THE MODAL DIVERSION INDUCED BY HIGH QUALITY PUBLIC TRANSPORT: USE OF ATTITUDINAL VARIABLES FOR TRAVELLERS' SEGMENTATION

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ABSTRACT

Traffic congestion due to excessive car use and its negative impacts on environment and people health really affects the life quality in metropolitan areas. Among possible transport solutions being recently experienced, high quality public transport systems, particularly metro and light rail, are wished to become a concrete alternative to car use.
This paper aims at investigating, for different groups of transit users, the rate of modal diversion, from private motorized to collective transport, induced by the new VAL system, introduced in 2006 in the city of Torino. To this extent, an ad hoc survey has been designed and addressed to metro and surface public transport users. The Exploratory Factor Analysis let recognize two latent constructs on which the K-means Cluster Analysis has been applied, allowing to individuate four different clusters: "thrifty and quality focussed", "highly quality focussed", "PT supporters for necessity", and "thrifty and not quality focussed" riders.
The travellers' segmentation suggests to invest money in improving public transport quality and image through a proper advertising, in order to get the users to like it and making it perceived as smart and cool. In this way, public transport could attract individuals having high profile status and income. In addition, making private transport more uncomfortable and expensive, through the introduction of strong constraints on parking (reducing parking places) and increasing its cost, could induce to divert car lovers who use it both for sake and out of opportunism.

Keywords: modal diversion, high service quality, public transport, market segmentation, travel behaviour, attitudes, habits, sustainable mobility, transport policies.

INTRODUCTION

The current trend in transport planning and management shows a growing attention to the policies addressed to increase the modal diversion from car to public transport (PT), allowing to reduce both traffic congestion and environmental concerns – as noise and air pollution – caused by the constant growth in car use (Steg et al., 2001).
High quality public transport, as the metro, is the mode on which decision makers want to stake on, despite the big financial investment they have to face in order to offer a real alternative to car. In particular, the new generation services, as VAL system (Véhicule Automatique Léger or automatic light vehicle, that is a type of automatic rubber-tired people mover technology) – quick, high performed, safe and comfortable – are able to effectively satisfy people need to rapidly move within the urban context or from suburban areas to the city centre. Thanks to the above characteristics, such a system can be a real alternative to car that still is, unquestionably, the most beloved mode by travellers, become a cultural phenomenon integrated in the society and in the everyday life (Jensen, 1999; Steg, 2005). In fact, it has been showed by Mackett and Babalik (2003) that an efficient service is attractive for people usually not willing to use PT systems. Concerning this, the greater Manchester Metrolink light rail came out to be very attractive to car users, thanks to its high frequency (10 trains per hour, except on early morning, late evening and Sundays), low cost (it is cheaper than the British Rail service) and direct and fast access to the city centre (Knowles, 1996).
A high quality transport seems then to be crucial within the public transport supply of big metropolitan areas, in order to reduce traffic congestion. The data (EC, 2007) show how, today, the car dominates land transport, even in urban ambits widely regarded as having good public transport systems. Across all 27 EU countries in 2006, it accounted for 82.3% of all passenger*km. In the 15 members, before the expansion of the last decade, passenger*km travelled by car grew by 170% between 1970 and 2006. Over the same period, car ownership within the 15 grew by a similar percentage, from 173 cars per 1000 people to 508.
Public transport plays a relatively minor role in most European cities, accounting for less than 25% of all trips made, and only in a few it accounts for more than one third; these include Budapest, Prague, Vienna and Warsaw.
In cities introducing metro system from scratch, where the PT network only includes surface transport (buses and trams), there is a relevant interest in understanding how much the metro line can help in obtaining modal diversion. In fact, the high costs related to new generation of transport services, especially the new metro models, are a relevant drawback for decision makers, as a return of investment cannot be expected before a well built up network will be running. It is just because of the relevant financial investment required to set up high quality transport services that decision makers could be interested in increasing their knowledge about the users' market segmentation (Wedel and Kamakura, 1998). This knowledge could indeed help in formulating "ad hoc" transport policies, specifically designed and addressed to different users' groups (Pas and Huber, 1992, Davies at al. 1997, Salomon and Mokhtarian, 1998, Outwater et al., 2003, Schade e Schlag, 2003; Anable, 2005). In fact, policy and decision makers must not think people would exactly behave how it could be supposed by the adopted policies, as the individual choice is very often due to several specific constraints (Salomon, Mokhtarian, 1997). Even more, it is important to consider

attitudinal and socio-economical variables in defining a market segmentation, as these could help to design tailored policies. As demonstrated by previous studies (Steg and Vlek, 1997), mainly on acceptance of pricing strategies (Schade and Schlag, 2003; Bartley, 1995; Jones, 1991a, 1991b; 1995; 1998; Luk & Chung, 1997), it is expected that specifically designed policies could be more effective in obtaining the desired results.

It is evident that in wealthy societies, as in European western countries, the cost for transport is always more and more internalized (Lu, 2009; van Woensela and Cruzb, 2009), and the improvement of public transport system, even introducing new lines having a high level of service, is not sufficient to obtain modal diversion without the concrete support of actions discouraging the use of private car (Golias, 2002).

This is also showed in a previous study by Mackett and Edwards (1998) who analyzed seventeen PT systems (mainly light rail ones) and recorded a common overestimation of potential new users, confirming that the introduction of a high quality public transport does not guarantee a significant modal diversion, if a proper policy for reducing car use is not adopted. In fact, the real challenge of a metro project is more evident in areas deeply affected by urban sprawl and being poorly supported by surface public transport, where car use is definitely dominant. In addition, in this case, surface PT is indeed often hampered by car traffic (a dedicated lane is available only on some roads), which grew up exponentially since the economical boom in the '60s, and further increased with the following strengthen of urban sprawl.

