Available online at www.sciencedirect.com

ScienceDirect

Procedia Economics and Finance 17 (2014) 238 – 247

Procedia Economics and Finance

www.elsevier.com/locate/procedia

Innovation and Society 2013 Conference, IES 2013

A multivariate analysis of the quality of public transport services

Francesco Domenico d'Ovidio[a]*, Domenico Leogrande[b], Rossana Mancarella[b], Andrea Schinzano[b], Domenico Viola[b]

[a] *Department of Economics and Mathematics, University of Bari "Aldo Moro", Largo Abbazia Santa Scolastica, 70124 Bari, Italy*
[b] *Department of Business and Private Law Studies, University of Bari "Aldo Moro", Largo Abbazia Santa Scolastica, 70124 Bari, Italy*

Abstract

The purpose of this study is to investigate what kind of observable and non-observable factors can influence passenger satisfaction on the quality of public transport services in a local context. Of course, these results can be used by the transport company in order to modify its business strategies and to improve its business performance. Relationships among latent dimensions (such as quality, satisfaction and loyalty) are first defined on the basis of a sample survey through suitable statistical measuring techniques (Factor Analysis with Categorical Principal Component Analysis). Then, multivariate methods of classification (Segmentation Analysis and Cluster Analysis), are used in order to explore the characteristics of the customers and their quality perception.

Selection and peer-review under responsibility of the Organizing Committee of IES 2013.

Keywords: Public transport; AMTAB; passenger's satisfaction; CatPCA factorial analysis; cluster analysis; segmentation analysis; impact.

1. Purposes of the research

This paper briefly describes an analysis of passenger satisfaction about the public regarding bus service of the town of Bari, with respect to several aspects of the service. The aim of this analysis is to better know the various profiles of the customers and the impact of some possible inefficiencies of the service on their judgements.

The survey covered the whole bus network of Bari, using a questionnaire derived with modifications from a previous one (used in the same context some year ago) with three sections. The *Section A* analyzes personal information of interviewees (e.g.: age, profession and residence district), raw opinions and characteristics of use of

* Corresponding author. Tel.: +39-080-5049313; fax: +39-080-5049210.
E-mail address: francescodomenico.dovidio@uniba.it

Selection and peer-review under responsibility of the Organizing Committee of IES 2013.
doi:10.1016/S2212-5671(14)00868-5

the service (e.g.: time-band, frequency of use, lines, type of ticket, etc.). The *Section B* concerns judgements on various aspects of the perceived quality of the bus service (e.g. staff courtesy and professionalism, cleanliness and hygiene, safety, comfort, etc.), expressed by the interviewees in a 6-levels Likert Scale (from "very bad" to "excellent"). The *Section C* contains few questions on the overall satisfaction of the customer (from 1, as minimum, to 10, as maximum), the dynamic of the service's quality in the last year, the modalities of complaints and the possible motives of low use of the bus services.

In order to respect the editorial limits, only the principal results of the analysis are described here.

2. Sampling design and descriptive analysis

Because this survey is a sort of "pilot experiment", the sampling design was very simple: in the course of two weeks, in random hours along the day, the interviewers walked randomly in each district of the town (randomly assigned to interviewers), submitting the questionnaire to travellers waiting at the bus stops (only one traveller at time, to avoid biasing of next interviewees). In this way, the obtained sample has most of the properties of a simple random sample, stratified by number of users of each district, because the probability to meet users at each bus stop is higher in districts with more bus users. The final sample consists of more than 700 interviewees, aged from 11 to 83 (mean age 32 years, s.d. 14.78), with asymmetrical distribution.

Table 1. Percent distribution of the interviewees according to some personal characteristic, by gender.

Characteristics of interviewees	Gender M	Gender F	Gender MF	Total number
Age class				
Up to 20 yrs	15.3	19.5	17.5	*124*
21-25	32.9	33.7	33.3	*236*
26-30	12.8	13.9	13.4	*95*
31-40	12.2	10.3	11.2	*79*
41-50	11.3	10.0	10.5	*75*
51-60	7.0	6.3	6.7	*47*
More than 60 yrs	8.5	6.3	7.4	*52*
Educational qualification				
N.A.	1.8	1.8	1.8	*13*
No qualification	3.4	2.6	3.0	*21*
Elementary	4.6	5.0	4.8	*34*
Middle school	13.1	12.7	12.9	*91*
Secondary school	52.7	49.2	50.8	*360*
University degree or higher	24.4	28.7	26.7	*189*
Working / non-working condition	***(p<0.005)***			
N.A.	1.5	2.4	2.0	*14*
Student	46.0	54.5	50.6	*358*
Housewife / Retired / Unemployed	18.6	22.5	20.7	*147*
Self-employed	10.1	6.3	8.1	*57*
Employee	23.2	13.2	17.8	*126*
Other condition	0.6	1.1	0.8	*6*
Overall satisfaction				
Unsatisfied (score 0-4)	43.0	46.1	44.6	*316*
Almost unsatisfied (score 5)	22.6	20.3	21.3	*151*
Satisfied (score 6-10)	34.4	33.7	34.0	*241*
Total	**100.0**	**100.0**	**100.0**	
Total number of interviewees	***328***	***380***		***708***

Table 2. Percent distribution of the interviewees according to some characteristic of their service's use, by gender.

