The impact of transportation demand management policies on commuting to college facilities: a case study at the University of Trieste, Italy.

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Abstract

Universities, like other types of public and private institutions, when located in a city, have both positive and negative impacts on the area where they are situated. On the one hand, they contribute to the prestige of the area; on the other hand, they are large generators\attractors of traffic. The ability to successfully balance the pros and cons of the urban location of these large traffic-generating institutions is crucial for their success and for the livability of the city. In this paper this issue has been analyzed selecting as a representative case the University of Trieste.

The aim of the research is to understand: (a) how mode choice decisions are made by the teaching and administrative staff and by the students at the various locations where academic activities take place, and (b) how they would be affected by 8 different transport management policies. It is found that changing the parking regulations (via the annual permit cost, the hourly parking fee, the number of parking spaces and the location of the parking lots) greatly influences mode choice in favor of bus use, especially for teaching and administrative staff and in the suburban locations. The students would be impacted by such changes only if an hourly parking tariff is introduced. The alternative approach of fully subsidizing the bus services would also have a large impact on bus ridership, affecting the mode choice in particular of the teaching staff and in the main university suburban sites.

Since the implementation of these bus-favoring policies could face the opposition either of the university staff or of the bus company, two more balanced policy mixes were tested: the first one, increasing parking price and imposing new parking restrictions, would increase bus ridership by 19%; the second one, reducing both bus and parking subsidies, would increase bus ridership by 13%.

Keywords: modal choice, commuters, parking pricing, transit subsidies

1. Introduction

Italian cities suffer from severe traffic congestion and air pollution. Vehicles' speed in major city centers is about 15 km per hour, dropping to 7-8 km during peak hours (Confcommercio, 2012, p. 3). In 2010, the PM_{10} average daily concentration limit beyond which it is necessary to adopt traffic restrictions was exceeded, on average, 45 days (Istat, 2012, p.9), while the violations of the noise pollution limits rose from 42.8% in 2009 to 57.2% in 2010 (Istat, 2011, p.13).

In 2011, 30% of the trips made within urban areas were due to people commuting to their place of study or work. Although these trips are generally short (41% of them are less than 2 km and 49% between 2 and 10 km), only a small percentage of them are made by public transport. In fact, 37% of short distance trips (less than 2 km) and 70% of medium distance trips (between 2 and 5 km) are made by private vehicles and only 12% by public transport. Similarly, long distance trips are made mostly by private vehicles (74%), while only 15% of them are made by public transport (Isfort, 2012a, p. 60). The striking strong preference for private transport is further testified by the very high motorization rate characterizing Italian cities. In 2010, the rate was equal to 615 cars per 1,000 inhabitants, with 10 towns having more than 700 cars per 1,000 inhabitants (Istat , 2011, p.15).

A university located in an urban environment, like other types of public (hospitals, courts, schools, administrative offices) or private (shopping centers, banks, headquarters of large firms) institutions, has both a positive and a negative impact on the surrounding area. The positive one is that it contributes to the prestige of the area. Bars, shops and other commercial and professional activities benefit from its presence. Apartments and houses gain in attractiveness and increase their value. In fact, in Italy most of the urban revitalization policies are based on using historical buildings located in the city center for university activities. The negative one is that it is a large generator\attractor of traffic[1]. Although public transport (mostly bus transport) is in Italy normally available and of good quality, students and employees generally prefer to use the car, the motorbike or the bicycle.

The ability to successfully balance the pros and cons of the urban location of a large traffic-generating institution is crucial for their success and for the livability of the city. An alternative solution would be to locate it in a suburban area: on the one hand, it would alleviate congestion and pollution in the city center but, on the other hand, it would negatively impact the attractiveness of the inner city and, due to the reduced parking constraints and the usually more difficult accessibility via public transport, would further shift the modal split towards the private car.

In this paper this issue has been analyzed selecting as a case study the University of Trieste. Trieste is a city located the northeast of Italy, close to the Slovenian border. The University of Trieste represents an interesting case study because it is organized over 7 locations in different areas of the city: 3 in the historical city center (Via Lazzaretto Vecchio, Via S. Anastasio\ Via Filzi and Ospedale Maggiore), 2 in the semi-periphery (Piazzale Europa and S. Giovanni) and 2 in the outskirts of the city (Via Valmaura and Cattinara).

Currently, the University of Trieste provides its employees (administrative and teaching staff) with a cheap annual parking permit (€40 a year) for the parking lots owned by the university, while the students are not allowed to park in these facilities and must compete with the city residents for the available public parking places. This discriminatory approach, common to many universities, solves (at least partially) the parking problem for the employees, but creates discontent among the students and the residents. Similarly, other institutions such as hospitals, courts or private firms tend to favor their employees (especially managers) at the expenses of the other users. In the case of the students, they react by asking for more parking places or more frequent (and possibly subsidized) bus services, shifting the burden to the city-owned bus companies.

The aim of the paper is twofold: a) to describe the transportation time, costs and mode split between car and bus with respect to each university location; b) to estimate how the modal split would be affected by 8 different transport demand management policies, paying special attention to how they would differently impact employees and students in the different university locations.

[1] The relationship between the built environment and travel is specifically analyzed by Cao et al. (2009).

Since transport demand policies have both efficiency and distributional consequences, having a clearer picture of both these effects could provide the university mobility managers with information useful for their decision making and for overcoming potential acceptability issues.

2. Literature review

Since the transport demand management policies analyzed in this paper mainly concern parking and bus regulation, the literature review is exclusively focused on these two topics.

Charging the parking facilities at the marginal or average cost is the travel demand management policy most frequently suggested for the American universities (Balsas, 2003; Shoup, 2005). Already in 1990, Willson and Shoup showed that subsidizing the cost of parking, regardless of the location of the place of work (central or suburban), the type of employment (public or private) and the type of job (administrative or professional), greatly increases the number of trips by solo drivers. According to Willson (1992, p.144) "between 25 and 34 percent fewer cars would be driven to work if commuters had to pay to park". Verhoef *et al.* (1996) further clarified that parking regulation is more effective if implemented at larger spatial scale, whereas Marsden (2006) underlined that the effectiveness of parking regulation and pricing is greatly affected by trip purpose and availability of public transport. A further important suggestion came from Shoup (1997, 2001, 2005) who showed that "cashing out the employer-paid parking" could reduce single occupant vehicles while increasing the use of carpooling and public transport. Up to now, however, Shoup's suggestion has been only rarely implemented (United States Environmental Protection Agency, 2005).

