MOBILITY STYLES AND ACCESSIBILITY IN NORTHERN ITALY: A FOCUS ON THE CITY OF TORINO

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ABSTRACT

The paper, through the analysis of the relationships between residential location, mobility styles, and accessibility, aims at defining a set of travellers' typologies based on perception of accessibility to urban services. In the city of Torino a survey was conducted on a sample of 699 households, including at least one under 16 child, and stratified according to the residential location (city centre, suburbs, and outer city). The goal was to investigate two main issues: a) mobility, travel behaviour (through a travel diary), and car availability and ownership; b) opinions about the accessibility to the work location and to the urban services. All the household characteristics, as well as socio-economical data and user behaviours were researched and analysed through the Exploratory Factor Analysis to find out the latent factors on which clustering the sample. The results show three travellers' profiles differentiated by household size and accessibility perception. One group, formed by the largest families, spread over the three areas, shows lower travel-to-work times and mobility time budget but is unsatisfied in terms of accessibility to services and work. The cluster formed by medium-size families living in the suburbs is highly satisfied with accessibility to urban services. The last cluster is made up by the smallest households living in the outer city, declaring average scores of accessibility, even though showing the highest times to get to work.
The results highlight the importance of the household composition and its socio-economical status, which induce different mobility patterns and accessibility perception. This allows decision-makers to define transport policies aimed at encouraging a more sustainable transport through tailored actions, information campaigns, and incentives targeted on the users attitudes and sensitivities.

Keywords: people mobility, people behaviour, urban accessibility, transport planning

INTRODUCTION

The "ease with which activities may be reached using a particular transportation system" is a definition of accessibility (Morris et al., 1979) that points out to a link among accessibility, territorial cohesion, and social exclusion. Individuals who have easy access to the services they need are not socially excluded, as they get a favourable spatial distribution. The EU Cohesion Report (CEC, 2004) includes the spatial distribution of accessibility in the list of indicators to measure the existing disparities among regions because the "equality of access" to "services of general economic interest" is considered a key condition for territorial cohesion. In fact, the social exclusion does not only mean lack of opportunities, but also the difficulty to accede to such opportunities (Preston and Rajé, 2007), and the existence of barriers making it difficult or impossible to participate in the social life or to get a proper level of life quality (SEU, 2003).The attention paid in literature to accessibility in the urban contexts has been based upon to the functionalist approach of the last century. The city was the place where productive and commercial settlements were located as the distance from the centre, the transport costs, and the land rent were the basis for such choices. Later on, also the residential choices followed the same principles. Thus, the levels of accessibility of the productive, commercial, and residential settlements were measured through their location and attraction power. Christaller (1933) proposed one of the best know theoretical and operating applications of the functionalist approach. He stated that the central locations are those offering diversified goods and services, and, above all, are those making available rare services of high rank. And instead, the peripheral locations, under a hierarchical and functional dependence as regards to the central locations, get only low rank goods and services, forcing people living in the suburbs to bear high time and monetary costs to access to them. This implies an inequality as regards the access to goods and services that can lead to those not being used.

The research has then progressed trying to give a more comprehensive approach to the meaning of service, and the word "opportunity" was introduced by Kwan (1999), then drawn upon by Dijst (2001). The opportunity is not only a service, but also a territorial collective good (e.g. a park, a square, a monument, etc.) whose access allows users to satisfy, in addition to their elementary needs, the more complex ones associated to identity, relation, participation.

It is evident how the principle of centrality expressed by Christaller (1933) has been overcome. In modern urban systems the opportunities or territorial resources have been increased and show a distribution no longer just related to gravitational criteria. This has prompted researchers to investigate if the peripheral areas and the suburbs, getting lower rank services, have also less opportunities as well as worse environmental and social quality opportunities than central locations. Some researchers (Naess, 2006: Mo.Ve 2007; Colleoni, 2011a,b) show that the geographical marginality of the settlements implies a lower quantity and quality of resources as well as a lower accessibility for people living there.

In addition, some studies in recent years were focused on the relationship amongst city characteristics and its morphology, socio-economical structure of the society, and people mobility. Some of these researches show that the increase of urban mobility is less influenced by gender, people occupation, income, and more by territory: the sub-urban areas are those

most interested by the increase of mobility (Mogridge, 1985; Newman and Kenworthy, 1989; Naess et al., 1995; Fouchier, 1998; Mo.Ve, 2005).
Some authors ascribe this phenomenon to changes in the labour market and to differences in urban development, showing an increase and concentration of job locations (mainly in tertiary sector) in the city centre, and an increase of sprawl residential locations in the suburbs (Martinotti 1999; Schwanen et al. 2001; Stead and Marshall 2001; Naess and Jensen 2004; Naess 2006).
Cao et al. (2009) examined a large amount of researches analysing the impacts of residential self-selection on travel behaviour; they concluded that built environment has a distinct influence on travel behaviour after self-selection is accounted for. However, they observe that
The influence of the built environment is less evident when increasing the level of complexity of the approach to treating self-selection. They suggest that the contribution of the built environment could be relatively small if compared to the contributions of socio-demographic and unmeasured variables (Ewing and Cervero, 2001).
However, the economical crisis affecting Europe since 2008 has influenced people behaviours both in terms of residential location and modal choice. People are travelling less and the walk-ability is becoming a key concept to describe the level of accessibility and of quality of life in the urban neighbourhoods (Cervero and Kockelman, 1997; Handy et al. 2002; Krizek, 2003; Levine et al., 2005).
Frank et al. (2009) proposed an index of walk-ability to analyse the correlation amongst the urban context characteristics, the main socio-demographic-economic variables, and the fondness of adult population to walk. This research refers to the American context that could be different from the European one. Moreover, in Europe, the diversity of life styles, cultures and habits allows to observe different perceptions among users in the various countries Such a potential difference and the willingness to go in depth into the variables influencing the relationship between mobility and accessibility rank among the reasons behind the research presented in this paper, as well as the need to understand the role of the urban context (central or peripheral locations) in the accessibility perception. In fact, it is interesting to observe that the common trend of increasing the use of soft modes for the daily trips is in decline in Italy. The last national survey on mobility carried out by ISFORT (2011) shows that, notwithstanding the pressure towards more sustainable transport modes, the percentage of trips made on foot and by bike have decreased from the 26% to the 21% from 1991 to 2011. The users less inclined to use soft modes are the men (18%), those from 20 to 45 years old (14%), the self-employed workers (14%), and the residents in cities having less than 20,000 inhabitants (16%). The missing data in the Italian survey, unlike from other European surveys (Gehl Architects, 2004), are those related to the average time to accede to services; this prevents to reach conclusions on the pedestrian and cycle accessibility to the urban opportunities.
Another aspect to consider is the accessibility related to the public transport services, as highlighted by the European Commission in its Green Paper (EC, 2007). Several researchers show the lack or weakness of public transport services as one of the factors increasing social exclusion, mainly for the disadvantaged users (Currie et al, 2009; Litman, 2009; Stanley and Vella-Brodrick, 2009; Currie, 2010). In 2010, the UK Transport Department proposed a measure for the accessibility to the public transport, named PTAL (Public Transport Accessibility levels), based on the access times on foot to stops and stations of the public transport, and on the frequency of the service (Department of Transport, 2010). Since the end of the ‘90s, in Australia, the accessibility to public transport systems has been studied

