A PERMUTATION APPROACH TO EXAMINE THE SATISFACTION OF THE ITALIAN POPULATION TOWARDS TRANSPORT SERVICE[1]

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Abstract: *When public transport system represents a primary need for citizens, the analysis of users' satisfaction is of the utmost importance to offer and obtain an efficient service. It is clear that a customer will be "satisfied", if his expectations are met and will be" disappointed", if his needs are ignored. In the transport field, the formulation and the definition of organizational and operational criteria are essential requisites to improve service quality. Restoring and improving modes and procedures will certainly guarantee an increasing efficiency, but the evaluation of customer satisfaction has been gaining more and more importance in order to achieve such a goal: different transport companies have been able to set such quality standards not only thanks to their own abilities, but also by taking into account specific service needs, directly expressed by customers through an adequate monitoring process.*
With this paper our aim is to make a study that analizes the satisfaction of the Italian population using transport service. With a particular reference to "Buses," "Coaches" and "Trains", we are going to evaluate the proportion of satisfied public transport users according to ISTAT indicators (frequency, punctuality and seats availability) both in regional and in geographical divisions. The methodology used is based on permutation tests.

Key words: *Permutation Approach; Transport Service; Italian Population; ISTAT Indicators*

Introduction

This work focuses on citizens' satisfaction towards the quality of transport services with reference to the great importance covered by this kind of service in the economy of every country.

According to the current priorities on the European Union agenda, high quality of transport services has become a goal to achieve (the White Paper "European transport policy

until 2010: time to decide " shows the member countries the direction to follow). Each country should ensure safe and efficient transport services and high quality standards to all the European citizens, compatibly with sustainable development policies.

In Italy the current transportation system has many critical points and does not fulfill users' needs in some areas. The inadequacy of rail transport, the lack of structural and technical coaches and the slow routes cause problems to commuters and students, especially at the opening of each school year and mainly in the South: service inefficiency reaches unbearable situations for the doubling of requirements due to the higher presence of students. Freight transport in cities and road problems certainly need a comprehensive political approach. In addition to that, the extremely high number of operators seems to be impeding efficiency and affecting the entire industrial system. Surveys and measurements as well as the monitoring and the evaluation of satisfaction level, achieved by transport service users, acquire a fundamental importance, because of the increasing attention towards citizens and their numerous rights.

From a methodological point of view, some scientific contributions related to users' satisfaction towards transport services have been provided in literature. In particular, Baltes [2][2] points out to specific service elements referring to bus rapid transit system, emphasizing the importance that customers occupy. In Washingston et al. [19] the most common statistical and econometric methods are applied to analyze transportation data; in Lawson and Montgomery [13] a logistic regression analysis is proposed, with reference to customer satisfaction data in transport service; in Morfoulaki et al. [14] a multinomial logistic model was developed and estimated to provide some understanding of the factors contributing to the overall satisfaction level of customers within public transport service; in Litman [12] some developing indicators for a sustainable transport planning are individualized; in Eboli and Mazzulla [6], [7] a tool for measuring customer satisfaction in public transport is proposed; in particular, a structural equation model is formulated to explore the impact of the relation between global customer satisfaction and service quality attributes.

The purpose of our paper is to compare the proportion of satisfied Italian users towards some ISTAT indicators of transport services by geographical divisions and by different modes. Since this phenomenon shows an elevated variability on the Italian territory, we are going to perform our analysis making a comparison between territorial divisions and, subsequently, among transport modes. With reference to the most used transport modes, we are going to analyze the proportion of satisfied users particularly according to frequency of routes, punctuality and seats availability and comparing different territorial areas.

Data and methods

The data

Our data are percentages, related to users in 2007 on the basis of three ISTAT indicators (*frequency*, *punctuality* and *seats availability*), three typologies of transport modes (*Buses, Coaches* and *Trains*), and three different geographical divisions; they are taken by the ISTAT Italian Statistical Yearbook in the "Transports and telecommunications" section [10]. In particolar, we referred to table 19.14 of the above-mentioned volume, entitled *"Persone di 14 anni e oltre che utilizzano i vari mezzi di trasporto (utenza), soddisfatte per frequenza delle corse, puntualità, posto a sedere, per regione e ripartizione geografica - Anno 2007"*.

As reported in the volume, in year 2007 passenger traffic (to place of study or work) regarded more than 32 million people.