Numerous studies focus on the price elasticity of parking (Axhausen and Pollak, 1991; Clark and Allsop, 1993; Hensher and King, 2001; Washbrook *et al*., 2006; Watters *et al*., 2006; Hensher, 2008; among the most recent reviews cited are: Litman, 2004; Spears and Handy, 2010). The results, however, differ substantially relative to the charge level, the parking location, the socio- economic characteristics of the individuals (particularly age, income, and number of vehicles owned), the trip purpose and the transport mode typically used to travel.

The debate about the usefulness and efficiency of public transport subsidies is also complex and lacking unanimous conclusions. On the one hand, as recently shown by Parry and Small (2009), the existence of the Mohring effect requires that the operating costs be at least partially financed by public subsidies, on the other hand, the economic assistance guaranteed by the public sector gives rise to X-inefficiencies, which are extremely difficult to be reduced via effective incentive mechanisms (Gomez-Lobo, 2011). Boyd *et al*. (2003), having conducted a survey involving 1,500 students enrolled at the University of Los Angeles, concluded that the public transport subsidization increased bus users by 50% and reduced solo drivers by 9%.

Recently, Barla *et al*. (2012) interviewed 705 employees and students of the University of Laval (Canada) collecting stated preference data and estimated the time and cost elasticities and the implicit value of time for students and teaching and administrative staff. Furthermore, they estimated the reduction in automobile modal share under different policy scenarios and concluded that a policy mix of public transport subsidization, parking pricing and increased public transport speed would reduce the use of private vehicles by 80%.

Two other studies, based on stated preference data collected from employees and students of the University of Eindhoven (van der Waerden *et al*., 2006) and in Israel (Albert and Mahalel, 2006), showed that parking pricing is an effective and politically acceptable policy in order to reduce solo driver vehicles in favor of public transport.

Zhou (2012) collected revealed preference data from a sample of 508 students at the University of Los Angeles. According to his analysis the most important factors affecting the choice between travelling by car and using other transport mode (public transport, carpooling, telecommuting, bike, walking) are the availability of a discounted transit pass and of a long-term on-campus parking permit.

3. Methodology

Building on the line of research described in the literature section and on a research project conducted in 2010 (Rotaris et al. 2012a, 2012b), we interviewed a sample of students and employees at the University of Trieste with the aim of detecting the impact of various parking pricing, parking restriction and bus subsidization policies. To the best of our knowledge, this is the first research conducted in Italy on this topic and on this type of users.

From a methodological point of view, our study is characterized as follows.

- We collected revealed and stated preference data but, differently from the studies previously reported, we used a pivoted efficient Bayesian experimental design, specifically aimed at increasing the realism of the hypothetical choices and the statistical significance of the parameters estimated.
- Instead of using a multinomial or a nested logit model, we used a mixed logit model with error components, allowing us to better control both the nested structure of the choices and the preference heterogeneity of the sample.
- We estimated the mode choice model using both the revealed and the stated preference data but we calibrated the scenario analysis on the individual specific revealed preference data, substantially increasing the estimates' reliability.

The paper continues: explaining how the data were collected and how the experimental design was defined (Section 3.1); describing the sample and the typical travel mode used by the people interviewed (Section 3.2); and discussing the econometric model (Section 3.3). Section 4 reports the scenario analysis, whereas Section 5 discusses the results obtained and the future lines of research.

3.1 Data collection and experimental design of the stated preferences scenarios

The buildings of the University of Trieste are spread out across the city. Each location is characterized by different accessibility and parking facilities. The sample has been selected in order to include students and employees commuting to each university location.

The questionnaire comprised three parts. The first one was aimed at collecting the socio-economic characteristics of respondents: age, sex, number of household members, type of activity carried out at the university. The second part focused on the characteristics of the commuting trip: destination, possible chained trip motives, transport mode, availability of a discounted bus transit pass or of an annual on-campus parking permit, time needed to find a parking place and cost of parking at home, commuting frequency, arrival time (departure time) at (from) the university, walking time from home to the means of transport used, in-vehicle travel time, time needed to find a parking place at the university location, walking time from the vehicle or the bus stop to the office building. The third part included the stated preference experiments. Each respondent was asked to examine ten hypothetical choice scenarios similar to the one illustrated in Table 1.

Table 1 – Example of stated preferences scenario

Which of the following transport possibilities would you choose?					
	Current transport mode (CPP_SPSQ)	**Car and hourly parking fee (CHP_SPH)**	**Car and annual parking fee (CPP_SPH)**	**Bus and one-way ticket (BOW_SPH)**	**Bus and monthly ticket (BMT_SPH)**
Cost	28 € (annual permit)	1.6€	60€	1€	30€
Time from home to car/bus stop	5'	4'	6'	9'	3'
In-vehicle travel time	14'	10'	8'	20'	12'
Parking searching time	10'	5'	12'		
Time from car/bus stop to university	2'	5'	10'	5'	7'

Since, according to the empirical evidence (Abrantes and Warman, 2011; Wardman 1998, 2001, 2004), the mode choice is differently affected by each travel time component and by the means of payment, the attributes used to describe the current transport mode (from now on the Status Quo, SQ) and the hypothetical alternatives were the following:

- transport mode: car, bus;
- cost components:
    - hourly parking price: €0 (status quo); €0.80; €1.20; €1.50;
    - annual parking permit: €40 (status quo); €45; €60; €75; €90;
    - one-way bus ticket: €1; €1.10 (status quo); €1.3; €1.5;
    - monthly bus ticket : €27; €28 (status quo); €30; €33; €36;
- walking time from home to the car or to the bus stop;
- in-vehicle travel time;
- searching time for parking;
- walking time from the car or bus stop to the university building.

All the time components were described as percentage changes (+/- 25%, +/- 15%; +/- 0%) from the current values reported by each interviewed person for each transport mode (pivot design)[2], increasing the realism of the choice scenarios.