It is also unquestionable, as reported in the aforementioned studies, that any transport policy implemented in an urban area can have different effects according to the population typology, attitudes and habits. Hence, the segmentation of transport users is needed and, to this extent, focusing on social, demographical, economical, attitudinal, and preference variables is of utmost importance. To this extent, several research works have analysed the influence of attitudes, perceptions, motivations, lifestyles or world-views to provide a greater understanding of mode choice (Redmond, 2000; Ajzen, 2002; Bamberg and Schmidt, 2003; Schwanen and Mokhtarian, 2005; Zhou et al., 2005; Chliaoutaki, 2005; Anable, 2005; Wall et al., 2007; Outwater, 2007; Choocharukul, 2008; Wall et al., 2008).

The current research wants to continue the exercise of segmentation, focusing on a sample of public transport users of a new implemented metro system in the city of Torino, to understand the reasons that induced former car users to shift to it.

The city of Torino, located in the north-western part of Italy, records about 900,000 inhabitants, with a metropolitan area including 31 municipalities and 1,5 million inhabitants, covering a surface of about 766 square Km. Although a metro project was proposed in the 1930s, it is only since February 2006 that the PT network – managed by Gruppo Torinese Trasporti (GTT) – includes a metro line connecting the eastern part of the metropolitan area to the city centre.

The research, focussed on the Torino metropolitan area, has two main objectives:

1. to characterize transit users' behaviour through the market segmentation. This would help in formulating ad hoc transport policies, focussed to a more sustainable mobility;
2. to record, after the introduction of the metro VAL system, the rate of modal diversion from motorized private to metro new service, and to understand which are the users' attitudes favouring it as well as the judgment given to the new transport system.

The next sections will present the methodology adopted in the research, providing a survey

and data analysis design, and the results of the statistical analysis carried out to fulfill the objectives.

1. METHODOLOGY AND WORKING PHASES

The first section of the metro was inaugurated in February 2006, on occasion of the XX Winter Olympic Games in Torino, and connects the Collegno municipality (west suburb) to the Porta Susa railway station (11 stations, for a total extension of approximately 7,5 km). In October 2007, the second section (including three new stations, for a line extension of about 2 km length), linking Porta Susa to Porta Nuova (the main railway station) was completed. After the opening, a considerable increase in the public transport share was observed, growing from 22.8% in 2006 to 26.4% in 2008 (Agenzia Mobilità Metropolitana Torino, 2008). This was particularly encouraging as from 2004 to 2006 an increase of about 8% was registered in car trips. To better understand the context in which the above figures take place, let's consider that, in 2008, 3,158,000 daily trips were recorded in the Torino metropolitan area, decreasing by 16% in respect to 2006 (3,763,000 daily trips), despite an increasing of 1% of the resident population.
The reason of this significant enhance in public transport share is specifically due to the link between the two railways stations, as it produced a considerable growth of metro trips: from 31,000 in 2006 to 75,000 in 2008 (Agenzia Mobilità Metropolitana Torino, 2008).
To better understand the causes behind the recorded modal diversion we need data shedding light on users' choices and consequent behaviour. The above data are collected by the Torino Mobility Agency (Agenzia Mobilità Metropolitana Torino), through a survey on mobility carried out each two years (IMQ: survey on mobility and quality of transport in the Province of Torino). The mentioned survey is a traditional one, aimed to collect the main data on daily trips (origin, destination, mode, scope, frequency, etc.) aside the socio-economic characteristics of respondents. As the above data were not proper to fulfill the main aim of the research, an ad hoc travel survey was designed to investigate public transport users attitudes and consequent behaviour, essential to carry out the market segmentation.
The methodology provides two main steps:

- the survey design, the sampling plan and the administration of the questionnaire;
- the data analysis design to define the latent constructs, through an Exploratory Factor Analysis (EFA), on which base the sample clustering to individuate homogeneous groups of public transport users and to better understand the reasons that induced them to modal diversion.

1.1 Survey design

The survey was designed to understand the respondents' behaviours after the opening of the new metro line and to investigate the attitudes of the sample towards such a service.
The sample was selected randomly among the Torino PT users, consisting of 602 respondents, to whom the questionnaire has been addressed through vis-à-vis interviews. The survey has been administered in two stages:

- in September 2007, few days before the opening of the second section of the line 1, till Porta Nuova, a first sample of 402 metro passengers was interviewed inside the

metro stations or on the trains, to investigate how the opening of the first section influenced the travellers;

- in January 2008, a second random sample, formed by 200 surface PT riders, was interviewed in front of Porta Nuova station, the main connection among different public transport modes (train, metro, tram and bus). This location was strategic allowing to include in the sample the PT users coming from the whole metropolitan area, as Porta Susa and Porta Nuova are the two connections between the extra-urban and the urban network. The survey period was chosen in order to consider the effects of the completion of the first part of the line 1, avoiding the potential bias in case the survey was addressed few weeks after the opening of the new stretch (October – November) or during Christmas holidays.

The questionnaire provided three sections, aimed to collect the respondents' mobility pattern, habits, attitudes and, finally, their personal as well their household characteristics (Table I):

- the first section was focussed on the main trip characteristics (origin, destination, scope, frequency, trip chain and relative modes, modes used on the return trip) and on the users' trip habits (the travel behaviour before the opening of the metro line);
- the second section asked for the users' attitudes. To this extent, the reasons inducing people to choose and use the metro for their daily trips were investigated. The respondents were asked to point out the relevance of several aspects as regards their choice to use the metro, assigning a judgment on a scale ranging from 1 (not at all important) to 6 (extremely important). The aspects respondents were asked to consider were: difficulty to find a parking place, cost of the parking place; trip duration and frequency; seats availability; personal safety; links to surface public transport; accessibility to metro stations; cleaning; comfort; and driving license and car non ownership. Then, the intention to use future metro sections (line 1 prosecution and line 2, now in a project phase), the willingness to live close to a metro station, the satisfaction level as regards the transport systems, and opinions about the desired transport service characteristics were asked too;
- the last section included questions about socio-economical data of the respondents: gender, age, educational level, occupation, income, driving license and transit pass ownership, household size and composition, vehicles (car, motorcycles, bikes) in the household.