(Murrey et al., 1998), showing that those systems are accessible if 90% of population can reach a stop within a distance of 400 metres.
In Italy few studies have researched the relation between mobility and accessibility; furthermore, the aforementioned results of the national survey, recording the decrease of the use of soft modes, leads to think about a worsening of the quality of urban space or of the accessibility. The lack of national surveys to understand the reasons of such phenomenon as well as the people habits and perceptions concerning mobility and soft modes, has induced to deepen the accessibility issue through the design of an ad hoc survey to investigate social and psychological aspects of the people behaviour. In fact, while there are several researches in literature analysing the relations between social and psychological variables and the modal choice (Jensen, 1999; Kaufmann, 2000; Garling and Axhausen, 2003; Bamberg et al., 2003; Kaufmann and Jamelin, 2004; Anable, 2005; Flamm, 2005; Flamm and Kaufmann, 2006; Pronello and Camusso, 2011), the relationship with the accessibility is less considered and studies in southern Europe, and notably in Italy, are clearly missing.
This paper aims at studying the effect of the urban context and of the people characteristics on the definition of different accessibility profiles in the metropolitan area of Torino, located in the north-west of Italy. The approach has been to design a survey to collect missing data in order to understand the reasons behind people behaviour and perceptions of people living in different urban contexts. Two main issues have been investigated: a) mobility, travel behaviour (through a travel diary), and car availability and ownership; b) opinions about the accessibility to the workplace and to the urban services. The survey was conducted on a sample of 699 households, including at least one under 16 child, and stratified according to the residence location (city centre, suburbs, and outer city).
The next sections will present the methodology adopted in the survey and data analysis design, and the results of the statistical analysis. Some considerations and comparison with the results of other researches in literature will follow.

THE METHODOLOGY: THE SURVEY AND THE DATA ANALYSIS

The methodology has been set up in a national project on three different Italian cities: Milano, Bologna and Torino, to investigate the relationship between mobility styles and accessibility, as a function of different territorial contexts (city centre, suburbs, and outer city).
The survey was designed to collect all the information useful to define the people mobility, completed by the information on socio-economic profiles and the existence of opportunities in their residential locations, as well as their quality in terms of accessibility. The methodology implies four steps: the definition of the study area, the sample selection, the questionnaire design and administration, and the data analysis.
The first step is crucial to analyze the influence of different urban contexts in terms of accessibility, people's characteristics, and service availability. The city of Torino was divided in three different zones:
- core: the centre of the city;
- suburbs: the near area around the city centre;
- outer city: the area just beyond the city boundaries, covering the territory of the

municipality of Orbassano.

The three zones follow an "axial criterion" as they are located along a "main mobility corridor" on the north-west/south-west axis (Figure 1), characterised by high flows of commuters from the ring to the core (and vice-versa), and where the future metro line 2 will be located (Città di Torino, 2008).

Figure 1 – Study areas of the metropolitan area of Torino

Survey sample selection and questionnaire design

The sample of interviewed people comes from families living in the three aforementioned areas having at least one under sixteen child. This last criterion was adopted to consider the influence on the mobility of family needs, notably of children without car access and with limited autonomy in daily trips.

The data collection was designed through a survey administered according two different approaches: a Computer Aided Telephone Interview (CATI) and on-site interviews using paper questionnaires. The second approach followed the CATI in order to increase the number of respondents and target the sample size of 700 people. A total of 699 persons were interviewed, as shown in Table 1.

Table 1 - Interviewed sample

Area		Number of interviewed persons through CATI	Number of interviewed persons through paper questionnaires	Total
Core	City centre (Torino municipality)	142	54	196
Suburbs	S. Rita neighbourhood (Torino municipality)	152	96	248
Outer city	Orbassano municipality	152	103	255
Total		446	253	699

The questionnaire was designed to collect the information useful to test two hypotheses:

– if the urban structures influences the presence and specificity of the opportunities;

– if the location of the residential areas and of the opportunities, together with the accessible mode of transport, influences the mobility styles, the accessibility to the opportunities and, hence, the urban and social inclusion.

The questionnaire was structured to investigate seven main issues:

1. family composition: number of members with related age and gender;
2. occupation: typology, location, working hours;
3. opinion on accessibility to the job location;
4. opinion on accessibility to the services;
5. daily mobility collected through a travel diary: all the trips in a typical working day, transport modes used to get to each service and the related travel time;
6. availability of transport means: numbers and typologies of cars, bicycles, driver licences and public transport passes in the family;
7. socio-economical characteristics of the family (e.g. income).

Opinions on accessibility were collected using an eleven point (0-10) Likert scale (Likert, 1932). This choice is due to the natural tendency of respondents to use a 0 to 10 scale and is common in several other applications (ISO, 2003).

The data analysis design

The mobility styles and the levels of accessibility to opportunities and work have been studied using different statistical methods, according to the variable typology. Furthermore the analyses have taken into account key indicators, used to assess in depth the reasons behind people residential and mobility choices:

– average duration of the daily trips (minutes) to each kind of opportunity, according to the more frequently used mode;
– average number of daily trips by each mode, opportunity and area (residential or external);
– opinion on the level of accessibility to the different opportunities (scale 0-10).

The data base is made up by 242 variables of different typology: numerical (travel time, age, frequencies, etc.); qualitative multinomial (occupation typology, residential area, transport mode, etc.); binary (yes/no); quantitative on scales 0-10 (Likert scales).

The qualitative variables have been studied by means of the analyses of frequency and test of independency χ^2 on matrixes containing frequency data.

The numerical and categorical variables have been investigated through the analysis of variance (ANOVA) and the multiple linear regression.

For the joint study of numerical and qualitative data, the analysis of correspondence, the factor, and the cluster analysis have been adopted.

While several sophisticated clustering methods (Bock, 1996, 1998; Janssens et al., 2007; Sohn and Yun, 2009; Cools et al., 2009) have proven to be useful in a research context, the transport policy analyst could have some difficulties in readily using them, at least as far as they are not implemented in the most commonly used statistical software packages. The aim is therefore to use an alternative method to define segments aside the ‘‘standard’’ cluster analysis while keeping the complexity of the analytical procedure at a reasonable level, therefore providing a tool which is more readily usable in a decision-making process. We will then assess the potential of a multivariate analysis technique which has been little used in travel behaviour studies, namely correspondence analysis (Benzécri, 1992; Greenacre, 1984,

2007, Diana and Pronello, 2010). Correspondence analysis is an interdependence statistical technique that can portray the ‘‘correspondence’’ of nominal variables by representing their categories in a single plot. It is then a non parametric approach that in a sense generalizes factor analysis, by allowing the researcher to treat those nominal variables which are commonly encountered when considering the self-related evaluations.

The main strength of correspondence analysis is its capability of representing categorical variables. By contrast to other methods used to interpret such data, it does not assume any underlying theoretical distribution (BMDP, 1992). Therefore this is a model-free method where the data are not subjected to any restrictive assumptions. It is also readily available in virtually any statistical software package. Beyond those benefits of correspondence analysis over other clustering techniques on technical and statistical grounds, another advantage also comes at the stage of the interpretation of the analytical outcomes, when some policy implications must be drawn.

After a descriptive analysis of the sample to go in depth into mobility and life styles, users' profiles have been described with the aid of factor analysis, allowing to define the latent factors on which the cluster analysis has individuated the groups of individuals having similar attitudes towards accessibility.