Frequency, punctuality and seats availability are the indicators chosen by ISTAT to detect the population's satisfaction towards the quality of public transport [10].

The original contribution of our work is not based on the choice of appropriate indicators to assess the quality of transport, but it concerns the statistical methodology with which we make comparisons among different territorial divisions and public transport modes.

In the figures 1-3, the radar plots show users' satisfaction according to the frequency, the punctuality and the *seats availability* of the considered transport modes in three different territorial divisions.

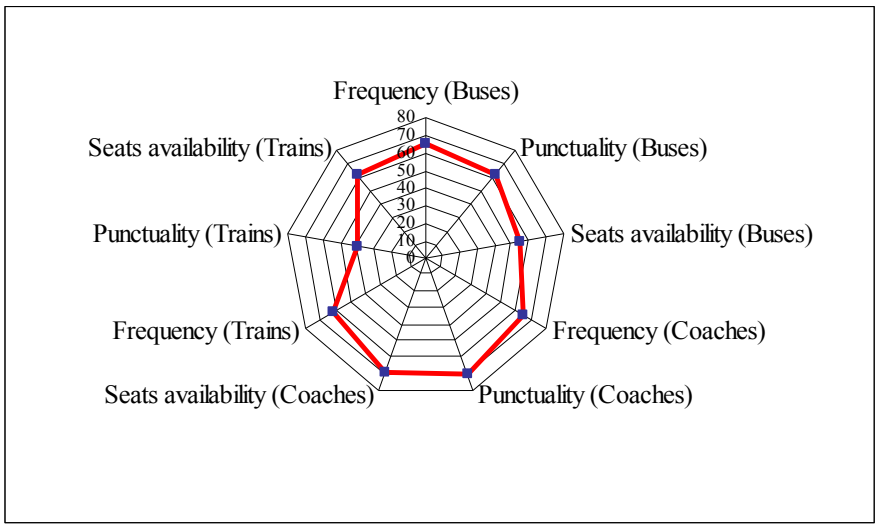

Figure 1. Users' satisfaction according to indicators and transport modes – North division

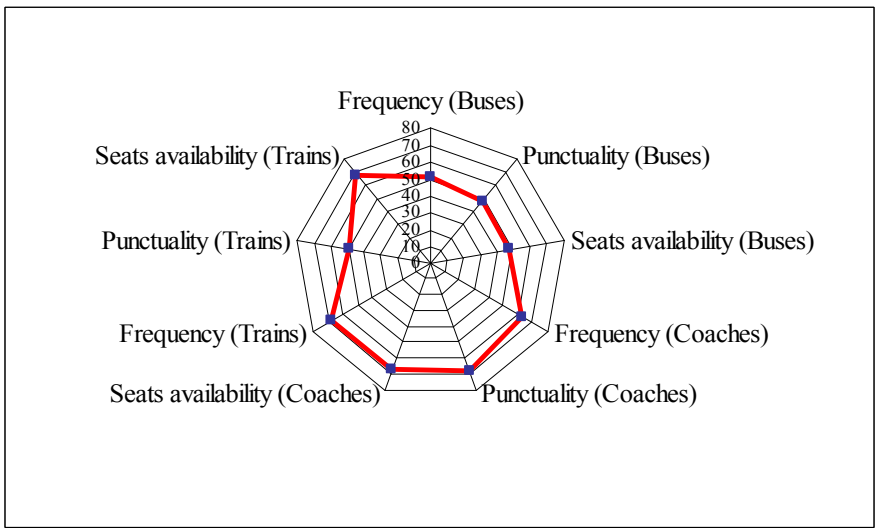

Figure 2. Users' satisfaction according to indicators and transport modes – Center division