Moreover, in order to further increase the realism of the choice experiment, we created 4 efficient designs since we have to deal with 4 types of SQs according to the transport mode and the mode of payment currently used by the respondent (i.e., car with annual permit, car without annual permit, bus with single ticket, bus with monthly pass). The efficient designs were produced using NGENE (version 1.1.0, a software made by ChoiceMetrics, www.choice-metrics.com).

Efficient designs are not necessarily orthogonal[3] but capture the maximum amount of information by minimizing the asymptotic joint confidence sphere surrounding the parameter estimates (Rose e Bliemer, 2004, Sandor and Wedel, 2002). An experimental design is called efficient if it yields data that enables the estimation of the parameters with as low as possible standard errors. In order to obtain an efficient design, however, it is necessary to have some prior information on the sign and the magnitude of the parameters to be estimated. They can be drawn from the literature or from previous experiments dealing with similar topics. Since we had some priors on the sign of the parameters to be estimated, but we were not sure

[2] There are also drawbacks connected with a pivot design. In fact, in our case study when we asked to describe the attribute "searching time for parking", most of the respondents described it as being currently negligible, implying very small values also for the hypothetical alternatives that were obtained as percentage changes of the values reported for the SQ. As a result, the econometric estimates of this parameter turned out to be much less relevant than travel time, contrary to what it is typically reported in the literature. It is then conceivable that our results could have been influenced by the design we have chosen to use.

[3] Traditionally, orthogonal fractional factorial designs are used to perform stated preference surveys, since they guarantee that the attributes are statistically independent (Kuhfeld, 1997).

about the precise values of the priors to be assumed, we used a Bayesian efficient design, which makes use of random priors that are described by random distributions, instead of fixed priors.
Note also that since the goal of our research was to test the users' sensitivity for transportation demand management policies that could be implemented at the local level, we did not include the fixed costs of owning a car (insurance, vehicle property tax, maintenance) and variable costs of using a car (in particular the fuel cost) other than the parking costs.

3.2 Current travel arrangements

In 2010, 18,464 students enrolled at the University of Trieste, the teaching staff consisted in 2,040 people and the technical and administrative staff in 771 people. Altogether 21,275 persons commuted to the University of Trieste. Our research, however, focused only on the persons who resided permanently or during the week in the province of Trieste and who used either their car or the bus to reach the university, hence excluding the daily commuters residing outside the province of Trieste and travelling more than 40 km per trip. This choice was made in order to restrict our sample to the commuters who could actually choose between the private car and the bus. Longer distance trips are, in fact, more complex and include also the train.
We have been able to collect 372 interviews, in the various university locations and administrative offices. Each interview lasted about 30-45 minutes. The sample consisted of 56% women and 44% men of different ages. The teaching staff is 8% of the sample, 21% is administrative staff, and 71% are students.
The question of how representative is this sample cannot be answered with certainty. The main reason is that the precise number of the population who resided in the Trieste province and commutes to the University is uncertain. The main source of uncertainty is the students who, depending on their needs, decide to reside in their hometown or in the city of Trieste. Our guess is that about 40% of the total mentioned above (i.e. 8,510 persons) resided in Trieste. This makes our sample quite small compared to the population, as it is usually the case for stated choice studies. However, given our time and resource constraints, we made our best effort to collect a sample which represents the various population segments.
Most of the sampled people stated that they commute to the university more than 4 days a week; only 28% of them go to university less than 4 days a week. 36% of the sampled people have a car, 27% have a car and a motorcycle\ scooter, 8% have only a motorcycle\scooter and 29% have no private vehicles[4].
A large portion of the respondents (39%) commute by car and park in the free parking spaces currently available at some of the university's locations (charged parking spaces are only limited to some downtown locations), 8% of the respondents pay an annual permit to park in the parking facilities owned by the university, 26% of the sampled people commute by bus buying a one-way ticket, and 27% commute by bus buying a monthly ticket.
The average travel time components reported by the respondents during the second part of the interview are described in Table 2 and 3. They are grouped according to the transport mode normally used to commute and the payment type usually chosen.

[4] We interviewed also the students and employees who don't have a private vehicle to check if their sensitivity for cost and travel time differs from that of the students and employees owing a private vehicle.

Table 2 – Travel time (in minutes) reported by car users

Time component	Persons parking in the free parking lots	Persons entitled to park in the restricted parking areas
Actual walking time from home to the car	2.1	1.4
Actual in-vehicle travel time by car	13.9	13.5
Actual parking searching time at the university	6.8	3.1
Actual walking time from the car to the university building	3.6	1.8
Actual total travel time by car	**26.4**	**19.7**
Estimated walking time from home to the bus stop	5.1	5.2
Estimated in-vehicle travel time by bus	31.0	35.4
Estimated walking time from the bus stop to the university building	4.1	2.4
Estimated total travel time by bus	**40.2**	**43.1**

The persons normally commuting by car report to have a travel time equal to 26.4 minutes if parking in the free-of-charge parking areas close to the university and to 19.7 minutes if parking in the restricted parking areas (upper part of Table 2). There appears to be an about 6 minute difference due to the longer parking searching time and to the further location of the free parking areas relative to the restricted ones. The same persons state that the travel time that they would incur into if using the bus would be much higher, on average 41 minutes. Much of the difference is due to the in-vehicle travel time, which is smaller when travelling by car than when traveling by bus, although it is partially compensated by the additional time needed to park.

Table 3 – Travel time (in minutes) reported by bus users

Time component	Persons purchasing a monthly ticket	Persons purchasing a one-way ticket
Estimated walking time from home to the car	4.8	5.6
Estimated in-vehicle travel time by car	12.5	10.6
Estimated parking searching time at the university	10.9	13.9
Estimated walking time from the car to the university building	4.8	5.4
Estimated total travel time by car	**33.0**	**35.5**
Actual walking time from home to the bus stop	3.5	4.2
Actual in-vehicle travel time by bus	18.5	15.1
Actual walking time from the bus stop to the university building	3.3	3.6
Actual total travel time by bus	**25.4**	**22.8**

The persons normally commuting by bus report a total travel time equal to about 23-25 minutes (lower part of Table 3). They also state that the travel time that they would need if using the car would be higher, on average 34 minutes.