The users' habits and attitudes were expressed through dichotomous variables (yes or no), categorical variables, and cardinal variables.

1.2 Data analysis design

Considering the nature of the collected data, multivariate statistical analysis has been carried out through the BMDP statistical software (BMDP Statistical Software Inc.,1992). The data analysis design is articulated in three different steps:

1. the common factor model has been chosen to get a parsimonious representation of the associations among measured variables. To define latent constructs based on respondents' opinions on private and public transport supply, the Exploratory Factor Analysis (EFA) was preferred to the Confirmatory Factor Analysis (CFA), to avoid a confirmation bias, also according to Velicer and Jackson (1990) stating that "exploratory analytic approaches should be preferred except for those cases where a

well-defined theory exists". As the data were not normally distributed, the Principal Axis Factoring (PFA) extraction method was used as it does not entail any distributional assumptions, while both scree test and Kaiser criterion were adopted to define the number of significant factors. In order to assure a better interpretation of latent constructs, the oblique rotation (oblimin) was used to allow correlated factors. Since the dichotomous and categorical variables collected through the questionnaire were not suited to the EFA, 10 out of the 17 attitudinal variables were retained to define the latent constructs, while the other ones were used to characterize the clusters, as showed in section 2.1;

Table I – Questionnaire structure

Trip characteristics and habits (Section 1)
Trip characteristics (urban/interurban)
Trip origin and activity at origin
Transport mode to arrive at metro station
Trip destination and activity at destination (trip scope)
Trip typology (systematic or not) and frequency
Mode used in the return trip
Trip before metro opening: if yes: modes used; if no: why no
Users' attitudes (Section 2)
Relevance (1-6 scale) of the following attitudes towards the choice to use the metro:
Private transport supply characteristics: - Parking difficulty - Parking cost
Metro characteristics: - Trip duration - Train frequency - Seat availability and comfort - Personal safety - Links to surface public transport lines - Stations' accessibility - Cleaning - Comfort
Respondents characteristics - Non ownership of a driving license - Non availability of a car
Use of metro when it will continue to Lingotto (next terminus of Line 1) and end trip station
Service quality satisfaction level (scale 1 to 6)
Choice of future route of Line 2 among three alternatives and reason of their choice
Metro characteristics to improve (choice among 13 attributes)
Importance of being close to a metro station in case of residence relocation (yes/no)
Socio-economical data (Section 3)
Car ownership
Pass ownership
Gender
Age
Educational level
Occupation
Household size and composition
Driving licenses owned in the household
Cars, motorcycles and bikes owned by the household
Income (≤ 1,000; 1,001-2000; 2001-4000; > 4000 €/month)

2. K-means Cluster Analysis was selected to perform the users' market segmentation and to define different transit users' groups. This method is not suitable for continuous data (Everitt et al., 2001) as it is based on Euclidean distances, finding an average of several patterns; it uses the iterative relocation with the sum of squares criterion (Mac Queen, 1967) and here was applied to latent constructs individuated through EFA. Even if this method has the limitation of subjectivity and depends on the experience of researcher in finding the optimal number of clusters, its choice is due to maintain a coherence with other segmentation exercises in literature that used the same method (e.g. Anable, 2005);
3. a cross-analysis with socio-economical, attitudinal (the ones that were not used for the EFA) and behavioural variables has been performed to understand which socio-economical characteristics and users' attitudes play a relevant role in differentiating the obtained clusters. As collected data had a non-normal distribution, the Mann-Whitney non parametric test was used.

2. RESULTS

The Exploratory Factor Analysis, conducted on 10 variables, allowed to individuate two latent constructs or factors, considering only those with a factor loading greater than 0.35 (Table II). The two factors explain 84% of the variance in the data space.

Table II – Variables' loading on rotated factors (loadings greater than 0.35 in bold)

Variables	Factor 1 *PT quality*	Factor 2 *Parking performance*
Parking diffcultlty	- 0.037	**0.934**
Parking cost	0.035	**0.928**
Personal safety	**0.663**	- 0.044
Cleaning	**0.625**	0.055
Comfort	**0.570**	- 0.138
Seats availability	**0.526**	- 0.098
Train frequency	**0.386**	0.061
Links to surface PT lines	**0.363**	- 0.042
Stations' accessibility	0.309	0.031
Trip duration	0.293	0.078

The first factor, named "*PT quality*", is characterized by a high loading on the typical variables forming the concept of public transport service quality: personal safety, cleaning, comfort, seats availability, train frequency and connections with surface public transport lines. The judgment users gave as regards the relevance of station accessibility and trip duration has not reached a sufficient correlation level with the other variables, probably because the accessibility and trip duration are highly competitive and even better than the other modes, so that they were considered as intrinsic characteristics of the service, not subjected to comparison with those of alternative systems.
The second factor is strongly related to the difficulty in finding a parking place and to its cost, variables that can be a key factor in modal diversion. In fact, since car drivers are used to

consider the parking attributes as related to private transport, a high or low attitude towards them can change the positive judgment transport users often have towards the private mode. This feeling could be smartly used by decision makers when they plan the accessibility to the different parts of the city, mainly to the city centre. This factor can be named "*parking performance*".

The two above latent constructs were used as the new variables on which segment the travellers, thanks to the K-means Cluster Analysis. As factor 1 is loaded by six variables, its values range from 1 to 36, while factor 2, only loaded by 2 variables, has values ranging from 1 to 12. These scores were then standardized for the cluster analysis.