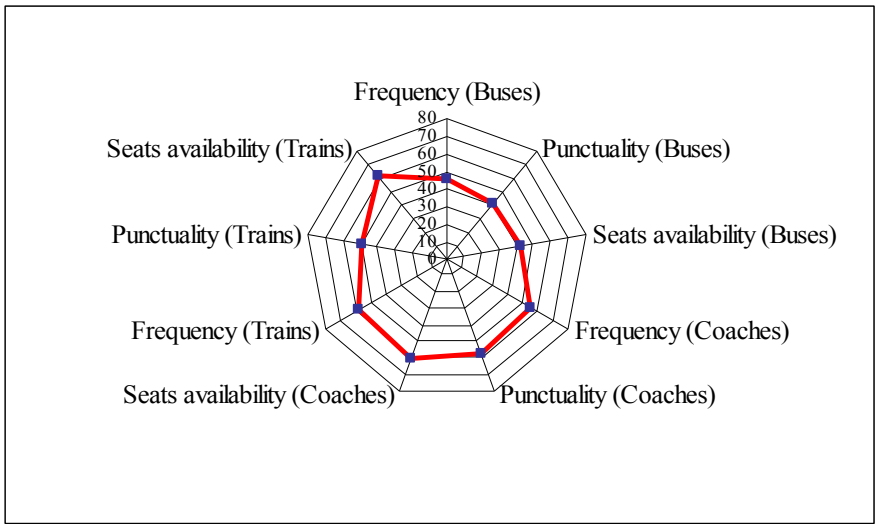

Figure 3. Users' satisfaction according to indicators and transport modes – South division

By examining Fig.1, we can see that, in the North, the lowest satisfaction is for train punctuality; the highest satisfaction is for punctuality and seats availability on coaches. In the Center (Fig.2), a low satisfaction for train punctuality persists; moreover, we can see low satisfaction regarding punctuality and seats availability on buses. By examining the South division, we can affirm that the satisfaction for punctuality and seats availability on buses is even lower, revealing the existence of serious problems related to urban transport service.

The methodology

The non-normality in the distribution of data does not guarantee valid asymptotic results, so analysis have been performed through a non parametric approach [18], using the Non Parametric Combination (NPC) test based on the permutation test [16], [5]. Permutation tests represent an effective solution for problems concerning the verifying of multidimensional hypotheses that are difficult to face in a parametric context. In comparison to the classical approach, the NPC test is characterized by several advantages: it does not require normality and homoschedasticity assumptions, it can include any type of variable [17], [11], it is reliable also in case of lacking data, it is efficient in presence of low sampling size [4], it resolves multivariate problems without needing to specify the structure of dependence among variables, it allows stratified analyses and resolves problems when observation numbers are less than variable numbers [8], [3]. The same methodology was used by Alibrandi and Zirilli [1] to analyze the customer satisfaction of the Italian population towards some aspects of socio-economic and relational life.

We consider that two or more (*k*) variables are observed on a set of *n* statistical units, gathered into two or more (C) groups, defined by a classification criterion (a treatment). The purpose of this procedure is to verify if there are any statistically significant differences among the various profiles of answer-variables of the C compared groups. We suppose that an appropriate *k*-dimensional distribution exists; the null hypothesis establishes equality in the distribution of the *k*-dimensional distribution among the C groups, against the alternative one, where at least one strict inequality is satisfied:

$$H_0 : [X_1 \overset{d}{=} \ldots \overset{d}{=} X_C]$$

that can be also expressed with

$$H_0 : [\bigcap_{i=1}^{k} X_{1i} \overset{d}{=} \ldots \overset{d}{=} X_{ci}] = [\bigcap_{i=1}^{k} H_{0i}] \quad (1)$$

$$H_1 : \bigcup_{i=1}^{k} [X_{1i} \overset{d}{\neq} \ldots \overset{d}{\neq} X_{Ci}] = [\bigcup_{i=1}^{k} H_{1i}] \quad (2)$$

where *i* represents the stratification index, referred to each stratum. Through the mentioned procedure it is preliminarily possible to define a set of *k* one-dimensional permutation tests, denominated partial tests, where the marginal contribution of every answer-variable can be examined with the comparison among groups. The partial tests are non-parametrically combined through CMC (Conditional Monte Carlo) procedure in combined tests, using a proper combination function (generally Fisher, Tippett or Liptak); these tests globally verify the existence of differences among the various distributions of the groups. If the analysis is stratified, it is possible to determine a specific test that combines the tests obtained by each stratification; it allows to draw evaluations on the possible differences among the groups in relation with all the examined variables and strata.

