given those problems, we have to pay close attention to the followed procedures for the collection, analysis and interpretation of data related to satisfaction. In particular, several conceptual models and procedures have been proposed in the literature. The UNI 11098:2003 represents a first attempt of standardization. However it has the disadvantage that wants to adapt to types of very different services, failing to capture the specific needs of particular services such as LPT those.

To develop a standard that is shared and applied by all companies of LPT is essential, especially if the commissioning body wants to use PS data to implement a system of rewarding or penalizing. One last point concerns the customer on which to focus research, of course, it is immediate to see that the research terms change if we are interested in analyzing only passengers or all potential users of the service.

For all the considerations relating to procedures to be adopted for the PS survey and the choice of the conceptual model to be applied, we refer to D'Ambra *et al.* (2006), Gallo *et al.* (2009) and Gallo (2009). We refer at the same contribution to the considerations relating to the set of parametric and nonparametric methods usable for the study of PS, below, instead, we address the issues concerning the application of Rasch Analysis and Simple Components analysis based on the RV coefficient (SCA-RV).

2. Data analysis

The PS surveys are carried out by administration of a questionnaire composed of a set of items structured to consider the different aspects that go to make a greater or lesser satisfaction of passengers.

These assessments are made using a Likert scale, where the collected data are on ordinal scale, so, before proceeding to their analysis it is necessary to quantify the data or to use a technique that allows their transformation into pseudo-interval values. Moreover the transformation in linear and quantitative measures has to guarantee a right calibration throughout the whole set of the real numbers avoiding an "compression effect" (Wright e Linacre, 1989).

A good analysis strategy requires the use of a combination of nonparametric techniques for exploring the structure of data and, if the modelling assumptions are verified, the use of the parametric methods for generalizing the results to all passengers. Furthermore, the results have to be analyzed to verify the presence or not of a type of passengers that differs significantly in terms of satisfaction, from others.

The combined application of the Rasch Analysis and SCA-RV can be an answer to such needs.

Based on the separability theorem, the Rasch Analysis is a parametric technique that allows to identify what aspects of the LPT service provide greater satisfaction. Among the main characteristics of this technique is the possibility of using ordinal data without their quantification, to obtain interval measures, to get optimal estimates of the parameters and the absence of distributional assumptions.

Unlike the Rasch Analysis, the SCA-RV is a nonparametric statistical technique that can only be used after transforming the ordinal data into pseudo-interval data. The SCA-RV, however, allows to investigate the structure of relationship among the items and to identify latent variables that otherwise would not be observable.

2.1. Rasch analysis

The need to evaluate a not directly observable aspect requires the administration of a questionnaire consisting of several items formulated to investigate the various dimensions of satisfaction. All items have the same set of response categories and it is assumed that the passengers choose a higher category in the scale of assessment only if they are more satisfied.

From these remarks, the assessment can be made on the basis of the ratio between the frequency with which a particular category has been chosen and the frequency with which it has not been chosen, this ratio is a continuous and easily linearizable measure with a logarithmic transformation.

Based on the assumption that the measure of satisfaction is achieved by the logarithm of the ratio between the probability that the passenger *i* scoring in category *m* of the item *j* and the probability that the passenger *i, having chose* the category *m-1* for the item *j,* do not reach the category *m* $(1-P_{ij\,(m)})$:

$$\log it = \ln\left(\frac{P_{ij\,(m)}}{(1-P_{ij\,(m)})}\right) \qquad (1)$$

the Rasch model not only allows to get a continuous and linear measure of PS latent variable, but Andrich (1978) and Masters (1982) showed that these estimators also have the optimal properties, such as sufficiency, consistency, efficiency and unbiasedness.

If the survey is consisted of items that are on the same ordinal scale, the best Rasch model for measuring latent variable is the rating scale. Such Rasch model decompose log *it* in the following three quantity:

$$\log it = \xi_i - \delta_j - \gamma_m \tag{2}$$

where ξ_i is the propensity of passengers *i*-th to be satisfied, δ_j is the propensity of item *j*-th to generate satisfaction, γ_m is the difficulty of category threshold *m.*

Sometimes, in addition to quantities already described, it can be useful to identify the existence or not of a different level of satisfaction generated by different companies of LPT or by different lines of the same company. In the latter cases, the probability that the passenger *i* scoring in category *m* of the item *j* has to be calculated on the basis that the passenger chose or not the company (line) k-th, Therefore, the equation (2) can be rewritten:

$$\log\left(\frac{P_{ijk(m)}}{1-P_{ijk(m)}}\right) = \xi_i - \delta_j - \upsilon_k - \gamma_m \tag{3}$$

where υ_k is the difficulty of the company (line) *k*-th to generate high level of satisfaction.