In order to assess the presence of "unobserved" or "latent" variables influencing the perception of accessibility, an EFA has been performed. Cronbach's alpha coefficient allowed a first appraisal of the internal consistency of the items included in the factor analysis and provided satisfactory results, always greater than 0.71. The Shapiro-Wilk normality test was applied and showed that data are not-normally distributed. All the measures conducted to assess test reliability and sampling adequacy allowed us to proceed with the application of the factor analysis. Principal Axis Factor (PAF) extraction method was performed through the software BMDP (BMDP, 1992). The advantage of PAF is it entails no distributional assumptions, most appropriate in this case of not-normally distributed data (Betz and Fassinger, 2011). The number of factors was chosen through the scree test, jointly used with the Kaiser criterion of computing the "eigenvalues" for the correlation matrix, thus avoiding eventual distortions in the results (Fabrigar et al., 1999). Factors were later rotated to obtain a simple interpretation, the oblique rotation being preferred as it permits correlation among factors. In case the factors structure includes orthogonal factors, a successful oblique rotation provides estimations of the correlations among those factors close to zero and produces a solution quite similar to that obtained by a successful orthogonal rotation (Fabrigar et a., 1999). Like in Wall's work (Wall et al., 2007) the oblique rotation was preferred, confirming a certain degree of correlation among factors.

The identification of the factors allowed us to consider new variables upon which to base the subsequent cluster analysis. The score for each person was calculated as a summated scale of the standardized variables forming each factor. The result was an indicator of the global opinion of each respondent to correlated items, and could be considered as a sort of attitudinal test towards the perception of accessibility. These multi-dimensional attitudes were used to segment the sample, using k-means cluster analysis.

Hierarchical clustering and k-means clustering are suitable for continuous data (Everitt et al., 2001); it provides a tool which is more readily usable in a decision-making process and it has been often used in previous researches. To support the choice, however, the cluster analysis was carried out on the whole sample of the three cities (Torino, Milano and Bologna) and on

three different subsamples (the three single metropolitan areas), varying from 3 to 4 cluster solutions. It has been interesting to observe that a strong stability of the solution was referred to 3 clusters, the same number found for each single metropolitan area. Finally, the F-like-ratio was used to indicate the relative importance of the factors in determining clusters and support the final choice.
Such clusters have been further analysed to understand if the individuals in either group are different in terms of mobility behaviours and personal characteristics. All the trips were analysed (in terms of frequency, typology, and duration) with a focus on trips to work. In such a case the Independency Test on categorical data and the ANOVA on cardinal data, aimed at defining differences in terms of travel habits of the residents in the three areas, were used.

RESULTS

The survey has allowed to define the mobility profiles of the interviewed sample as well as its perception of the accessibility both to opportunities and to the workplace.
The sample is made up by 38% men and 62% women, with an average age of 43 (from 23 to 73 years old). One parent households amount to 5.5%, similar in all the three areas, while those with three (37%) and four members (49.4%) make up 86% of the total. In average there are two children per family, with slight differences amongst the zones.
85% of interviewees are employed (43% white collars) while 8% are housewives and 4.3 % are unemployed (the remaining 2.7% is in maternity leave. sick leave or receives redundancy payments). White collar employees (about 20%) live mainly in the city centre, 25% versus 8.6% in the outer city. The educational level is above the average, with 33% holding a university degree and 47% a school-leaving certificate. People with the highest educational levels live mainly in the city centre: 76% of interviewed household living in the city centre boast a high educational level versus 22% living in the outer city (Orbassano), showing how this variable plays an important role in the residential choices. If combining the occupational with the educational status to calculate the index expressing the socio-economical status, it can be concluded that against 47% of families with a high socio-economical status living in the city centre, a 17% with the similar status live in the outer city. On the contrary, 26.6% of families with a low socio-economic status live in the outer city, versus 9.3% in the city centre. Concluding the description of people characteristics, a last interesting issue regards the income, even though several missing data affect the results. The average monthly income is about 4,000 Euros (5,700 in the city centre, 2,900 in the suburbs and 3,400 in the outer city).

Mobility habits and behaviour

Considering car ownership, we observe that 58.5% own two cars, while 38% only one car. The average figures change when considering the individual areas; in fact, in the outer city the percentage of families owning two cars increases significantly (72%) while no-car households range from 3.5% in the centre to barely 0.2% in the outer city. The car fleet age is quite low (4-5 years old), without differences in the three areas. Petrol is the most used fuel (more than 50%), followed by diesel (35%) and GPL (15%, higher than the national average value). The low-powered cars are the majority (44.1%) versus only 5.2% of high-powered cars that are

more present in families living in the city centre (12%). In 80% of the households at least two members hold driving licences and, crossing this figure with the number of motorized vehicles in the family, 75% of persons holding a driving licence have access to, at least, one vehicle. Concerning public transport passes, 25.5% of families have one or more passes. In fact, speaking about modes other than the motorized vehicles (public transport and bike), 81% show the availability of such modes. The survey shows an average ownership of transport means, expressed by the following figures per household: 1.5 cars, 0.2 motorcycles, 2.9 bikes, 1.9 driving licences, 0.3 passes. Differences amongst the zones are not significant, even though the number of motor vehicles is higher in the outer city against a lower number of passes. The availability of transport means, however, does not imply that they are used. Thus, it is important to understand the travel behaviour of the sample and the effect of the residential location on it.

The interviewed sample shows that 63.8% of employees work in the municipality where it lives. But the percentages change considering the three areas; in fact, the 73% of households living in the outer city versus the 16% of those living in the city centre commute towards other areas. The mobility patterns are made clear from the travel diaries related to the typical working day. The maximum number of trips during the day is equal to 10 and very few individuals make none or only one trip (0.7%). The analysis by area, carried out with the χ^2 test, shows a relationship between the number of trips and the residential area. The highest level of mobility is recorded in the outer city (municipality of Orbassano) with an average from 2 to 4 trips per day. However, the same average is recorded in the city centre and in the suburbs. The first trip of the day is usually devoted to get to work (49.5%) and to visit someone (40.6%); the work prevail also as purpose for the second trip. Analysing the daily trip chain, we can observe that the most used mode is the car as driver for any trip typology, while people travel on foot mainly for recreation/sport and shopping in general. Public transport is more used for health reasons. Bike is little used for any reason.

The analysis of variance has showed a difference amongst the travel times of the residents in the three different areas. with residents in the outer city showing the highest figures for time spent travelling (74 minutes). A correlation analysis and an ANOVA have been conducted between the total daily travel time and the number of trips. The ANOVA showed how the total travel time statistically increases with the number of trips, but no difference between the three areas is recorded. Less intuitive are results regarding the longest trip in the day as related to the total number of trips and to the residential area. The longest trip is 27 minutes in average per each user group and each zone, apart from the number of trips made during the day.

Accessibility to work and to opportunities

Accessibility analysis has been focused on pedestrians walking (walk-ability) to get to work and to opportunities.

The workplace ranks among the hardest to get to. This implies that the residential location is no longer chosen as a function of the job location and often is far enough to require the use of modes other than foot. Only 33.4% of the sample can get to work on foot employing 12-15 minutes. Over half of the sample using public or private transport take an average time to get to work of about 20 minutes; 30.7% take 40 minutes and 13.4% longer than 40 minutes.

Living in the city centre is preferable as 41% of residents can get to work on foot against 24.6% in the suburbs and 20% in the outer city. Those unable to travel on foot use mainly a motor vehicle (51.3% the car and 4.6% the motorcycle), while only the 10.7% go by public transport and 2% use the bike.