Characteristics of the service's use	Gender M	Gender F	Gender MF	Total number
Frequency of use buses in the last year				
N.A.	0.3	0.5	0.4	3
At least 1 time per day	49.7	53.7	51.8	367
At least 1 time per week	32.7	32.4	32.5	230
At least 1 time per month	14.9	11.8	13.3	94
At least 1 time in the last year	2.4	1.6	2.0	14
Main reason to use the bus service	***(p<0.005)***			
N.A.	0.0	0.3	0.1	1
To reduce pollution	16.8	9.7	13.0	92
To get closer to other transports	8.2	7.4	7.8	55
For lack of own transport	49.4	60.8	55.5	393
For economic reasons	22.2	20.0	21.1	149
Other reason	3.4	1.8	2.5	18
Usual ticket				
N.A.	0.3	0.0	0.1	1
Hourly ticket	32.7	29.6	30.9	219
Daily ticket	17.2	15.8	16.8	116
Weekly ticket	5.3	5.8	5.2	39
Monthly subscription	24.6	26.2	25.6	182
Annual subscription	16.4	20.8	18.7	132
Indifferent / not sure	3.5	1.8	2.7	19
Dynamics of bus service in the last year				
N.A.	0.6	0.5	0.6	4
Improved	13.4	11.8	12.6	89
Unchanged	47.9	41.9	44.6	316
Worse	23.5	28.7	26.3	186
I do not know	14.6	17.1	15.9	113
Total	**100.0**	**100.0**	**100.0**	*708*

Table 3. Percentages of the interviewees according to some characteristic of their service's use, by gender.

Characteristics of the service's use *(multiple answers)*	Gender M	F	MF	Total number
Usual time slot to use the bus				
N.A.	1.5	1.3	1.4	10
4-7	4.6	1.8	3.2	22
7-9	45.1	43.9	44.5	315
10-12	24.4	24.5	24.5	172
13-15	13.1	16.1	15.0	104
15-18	18.6	21.1	19.9	141
18-21	18.9	18.4	18.6	132
21-24	4.0	1.8	2.8	20
Purposes of use of bus services				
To go to work / school / college	67.4	63.2	65.1	461
To go shopping (***p<0.0001***)	15.9	27.4	22.0	156
Health or hospital purposes	11.9	10.0	10.9	77
Leisure or personal purposes (***p<0.001***)	36.9	28.4	32.3	229
Interviewees	***328***	***380***	***708***	

Table 4. Percentages of the interviewees according to some negative aspect of their service's use, by gender.

Negative aspects of the service's use *(multiple answers)*	Gender M	F	MF	Total number
Complains				
N.A.	0.9	0.8	0.9	6
Never claimed	46.3	45.5	45.9	325
Written complaints	9.8	9.7	11.3	80
Toll-free number	18.0	25.3	21.8	154
Verbal complaint to the staff	22.9	18.7	20.8	147
E-mail	3.7	2.9	3.2	23
Motivations for low utilization of buses				
N.A.	1.8	1.8	1.8	13
Low reliability on the arrival times	64.6	64.0	64.3	455
Long travel time / unsuitable routes	22.0	17.1	19.4	137
Difficulty in finding info on timetables	14.6	14.5	14.5	103
Lack of connections with other transports	24.7	21.8	23.2	164
Lack of facilities at bus stops/on board	28.7	27.9	28.3	200
Interviewees	***328***	***380***	***708***	

The following brief notes synthesize a basic profile from the information shown in Tables 1-4.

One third of the total sample is aged from 21 to 25, while just 14% is over 50. However, this result is consistent with the actual distribution of the travelling population in Bari, an universitary town. In about half cases, passengers have the secondary school diploma, are still students and use the service at least once a day, in the early hours of the morning (7-9). The main aim, using bus transports, is obviously to go to school or college (or at work) [1], because the interviewees have no an own transport (and this motivation is more frequent for women). Mostly, passengers travel with ordinary ticket or monthly subscription. Many users (almost half) never formally complained against the company, but two-thirds of them say they are not satisfied with the transport service; in addition, 70% of the sample says that in the last year the service's quality was unchanged or worsened. The reason for such dissatisfaction seems to coincide with the reason for the low use of the bus: some unreliability in the arrivals, which affects nearly two-thirds of respondents.