We can assume that, without loss of generality, partial tests acquire real values and they are marginally correct, consistent and significant for great values. The NPC test (based on Conditional Monte Carlo resampling) is carried out in the following way:

1. the value of the k-variated statistic is calculated on observations;
2. for every resampling conditioned by the observed data, we calculate the vector of the permuted statistics;
3. for each partial test and resampling, the transformation in rank is performed;
4. p-values related to the partial tests are calculated;
5. the combined resampling value is calculated using Fisher's combination function;
6. the observed value of the second order combined test and its p-value are calculated.
7. if p-value is minor than α, the H_0 hypothesis is rejected at a fixed significance level.

Results

Statistical comparisons between territorial divisions

We applied the Non Parametric Combination test in order to evaluate the existence of possible significant differences among the three geographical divisions (North, Center and South) the Italian territory can be divided in. The observations per region are considered as replications. The hypotheses system is expressed as follows:

$$H_{0i} : \left\{ Frequency_{1i} \overset{d}{=} Frequency_{2i} \right\} \cap \ldots \cap \left\{ Seats\ availab._{1i} \overset{d}{=} Seats\ availab._{2i} \right\} \quad (3)$$

$$H_{1i} : \left\{ Frequency_{1i} \overset{d}{\neq} Frequency_{2i} \right\} \cup \ldots \cup \left\{ Seats\ availab._{1i} \overset{d}{\neq} Seats\ availab._{2i} \right\} \quad (4)$$

where 1 and 2 represent the geographical division (North, Center and South) and the stratification index i (i=1,…,3) is referred to the examined transport services (buses, coaches, trains).

Table 1 shows the p-values of the partial and combined tests, calculated by Tippett's combination function [9]. The results underline an articulated territorial situation: the population residing in the North and in the Center has more elevated levels of satisfaction than the population residing in the South towards the frequency of the routes and the punctuality of "Buses" and "Coaches". The p-values associated to these comparisons are statistically significant, with a directionality of the comparisons major for the North and the Center than for the South (see the p-value reported in bold in Table 1). The satisfaction towards the railway service appears, instead, homogeneous on the entire territory, since no statistically significant differences exist in the comparisons among the territorial divisions.

Table 1. p-value of partial and combined test for comparison between divisions.

		Frequency	Punctuality	Seats availability		Comb.
NORTH VS CENTER	BUSES	0.661	0.837	0.800	→	0.850
	COACHES	0.904	0.749	0.870	→	0.957
	TRAINS	0.237	0.288	0.448	→	0.297
		↓	↓	↓		↓
	Combined	0.689	0.750	0.882	→	0.827
CENTER VS SOUTH	BUSES	**0.026 (>)**	**0.035 (>)**	0.130	→	0.042
	COACHES	**0.046 (>)**	**0.031 (>)**	0.243	→	0.054
	TRAINS	0.841	0.600	0.257	→	0.252
		↓	↓	↓		↓
	Combined	0.071	0.047	0.137	→	0.061
NORTH VS SOUTH	BUSES	**0.002 (>)**	**0.003 (>)**	**0.046 (>)**	→	0.003
	COACHES	**0.019(>)**	**0.008 (>)**	0.060	→	0.018
	TRAINS	0.074	0.628	0.068	→	0.082
		↓	↓	↓		↓
	Combined	0.006	0.008	0.096	→	0.010

Comparisons among transport modes

The Non Parametric Combination Test has also been applied in order to evaluate the existence of possible significant differences between transport modes (Buses, Coaches, Trains), considered two by two. The hypotheses system is expressed as follows:

$$H_{0i}: \left\{ Frequency_{1i} \overset{d}{=} Frequency_{2i} \right\} \cap \ldots \cap \left\{ Seats\ availab._{1i} \overset{d}{=} Seats\ availab._{2i} \right\} \quad (5)$$

$$H_{1i}: \left\{ Frequency_{1i} \overset{d}{\neq} Frequency_{2i} \right\} \cup \ldots \cup \left\{ Seats\ availab._{1i} \overset{d}{\neq} Seats\ availab._{2i} \right\} \quad (6)$$

where 1 and 2 represent the examined transport services (Buses vs Coaches, Coaches vs Trains, Coaches vs Trains) and the stratification index i=1,…,3 is referred to the territorial

division in exam (North, Center, South). The tab. 2 shows the p-values of the partial and combined tests.

Table 2. p-value of partial and combined test for comparisons between divisions.