The analysis of the accessibility to the opportunities has considered 14 different services grouped in six typologies: commercial services (supermarket), health services (pharmacy and ambulatory, family doctor), educational/school services (crèche, primary and secondary school), public services (post office and library), public transport services (stops and stations), services for leisure time and recreational activities (parish youth club, church, park or public garden, sport facilities and fitness centre). The questionnaire investigated accessibility on foot and results show that more than 90% of households can walk to such services from their house. Slightly lower (82-88%) is the figure for sport facilities, the library, the crèche, and the family doctor, while the railway station can be reached on foot by just 33% of the respondents. The high accessibility to opportunities is similar across the three areas; in fact, except for the post office and the railway station, peripheral areas show even higher accessibility than the city centre and the outer city. Notwithstanding the good accessibility on foot, the people behaviour shows that users prefer definitely to use the car to get to the opportunities and even more in the outer city where the public transport supply is lowest. As for work trips, women use the car less and rely on public transport more often than men (8.6% versus 3.9%). Walking is the most frequent choice when the distance does not exceed five minutes; for longer trips car becomes the preferred mode.

Time-wise, it is interesting to observe that the most reachable services are the public transport stops as 89% of respondents take five minutes to reach them, while the railway station remains the most difficult to access (about 40 minutes).

An analysis of correspondence has been conducted to highlight eventual correlations between services in terms of their accessibility perception. A map of service profiles has been built in a multidimensional space, with the aid of BMDP software (BMDP, 1992). As said, the assessment of services accessibility was expressed on a 0-10 Likert scale; to make the analysis of correspondence feasible, variables have been classed in three groups: low accessibility (score ≤ 3), medium accessibility (score ≥ 4 and ≤ 6), high accessibility (score ≥ 7). Usually, the optimal number of factors was attained when the value of inertia is equal or greater than 90% (BMDP, 1992); in our case the first axis reached the 81.3% of inertia, so that a second axis was not deemed necessary: that would have increased marginally the inertia, compromising the results readability. In Figure 2 the variables charged on the only factor are represented; at the negative part of the axis the services having a high accessibility can be observed: public transport stops, pharmacy, church, park, supermarket, elementary school, parish youth club, crèche. Instead, on the positive side of the axis, services with medium-low accessibility do appear: secondary school, family doctor, gym, post office, library, job, railway station.

The correspondence analysis has been conducted for each residential area. Figure 3 represents on a unique axis both distributions of service typology and accessibility level. The level of correlation is the product of the distances from the centre of the variables; if the variables are very close to "0", the level of correlation will be low. In case of some services are close to"0", but also close the "high" value, the variables are averagely correlated with a high level of accessibility, but have such a dispersion that they cannot be considered highly correlated.

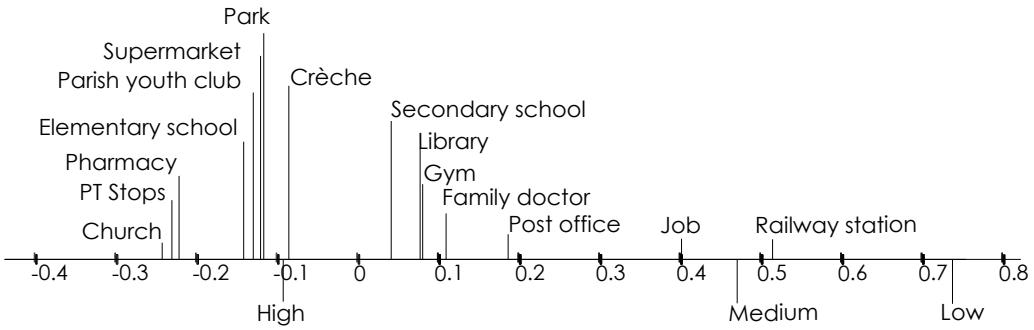

Figure 2 – Analysis of correspondence: profiles' map

In case of Torino suburbs and Orbassano the high correlation between railway station and a medium-low level of accessibility is clear because both variables are very close each other and far from the origin of the axis. For the same reason the other services (e.g. schools, supermarket, PT stops, etc.) are weakly correlated with a high level of accessibility. The same happens for the city centre, even though with different intensity and the railway station shows a weak correlation with a low level of accessibility.

The next step has been to use the ANOVA to check if the perception of accessibility to services is influenced by the time to get to them on foot and if this is different as a function of the opportunity typology. The ANOVA shows how the opportunities are perceived as accessible on foot, but differently in accordance to their typology ($p<0,01$). Thus, the work is perceived as accessible on foot if the time taken does not exceed 17 minutes, while the pharmacy is accessible if the time on foot is about 5 minutes (fig. 4).

A more detailed analysis of the accessibility to work has been carried out, as this is the place people travel to with the highest frequency. The time needed to get to work is different in function of the used transport mode. Trips by public transport are the longest ones: about 49 minutes by bus and 58 by train, while the time decreases to 24 minutes by car. People getting to work on foot take in average 18 minutes. A deeper analyses of respondents who declared that their workplace was accessible on foot has been conducted Three different ANOVAs have been conducted between the transport mode effectively used to get to work and: a) the assessment of accessibility to jobs (fig. 5), the time perceived to get to work on foot (fig. 6), and the time taken to get to work with the preferred mode (fig. 7).

The scores of accessibility are quite high (fig. 5), but non-significant in function of the used mode ($p<0.05$). The generalised high value of accessibility is high because, probably, everybody choose the mode to get to work that maximises their accessibility. In addition, the mode effectively used to get to work, by people perceiving the work accessible on foot, affects the perception of the time taken to get it on foot. In fact, those using public transport declare an average time to get to work on foot of about 35 minutes, while, car users declare an average time of 20 minutes (fig. 6). This means that car use is not dependent on the distance, even because 20 minutes on foot are not a high amount of time, and that the public transport users perceive as accessible a wider area, in terms of time and distance, as regards the car users. Probably this is due to the higher times public transport users are prepared to accept in order to reach their destinations; that often includes waiting time at stops, transfer time between lines, and time on foot to reach the stop and the final destination.

However, people using public transport take longer than those using other modes (fig. 7) and assign the lowest scores to accessibility to work (fig. 5).