Although it don't affects the aims of this research, note that significant gender differences were found, as well as those from working condition, from main reason to use buses and from purposes (shopping and leisure facilities)

3. Factorial analysis of the quality perceptions

In order to obtain consistent relationships among the quality perceptions about the bus service, we first tested with Spearman's rho all correlations between the judgments of the *Section B* and the overall satisfaction expressed by the interviewees (main objective of our analysis). Only the relationships that were significant (with α=0.05) as well as important (ρ>0.25) were used in further analyses. Then, given that all the selected variables are measured in ordinal scale and their distribution is strongly non-normal, a Categorical PCA[2] was used, choosing components with eigenvalue > 1.1 and applying the backward elimination of the items which had low communality[3] (< 0.55).

[1] This variable and the other three shown in Tables 3-4 are syntheses of multiple responses given to te relative questions: thus, their sum of percentages is higher than 100,0.

[2] The CATPCA (*Categorical Principal Component Analysis*) algorithm is due to the *Data Theory Scaling System Group* of the Leiden University, NL (De Leeuw *et al.*, 1976; Meulman & Heiser, 1999; Meulman *et al.*, 2004). It belongs to the PrincAls family, based on *Alternative Least Squares Optimal Scaling* procedures, allowing researcher to use categorical variables, while PCA requires normal distribution of residuals.

[3] Although communality isn't directly provided by CATPCA, it is easily calculated by sum of variance percentages accounted for each original variable by the selected components , as well as in the simple PCA.

Table 5. Descriptive statistics and communalities of the interviewees' judgments; factor loadings > 0.33 (Promax rotation)

Judgments	Observed mean values	Standard deviations	*Communalities*	Comfort and cleanness	Service organization	Information's availability	Service's accessibility	Costs	Staff's behaviour	Behaviour of inspectors
Cleanness and hygiene on board	2.55	1.19	*0.713*	0.824						
Vehicles' crowding	2.33	1.21	*0.639*	0.778						
Cleanness and hygiene at bus stops with shelter	2.56	1.14	*0.587*	0.752						
Vehicles' modernity	2.74	1.21	*0.667*	0.740						
Vehicle's air conditioning	2.66	1.17	*0.624*	0.705						
Comfort on board	2.80	1.09	*0.698*	0.699						
Safety for passengers against theft and harassment	2.82	1.10	*0.560*	0.608						
Reliability of the buses	2.99	1.08	*0.672*	0.589						
Comfort at the stops	2.78	1.05	*0.588*	0.499						
Driving style of the staff	3.09	1.10	*0.595*	0.377					0.357	
Waiting time at bus stops off-peak hours	2.56	1.17	*0.756*		0.775					
Waiting time at bus stops during the peak times	2.21	1.17	*0.728*		0.749					
Service's punctuality	2.56	1.21	*0.759*		0.708					
Service regularity	2.86	1.17	*0.663*		0.640					
Number of trips during the day	2.87	1.14	*0.697*		0.491		0.415			
Clear timetable information at bus stops	2.80	1.12	*0.706*			0.816				
Website	2.94	1.24	*0.595*			0.784				
Informative screens on the vehicles	2.84	1.20	*0.660*			0.737				
Diffusion of the time-tables at bus stops	2.90	1.13	*0.632*			0.615				
Visibility of the bus stops	3.06	1.06	*0.562*			0.576				
Diffusion of the line-maps at bus stops	2.82	1.07	*0.592*		0.426	0.448				
Distance between the bus stops	3.36	1.14	*0.734*				0.869			
Dislocation (territorial coverage)	3.18	1.10	*0.691*				0.810			
Ease of buying tickets	3.29	1.24	*0.625*				0.778			
Speed of the travel	3.13	1.10	*0.656*				0.622			
Price of hourly tickets	3.66	2.46	*0.725*					0.794		
Price of daily tickets	4.09	2.47	*0.739*					0.832		
Price of weekly tickets	4.43	2.38	*0.795*					0.874		
Price of monthly subscriptions	5.00	2.47	*0.762*					0.825		
Price of annual subscriptions	5.33	2.76	*0.668*					0.689		
Willingness of the staff on board and at the bus stops	3.07	1.13	*0.806*						0.794	
Courtesy of the staff on board and at the bus stops	2.96	1.13	*0.802*						0.788	
Professionalism of the staff on board and at the bus stops	3.08	1.09	*0.799*						0.764	
Courtesy of the ticket inspectors	2.71	1.15	*0.849*							0.851
Willingness of the ticket inspectors	2.77	1.14	*0.871*							0.885
Professionalism of the ticket inspectors	2.84	1.18	*0.824*							0.868

Note: since the observed values vary from 1 (very bad) to 6 (excellent), the mean values could be interpreted only as *proximity* of the whole sample to each judgment.