In both cases, hence, it appears that the mode choices made by the sample are rational.

The travel time reported, however, differs significantly according to the status of the respondents and the university location.

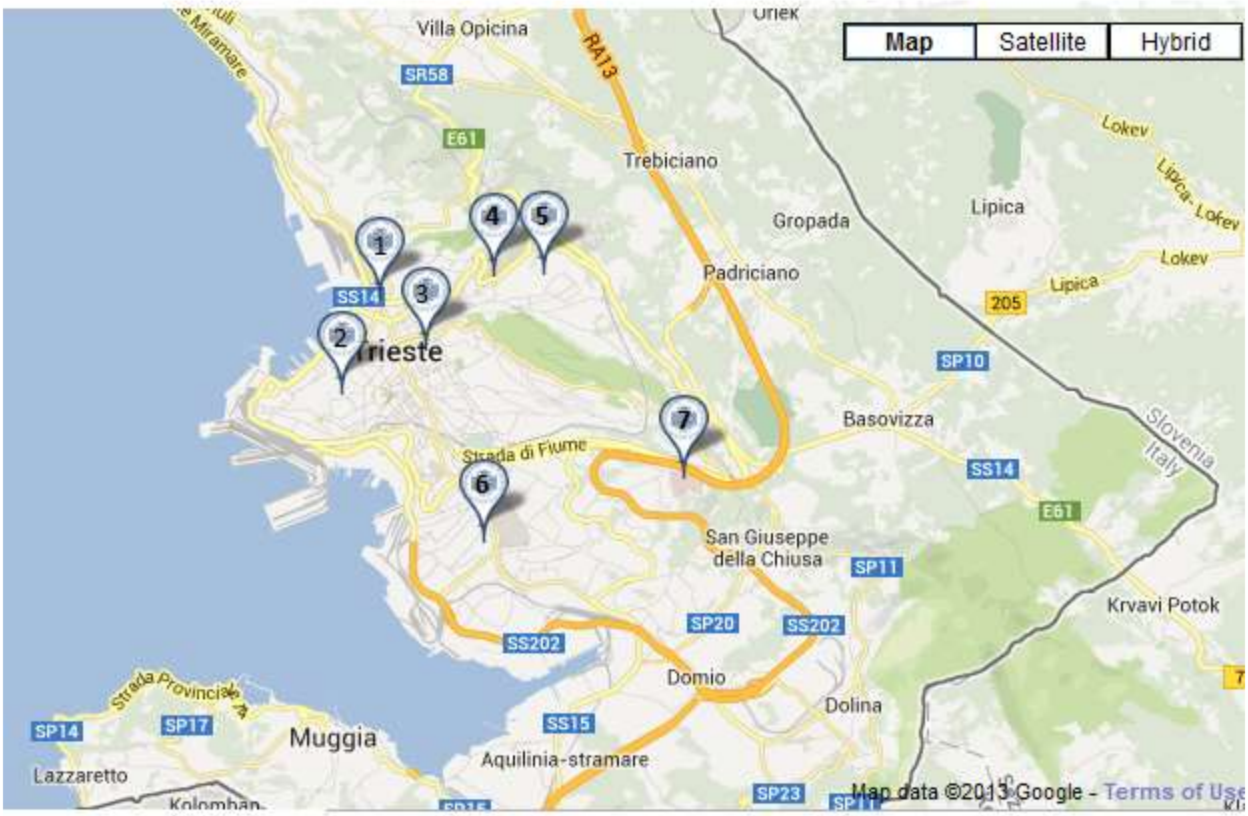

Figure 1 Map of the university locations in Trieste
Legenda: Via S. Anastasio\Via Filzi (1), Via Lazzaretto Vecchio (2), Ospedale Maggiore (3), Piazzale Europa (4), S. Giovanni (5), Via Valmaura (6), Cattinara (7)

Five types of location sites are considered (3 have been grouped together because of their small size and similar characteristics):

- Piazzale Europa: it is the main location of the university, hosting several departments such as Economics, Law, Engineering, Physics, Pharmacy, and Earth sciences; the majority of students and staff commute to this location; it is suburban, about 2 km from the city center and it has about 200 parking spaces, 100 of which are reserved to the administrative and teaching staff; about four bus lines, one of which is specifically meant for the transport needs of the students, connect the city with this location;
- S. Giovanni: it is an area previously devoted to the mental hospital and it lies within a park. It hosts the Mathematics and Geology departments; it is suburban about 3 km from the city center. Parking spaces are abundant, some of them are reserved to the administrative and teaching staff; the connection via the bus is not very convenient;
- Via Lazzaretto Vecchio, Via S. Anastasio\Via Filzi, Ospedale Maggiore are in the city center. They host the Human Science department, the Foreign language department and some hospital Clinics. The university owns no private parking spaces and finding a parking place is difficult. Bus service is quite convenient. Because these locations share many features and because they host fewer people and are therefore less represented in the sample, we have grouped them in one representative location called City Center;
- Via Valmaura: it hosts Biotechnology and part of the Medicine department; it is peripheral, about 4 km from the city center, and it has no parking spaces reserved to the administrative and teaching staff; few bus lines connect the city with this location, none of them is specifically meant for the needs of the students;
- Cattinara: it hosts the city hospital and part of the Medicine department. It is peripheral and lies 4 km from the city center. There are some parking spaces reserved for the administrative and

teaching staff, the rest of the parking spaces are either charged or free, but the competition with the hospital users is quite fierce. Two bus lines connect this location to the city center.

Table 4 – Car share for the entire sample, by respondent's status and by university location (in percentage terms). The bus share is the complement to 1

Category	Total	Piazzale Europa	S. Giovanni	City Center*	Via Valmaura	Cattinara
Full sample	48	50	37	28	33	34
Students	35	48	31	27	30	30
Teaching staff	68	76	89	33	54	71
Administrative staff	69	81	75	57	50	71

* City Center includes 3 locations Via Lazzaretto Vecchio, Via S. Anastasio\ Via Filzi, and Ospedale Maggiore
Piazzale Europa (Suburban site): 2 km from the city center, reserved parking spaces;
S.Giovanni (Suburban site): 3 km from the city center, reserved parking spaces;
City Center: no reserved parking spaces;
Valmaura (Periphery site): 4 km from the city center, no reserved parking spaces;
Cattinara (Periphery site): 4 km from the city center, reserved parking spaces.