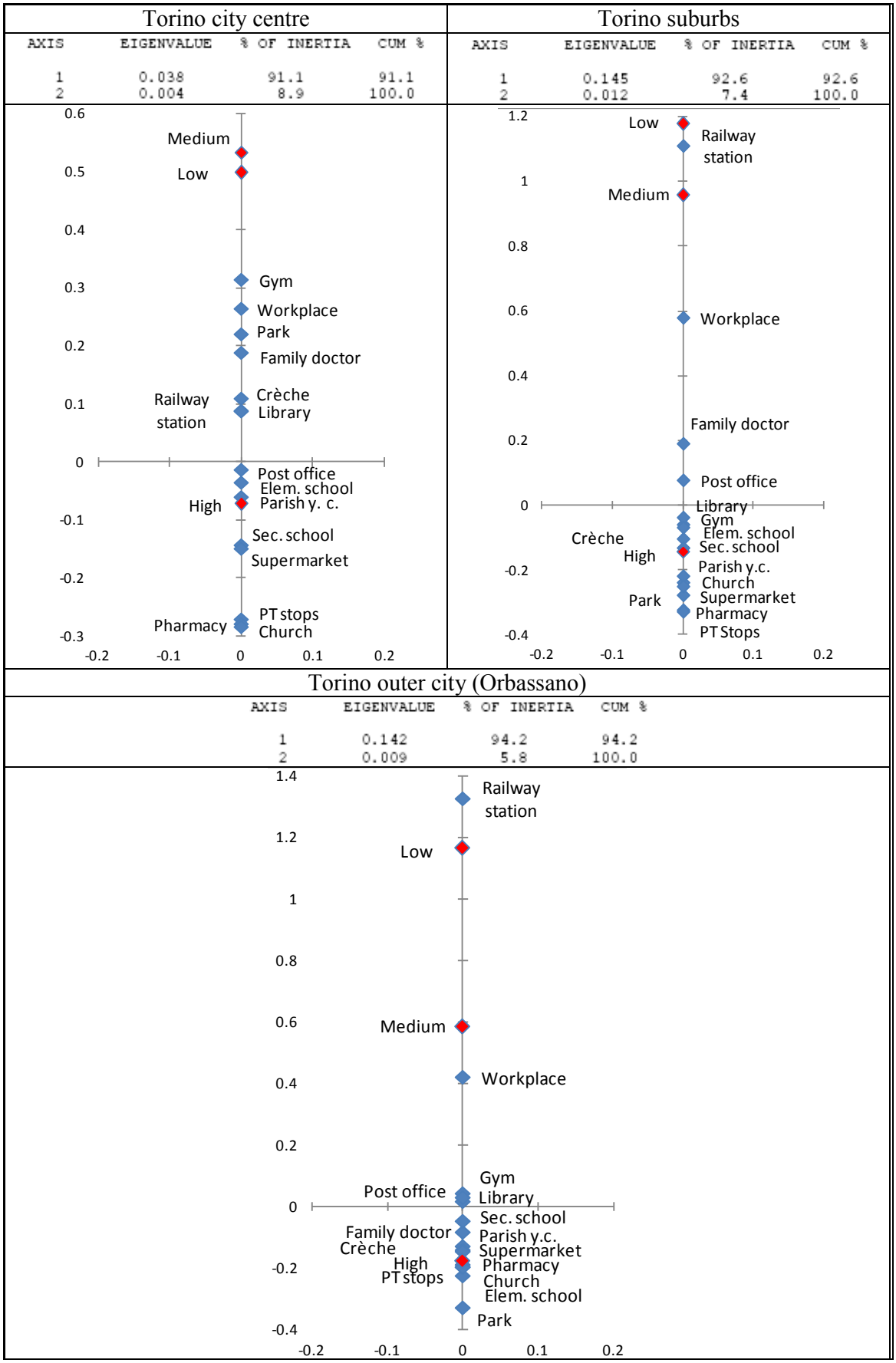

Figure 3 – Correspondence analysis: accessibility versus opportunities

In figure 7 we can observe the distribution of the transport modes effectively used to get to work and the related travel time, as stated in the travel diary. Comparing the results of figure 6 and 7, it can be concluded that the time perceived to get to work on foot (10.78 minutes, fig. 6) is very close to the time reflected in the travel diary (9.98 minutes, fig. 7). In addition, it seems that people choose the mode allowing to halve the time to get to work as related to the time perceived to go on foot:

- who uses the car declares to spend 10 minutes by car (fig. 7) and declares 20 minutes on foot (fig. 6);
- who uses the bike spends about 10 minutes and perceives 20 minutes on foot;
- who uses the public transport takes 22 minutes and perceives 38 minutes on foot.