2.2 Simple Component Analysis based on RV coefficient

Among the explorative methods, Principal Component Analysis (PCA) has optimal properties. The data for Customer Satisfaction (CS), however, present the peculiarity of generating all the positive correlations. Therefore, the first component is typically the mean or the sum of observed scores on different items. It is merely a measure of satisfaction.

Moreover all the variables are represented on the same quadrant obtaining little interesting and useful results. To improve the interpretability of the results, several methodological developments have been proposed: Lasso (Jolliffe *et al.*, 2003), Constrained Multivariate Analysis (Choulakian *at al.*, 2006), Simple Component Analysis (Rousson *et al.*, 2003), Simple Principal Components (Vines, 2000), SCA-RV (Gallo *et al.*, 2005). These methods lead to sub-optimal but more useful results for make decisions.

In this paper we apply the SCA-RV. It maximizes the quantity:

$$\left[p_1{'}Cp_1+\sum_{j=2}^{q}p_j{'}C_{(j-1)}p_j\right]/\,tr(C) \qquad (4)$$

where C is the correlation matrix among the original variables, q is the rank of C, p_1 is the first principal component, p_j is the *j*-th principal component, *tr* is the trace operator.

This maximization criterion assures equivalent results to PCA only in case of uncorrelated components, while it is a penalized version of PCA criterion for correlated components, because less variability is extracted from the original variables.

SCA-RV is based on two stages SCA algorithm proposed by Rousson and Gassen (2003). Fixed the number of components q and the number of block b, the first stage of SCA classifies the p original variables into b disjoint blocks. The approximate block-structure in the correlation matrix leads to a maximal within block correlations and in the meantime to a minimal between blocks correlations. The authors solved this problem with an agglomerative hierarchical procedure based on a dissimilarity measure between clusters called "median" linkage alternative to the possible "single" or "complete" linkages. Coming from the loadings matrix corresponding to the b simple block-components of the first stage, the second step of the algorithm is based on a suitable difference-component shrinkage procedure of the sequential first components of the residual variables obtained by regressing step by step the original variables on the first $(J-1)$ simple components.

The SCA-RV modifies the first stage criterion. Instead to use an agglomerative hierarchical procedure based on simple correlation coefficient, which can lead to very different solution with a choice of a possible different link criterion, it uses the RV vectorial correlation coefficient (Robert and Escoufier, 1976). This coefficient gives a measure of similarity of the two configurations, taking into account the possibly distinct metrics to be used on them to measure the distances between points.

3. A case study

The capability of the techniques is illustrated by a PS survey carried out on a sample of 1933 passengers. The survey is composed of seven items for evaluating the PS.