Table 4 reports the current modal split as derived from the interviews. It is differentiated by respondent status and by university locations. On average, 52% of the respondents use the bus, a very high percentage if compared with the regional or national average which is 7.7% (2007) and 13.6% (2011), respectively, raising to 31.6% (2011) if only the large cities are considered (Isfort, 2012a,b). Barla et al. (2012) quote a 35% bus share for the suburban Université Laval à Québec, Canada.
On average students use the car much less extensively than the administrative or teaching staff (35% versus 68-69%). However, these results are highly differentiated by location. Piazzale Europa, the location where the number of parking spaces is highest, has the highest percentage of students using the car (48%, that is 13% more than the average). The percentage of administrative and the teaching staff using the car is lower where parking is difficult and expensive, like City Center and Valmaura. On the contrary, at Piazzale Europa, S. Giovanni and Cattinara the car use prevails.
Apparently, hence, the mode choice is mainly driven by the availability and cost of parking spaces. In the next section the econometric choice model will allow us to test the role played by other variables such as: in-vehicle time, parking searching time, time needed to reach the university from the parking lot, parking tariff, and bus ticket.

3.3 The mode choice model

In order to analyze the mode choice, a logit model is specified and estimated. The model is characterized by 12 utility functions. The first 8 utility functions describe the 4 hypothetical alternatives (SPH, Stated Preference Hypothetical) and the 4 possible Status Quos (SPSQ, Stated Preference Status Quo). The remaining 4 utility functions describe the 4 actual alternatives (RP, Revealed Preferences). The dependent variables are termed as follows:

1. CHP_SPH: Car with Hourly Parking tariff, Stated Preference scenario, Hypothetical alternative;
2. CHP_SPSQ: Car with Hourly Parking tariff, Stated Preference scenario, currently chosen mode;
3. CPP_SPH: Car with Parking Permit, Stated Preference scenario, Hypothetical alternative;
4. CPP _SPSQ: Car with Parking Permit, Stated Preference scenario, currently chosen mode;
5. BOW_SPH: Bus, One-Way ticket, Stated Preference scenario, Hypothetical alternative;
6. BOW _SPSQ: Bus, One-Way ticket, Stated Preference scenario, currently chosen mode;
7. BMT_SPH: Bus, Monthly Ticket, Stated Preference scenario, Hypothetical alternative;
8. BMT _SPSQ: Bus, Monthly Ticket, Stated Preference scenario, currently chosen mode;
9. CHP_RP: Car with Hourly Parking tariff, Revealed Preference data;
10. CPP_RP: Car with Parking Permit, Revealed Preference data;

11. BOW_RP: Bus, One-Way ticket, Revealed Preference data;
12. BMT_RP: Bus, Monthly Ticket, Revealed Preference data.

$$U(CHP\_SPH) = \beta_{CSP}*CARSP + \beta_{CHP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(1)}$$

$$U(CHP\_SPSQ) = \beta_{HY\_C}*SQ + \beta_{CSP}*CARSP + \beta_{CHP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(2)}$$

$$U(CPP\_SPH) = \beta_{CSP}*CARSP + \beta_{CPP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(3)}$$

$$U(CPP\_SPSQ) = \beta_{HY\_C}*SQ + \beta_{CSP}*CARSP + \beta_{CPP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(4)}$$

$$U(BOW\_SPH) = \beta_{COW}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(5)}$$

$$U(BOW\_SPSQ) = \beta_{HY\_B}*SQ + \beta_{COW}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(6)}$$

$$U(BMT\_SPH) = \beta_{CMT}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(7)}$$

$$U(BMT\_SPSQ) = \beta_{HY\_B}*SQ + \beta_{CMT}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(8)}$$

$$U(CHP\_RP) = \beta_{CRP}*CARRP + \beta_{CHP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(9)}$$

$$U(CPP\_RP) = \beta_{CRP}*CARRP + \beta_{CPP}*COST + \beta_{THC}*THC + \beta_{TTC}*TTC + \beta_{TSP}*TSP + \beta_{TCU}*TCU \qquad \text{eq.(10)}$$

$$U(BOW\_RP) = \beta_{COW}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(11)}$$

$$U(BMT\_RP) = \beta_{CMT}*COST + \beta_{THB}*THB + \beta_{TTB}*TTB + \beta_{TBU}*TBU \qquad \text{eq.(12)}$$

The independent variables are:

- SQ: dummy variable equal to one if the alternative used in the stated preference scenario describes the transport mode and payment type currently used by the respondent;
- CARSP: dummy variable equal to one if the alternative used in the stated preference scenario refers to travelling by car;
- CARRP: dummy variable equal to one if the alternative describing the revealed preference data refers to travelling by car;
- COST: cost (in euros) of parking, paying an hourly tariff or an annual permit, or cost of taking the bus, buying a one-way ticket or a monthly ticket;
- THC: Time (in minutes) walking from Home to the Car;
- TTC: in-vehicle Travel Time (in minutes) by Car;
- TSP: Time (in minutes) Searching for a Parking lot;
- TCU: Time (in minutes) walking from the Car to the University;
- THB: Time (in minutes) walking from Home to the Bus stop[5];
- TTB: in-vehicle Travel Time (in minutes) by Bus;
- TBU: Time (in minutes) walking from the Bus stop to the University.