		Frequency	Punctuality	Seats availability		Comb.
BUSES VS COACHES	NORTH	0.977	0.168	**0.030 (<)**	→	0.065
	CENTER	0.880	0.331	0.291	→	0.491
	SOUTH	0.250	0.257	0.062	→	0.102
		↓	↓	↓		↓
	Combined	0.577	0.161	0.083	→	0.177
COACHES VS TRAINS	NORTH	0.131	**0.002 (>)**	**0.029 (>)**	→	0.001
	CENTER	0.114	**0.007 (>)**	0.097	→	0.007
	SOUTH	0.771	**0.042 (>)**	0.332	→	0.092
		↓	↓	↓		↓
	Combined	0.304	0.001	0.080	→	0.001
BUS VS TRAIN	NORTH	0.139	**0.001 (>)**	0.423	→	0.001
	CENTER	0.203	**0.045 (>)**	0.943	→	0.120
	SOUTH	0.368	0.908	0.165	→	0.274
		↓	↓	↓		↓
	Combined	0.357	0.001	0.409	→	0.001

The results underline that, mostly in the North and in the Centre, there is a greater satisfaction of the Italian population towards coaches, in terms of punctuality and seats availability, in comparison to the other modes in examination (see the p-value reported in bold in Table 2). Trains seem to be the less preferred transport mode among the examined ones.

The problem of performance evaluation of a transport service has significant aspects of complexity. Evaluation process must necessarily reflect the points of view of the different concerned parts: the company that runs the service and the users directly or indirectly involved with the transport service. In particular, the users' point of view is mainly influenced by the criteria of regularity (frequency of service and punctuality) and comfort (seats availability) and is related to the use of the service (ISTAT indicators). Focusing on these indicators, the authors have applied the NPC test to compare the proportion of satisfied users towards transport service according to three different transport modes (buses, coaches, trains) in three geographical divisions (North, Center, South).

Looking at the results, we can affirm that the satisfaction level of the Italian population towards the considered aspects of the transport service is a territorially divided reality: in the North and in the Center, the factor with the lowest satisfaction is the punctuality of trains; moreover, both in the Center and in the South, there exists low satisfaction regarding punctuality and seats availability on buses, revealing the existence of problems related to urban transport. Examining the results of our analysis, performed by a permutation approach in order to observe potential differences among different territorial divisions, we are able to underline that the population of the North and of the Center has more elevated levels of satisfaction regarding the frequency of the routes and the punctuality of Coaches. The satisfaction towards railway service appears, instead, homogeneous on the entire territory, since no statistically significant difference exists. The comparison between

transport modes shows that, especially in the North and in the Center, there is a higher proportion of satisfied Italian users of coaches (in terms of punctuality and seats availability) than of other transport modes. Trains seem to be, among the examined ones, the less preferred.

Final remarks

In this article a permutation approach has been proposed to compare users' satisfaction in different territorial divisions (North, Center and South) with reference to three transport modes (trains, buses and coaches) and to three ISTAT indicators (frequency, punctuality and seats availability). Although NPC methodology is well-known and widely applied in several fields of research, presently there aren't many practical applications in the public transport sector, and specifically in order to examine satisfaction degree. In our paper we have applied this methodology on the basis of the non-normality of data distribution and for the flexibility of this procedure, in particular, it does not require normality and homoschedasticity assumptions, it can draw any type of variable (also percentages), it can resolve various problems [15] without needing to specify the structure of dependence among variables and it can allow stratified analyses. With the results obtained, we are to able to affirm that in the North there is the highest share of positive reviews; in the South and, partially, in the Center, we observed the largest percentage of negative reviews, probably due to the lower standard of living and to the minor efficiency of transport service. Even though data have been obtained by reliable existing sources (ISTAT yearbook), a limitation of this paper could be that these data consist of percentages. Furthermore, the analysis according to territorial divisions gives quite generalized results. To have more detailed results a comparison of users' satisfaction among regions within each division could be made. In spite of its limitation, this study could be a starting point for more exhaustive researches: as a future development, it could also perform a more focused analysis by means of a sample survey that allows to identify the users' satisfaction predictors, more related to service quality in public transport. In our country, the planning of transport services does not pay adequate attention to users' necessities and to their implicit and explicit expectations; in the reality of many public and private transport companies, quality systems are implemented without a real customer involvement; in this context a survey on users' satisfaction level is, instead, a useful tool that could overcome these gaps, allowing to monitor and measure performance quality.

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[2] **Codification of references in text:**

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