After deleting a single item, obviously, the whole procedure was repeated until all the communalities are good (see 4th column of Table 5). Finally, the 36 variables resulting of all iterations, correlated to seven components explaining almost 70% of the total variance (see Table 6), were saved as optimally transformed data (in theory, normally distributed). The stability of this solution was checked through a bootstrap procedure (Efron, 1979) with

2,000 samples, giving quite good results: the medians of all the bootstrapped eigenvalues are very close to their mean, and also the 90% percentile intervals are quite narrow: 5th and 95th percentiles deviate less than ±10% of the respective median's value, and in most cases they are close to ±5%. Also the Efron's percentile confidence limit with α=0.05 are acceptable. The bootstrapped eigenvales are normally distributed in every case, with very acceptable skewness (minimum -0.082 for the 2nd component, maximum 0.203 for the 5th component).

Using the classical PCA, a Factorial Analysis was applied to the optimally transformed data, with oblique Promax rotation (Manly, 1986). The resulting Factor Loadings Matrix defines the latent dimensions of the service's quality, even correlated each other (see again Table 5, last seven columns).

Table 6. Factor analysis with Promax oblique rotation.

	Initial solution			Extracted solution			*Promax oblique rotation*[(a)]
Components	Eigenvalues	% of Variance	Cumul. % of variance	Eigenvalues	% of Variance	Cumul. % of variance	*Eigenvalues*
1	14.516	40.323	40.323	14.516	40.323	40.323	*11.352*
2	3.154	8.760	49.083	3.154	8.760	49.083	*8.486*
3	1.954	5.429	54.512	1.954	5.429	54.512	*9.134*
4	1.629	4.524	59.036	1.629	4.524	59.036	*8.371*
5	1.387	3.854	62.890	1.387	3.854	62.890	*3.983*
6	1.253	3.480	66.369	1.253	3.480	66.369	*7.034*
7	1.147	3.186	69.555	1.147	3.186	69.555	*7.668*
8	0.942	2.617	72.172				
9	0.804	2.232	74.404				
10	0.692	1.922	76.326				
…	…	…	…				

(a) When components are correlated, eigenvalues cannot be added to obtain a total variance.

Table 7. Component Correlation Matrix.

Components	Comfort and cleanness	Service organization	Information's availability	Service's accessibility	Costs	Staff's behaviour	Behaviour of inspectors
Comfort and cleanness	1,000						
Service organization	0,523	1,000					
Information's availability	0,586	0,521	1,000				
Service's accessibility	0,556	0,413	0,479	1,000			
Costs	0,148	0,099	0,193	0,203	1,000		
Staff's behaviour	0,463	0,399	0,422	0,368	0,162	1,000	
Behaviour of inspectors	0,530	0,376	0,453	0,474	0,203	0,420	1,000

Interpreting each factor through the observed variables more correlated with it, we identified (in decreeing order, according to the ordered eigenvalues of the rotated solution) the **1st factor** as "*Comfort and cleanness*", the **2nd** as "*Service organization*", the **3rd** as "*Information's availability*", the **4th** as "*Service's accessibility*", the **7th** factor as "*Behaviour of inspectors*", the **6th** as "*Staff's behaviour*" and the **5th** (explaining the lower part of the total variance) as "*Ticket costs*". Those seven factors, because of the rotation type here chosen, are almost all strongly correlated with each other (Table 7): in the majority of cases, the coefficients reported in Component Correlation Matrix are higher than 0.32, indicating that at least 1/10 of the variability of one factor is explained by each factors to which it is connected. The only exception is the 5th factor (Costs), which has low correlations with others: likely, in the customers' perceptions it isn't an actual aspect of the transport service quality.

In order to carry on the further steps of this impact analysis, all the individual factor scores of the rotated solution were saved in our database with the Bartlett method (which produces scores with mean 0 and minimized sum of squares of the unique factors, saving also the correlation between factors).

4. Factors as hierarchical determinants of overall satisfaction

Because the factorial analysis used only variables which are correlated with overall satisfaction, the correlation of this variable with extracted factor appears obvious. But the knowledge of the correlation hierarchy could be useful to refine the business strategies. For this reason, a top-down segmentation analysis (Breiman et al., 1984) was applied using all factors as predictive variables and the overall satisfaction as response variable. In order to draw significant relations, we applied the C*a*RT algorithm with explorative stop criteria (max depth=10 levels, minimum parent-node size=35 units, minimum child-node size=5 units) and *pruning option*[4] in order to reduce noise and errors.

Looking for the simplest interpretation, such analysis was applied both to original variable and to its binary transformation with cut-off point in the centre of the values scale: *Unsatisfied*, 1 to 5, vs. *Satisfied*, 6 to 10.