In order to capture the respondents' preference heterogeneity, having considered various distribution types, we opted for specifying the model using triangularly distributed random parameters, which in the case of the time and cost variables, following our theoretical *a-priori*[6], are constrained to be negative. The triangular distribution provided estimates in line with our a-priori and a quite satisfactory goodness-of-fit. In order to identify the sources of the preference heterogeneity, two socio-economic covariates were introduced in the model (identified with an asterisk in Table 5), detecting how the status of the respondents and the availability of a car affect the generalized travel cost components. The correlation induced by the repeated information collected from each respondent is also taken into account. Finally, the

[5] Although the time spent waiting for a bus at the bus stop is reported as being an important factor affecting travel mode choices, it was not included since the choice exercise was already quite complex. Its effect might have affected the parameter of the travel time by bus or the parameter of the time needed to reach the bus stop.
[6] Relative to a unconstrained normal distribution the loss of goodness-of-fit is equal to 18 points (difference of the value of the LLF) and the number of individual specific parameters with the wrong sign varies between 0 and 3 per cent.

correlation characterizing the following groups of alternatives is controlled for via the specification of six error components[7]:

- the alternatives describing the status quo in the stated preference scenarios (eq. 2, 4, 6, 8) and the alternatives describing the revealed preference data (eq. 9, 10, 11, 12);
- the alternatives describing travelling by car paying a hourly parking fee (eq. 1, 5, 9);
- the alternatives describing travelling by car paying an annual permit (eq. 2, 6, 10);
- the alternatives describing travelling by bus buying a one-way ticket (eq. 3, 7, 11);
- the alternatives describing travelling by bus buying a monthly ticket (eq. 4, 8, 12);
- the alternatives describing travelling by car (eq. 1, 2, 5, 6, 9, 10).

A further error component was also specified in order to take into account for the scale difference between the RP and SP data. Since the parameter was found not statistically significant, it was concluded that the RP and SP data could be pooled.

The model is estimated on the basis of 4,092 observations: 3,720 stated preference data (10 per respondent) and 372 revealed preference data (1 per respondent). The estimates are performed using Nlogit 4.0 (by Econometric Software Inc., www.nlogit.com). The results are summarized in Table 5. The model fit is quite high: the Rho^2 is 0.42, the AIC is 1.2. The model is able to correctly predict 75% of the RP data. All the parameters are statistically significant and have the expected sign.

The estimates reveal high preference heterogeneity for all the components of the generalized travel cost, since the spread of the triangular distribution of all the random parameters is always statistically significant. The two socio-economic covariates specified in the model explain some of the preference heterogeneity.

In particular they show that parking searching time (PARKING SEARCH & FACULTY ADM STAFF) and travel time by car (TRAVEL TIME CAR & FACULTY ADM STAFF) impact the utility of the teaching and administrative staff comparatively more than that of the students, probably due to the different time constrains. Reaching the university from the parking lot (TIME CAR-UNIV & FACULTY ADM STAFF) is relatively more burdensome for the students, since they are not allowed to park on campus. In addition, reaching the bus stop from home (TIME HOME-BUS & NO CAR AVAILABILITY) impacts less the utility of those who don't have a car, probably because they have chosen to live closer to the bus stop and because they have no other travel options, while travelling by bus (TRAVEL TIME BUS & FACULTY ADM STAFF) is more burdensome for the teaching and administrative staff, possibly because this transport mode requires more in-vehicle time and is less flexible. Finally, the disutility of higher parking cost (PARKING PERMIT & FACULTY ADM STAFF) is larger for the teaching and administrative staff, whereas those not owning a car have a lower sensitivity to the cost of a one-way bus ticket (ONE-WAY TICKET & NO CAR AVAILABILITY).

Everything else being equal, the bus is preferred to the car, since the car constant, both for the SP (CAR_SP) and for the RP (CAR_RP) data, is negative[8]. There is also a significant hysteresis effect for the mode currently chosen (HYSTERESIS CAR and HYSTERESIS BUS), especially for the car.

[7] The error component model is more flexible than the nested logit model since it allows controlling for the correlation of overlapping groups of alternatives. Moreover, differently from the nested logit model, it allows us to specify the parameters of the variables of the utility functions as being randomly distributed.

[8] This result could depend on the fact that while for the public transport mode all the major components of the generalized cost of transport were included in the utility functions, for the private mode the fuel cost and other important components of the monetary cost (tax, insurance , wear and tear) were omitted.

Table 5 – Mixed logit with constrained parameters and error components

LLF	-2,428			
CONSTANTS ONLY	-4,201			
RHO^2	0.42			
AIC	1.204			
N. OBS.	4,092			
Parameter		**Parameter spread**	**Error Components**	
CAR_SP β_{CSP}	-9.84 *(-13.60)*	4.32 *(6.29)*	**SQ (SP) + RP**	0.24 *(1.96))*
CAR_RP β_{CRP}	-13.64 *(-16.93)*	7.48 *(5.72)*	**CAR HOURLY PARKING**	2.00 *(8.57)*
HYSTERESIS CAR β_{HY_C}	1.45 8.23	3.40 *(9.77)*	**CAR PARKING PERMIT**	1.81 *(8.66)*
HYSTERESIS BUS β_{HY_B}	0.46 *(5.40)*	0.93 *(2.68)*	**BUS ONE-WAY**	4.42 *(12.54)*
TIME HOME-CAR β_{THC}	-0.27 *(-6.83)*	-0.27 *(-6.83)*	**BUS MONTHLY TICKET**	5.58 *(16.22)*
TIME CAR-UNIV β_{TCU}	-0.47 *(-7.48)*	-0.47 *(-7.48)*	**CAR**	2.00 *(7.00)*
TIME CAR-UNIV & FACULTY ADM STAFF*	0.44 *(2.21)*			
TIME SEARCHING PARKING β_{TSP}	-0.08 *(-2.77)*	-0.08 *(-2.77)*		
PARKING SEARCH & FACULTY ADM STAFF*	-0.48 *(-5.18)*			
TRAVEL TIME CAR β_{TTC}	-0.23 *(-8.84)*	-0.23 *(-8.84)*		
TRAVEL TIME CAR & FACULTY ADM STAFF*	-0.13 *(-2.90)*			
TIME HOME-BUS β_{THB}	-0.45 *(-6.66)*	-0.45 *(-6.66)*		
TIME HOME-BUS & NO CAR AVAILABILITY*	0.40 *(4.26)*			
TIME BUS-UNIV β_{TBU}	-0.18 *(-2.71)*	-0.18 *(-2.71)*		
TRAVEL TIME BUS β_{TTB}	-0.24 *(-17.65)*	-0.24 *(-17.65)*		
TRAVEL TIME BUS & FACULTY ADM STAFF*	-0.20 *(-8.11)*			
HOURLY PARKING COST β_{CHP}	-3.82 *(-9.83)*	-3.82 *(-9.83)*		
HOURLY PARKING & FACULTY ADM STAFF*	-1.64 *(-3.95)*			
PARKING PERMIT COST β_{CPP}	-0.05 *(-10.39)*	-0.05 *(-10.39)*		
PARKING PERMIT & FACULTY ADM STAFF*	-0.02 *(-3.55)*			
ONE-WAY TICKET COST β_{COW}	-13.77 *(-22.22)*	8.17 *(10.62)*		
ONE-WAY TICKET & NO CAR AVAILABILITY*	4.00 *(7.18)*			
MONTHLY TICKET COST β_{CMT}	-0.41 *(-21.82)*	0.22 *(8.89)*		