In Table III, the means and standard deviations of the clusters, before standardization, are depicted, as also the F-ratio, showing how the two factors are both important in determining clusters, with main emphasis on "parking performance".

Table III - Cluster means and standard deviations

Cluster Means			
	Size	**PT quality**	**Parking performance**
1 (Thrifty and quality focussed)	149	27.5734	9.9664
2 (Highly quality focussed)	155	28.1497	2.4295
3 (PT supporters for necessity)	64	18.5156	2.8281
4 (Thrifty and not quality focussed)	81	20.0127	10.1605
Grand mean		25.0508	6.3733
Cluster Standard Deviations			
		PT quality	**Parking performance**
1(Thrifty and quality focussed)		2.5522	1.6580
2 (Highly quality focussed)		3.0099	1.0602
3 (PT supporters for necessity)		3.8586	1.4316
4 (Thrifty and not quality focussed)		2.8756	1.4702
Mean squares		**PT quality**	**Parking performance**
Between		2353.413	2105.400
Within		8.929	1.980
D.F.-S		3.429	3.446
F-Ratio		*263.562*	*1063.334*
P-value		0.000	0.000

The four clusters are then represented in figure I, each in one different box of the diagram where factor 1 (*PT quality*) is on the horizontal axis, and factor 2 (*parking performance*) on the vertical one. Figure I shows how both factors seem to be very relevant for cluster 1, as its position matches with high values for both axes. "PT quality" (factor 1) is relevant for cluster 2 as well, while "parking performance" (factor 2) is significant in determining cluster 4. On the other hand, cluster 3 does record low values for both axes.

The first cluster is strongly interested in a high quality of public transport, and time and money consumption play a relevant role in their choice to use the metro for their trips, due to the difficulties to find a parking place and to its cost. This cluster is formed by 149 individuals and can be named "*thrifty and quality focussed*" travellers.

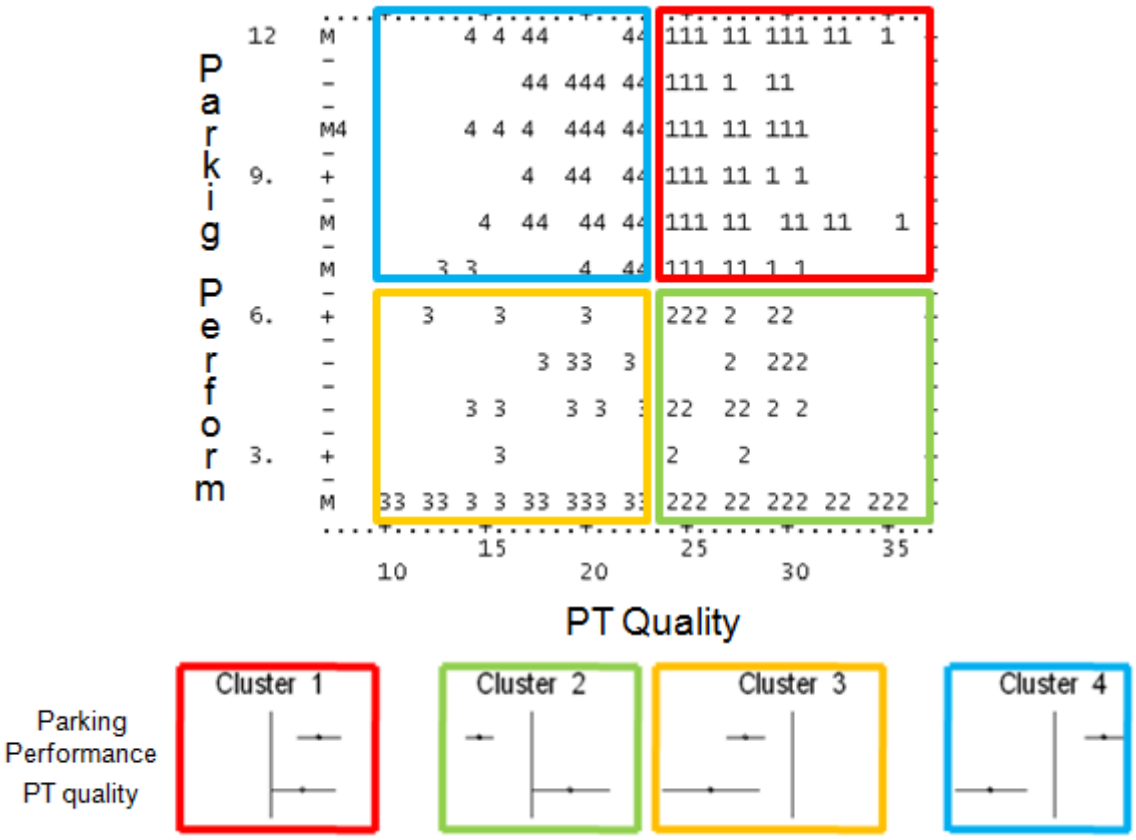

Figure I - Cluster representation

Conversely, cluster 2, composed by 155 individuals, does not care about looking for a car park neither about paying for it, also because they have a relatively lower car ownership rate. These persons can be labelled as "*highly quality focussed*" riders.

The two other clusters seem to be more interested in transport service functional capacity as they choose PT due to necessity and lacking of alternatives (cluster 3), or because they appreciate the practical aspects of using PT in a metropolitan area (cluster 4). In fact, individuals in cluster 3 (64 persons) assign the lowest importance to both PT quality and parking performance as regards their choice to use the metro. This means that although they may appreciate the service quality, they do not take care so much about it; moreover, they are not so influenced by parking constraints. They choose the metro because they prefer to use public transport, even given their constraints in terms of driving license and car ownership. For these reasons, we can name them "*PT supporters for necessity*".