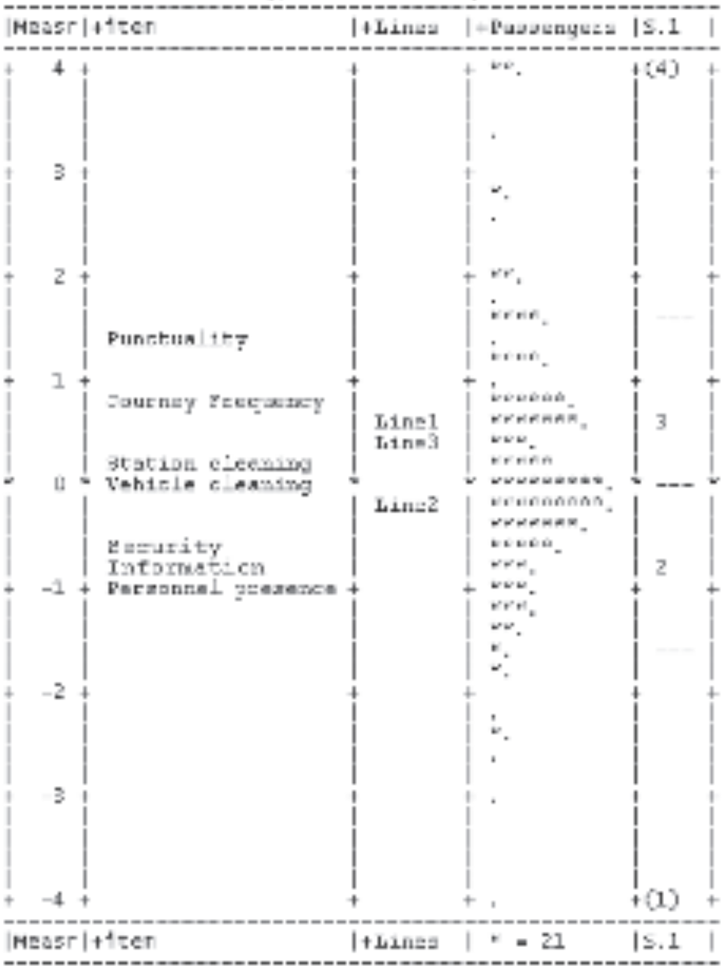
All the items have four response categories (1 - negative, 4 - positive) and concern "punctuality" "frequency of the journeys", "cleaning of stations", "cleaning of vehicles", "information", "presence of personnel" and "security".

The 1933 questionnaires has been collected on three separate lines that characterize the LPT company under consideration. In particular, 1124 interviews have been carried out on Line 1, 354 on line 2 and 455 on line 3. The statistical software Facets has been utilised for Rasch Analysis and the meta-language S-plus for SCA-RV.

3.1 The results of Rasch analysis

The Rasch Analysis shows that the items that generate higher customer satisfaction are the "punctuality" and the "frequency of journey", while the aspects of service that are less satisfactory are the "presence of personnel", the "information" and the "security". From the point of view of the three lines, it can be showed that the line 1 and 3 generate a higher satisfaction level than the line 2.

Fig. 1 - Item map



To verify the goodness of fit of the model we focus on Infit and Outfit statistics and point-biserial correlation coefficients. The Tab. 1 show the measure for the items and their Standard Errors (S.E.), Infit and Outfit statistics and the point-biserial correlation coefficients. The Infit and Outfit statistics are in the range [0.8; 1.3] so the model fits each item well. There are no outliers.

Tab. 1 - Item statistics: measure, S.E., Infit, Outfit, point-biserial correlation coefficients

N	item	Measure	Model S.E.	Infit MnSq	Outfit MnSq	PtBis
1	Punctuality	1.31	.04	1.1	1.0	.44
2	Journey frequency	.81	.03	1.1	1.2	.36
3	Station cleaning	.23	.03	.8	.8	.50
4	Veheicle cleaning	.01	.03	.8	.8	.52
7	Security	-.63	.03	1.2	1.3	.34
5	Information	-.78	.03	1.0	1.1	.36
6	Personnel presence	-.95	.03	1.0	1.0	.39

The goodness of fit is confirmed by reliability index and by point-biserial correlation coefficients and by chi-squared test. The reliability index, equal to 1.0, ensures the reproducibility of obtained results. All the point-biserial correlation coefficients are positive values, so there no problem in the dataset. The chi-squared test is significant ($\chi_6^2 = 3889.6$), the items do not generate the same level of satisfaction.