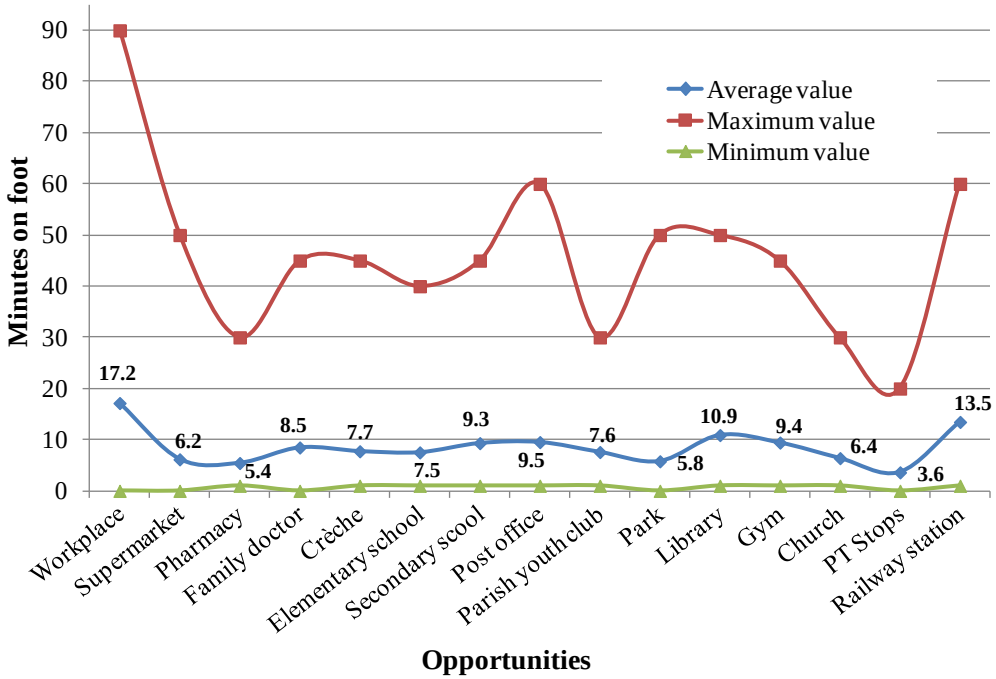

Figure 4 – Distribution of the access time on foot Vs opportunities

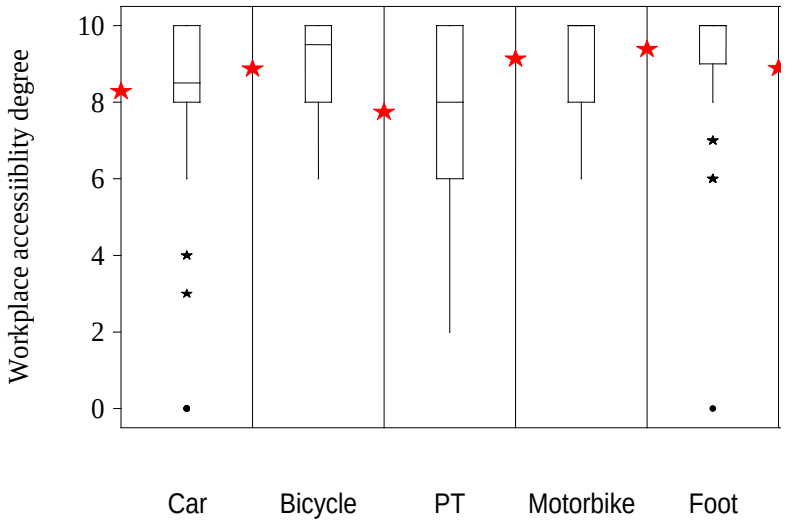

Figure 5 - Distribution of the accessibility score in function of the used mode

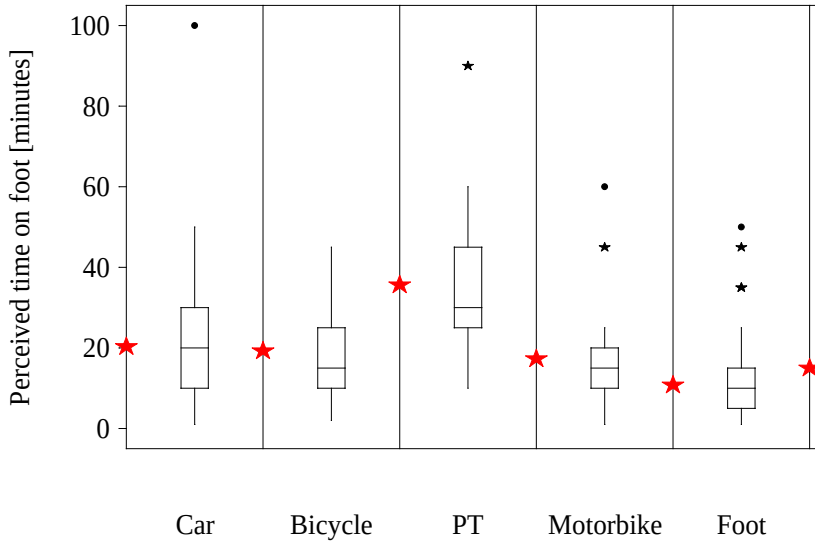

Figure 6 – Accessibility to work: perceived time to get to work on foot versus transport mode used

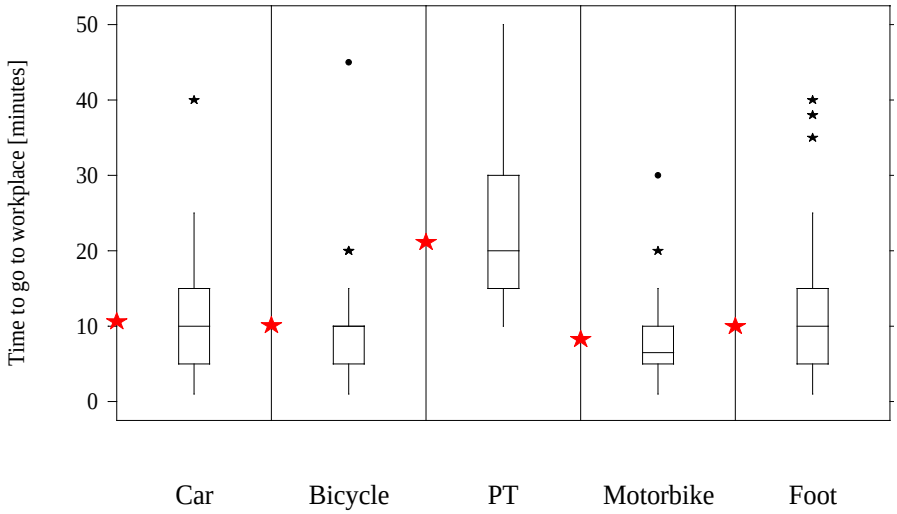

Figure 7 – Travel time to work and mode effectively used to get it

The group of people declaring the work accessible on foot has been further divided in subgroups in accordance to the mode effectively used to travel to work, as stated in the travel diary. Correlation analyses between the score of the accessibility to work and, respectively, the travel time to work with the preferred mode, and the time perceived to get to work on foot have been carried out. The results are shown in table 2 and prove that:

- the correlation between the accessibility score and travel time on foot exists only for those getting to work on foot;
- the correlation between the accessibility score and travel time perceived to get to work on foot exists only for those getting to work by car or bike;
- for people using public transport, a correlation exists between the accessibility score and both travel time by public transport and the time perceived on foot;
- for people using the motorbikes no significant correlation has been found.

Those results allow to argue that the "concept" of accessibility cannot be univocally associated either to access time to the opportunity with the chosen transport modes (probably the habitual one) or to the perceived access time on foot. This implies that people do not

interpret in the same way the concept of accessibility and that it should be clearly defined prior to the survey in order to avoid such a risk.

Table 2 – Correlation analysis: accessibility score and travel times

Transport mode to get to work (from travel diary)	Travel time to get to work with the chosen mode (declared in the travel diary)	Travel time perceived to get to work on foot
Foot	**R=-0,201 p=0,043**	R=-0,125 p=0,209
Motorbike	R=-0,367 p=0,085	R=-0,388 p=0,062
Public transport	**R=-0,552 p=0,001**	**R=-0,583 p=0,001**
Bike	R=-0,322 p=0,046	**R=-0,697 p=0,001**
Car	R=-0,024 p=0,783	**R=-0,238 p=0,002**

The accessibility profiles

As explained in the methodology, an Exploratory Factor Analysis (EFA) with oblique rotation allowed to define the latent factors on which the clusters have been defined. The set of variables used to carry out the EFA is presented in table 3 and has grouped in three classes:

- variables regarding the household composition;
- variables regarding the accessibility opinions to opportunities, measured on a Likert scale from 0 to 10;
- variables regarding the trips as obtained from the travel diary.

Table 3- Variables used in the factor analysis

Groups of variables	Label	Description of the variable
Variables regarding the household	TotFam	Number of members of the family
	Tot_figl	Number of children
Variables regarding the accessibility judgements to opportunities	AccLv	Accessibility to work
	AccSup	Accessibility to supermarket
	AccFar	Accessibility to pharmacy
	AccAmb	Accessibility to family doctor
	AccNid	Accessibility to crêche
	AccEle	Accessibility to elementary school
	AccMed	Accessibility to secondary school
	AccPos	Accessibility to post office
	AccOra	Accessibility to parish youth club
	AccPar	Accessibility to park
	AccBib	Accessibility to library
	AccSpo	Accessibility to sport facility
	AccChi	Accessibility to church
	AccTP	Accessibility to public transport stop
	AccFer	Accessibility to railway station
Variables regarding the trips (travel diary)	TempSp1	Duration of the first trip [minutes]
	TempSpos	Duration of all the trips during the day [minutes]
	TemLavDi	Duration of the work trip [minutes]

According to the methodology, three factors have been found. In figure 8 those three factors and the loadings of variables on the factors are shown.

The first factor is made up by the variables measuring opinions on accessibility to the opportunities, and is labelled as “accessibility to services”.

The second factor includes the variables related to:
– the time to get to the work;
– the duration of the first trip;
– the duration of all the trips during the day;
– the judgement of accessibility to get to work;
and is code-named "accessibility to work".
The negative sign of the loading of the last aforementioned variable is consistent, since as travel times increase, the accessibility score decreases.
The last factor is made up by the variables related to the household size and the number of children and has been code-named "Household".

	FACTOR1	**FACTOR2**	**FACTOR3**
	Accessibility to services	***Accessibility to work***	***Household***
AccOra	0.814	0.000	0.000
AccEle	0.805	0.000	0.000
AccChi	0.800	0.000	0.000
AccMed	0.799	0.000	0.000
AccFar	0.713	0.000	0.000
AccNid	0.703	0.000	0.000
AccBib	0.680	0.000	0.000
AccPos	0.657	0.000	0.000
AccSup	0.625	0.000	0.000
AccPar	0.611	0.000	0.000
AccTP	0.610	0.000	0.000
AccAmb	0.583	0.000	0.000
AccSpo	0.530	0.000	0.000
TemLavDi	0.000	0.969	0.000
TempSp1	0.000	0.787	0.000
TempSpos	0.000	0.501	0.000
Tot_figl	0.000	0.000	0.983
TotFam	0.000	0.000	0.935
AccFer	0.401	0.000	0.000
AccLv	0.000	-0.401	0.000

Figure 8 – Factor analysis: loadings of the rotated solution

The three factors above were the basis to form homogeneous clusters. To this extent, each factor assumed the value obtained adding those of the variables making it up. Thus, factors were measured by a quantitative score ranging from 0 to 140 for factor 1; from 0 to 40 for factor 2; from 0 to 20 for factor 3 and, then, standardized for the successive analysis, since the variables range in different intervals.
The cluster analysis allowed to define three groups of people showing significant differences (fig. 9).