The 81 individuals composing the last cluster can be defined "*thrifty and not quality focussed*" travellers, as they give high importance to difficulty of parking and to the relative cost while they have a low interest to service quality. This means that the choice of the metro is mainly due to parking constraints and because they are little bit tightfisted, even observing that they record the higher income.

2.1 Discussion on the clusters through the socio-economical, behavioural and attitudinal variables of respondents

In order to better characterise the different clusters, these ones were compared analysing the

socio-economical and behavioural data, as also the attitudinal variables not used in the factors calculation. The non parametric Mann-Whitney test, adopted for this analysis, highlights a statistical difference for several socio-economical and behavioural variables, mainly between cluster 1 (thrifty and quality focussed) and 2 (highly quality focussed) and between groups 2 and 4 (thrifty and not quality focussed). Instead, few specific attitudinal variables show different opinions between individuals belonging to cluster 1 and 3 (PT supporter for necessity) and to 3 and 4.

As already mentioned, both thrifty and quality focussed (1) and highly quality focussed (2) riders would expect a high quality public transport, but different reasons justify their interest. The individuals in cluster 1 choose the metro as looking for a parking place is too expensive in terms of money and time consumption. Despite they are conscious that private transport has objective constraints related to parking, however they demand an excellent transport service. On the other hand, users in cluster 2 do not seem to be so influenced by such parking constraints; to this extent it has to be considered they are the group having the highest rate of individuals not owning a car. In fact, even if the 18.7% of non car ownership could seem not very relevant as an absolute value, it is significant considering the specific context. The car ownership rate in Torino is equal to 0.62 cars/person, data well in line with the Italian situation, where the car ownership rate of the first 50 biggest cities is equal to 0.61 cars/person (Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2008).

The socio-economical variables showing a statistical difference among the clusters are educational level; gender; income; household size and typology; and car, driving license and pass ownership. Looking at Table IV, the educational level in cluster 1 and 4 is higher (53-57% high school, 33-40% degree or higher) than for cluster 2 (primary school 2.6%, secondary school 22.7%). Similarly, also the income level is higher in cluster 1 than in the second one, as this latter seems to be the poorest group (45.1% earn less than 1,000 € per month). Cluster 4 is close to 1, even if it records the highest rate of people earning more than 2,000 €/month (42.8%). Concerning the attitudinal variables, it is interesting to observe how the "richest" groups pay more attention to those related to parking and, concerning cost, the 90% gives a high importance to it in choosing metro. This reveals a thrifty attitude quite close to meanness , as both cluster 1 and 4 show the highest number of cars in the households and almost all of them have got a driving license (respectively, 96% and 100%).

Differently, the "highly quality focussed" (2) and the "PT supporters for necessity" (3) riders range, respectively, from about 36 to 33% of individuals not having a driving license, due also to their younger age. In fact, in clusters 2 and 3, 38.3% and the 48.4% are from 14 to 25 years old, that's why they have a higher rate of pass ownership, while in groups 1 and 4 a consistent portion of cluster members have not got pass at all (37.6% and 48.1%, respectively) and are more inclined to single tickets' use. Similarly to cluster 3, a significant portion of cluster 2 as well owns a year's (26.5%) or a monthly (36.9%) pass.

Finally, the household size differentiates the "thrifty and quality focussed" riders (1) from "PT supporter for necessity" (3) as the first ones record a higher rate of households having one member (15.6% instead of 8.7%) and five members (12.5% instead of 4.7%). Similarly, clusters 1 and 3 record the same pattern concerning the household typology. Cluster 1 members living with their parents are 36.2%, while 10.1% are singles or living with roommates; 18.1% lives with a partner; 34.2% lives with their partner and kids, and finally 1.3% are singles living with their children. A very significant part of both cluster 2 and 3

Table IV – Socio-economical characteristics of the clusters

		Cluster 1 ***Thrifty and quality focussed (%)***	**Cluster 2** ***Highly quality focussed (%)***	**Cluster 3** ***PT supporters for necessity (%)***	**Cluster 4** ***Thrifty and not quality focussed (%)***
Cluster size		33.2	34.5	14.3	18
Gender	Female	58.4	66	40.6	40.7
	Male	41.6	34	59.4	59.3
Age	14 to 25	29.5	38.3	48.4	25
	26 to 35	22.8	18.2	15.7	27.5
	36 to 50	32.3	24	17.1	21.2
	51 to 65	10	13.7	11	23.8
	Over 65	5.4	5.8	7.8	2.5
Education	Primary school	1.3	2.6	3.1	0
	Secondary school	7.4	22.7	18.8	6.2
	Training courses	0.7	1.3	0	0
	High school	57	50	45.3	53.1
	Degree or higher	33.6	23.4	32.8	40.7
Occupation	Worker	2.7	5.1	7.8	1.2
	White collar	37.8	34.7	25	42
	Teacher	8.1	4.5	3.1	2.5
	Professor / researcher	2	0.6	3.1	0
	Self-employed workers	14.2	6.4	11	19.7
	Manager	0.7	0.6	3.1	2.5
	Student	23	29.5	37.6	21
	Unemployed	2.7	5.8	3.1	2.5
	Retired / housewife	8.8	12.8	6.2	8.6
Income	< 1000 € / month	25	45.1	31.8	19.4
	1000 to 2000 € / month	44.8	35.1	50	38.8
	2000 to 4000 € / month	25	17.1	15.9	29.9
	More than 4000 € / month	5.2	2.7	2.3	11.9
Household size	1	8.7	14.8	15.6	16
	2	21.5	28.4	15.6	29.7
	3	36.2	22.6	25	24.7
	4	28.9	29.7	31.3	28.4
	5	4.7	4.5	12.5	1.2
Household typology	Parents / Origin family	36.3	41.3	53.1	34.7
	Single / roommate	10.1	19.4	20.3	16
	Couple	18.1	21.9	7.8	18.5
	Couple with kid(s)	34.2	16.1	17.2	29.6
	Single with kid(s)	1.3	1.3	1.6	1.2
Number of cars in the household	0	5.4	18.7	14.1	3.7
	1	36.9	40	40.6	47
	2	49	31	35.9	33.3
	3	8.7	7.7	9.4	12.3
	4	0	2.6	0	2.5
	5	0	0	0	1.2
Number of passes in the household	Year's	18.1	26.5	32.8	18.5
	Monthly	30.9	36.9	28.2	23.5
	Weekly	13.4	12.9	6.2	9.9
	Non owner	37.6	23.9	32.8	48.1
Driving licence	Owner	96	63.5	67.2	100
	Non owner	4	36.5	32.8	0