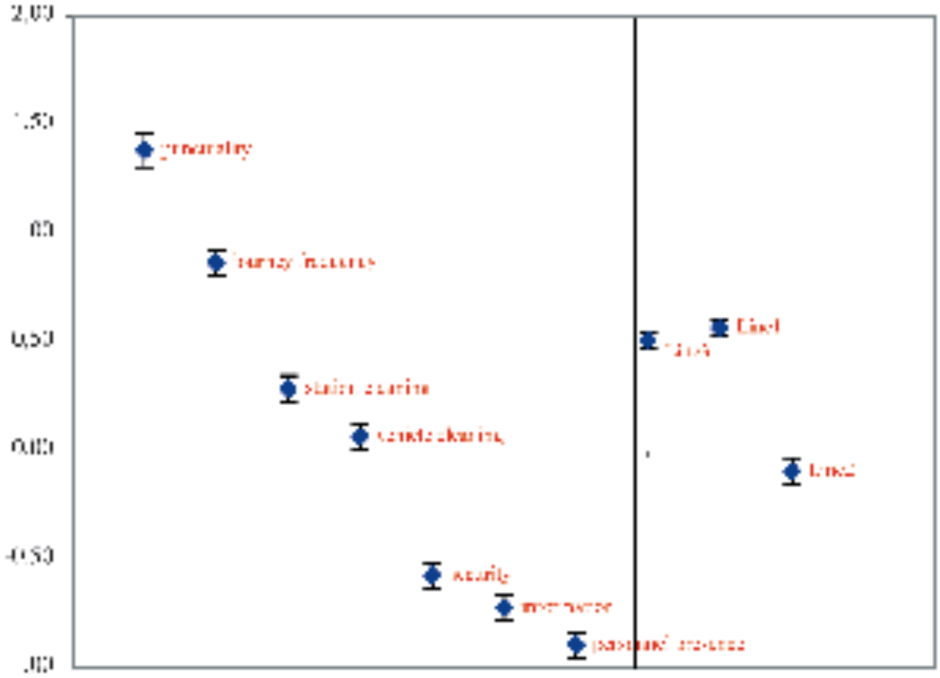
Also for the lines the goodness of estimates is confirmed by reliability index, equal to 0.99, by point-biserial correlation coefficients (all positive) and significant chi-squared statistics.

Tab. 2 - Line statistics: measure, S.E., Infit, Outfit, point-biserial correlation coefficients

N	Lines	Measure	Model S.E.	Infit MnSq	Outfit MnSq	PtBis
1	Line1	.53	.02	1.0	1.0	.35
3	Line3	.47	.02	1.0	1.0	.36
2	Line2	-.15	.03	1.0	1.1	.29

The Fig. 2 presents an hierarchy for the items and the lines. Moreover it shows that all the items are well separated among them and there are no significant differences between the lines 1 and 2.

Fig. 2 - Confidence interval for items and lines



The Tab. 3 gives an overview of results for the categories. We can observe that only the 16% of the passengers chose the category "negative", the 23% "slightly negative", while the 32% "fairly positive" and the 28% "positive." The diagnostics confirm that the estimates are good, so the results are reproducible

Tab. 3 - Category statistics.

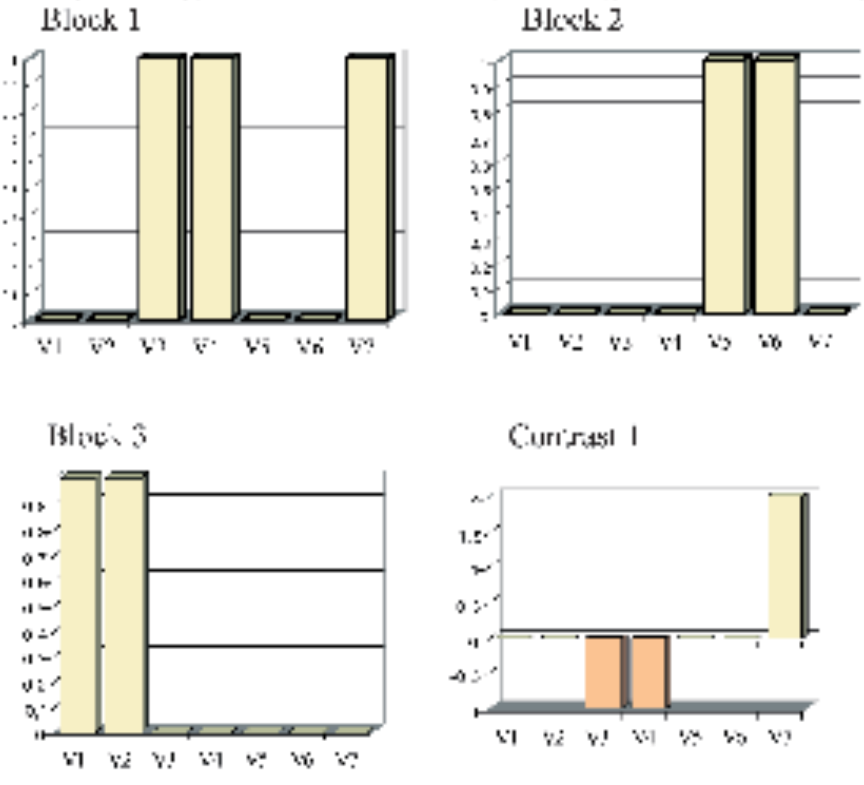
DATA Category Score	Counts Used	%	Cum. %	QUALITY CONTROL Avge Meas	Exp. Meas	OUTFIT MnSq	STEP CALIBRATIONS Measure	S.E.	EXPECTATION Measure at Category	-0.5
1	2129	16%	16%	-1.17	-1.15	1.0			(-2.34)	
2	2950	23%	39%	-.25	-.26	1.0	-1.02	.03	-.73	-1.60
3	4197	32%	72%	.60	.59	1.0	-.19	.02	.67	-.05
4	3846	28%	100%	1.59	1.60	1.1	1.22	.02	(2.45)	1.84