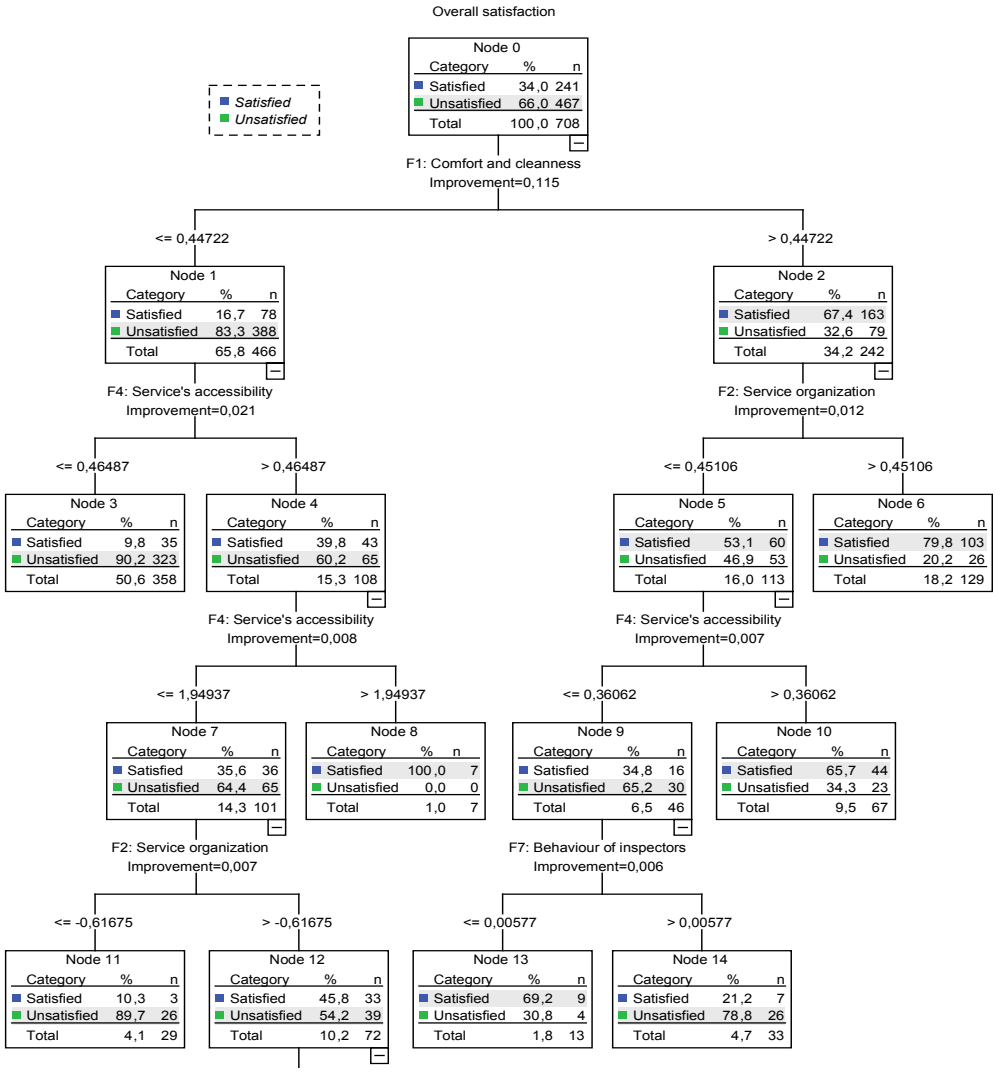

Figure 1. Classification tree of the binary overall satisfaction through the "dimensions of quality" (pruned tree, first 4 levels under the root).

[4] The *pruning method* reduces the size of classification trees by removing tree sections (in a bottom-up way) which provide little power to classify instances. The second purpose of the pruning technique is provide a better predictive accuracy by the reduction of *overfitting*.

In terms of both parsimony and efficacy, the best classification was reached applying the procedure to the binary variable, despite its strong asymmetry: 10 final nodes on 6 levels with prediction risk 0.165 (s.e. 0.014), versus random prediction error=0.34; the regression tree obtained by the original overall satisfaction had 20 terminal nodes on 7 levels with prediction risk 1.634 (s.e. 0.89)[5] versus the total variance 3.305; that is, a better improvement rate with half number of terminal nodes.

In order to allow a sufficient clarity of reading, Figure 2 shows only five levels of the classification tree given by the analysis of binary overall satisfaction with *pruning* option (the root and the first four levels); the classification tree relative to the original 10-levels *overall satisfaction* is quite similar to this, even if the results are not so good.

In both cases, the most important factors (Tab. 8) were "1. Comfort and cleanness" and "4. Service's accessibility"; "3. Information's availability" and "2. Service organization", in this order, follow the first couple of factors, then we have "6. Staff's behaviour" and "7. Behaviour of inspectors", which importance is almost 50% respect the most important factors. In the same way of previous analysis, being less discriminative than others, the last factor ("5. Ticket costs") has very low importance.