members lives with their parents (41.3% and 53.1%), and, respectively, 19.4% and 20.3% are singles or living with roommates (Table IV).

To summarize, we can see that the "thrifty and not quality focussed" travellers (cluster 4) show the highest educational (diploma 53.1%, degree 40.7%) and income levels (41.8% earns more than 2,000 € / month) and a majority of men (59.3%), differently from cluster 2, which shows a more modest income (45.1% earn less than 1,000 € / month), a lower educational level and car ownership rate, and a majority of women (66%).

The "PT supporters for necessity" (cluster 3) are mainly young people and students (37.6%), a significant portion of them owns a year's transit pass (32.8%), and the PT service's high quality is not determinant in their choice to use PT, differently from the first two clusters.

The above considerations point out that the defined clusters are interestingly related to some social attributes, as educational and income level, gender, household size and typology, number of cars owned in the household and ownership of a transit pass, all important in determining the clusters' characteristics. On the other hand, age, occupation, trip scope and typology (urban/interurban) are not relevant in differentiating the clusters.

The absence of influence of trip scope in individuals' attitudes and behaviours seems quite interesting. In fact, this research wants to distinguish itself from some previous studies (as those mentioned in the introduction) that defined their segmentation on pre-defined users' typology based on mode (as in this case), but also on the scope, differentiating commuting trips from errand ones. Here we wanted to focus more on attitudinal variables, independently from the behaviour – as mode, trip scope and frequency – thinking that, today hurry and stressful conditions seem cut uniformly across demographic and behavioural characteristics.

To fully understand the clusters' profiles, the attitudinal variables not taken into account in the factor analysis have considerably helped (Table V).

Table V – Behavioural and attitudinal characteristics of the clusters

		Cluster 1 ***Thrifty and quality focussed (%)***	**Cluster 2** ***Highly quality focussed (%)***	**Cluster 3** ***PT supporter for necessity (%)***	**Cluster 4** ***Thrifty and not quality focussed (%)***
Trip's Information					
Trip typology	Urban	55.7	50	51.5	51.9
	Suburban	41.6	48.7	39.1	44.4
	Interurban	2.7	1.3	9.4	3.7
Is the trip systematic ?	Yes	68.5	76.9	82.8	59.3
	No	31.5	23.1	17.2	40.7
Trip scope	Go back home	0	1.3	0	2.5
	Work	53.8	44.9	50	49.5
	Study	20.8	23.7	21.8	12.3
	Shopping / Free time / Sport	6	9.6	7.8	11.1
	Health	4	3.8	1.6	4.9
	Errands	10.7	10.3	12.5	14.8
	Visit friends / relatives	2.7	4.5	4.7	0
	Pick up / drop someone	2	1.3	1.6	4.9
Trip frequency	Seldom)< 1 / week)	30.9	22.4	18.8	42.1
	Once or twice / week	3.4	7.1	3.1	2.5
	3 – 4 times / week	6.7	6.4	6.2	2.4
	Every day (5 – 7 / week)	6.7	7.7	7.8	6.1
	> 7 / week	52.3	56.4	64.1	46.9

Table V – Behavioural and attitudinal characteristics of the clusters *(continued)*

		Cluster 1 ***Thrifty and quality focussed (%)***	**Cluster 2** ***Highly quality focussed (%)***	**Cluster 3** ***PT supporter for necessity (%)***	**Cluster 4** ***Thrifty and not quality focussed (%)***
Former behaviour (before the opening of the metro line)					
Did (s)he the same trip before the opening of the metro?	Yes	63.8	64.5	66.7	67.9
	No	36.2	35.5	33.3	32.1
Main mode used for that trip before the opening of the metro	PT	79.9	90	76.1	72.8
	Train	7.4	0	4.8	3.6
	Taxi	1.1	0	2.4	0
	Car as a driver	9.5	7	11.9	23.6
	Car as a passenger	2.1	1	2.4	0
	Bike	0	1	2.4	0
	Foot	0	1	0	0
Attitudinal variables					
Importance of "not having a driving license" in choosing the metro	Not at all	84.9	62.4	65.6	96.1
	Very little importance	1.4	3.9	0	0
	Little importance	1.4	0.6	1.6	1.3
	Enough importance	4.8	2.6	3.1	1.3
	Very important	4.1	11.7	20.3	1.3
	Extremely important	3.4	18.8	9.4	0
Importance of "not having a car" in choosing the metro	Not at all	74.3	43.6	53	80
	Very little importance	2.7	4.5	1.6	2.5
	Little importance	3.4	1.3	1.6	2.5
	Enough importance	6.1	5.2	4.7	5
	Very important	8.1	18.8	26.6	5
	Extremely important	5.4	26.6	12.5	5
Would (s)he move next to a metro stop?	Yes	78.5	76.8	57.8	72.8
	No	21.5	23.2	42.2	27.2
Is there a need to improve the metro quality?	Yes	69.8	58.7	64	71.6
	No	30.2	41.3	36	28.4
1st aspect to improve	Opening and closing time	33.6	25.2	30.2	35.9
	Train frequency	1.3	0.6	0	0
	Route / path	19.5	18.7	15.9	18.5
	Seats availability	1.3	0.6	3.2	0
	Personal safety	5.4	2.6	3.2	3.7
	Link to surface PT	2.7	3.9	4.8	3.7
	Metro station accessibility	0.7	0	0	2.5
	Cleanliness	0	0	0	1.2
	Disables accessibility	1.3	1.3	1.6	1.2
	Comfort	1.3	0.6	1.6	2.5
	Turnstiles and assistance	3.4	2.6	3.2	1.2
	No service differences between week days and weekend	0	1.9	0	0
	Do not know, as (s)he never used the metro	29.5	41.4	36.3	28.4