	Fac1Sum	Fac2Sum	Fac3Sum
	Accessibility to services	*Accessibility to work*	*Household*
MEAN SQUARES			
BETWEEN	13156.523	154.583	202.761
WITHIN	18.182	4.045	3.221
D.F.-S	2, 396	2, 594	2, 643
F-RATIO	723.614	38.218	62.943
P-VALUE	0.000	0.000	0.000

CLUSTER PROFILES - VARIABLES ARE ORDERED BY F-RATIO SIZE

Accessibility to services ---1-- -----2----- ---3---
Accessibility to work ---------1--------- -------2-------- --------3---------
Household ----------1---------- --------2------- ----------3----------

Figure 9 – Clusters representation and clusters' profile plotter

It can be observed that the first factor (accessibility to services) is the one affecting the group characterisation (F-ratio value in fig. 9); in fact the second cluster shows the lowest scores on accessibility to the opportunities.
The analysis of the three clusters highlight how Cluster 1 is integrated mainly by users living in the suburbs, while Cluster 3 includes people living in the outer city (Orbassano). Cluster 2, instead, is quite evenly composed by people living in the three areas (fig. 10).

	AREA			
CLUSTER	Torico centre	Suburbs	Outer city	TOTAL
1 *Satisfied suburbanites*	92	129	96	317
2 *Insatiable clans*	26	27	37	90
3 *Resigned commuters*	64	72	103	239
TOTAL	182	228	236	646

Figure 10 – Distribution of the people per cluster in function of their residential area

The main transport mode to get to work, in all the clusters, is the car. However, Cluster 2 is the one relying less on public transport and the soft modes (bike, foot). Walking is uniformly distributed across the clusters, ranging from 11 to 13% (fig. 11).

	Used transport mode to go to work (ModLavDi)					
CLUSTER	Car	Bicycle	Public Transport	Motorbike	Foot	TOTAL
1 *Satisfied suburbanites*	179	14	39	6	34	272
2 *Insatiable clans*	53	3	6	4	8	74
3 *Resigned commuters*	147	7	25	3	25	207
TOTAL	379	24	70	13	67	553

Figure 11 - Distribution of the people per cluster in function of the mode used to get to work

A deeper analysis of clusters in terms of socio-economic profiles shows statistical differences are not obvious in terms of age, income and number of daily trips ($p>0,05$), while those differences become more significant in what regards the daily total time devoted to travel and the time for the trip to work ($p<0,05$).
Figure 12 highlights the distribution of the two variables; it is possible to observe that Cluster 3 shows the highest times both for the work trip and the total time for mobility, while Cluster 2 presents the lowest values.
The analyses allow to make the following considerations:

- Cluster 1 is mainly made up by residents in the suburbs, living in medium size households, and assigning high scores to accessibility to opportunities. They mainly use the car to get to work, taking in average 21 minutes. The global time they devote to move, during the day, amounts to about 67 minutes. This group can be coded-named "*satisfied suburbanites*";
- Cluster 2 is formed by bigger households residing in all the three areas (city centre, suburbs, and outer city). They declare a low accessibility to the opportunities, even though they record the lowest travel time to get to them. In fact, they declare a lower travel time to work (about 13 minutes) and a lower daily time devoted to mobility (about 41 minutes). They can be referred to as "*insatiable clans*";
- Cluster 3 is made up by the smallest households living in the outer city (Orbassano). They declare average scores of accessibility, but show the highest times to get to work (about 25 minutes) as well as the highest daily time devoted to mobility (about 79 minutes). This group can be labelled as "*resigned commuters*".

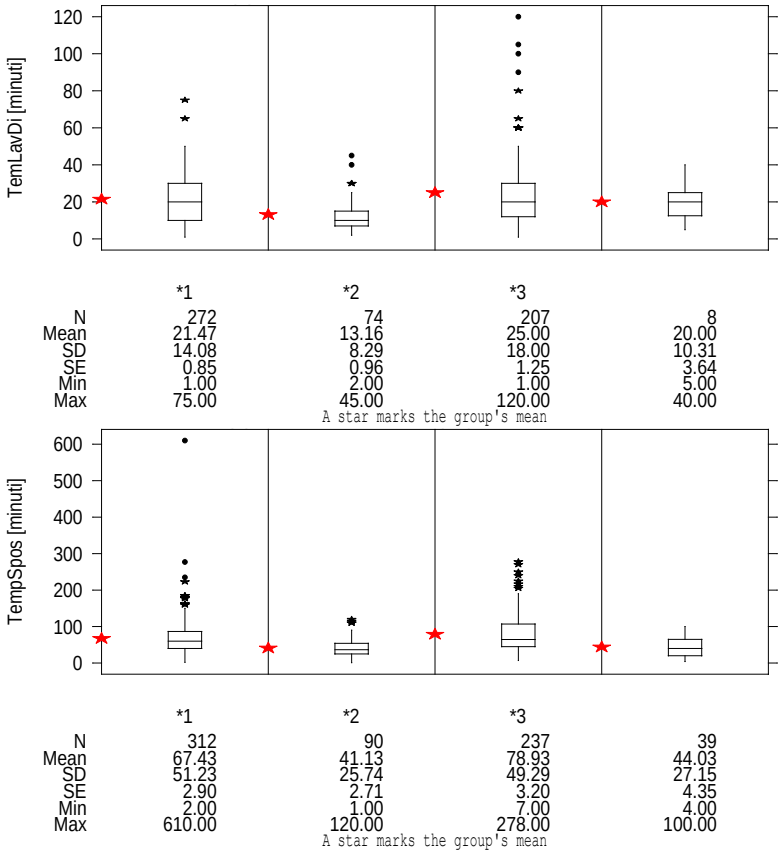

Figure 12 - Distribution of travel time by cluster

DISCUSSION AND CONCLUSIONS

The paper has presented the results of a survey carried out in the metropolitan area of Torino, geared to analyse the relationship between mobility and accessibility. The goal was to understand if the urban structure influences the presence and specificity of services and in which way the joint effect of residential location and access to transport means affects travel behaviour, the accessibility to opportunities and, consequently, the level of urban and social inclusion.