Table 8. Importance of the independent variables (dimension of service's quality)

Independent variables	Importance	Normalized Importance
F1: Comfort and cleanness	0.123	100.0%
F4: Service's accessibility	0.116	93.7%
F3: Information's availability	0.112	90.4%
F2: Service organization	0.102	82.6%
F6: Staff's behaviour	0.057	45.9%
F7: Behaviour of inspectors	0.055	44.6%
F5: Costs	0.009	7.1%

Expansion method: CRT, with *pruning* option Dependent variable: *Overall satisfaction*

The power of this classification tree is good: the risk estimate is 1.313 (s.e. 0.79) to predict the original variable and 0.165 (s.e. 0.014) to predict its binary transformation. Moreover, in this case the CRT algorithm allows to predict more than to 85% of "unsatisfied" responses and close to 80% of satisfied ones (Tab. 9), while a random attribution "predicts" 66% and 34% respectively.

Table 9. Classification table (confusion matrix) of the binary variable *overall satisfaction*

	Predicted				
Observed	Unsatisfied	Satisfied	*Total observed*	% observed	*Percent Correct*
Unsatisfied	406	61	*467*	66.0	*86.9*
Satisfied	51	190	*241*	34.0	*78.8*
Total predicted	*457*	*251*	*708*	100.0	*84.2*
% predicted	64.5	35.5	100.0		

Validating this procedure by using a split-sample procedure, a similar classification tree was obtained, with best results in the training set (estimated risk 0.144 *vs.* random risk 0.303) than in the test set (estimated risk 0.239 *vs.* random risk 0.377); the regression tree concerning overall satisfaction showed the same results (estimated risk in training set=1.804, estimated risk in test set=2.301). This difference can be due to the reduced size of split samples.

For this motive, a 1000 samples bootstrap procedure was applied to both classification and regression tree, obtaining quite good results in terms of estimated risk error: normal distribution of estimated risk for binary satisfaction: skewness 0.22, mean 0.165, median 0.163, 5th percentile 0.145, 95th percentile 0.199, Efron's percentile confidence limits [0.131, 0.205].

[5] Note that in the first case the risk is the proportion of cases correctly classified, while in the other the risk estimate is the within-node variance.

5. Clustering the factors

The previous factors express the basic dimensions of quality in the perceptions of interviewees better than observed variables (which are affected by noise factors, as measurement bias or survey errors).

Then, a cluster analysis of all interviewees was applied by using such factors.

In order to identify the optimal number of clusters, the first analysis was based on several hierarchical algorithms (between-groups linkage, within-groups linkage, nearest neighbour, furthest neighbour, centroid clustering, median clustering and Ward's method: see Lis and Sambin, 1977; Delvecchio, 2010; Ward, 1963), but, in terms of ratio "between/total variance", the best results was given by the between-groups linkage and by the Ward's method, which provide *three* clusters as the best partition[6]. Then, a non-hierarchical analysis (with Lloyd-Forgy's "k-means" method[7]) was realized, obtaining better balanced clusters with good split and a greater "between/total variance" ratio (0.400) than those provided by both between-groups linkage (0.353) or Ward's partition (0.359).

The Tukey's hinges in Fig. 2 show that the cluster's partition follows the distribution of interviewees by overall satisfaction in a quite good way (but not perfectly): 1st cluster is mainly composed of dissatisfied customers, the 2nd groups customers fairly neutral (although the median score, 5, is basically negative), while the 3rd cluster aggregates mainly those who "passed" the transport service, even if lower outliers exist.

Table 10 shows the cluster profiles related to factors and some quantitative characteristic of the interviewees (age, seniority in use of bus service, number of bus lines daily used). Observing the Tukey's hinges of the factors in each cluster, the good split of the cluster's partition is clear for all factors, except for the 5th (costs), which is the only one who observes a positive limit in the group of dissatisfied and a negative limit in the group of satisfied.

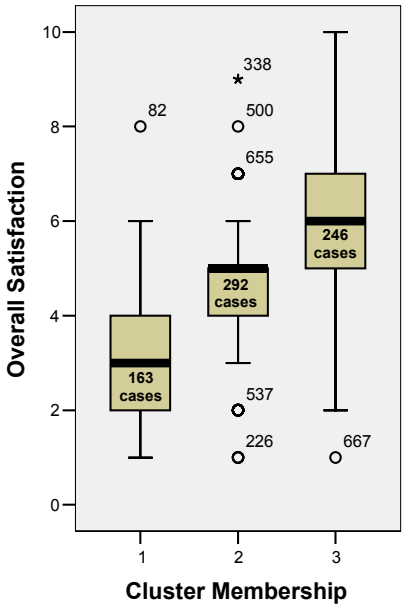

Figure 2. Boxplot of the overall customer satisfaction, by cluster membership

Table 10. Cluster profiles: Tukey's hinges (median and other corrected quartiles)