4. Scenario analysis

On the basis of the above model it is possible to estimate the impact that transport demand management policies would have on the modal shift of the sample between car and bus use. Please note that since these two modes of transport are not the only modes which could be used to reach the various locations of the University of Trieste - walking, riding a motorbike or a bicycle (to a very small extent due to the hilly nature of the city), or using a taxi are also possible – these modal shares should not be interpreted as absolute modal shares, but simply as a proportion between the two modes. The following policies have been analyzed[9]:

A. increasing the cost of the annual permit from the current level of €40 to €80, €160, €550 (half the minimum cost for a parking lot in Trieste), €1,100 (minimum cost for a private parking space in a garage in Trieste) and to €2,100 (maximum cost for a private parking space in a garage in Trieste);
B. setting an hourly parking tariff equal to €0.6 (minimum tariff in Trieste), €1 and to €1.6 (maximum tariff in Trieste);
C. reducing the number of parking spaces on campus, inducing an increase of the time needed to find a parking space from the current level to 15' and 20';
D. moving the parking facilities outside the campus or further away from the university sites, inducing an increase of the time needed to reach the university from the parking lot from the current level of 4.2' to 10' and 15';
E. decreasing the one-way ticket from the current level of €1.1 to €0 (fully subsidizing the variable cost of the bus service) or increasing the one-way ticket from the current level, covering 30% of the variable cost of providing the bus service, to €2.2 and to €3.3, covering, respectively, 60% and 100% of the variable cost of the bus service;
F. decreasing the monthly pass from the current level of €28 to €0 (fully subsidizing the variable cost of the bus service) or increasing the monthly pass from the current level, covering 30% of the variable cost of providing the bus service, to €56 and to €84, covering, respectively, 60% and 100% of the variable cost of the bus service;
G. Policy mix 1 – Parking pricing and restrictions. This policy envisions the possibility of eliminating the annual parking permit, of setting the hourly parking tariff at €0.6, and of reducing the number of parking spaces so that the time needed to find a parking space on campus is raised to 20';
H. Policy mix 2 – Cutting both bus and parking subsidies. This policy proposes an increase of the hourly parking tariff at €1.6, of the time needed to reach the university from the parking lot to 15', of the time needed to find a parking space equal to 15', and finally an increase of the one-way ticket to €1.65 and of the monthly ticket to €42, allowing the bus company to cover 50% of the variable costs.

Policy G and H incorporate the suggestion by Barla et al. (2012) that policy mixes can be more effective than the sum of each measure taken separately. The scenario analysis is performed on the basis of the RP data reported by each respondent. Since the model slightly overestimates the modal choice in favor of car use[10], the results reported in Table 6 should be considered as conservative estimates of the modal shift. The estimates are adjusted to the current university population composition by status.

[9] The set of policies considered is quite different from the one analyzed in other case studies such as Shannon et al. (2006), Akar et al. (2012) and Whalen et al. (2013) which, for instance, include the provision of bicycle lanes, because bicycle use is almost inexistent in Trieste due to its hilly morphology. On the contrary, motorcycle use is quite common but could not be included in the mode choice analysis due to its seasonal nature.

[10] The modal share predicted by the model on the basis of the RP data is 55% car and 45% bus.

Table 6 – Mode share change by transport demand management policy (%)

Transportation demand management policies	Current car share: 47	Current bus share: 53	car share change in % terms
A1 annual parking permit €80	44	56	-6%
A2 annual parking permit €160	39	61	-17%
A3 annual parking permit €550	26	74	-45%
A4 annual parking permit €1100	24	76	-49%
A5 annual parking permit €2100	23	77	-51%
B1 hourly parking tariff €0.6	40	60	-15%
B2 hourly parking tariff €1	36	64	-23%
B3 hourly parking tariff €1.6	29	71	-38%
C1 parking searching time 15'	45	55	-4%
C2 parking searching time 20'	44	56	-6%
D1 time from car to univ. 10'	38	62	-19%
D2 time from car to univ. 15'	31	69	-34%
E1 free one-way ticket	18	82	-62%
E2 one-way ticket 60% of variable costs	70	30	49%
E3 one-way ticket 100% of variable costs	76	24	62%
F1 free monthly ticket	39	61	-17%
F2 monthly ticket 60% of variable costs	59	41	26%
F3 monthly ticket 100% of variable costs	64	36	36%
G policy mix 1 Parking pricing and restrictions	37	63	-21%
H policy mix 2 Cutting both bus and parking subsidies	40	60	-15%