It is very interesting, in fact, to observe that the groups did not behave differently before the opening of the metro, since the mode used before does not emerge as statistically different among the clusters. The question about the need of improving some aspects of the current service shows as well a good agreement on the high quality of the metro and, when some suggestions are given, they are dispersed without significance among all the respondents.

The only attitudes emerged as significant are, on one side, the willingness to move the residence close to a metro station and, on the other side, the importance given to not owning a car and driving license in choosing the metro.

Concerning the residence relocation, both the "thrifty and quality focussed" (1) and the "highly quality focussed" riders (2) show different intentions in respect to "PT supporters for necessity" (3), as the formers think the proximity to a metro station is an important factor to be considered whether they decided to relocate (respectively, 78.5% for cluster 1, 76.8% for cluster 2). On the other hand, the "PT supporters for necessity" (3) do not reveal the same attitude: 42.2% are not willing to move close to a metro station.

As previously mentioned, car ownership and driving license came out to be relevant variables in determining the reasons why different groups choose to use the metro for their trips. For the richest groups (clusters 1 and 4), the variables "not having a car" and "not having the driving license" are not relevant towards the choice to use the metro or the surface PT for their trips, as almost all of them own the driving license and many of them could have a car available for their trips. On the other hand, cluster 2 and 3 consider quite relevant the non availability of a car (respectively 45.4% and 39.1%) as regards their modal choice.

2.2 Modal diversion

The survey shows a quite encouraging result concerning the effects induced by the metro on modal diversion, as about 15.5% of the respondents, who already made that trip before the opening of the new line, shifted from motorized private transport to metro. These results, even if they do not claim knowing modal diversion rates, as the surveys was only directed to PT users, can show why the transport users, who were former users of private motorized mode, diverted to the new public transport system. The survey should be enlarged to a wider sample of all transport users, however the results are confirmed by the data from the Torino Mobility Agency (Agenzia Mobilità Metropolitana Torino, 2008) that show a considerable increase of public transport share after the introduction of the metro. Despite the sample does not cover all the users, the data are coherent to what happened in other Western European metropolitan areas that recently introduced the metro within their PT supply.

In particular, Golias (2002) studied the modal diversion in Athens after the introduction of two new metro lines, integrating the already existing one. The survey was addressed both to PT users (metro and surface PT) and to car users (4,200 total interviews) and about 16% of the respondents shifted from car to metro. Another interesting study was carried out by Vuk (2005) after the introduction of two metro lines integrating the well structured PT supply that traditionally characterizes the Copenhagen metropolitan area. The survey included both traffic counts and telephone interviews and the modal diversion from private car to PT was of about 14%. As pointed out by the above mentioned data, the modal diversion rate is very similar in the three metropolitan areas, nevertheless in Copenhagen it is slightly lower. It can be considered that the Copenhagen metropolitan area already had a quite good public transport supply, so the introduction of the two metro lines, although improving the service, might has not been as relevant as in Torino and in Athens, where the new infrastructure is definitely deemed a significant benefit by regular transit users.

It is clear that the three metropolitan contexts are different considering geography, transport supply, and urban and transport planning traditions. However, this comparison among Athens, Copenhagen and Torino is significant because of the recent implementation of a metro system when the urbanization process was already completed, differently from other European cities that introduced the metro in order to support urban growth.

Considering each cluster modal diversion's rate, it appears that the "thrifty and not quality focussed" riders (cluster 4) particularly changed their behaviour after the introduction of the metro line. In fact, the 23,6% of them shifted from car to metro, while this value is far lower for other groups' members (11,6% for "thrifty and quality focussed", 8% for "highly quality focussed", 14,3% for "PT supporters for necessity") (Table V).

What is of particular relevance is that the "thrifty and not quality focussed" riders are quite wealthy – 11,9% earns more than 4000 € per month, significantly higher than in other clusters – and record a high car ownership rate, as the 50,2% has at least two cars within the household; this figure is even more significant as the Mann-Whitney test did not revealed the household dimension as a relevant variable in differentiating cluster 4 from the other ones.

The above considerations show that the appreciation of a high quality transport, as that offered by metro, is transversal to demographic characteristics, to wealth as well as objective constraints as car and driving license ownership, cutting across people behaviour in mode selection. In the modern society, where time constraints are quite common to every individual, from workers to elderly people, and the hurry induces people to convenient arrangements, the modal diversion from car to public transport can be obtained only stressing the PT quality and making more difficult and costly for car drivers to use and park the car.

Concerning the PT quality, it should be highlighted that the Torino metro has been conceived paying a high attention to the visibility inside the stations, to induce a greater feeling of safety. The personal safety is in fact a key factor in determining the success of a PT system, as pointed out by Mackett and Babalik (2003). This aspect is very appreciated by the users and it shows how Torino's metro is different from the underground system in many other cities. Another element playing a major role in increasing the use of public transport is the positive image the users have got from the service. In fact, if the feeling is positive, they are inclined to advertise the system, spreading the excellent perception they have had using it.