Factors and personal characteristics	Cluster		
	Unsatisfied	Quite unsatisfied	Basically satisfied
1: Comfort and cleanness	-1.15 *-1.48 -0.70*	-0.17 *-0.62 0.40*	0.86 *0.37 1.38*
2: Service organization	-0.88 *-1.23 -0.36*	-0.32 *-0.84 0.22*	0.91 *0.34 1.39*
3: Information's availability	-1.08 *-1.53 -0.48*	-0.12 *-0.60 0.35*	0.94 *0.48 1.19*
4: Service's accessibility	-1.14 *-1.71 -0.49*	0.08 *-0.40 0.57*	0.59 *0.29 0.90*
5: Costs	-0.73 *-1.52 0.23*	0.13 *-0.45 0.76*	0.23 *-0.39 0.76*
6: Staff's behaviour	-1.04 *-1.63 -0.34*	0.00 *-0.51 0.47*	0.77 *0.24 1.00*
7: Behaviour of inspectors	-0.98 *-1.61 -0.57*	0.13 *-0.45 0.76*	0.82 *0.21 1.10*
Age (years)	23 *21 35*	24 *21 32*	31 *23 47*
Seniority in use of buses (yrs)	3 *2 7.5*	3 *2 6*	4 *2 10*
Number of used bus lines	2 *1 2*	2 *1 2*	1 *1 2*

[6] In order to identify the best solution, all partitions suggested by such hierarchical algorithms (3-5 clusters) were tested not only by variances' ratio, but also with the results provided by the various applications of the *k-means* method..

[7] K-means (Forgy, 1965; MacQueen, 1967) is a simple unsupervised algorithm to classify a dataset through a given number k of clusters. The algorithm works recursively, joining all observations in a m-dimensional space (identified through m variables) to the nearest k group centroids, re-calculating step by step such centroids in order to find the best attribution of the units in terms of distance among them. It is a non-hierarchical algorithm because it allows to join an unit to a cluster extracting it from a previous cluster, if its distance from the new centroid is smaller.

Table 11. Cluster profiles: statistically significant characteristics of interviewees and their service's use (percent distribution by cluster).

Characteristics of interviewees and their service's use	Cluster 1	Cluster 2	Cluster 3	Overall sample
Gender (p<0.03)				
M	41.5	43.4	53.0	46.3
F	58.5	56.6	47.0	53.7
Educational qualification (p<0.02)				
N.A.	0.6	1.3	3.2	1.8
No qualification	6.7	1.7	2.0	3.0
Elementary	3.7	4.7	5.7	4.8
Middle school	13.4	10.5	15.4	12.9
Secondary school	52.4	56.2	43.3	50.8
University degree or higher	23.2	25.6	30.4	26.7
Working/non-working condition (p<0.0001)				
N.A.	1.8	2.0	2.0	2.0
Student	61.6	58.2	34.0	50.6
Housewife / Retired / Unemployed	17.1	15.2	30.0	20.7
Self-employed	5.5	7.1	10.9	8.1
Employee	11.0	17.2	23.1	17.8
Other condition	3.0	0.3	0.0	0.8
Main reason to use buses (p<0.0001)				
N.A.	0.6	0.0	0.0	0.1
To reduce pollution	7.9	11.1	18.6	13.0
To get closer to other transports	6.1	7.8	8.9	7.8
For lack of own transport	65.3	62.3	40.9	55.5
For economic reasons	17.1	16.8	28.8	21.1
Other reason	3.0	2.0	2.8	2.5
Dynamics of bus service in the last year (p<0.0001)				
N.A.	1.2	0.0	0.8	0.6
Improved	4.9	9.8	21.1	12.6
Unchanged	37.2	49.5	43.7	44.6
Worse	46.3	27.2	11.7	26.3
I do not know	10.4	13.5	22.7	15.9
Total	**100.0**	**100.0**	**100.0**	**100.0**
Total number of interviewees	***164***	***297***	***247***	***708***

Table 12. Cluster profiles: statistically significant characteristic of the service's use by the interviewees (Percentages on total sample)

Characteristics of the service's use *(multiple answers)*	Cluster 1	Cluster 2	Cluster 3	Overall sample
Purposes of use of bus services				
To go to work / school / college ***	72.0	69.0	55.9	65.1
To go shopping **	22.6	17.2	25.9	23.4
Health or hospital purposes ***	10.4	10.8	25.1	23.3
Leisure's or personal purposes **	22.0	32.3	29.1	22.5
Complains				
N.A.	1.2	0.0	1.6	0.8
Never claimed	42.7	45.1	49.0	45.9
Written complaints	4.9	10.8	7.3	8.2
Toll-free number	24.4	20.2	22.7	22.0
Verbal complaint to the staff *	26.2	22.2	15.0	20.6
E-mail	1.2	3.4	4.5	3.2
Motivations for low utilization of buses				
N.A.	3.7	0.3	2.4	1.8
Low reliability on the arrival times ***	75.0	72.1	47.8	64.3
Long travel time / unsuitable routes	20.1	17.5	21.1	19.4
Difficulty in finding info on timetables	17.1	12.8	15.0	14.5
Lack of connections with other transp.	22.6	23.2	23.5	23.2
Lack of facilities at bus stops/on board	27.4	28.3	28.7	28.2
Total number of interviewees	***164***	***297***	***247***	***708***

**** p<0.02; ** p<0.01; *** p<0.0001***

Since the factors are configured as standardized variables with zero mean, and, in the previous analysis, they were consistent with each other, all negative values identify elements of dissatisfaction, while positive ones identify satisfaction.