3.2 The results of SCA-RV

After transforming the ordinal data into pseudo-interval data trough the Rasch analysis, we applied the SCA-RV on the seven items for evaluating the PS.

The SCA-RV shows the presence of three blocks of variables and a contrast. In particular, observing the Fig. 3 we can see the first block (that explains the 28.2% of variability) is consisted of the items "Security of Station" (V7), "cleaning of vehicle" (V3) and "cleaning of station" (V4), the second block (that explains the 23.5% of variability) is characterized by the items "information"(V5) and "presence of personnel" (V6), the block 3 (that explains the 21.6% of variability) is characterized by the items "punctuality" (V1) and "frequency of journeys", finally the first contrast (that explains the the 11.1% of variability) sets against the items which constitute the first group emphasizing that the greatest differences occur between the cleanliness and safety.

Fig. 3 - SCA-RV results: the first component explains the 28.2% of variability (Block 1), the second one the 23.5% (Block 2), the third the 21.6% (Block 3), the fourth the 11,1% (Contrast 1).

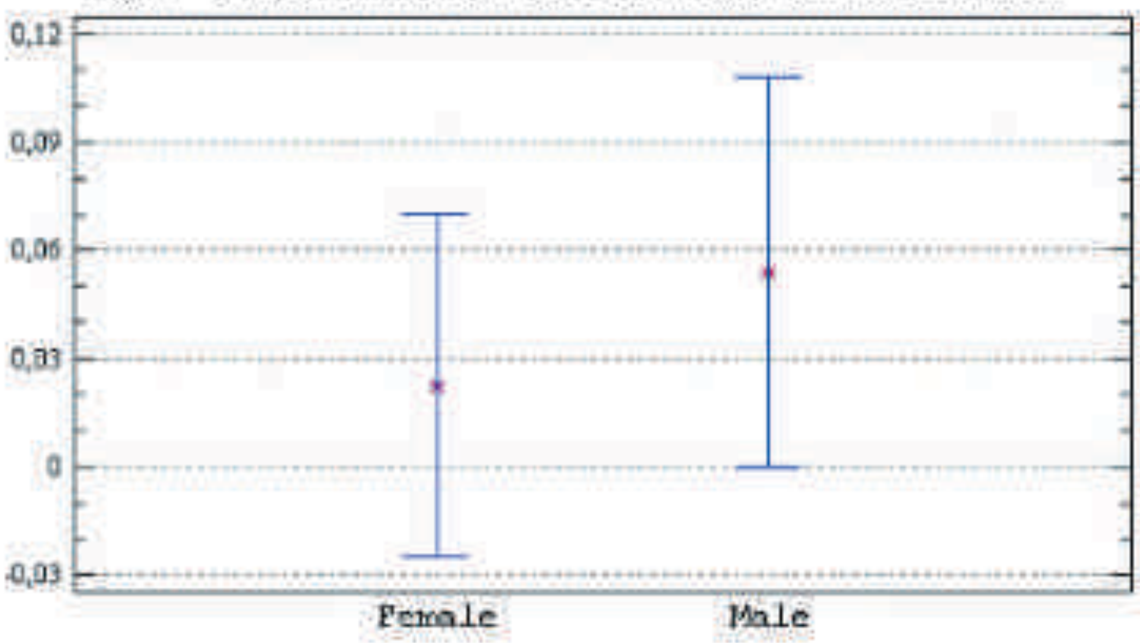


The variability explained by the first four principal components is 84%, The variability explained by SCA-RV solutions is 76%. Thus, the SCA solution is 90% optimal.