3. DISCUSSION AND CONCLUSIONS

As regards the policy approach, the EU Green Paper, "Towards a new culture for urban mobility" (2007) identifies five challenges in urban mobility, namely progressing towards:

- free-flowing towns and cities;
- greener towns and cities;
- smarter urban transport;
- accessible urban transport;
- safe and secure urban transport.

These challenges are definitely hard to manage and we think that a smoother and more sustainable mobility should pass through a deeper insight in the motivation of users' choices and their segmentation.

To this extent, the multivariate statistical analysis has provided greater insight into mode choice than other competing methods. In fact, even if the factors identifying the clusters (PT quality and parking performance) are typically what is covered by the Stated Preference approach, we preferred to investigate the attitudes and the reasons inducing the respondents to use the metro through questions asking the judgment on a scale. This choice allowed to provide several attitudinal questions instead of a dedicated game cards (Arentze et. Al., 2003) section in the questionnaire. Carson et al. (1994) mentioned both a fatigue effect and a nuisance effect that were observed in individuals faced with numerous choice situations, confirmed also by other researchers (Ortúzar et al., 2000). In the context of the survey, interviewing people waiting for the metro/bus, usually in a hurry, the risk of low reliability of responses was high, even more so if the SP approach was used. This is the reason why users' attitudes were investigated adopting an alternative approach that allowed also to shed light on aspects usually not faced by traditional mobility surveys.

The clusters obtained in this research, focussed on a sample of transport users of the first part of metro line 1, introduced in Torino in 2006 (first section) and 2007 (second section), are quite informative and policy relevant, highlighting the importance of opinions and attitudes items. These have been significant in fostering market segmentation, individuating each cluster specific modal diversion and recognizing different users' categories to whom addressing specific policies to best suit different travellers' profiles.

The research has allowed to define four clusters within the sample of PT users, named as "thrifty and quality focussed" (cluster 1), "highly quality focussed" (cluster 2), "PT supporters for necessity" (cluster 3), and "thrifty and not quality focussed" (cluster 4) riders.

The above profiles show a strong correlation between transport system opinions and some social attributes concerning people background (as education) and income, leading users, even if choosing the metro, to prefer owning the car and not buy a transport pass (cluster 1 and 4).

Attitudinal variables, as well, are very important in enabling the relevance of clusters' differences, as, for example, the intention to move close to a metro station (the highest one for "thrifty and quality focussed" riders) and the importance assigned to not owning car and driving license in choosing the metro. In fact the attitudinal variables have allowed to enter in a greater detail as regards the traditional surveys, shedding light to the personality traits of respondents and attitudes that are the main determinants of their behaviours (Bamberg, 2003; Anable, 2005; Ajzen, 2008). The "highly quality focussed" travellers (cluster 2) and "PT supporters for necessity" (cluster 3) attribute major importance to the car and driving license ownership constraints in the mode selection, while the highest income groups (1 and 4) do not consider them significant, while pay more attention, quite paradoxically, to difficulty and cost of parking in choosing the metro. Moreover, while the general attitudes reveals a strong preference for owning a car, the specific attitudes towards the mode chosen in usual trips are coherent with the behaviour, that is the use of the metro.

Another interesting outcome is the definition of each cluster's potential modal diversion, revealing the individuals of cluster 4 (thrifty and not quality focussed) as those most willing to change mode, since the 23.6% did it.

As the recorded modal diversion's rate is quite encouraging, it is clear that the portion of car drivers that would renounce to their car and use the metro would be far higher if a wider and well structured network would be working. To give a wider picture of the situation, it is useful

to report some data coming from the already mentioned survey IMQ 2008. This survey revealed that the 11% of those using the metro declared that they previously used the car to do the same trip. This means that 8,500 daily trips are not any more made by car.

Besides, the 6% of the interviewed declared they did not make that trip before the metro opening (4,600 more trips). In our sample we have recorded an average value of modal diversion from car to metro equal to 15.5%. Such higher amount is recorded because our sample was interviewed on the metro, representing the population in the line 1 users' area, while IMQ survey's sample represents all the Torino citizens. For the same reason, the induced travel recorded in our sample is equal to 38%, far higher than what came out as regards the whole metropolitan area.

Traffic congestion and the consequent travel time extension, together with the growing awareness towards environmental concerns, produce an increase in travellers' bent to choose PT, if having high quality standards and satisfying specific and individual space and time needs. The modal diversion effective rate and its potential increase in case of a network development constitutes a very encouraging result for decision makers and stakeholders, considering the big financial effort required to build up an efficient public transport network in the metropolitan area. As a governmental investment is hard to obtain, the role played by local decision makers and local stakeholders turns out to be determinant. On the other side, strategic long term objectives, leading towards the concrete improvement of citizens life quality (urban mobility, public health, reduction of air and noise pollution), are wished.

As regards Torino metropolitan area, there is an effective need to undertake challenging choices leading to adopt policies supporting collective transport.

The market segmentation leads to suggest the following tailored policies:

- to invest money in improving public transport quality, in order to get the users to like it. This action could change "PT supporters for necessity" (cluster 3) in "PT lovers". It would be as well crucial to improve the transit image through a proper advertising in order to make it perceived as smart and cool. In this way, public transport could attract individuals having socio-economical characteristics close to cluster 1 and 4 (those having the highest car ownership rate and income level);
- to make private transport more uncomfortable and expensive, introducing strong constraints on parking (reducing parking places) and increasing its cost, inducing to divert car lovers who use it both for sake and out of opportunism.

Such a political choice would be really challenging as it is evident that an economical revenue cannot be expected, unless – but maybe neither – when a real metro network would be running through the whole metropolitan area.

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