The accepted paradigm stating that the residential location is chosen in relation to the working place (Alonso, 1964; Kain, 1962; Muth, 1969; Brown, 1975) seems outdated in accordance to obtained results. The theories (Martinotti, 1999; Schwanen et al., 2001; Stead and Marshall, 2001; Naess and Jensen, 2004; Naess, 2006) about changes in modern cities seeking an increasing concentration of jobs (mainly management and directive functions) in the central areas of the cities and the housing location in the suburbs, favouring the urban sprawl are, here, partially confirmed. Concerning this issue, it is interesting to cite the theory of Leroy and Sostenlie who, in 1983, presented a model relating urban residential patterns to the availability of a fast transport mode, cheap enough to be used economically by the rich but too costly for the poor. They showed that when "*such a mode exists (paradise lost), the rich live in the suburbs and the poor downtown. When such a mode is not available, either because the faster mode is too expensive even for the rich (paradise), or is cheap enough even for the poor (paradise regained), then the rich live downtown and the poor in the suburbs*"

(Leroy and Sostenlie, 1983, pp. 78-79). This interesting theory was based partly on an historical analysis of the travel and residential patterns in USA. In fact, in the 18th and first half of the 19th centuries, almost all the Americans living in cities worked near the centre and walked to work. The access to private transport means, the carriages, was very scarce and only the very rich owned them. At that time, the carriages were the fast mode of transport, available for few and too expensive for commuting. In that period the rich lived in the city centre and household income declined with the distance to the centre. Thus, when all workers commuted by the same slow but inexpensive mode (walking), the rich lived closer to the centre than the poor. When, in the second half of 19th century, alternative transport modes other than walking appeared, and these modes were, relatively speaking, fast modes, significant effects on residential patterns were recorded and rich citizens started to move out towards the suburbs. When the public transport became more affordable for everybody, the car arrived, replacing the streetcars as a fast mode, and, again, prompting the suburbanization by rich people. The increase in car ownership accelerated the phenomenon that reached the peak in the 1950s and 1960s when, in the American cities, the rich lived on the edges while the poor lived in the centres. This continued up to 1970, when this trend turned around and the rich changed their residential patterns moving back into the city centres, displacing the poor and inducing the re-gentrification of central locations.

The decline of the car costs induced the lower income groups to increasingly move to the suburbs and commute by car. At the same time, the higher income groups returned to the city centres, thus using the car less than those living in the suburbs.

In Italy this trend happened with a certain delay and it is mainly in the last decade that the city centres have again become attractive, highlighting a significant return of the high income people. Torino observed this change at the end of the 1990s when a re-gentrification of the historical city centre occurred and the prices of housing largely increased.

The economical crisis that started in 2008 has changed the scenario: an impressive increase in the cost of gasoline is evident, and cars thus transforming cars over and over into an expensive transport mode.

Leroy and Sostenlie (1983) state that an increase of the cost of gasoline should discourage the re-gentrification, because such a cost bears more on lower income people, who should come back to the city centre. Instead, in Torino, a widespread decrease in car usage has been recorded in favour of public transport, transversally to all the citizens, and the public transport usage has gone up by 3.6% as regards the 2006 (IMQ, 2010). Moreover, and notwithstanding the current crisis, the real estate in the city centre maintains the values and, contrary to what the model of Leroy and Sostenlie (1983) predicted, the increase in gasoline prices is not discouraging re-gentrification of the city centre.

Our survey shows marked differences between areas of residence of the respondents. The most significant difference is recorded between the city centre and the outer city, Orbassano, in terms of educational level, occupation status and income level. It could simply be argued that the city centre hosts the largest part of educated white collar people, while the low-wage citizens live more in the outer city. This seems to confirm theories above; however, mobility demands and transport costs are not the only reason to choose the place for living. In fact, even though for households with children, the location as regards work and services is important, results, nonetheless show that a remarkable difference in the perception of the accessibility to the opportunities is not obvious, and that this is quite high for all the three

different areas. This fact confirms the theories stating that the services of first level and, indeed, some commercial services, have been moved away from the centre, while the opportunities related to the health/medical care and to the recreational activities continue to be more present there (Martinotti, 1999; Schwanen et al., 2001; Stead and Marshall, 2001; Naess and Jensen, 2004; Naess, 2006).

The situation concerning the accessibility to work is, however, different. 63.8% of the employed people work in the municipality where they live, while 73% of families living in the suburbs versus the 16% of families living in the city centre commute towards other areas. Living in the city centre shows an additional bonus, since 41% of residents can get to work on foot against 24.6% in the suburbs and 20% in the outer city. In fact, these last are those showing the largest dependency on the car to get to work.

The analysis of the mobility behaviour confirm the received wisdom related to the increase of daily mobility with even less important differences between gender, occupational status, income levels (Mogridge, 1985; Newman and Kenworthy, 1989; Næss et al., 1995; Fouchier, 1998; Schwanen et al., 2001; Stead and Marshall, 2001; Næss and Jensen, 2004; Colleoni, 2008). In fact, the mobility patterns have shifted over the years thus becoming:

- shorter: few kilometres travelled;
- more frequent: several trips per day that amount to more than one hour for 46% of respondents and more than 1.5 hours for 11.2% of them;
- different in terms of scope: more trips are unrelated to work, but rather, for family care and recreation;
- outspread: the residents in the suburbs are those travelling more and to different destinations, not necessarily towards the city centre.

Again, theories arguing that the territorial mobility affects mainly the suburban areas and their population (Mogridge, 1985; Newman and Kenworthy, 1989; Naess et al., 1995; Fouchier, 1998; Mo.Ve, 2005) are confirmed. However, the ownership of transport means is a transversal characteristic to all the respondents, apart from the residential location and their socio-economic characteristics. Furthermore, the average age of car fleet is low, confirming that households consider it is worth to invest in mobility. The difference in mobility styles is more related to gender; women favour work locations close to home, so that they can get to it on foot. However the use of car is transversal to the gender, unlike the motorbike, preferred by men. Public transport, instead, is favoured by women who show more fragmented and complex mobility patterns across the day as they travel to meet different needs: children care, home care, work. The large households opt for the car to carry out the daily activities and make more and longer trips when they have children over five years of age.

The residential location becomes significant as regards car usage. In fact, while car ownership is high in all the three areas, its use is greater in the households living in the outer city. People living in the city centre show more reliance on motorbikes and bikes.

What is, arguably, counterintuitive is that the number of trips and total travel time is not necessary related to the perception of the accessibility to opportunities and work.

Looking at the results of the cluster analysis, it can be observed that the largest households, even though they present the lowest travel times both to opportunities and to work show the poorest opinions on accessibility. The households size plays an important role in accessibility perception. In fact, the complexity of the daily organization of a multi-children household strongly affects the perception of the accessibility, even though they spend less time to travel;

furthermore, this is not related at all to the residential location (city centre, suburbs or outer city), as this group (*insatiable clan*) is present in all the three areas. Furthermore, the most unsatisfied respondents often live in the city centre.

Broadening the analysis of the clusters, it can, likewise, be observed that the majority of the respondents belonging to the "*insatiable clan*" (Cluster 2) show a high educational level as well as a high level occupation. Those have, on average, more children than any other respondents, boast a more articulated organization of the daily life, a more complex mobility, and, above all, higher expectations and claims as regards the accessibility. Of course, the relation between mobility and accessibility has been confirmed: the fragmentation of mobility and the high number of trips – typical of larger households, having several interests and a socio-economic status high enough to undertake several activities during the day (further than work, care of children and house) – negatively affect their views on accessibility. This aspect cuts across the choice of the residential location, showing that the aforementioned theories (and notably that of Leroy and Sostenlie, 1983) are insufficient to explain the real choices that are even more influenced by attitudes, perceptions and expectations related to the desired quality of life.

The modern society, more and more affected by new standards of life promised by the new technologies, shows higher expectations in terms of enjoyment of opportunities and demands them quickly and easily. This evokes the personal rapid transport systems with flying glass pods from the Jetsons, but it clashes with the possibilities of the current transport systems. It clashes also with the insatiable attitude of people never perceiving accessibility at the height of their expectations. Our results seem to highlight this issue as the perception of travel times, both for people living in the centre or out of it, is not related to the effective time spent in travelling, but to the several activities they carry out during the day. And the more these activities are numerous, because fragmented, the more people complain, feeling dissatisfaction towards the transport means that guarantee access to them.

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