4. Conclusions

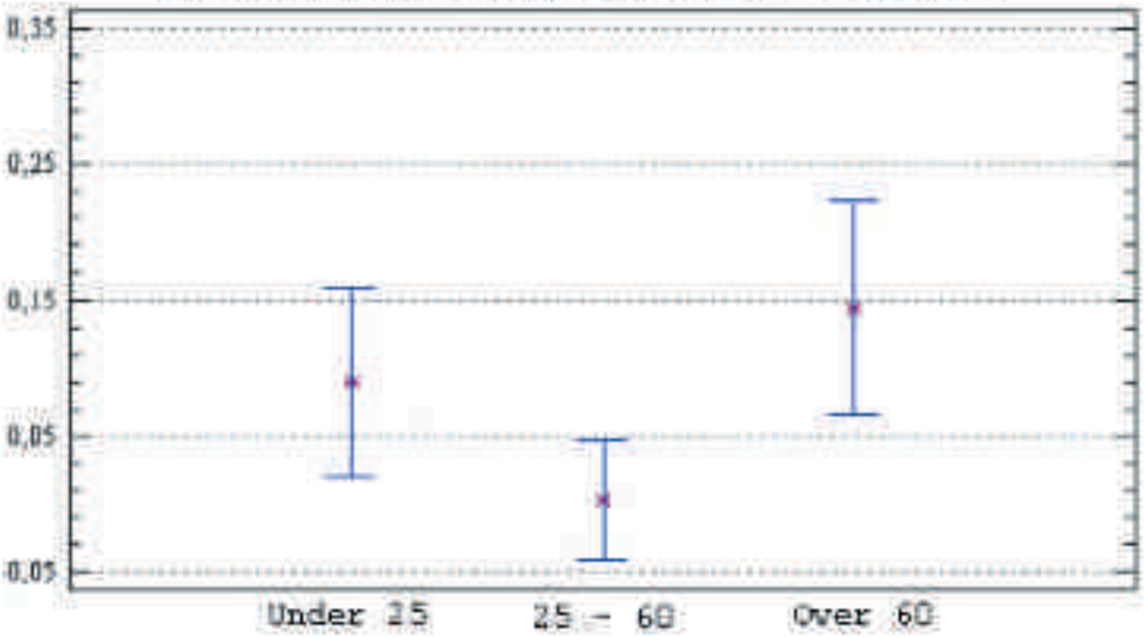
In this contribution we tried to illustrate in a simplified way that a combined approach of different statistical techniques can lead to useful and not repetitive information. We can further observe that quantitative measures allow to company managers to identify which types of passengers are less satisfied. In particular, considering the gender of passengers it is possible to point out that the women are less satisfied than the men. However, these differences are not statistically significant at 5% level.

Fig. 4 - Comparison between the level of PS for females and males.



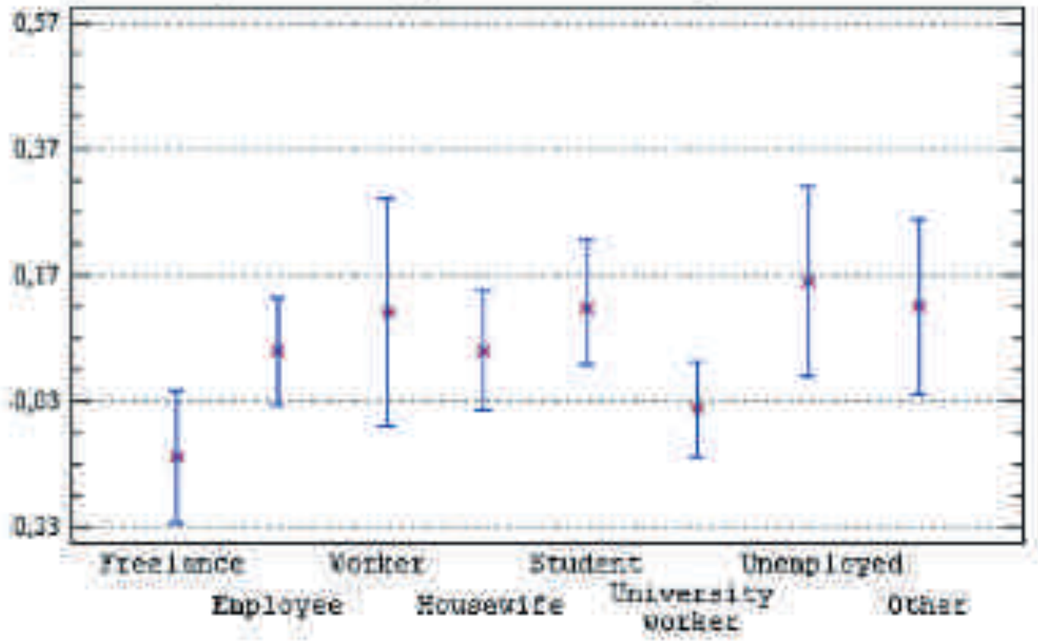
Concerning the age of the passengers, we can highlight a significant difference in the level of satisfaction between the passengers over 60 years and those aged 25-60, instead, there are no significant differences between the younger (under 25 years) and the other two categories, although the average satisfaction level of younger is higher than the passengers aged 25-60.