Obviously, the characteristics of the respondents, which weren't classification variables, have much worse split.

With regard to categorical characteristics of interviewees which are significantly different among the clusters (Tab. 11), referring just to primary and secondary modality of each distribution, the "unsatisfied customers" are mainly females, students, using the bus service to go school, university or work (or go shopping) because they have no own vehicle. Many of them think that the transport's service has gotten worse in the last year (or unchanged), and use it less than necessary because of its low reliability on the arrival times.

The satisfied ones, instead, are male and often have leisure's or personal purposes, as well as work/study reasons; many of them are nonprofessional (housewives, retired or unemployed), using buses also for "economic reasons". They judges that the service quality in last year was unchanged, but not few of them saw an improvement.

The "quite unsatisfied customers" are similar to unsatisfied (mostly females, students, without own vehicles), but like the satisfied ones they use the bus service also for leisure's or personal purposes. Many of them are employees, and their opinion about the dynamics of the service vary from immutability to worsening.

6. Concluding considerations

The previous analyses underlines the importance of comfortable and accessible transports in the town, without forget the factors of information and organization (which can be easily enhanced by management); the human resources are important, but, likely, this occurs because the judgments of customers on this factors are better and more consistent than some others (excluding the prices of the tickets, whose scores are the highest), as shown by the explorative analysis of the quality items (Tab. 5).

The reduced importance of the ticket costs in the multivariate analyses raises some doubt, given their good scores, but it could be due to the joint influence of several elements: first, customers who have financial resources know that the prices of urban transport in the town of Bari are quite low, compared to other towns; instead, who has less financial resources, often enjoys special rates (especially students and elderly people), or doesn't think at all to pay the ticket, given a certain facility to evade the inspectors. Moreover, the passengers may believe that the cost of the ticket has no relation with the quality of service received, because its amount is decided by the policy, regardless of the actual operating costs of public transport.

Indeed, the factor analysis has highlighted that, in the overall intercorrelation of the factors due to the performed rotation, the "cost" dimension is very little correlated with the other factors.

In conclusion, the results from this study identify some intervention areas for the Bari bus company to act upon. in order to modify its business strategies and to improve its business performance, increasing overall user satisfaction. The aspects related to the dimension of comfort and cleanness (of vehicles and bus stops) are clearly those on which the AMTAB firm must focus more attention, followed by the issues related to accessibility of the service, to availability of information and, finally, to the organizational.

Acknowledgements

The Authors jointly designed and realized the work here described. However, F. D. d'Ovidio edited the section 5, D. Leogrande sections 1 and 5, R. Mancarella section 3, A. Schinzano section 4 and D. Viola wrote the section 2.

The Authors thank the President and the General Director of AMTAB S.p.A., T. R. Binetti and A. De Robertis, for their support in starting this survey. The usual disclaimer applies.

References

Breiman L., Friedman J.H., Olshen R.A., Stone C.J., 1984. *Classification and Regression Trees*. Chapman & Hall, New York-London.

De Leeuw J., Young F.W., Takane Y., 1976. Additive Structure in Qualitative Data: an Alternative Least Squares Method with Optimal Scaling Features. *Psychometrika* 41, 471-504.

Delvecchio F., 2010. *Statistica per l'analisi di dati multidimensionali*, Cleup, Padova.

Efron B., 1979. Bootstrap methods: another look at the jackknife. *Annals of Statistics*, 7: 1–26.

Forgy, E.W., 1965. Cluster analysis of multivariate data: efficiency versus interpretability of classifications. *Biometrics* 21, 768–769.

Lis A., Sambin M., 1977. *Analisi dei cluster*, Cleup, Padova.

MacQueen, J. B., 1967. Some Methods for classification and Analysis of Multivariate Observations, *Proceedings of 5-th Berkeley Symposium on Mathematical Statistics and Probability*, Berkeley, University of California Press, 1, 281-297.

Manly B.F.J., 1986. *Multivariate Statistical Methods: a Primer*, London, Chapman & Hall, p. 77.

Meulman J.J., Heiser W.J., 1999. *Categories 10.0*. SPSS Inc., Chicago.

Meulman J. J., Van der Kooij A. J., Heiser W. J., 2004. Principal components analysis with nonlinear optimal scaling transformations for ordinal and nominal data. In: Kaplan D. (ed.), *Handbook of quantitative methodology for the social sciences*, Sage, London , 49-70.

Ward J., 1963. Hierarchical grouping to optimize an objective function, *Journal of the American Statistical Association*, 58, 236-244.