Fig. 5 - Comparison among the level of PS for age classes.



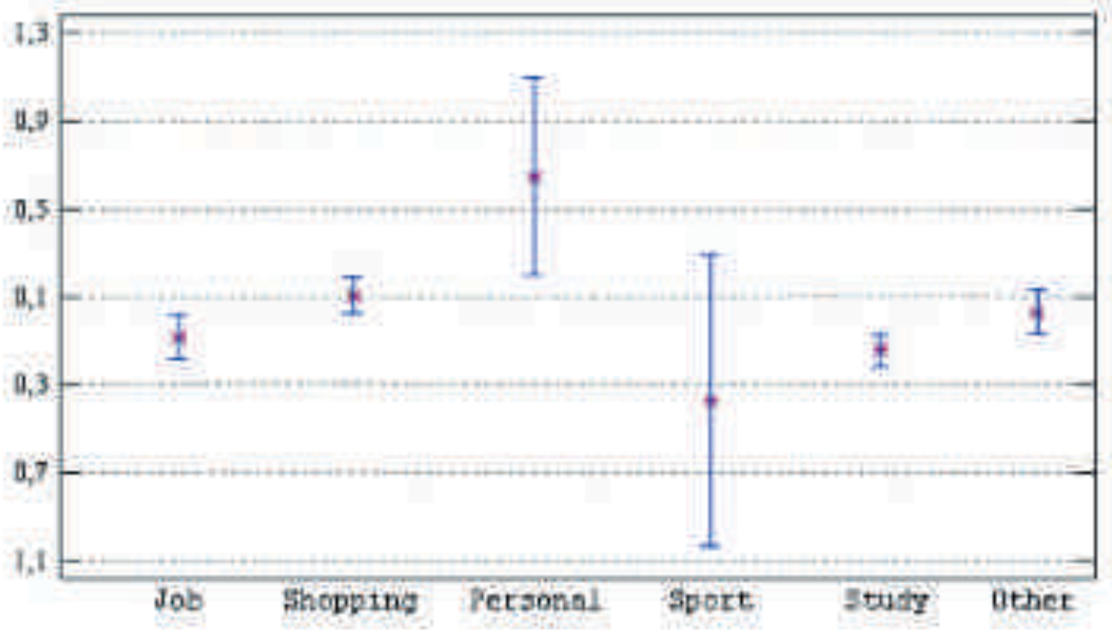
Considering the profession of the passengers, there are significant differences between the level of satisfaction of freelancers and students. The freelancers are less satisfied than the students. There are no significant differences among the other professions.

Fig. 6 - Comparison among the level of PS for professional activities.



Concerning the trip reason, the passengers who travel for personal reasons are statistically more satisfied than those using the LPT services for work, study or other reasons.

Fig. 7 - Comparison among the level of PS for journey reasons.



In conclusion, we can observe that, in many cases, the companies carry out PS surveys (expressly provided for the mobility charter). However, often, the data analysis is limited to the application of descriptive and explorative statistical techniques. In this way, the collected data are used in inefficient way and information that are transferred to the company management are not sufficient to make decisions. Furthermore, such information could include the only interviewed passengers.

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