For the sample considered the current car use share is 47% and, hence, 53% is the current bus use share.
A first possibility available to the university mobility manager is to increase the annual cost of the parking permit, currently set at €40 per year. An annual parking permit set at €80 (less than €0.5 a day assuming a frequency of 200 days per year) would decrease car share to 44% (a 6% decrease), while a still reasonable increase to €160 per year would decrease car share to 39% (a 17% decrease). Higher values, more in line with the cost of a private parking space in Trieste, but most probably politically unacceptable, would drastically reduce car use, to a minimum of 23-24% reached when the cost is as high as €1,100 per year.
Similarly, large effects could be achieved varying the hourly parking tariff. An hourly parking tariff of €0.6, in line with the minimum fee currently paid in the city center, would reduce car share to 40%. These findings are in line with Toor and Havlick, (2004) who argued that the increase of parking fees in the US universities is one of the most effective strategies that can be employed to reduce Single Occupancy Vehicle use.
A further possibility is to vary the time needed to search for a parking space or for reaching the university buildings from the parking lots. Increasing up to 15' the time needed to find a parking space in a parking facility by the university would decrease the current modal split only by 2%, while increasing up to 10' the walking time needed to reach a university building would reduce car share to 38%.
Alternatively, as frequently requested by the students' organizations, the bus ticket could be fully subsidized. This policy would substantially affect the modal split in favor of the bus, increasing the bus share up to 82% and 61% according to the payment type subsidized. These car share changes are much higher than the 18% change obtained for a similar policy by Barla *et al*. (2012). On the contrary, increasing the ticket cost by 100%, in order to cover at least 60% of the bus service operating costs, would reduce the bus share to 24% and 36%, according to the payment type considered.
Policy mix 1 "Parking pricing and restrictions" achieves a reduction of the car share to 37%. This further demonstrates the effectiveness of the parking regulations switching from the annual parking permit to hourly parking payments, along the lines suggested by Whalen et al. (2013, p. 140) who recommend a Flex Pass program for the McMaster University, in Hamilton, Canada.
Policy mix 2 "Cutting both bus and parking subsidies" would achieve a smaller car share reduction, setting it to 40%. Since it cuts subsidies both for car and bus users, it is less effective than Policy 1, but would probably be more efficient since public transport would increase its financial sustainability.
Overall, the impact of the policies on car share range between -51% and +62%, which are reached when parking is priced at market prices and when the bus is priced at full cost. More balanced and acceptable

approaches, as in the case of the two policy mixes, allow reducing the car share between 15 and 21%. These values are lower than the ones estimated by Boyd et al. (2013) - 50% bus user's increase - and by Barla *et al.* (2012) - 80% car use reduction- since they probably reflect the different contextual conditions and different transport demand management options.

The policies described, however, are likely to differently impact students, teaching and administrative staff, as suggested by Barla *et al.* (2012). In order to test this hypothesis, the percentage change of the car users is estimated by respondent type (Table 7).

Table 7 – Percentage variation of car users by status relative to the status quo

Transportation demand management policies	Students*	Teaching staff	Administrative staff
A1 annual parking permit €80	--	-3	0
A2 annual parking permit €160	--	-7	-4
A3 annual parking permit €550	--	-22	-18
A4 annual parking permit €1100	--	-28	-22
A5 annual parking permit €2100	--	-28	-22
B1 hourly parking tariff €0.6	-8	-5	-4
B2 hourly parking tariff €1	-13	-9	-6
B3 hourly parking tariff €1.6	-19	-14	-12
C1 parking searching time 15'	0	-3	-1
C2 parking searching time 20'	-2	-5	-1
D1 time from car to univ. 10'	-8	-8	-8
D2 time from car to univ. 15'	-15	-17	-16
E1 free one-way ticket	-30	-39	-32
E2 one-way ticket 60% of variable costs	28	14	9
E3 one-way ticket 100% of variable costs	34	19	10
F1 free monthly ticket	-7	-7	-8
F2 monthly ticket 60% of variable costs	15	7	8
F3 monthly ticket 100% of variable costs	21	10	10
G policy mix 1 Parking pricing and restrictions	-10	-7	-6
H policy mix 2 Cutting both bus and parking subsidies	-7	-7	-8

Note: (*) students are not currently allowed to buy an annual parking permit

The increase of the cost of the annual parking permit appears to affect more the mode choice of the teaching staff than that of the administrative staff. This is probably due to the fact that they commute less frequently and they have a more flexible time schedule. The students are not affected because they are not currently entitled to any annual parking permit.

The increase of the hourly parking tariff, as expected, impacts especially students' mode choice due to their lower disposable income. Again, the teaching staff appears to be more affected by this policy than the administrative staff.

The increase of the parking searching time due to a reduction of the number of parking spaces would mostly affect the teaching staff choices because of their higher value of time. For the same reason, increasing the time needed to reach the university site from the parking facilities seams to reduce more effectively the number of commuting trips made by teaching staff.

Subsidizing bus tickets would be, percentagewise, more effective in reducing the car use of the teaching and administrative staff than that of the students, since they both use their own vehicle more intensively. In fact, only 35% of the students use the car to commute to the university, whereas 60% of the teaching staff and 62% of the administrative staff are car users. On the contrary, increasing the cost of the bus ticket would impact, percentagewise, much more the students' mode choice than the mode choice of the teaching or administrative staff.

Finally, Policy mix 1 "Parking pricing and restrictions" would mostly impact the students' mode choice because of their lower disposable income and value of time, whereas Policy mix 2 "Cutting both bus and parking subsidies" appears to have a more balanced impact.

These policies are also likely to differently impact students and staff in the various university locations characterized by different availability of parking facilities and public transport services. In order to test this hypothesis, the percentage change of the car users is estimated by location (Table 8).

Table 8 – Percentage variation of car users by university location relative to the status quo

Transportation demand management policies	Piazzale Europa	S.Giovanni	City Center*	Via Valmaura*	Cattinara
A1 annual parking permit €80	0	0	--	--	0
A2 annual parking permit €160	-2	0	--	--	0
A3 annual parking permit €550	-5	-1	--	--	-1
A4 annual parking permit €1100	-6	-1	--	--	-1
A5 annual parking permit €2100	-6	-1	--	--	-1
B1 hourly parking tariff €0.6	-8	-6	-7	-10	-9
B2 hourly parking tariff €1	-12	-12	-12	-15	-13
B3 hourly parking tariff €1.6	-20	-18	-18	-25	-18
C1 parking searching time 15'	0	-6	0	-5	-2
C2 parking searching time 20'	-2	-6	-2	-5	-2
D1 time from car to Univ. 10'	-9	-12	-7	-10	-7
D2 time from car to Univ. 15'	-25	-18	-14	-21	-14
E1 free one-way ticket	-35	-32	-28	-26	-29
E2 one-way ticket 60 of variable costs	28	22	28	14	24
E3 one-way ticket 100 of variable costs	34	27	36	15	30
F1 free monthly ticket	-4	-6	-6	-15	-9
F2 monthly ticket 60 of variable costs	11	11	14	24	13
F3 monthly ticket 100 of variable costs	15	12	21	33	20
G policy mix 1 Parking pricing and restrictions	-10	-12	-9	-15	-11
H policy mix 2 Cutting both bus and parking subsidies	-10	-12	-7	-5	-7

Note: (*) annual parking permits are not available;
Piazzale Europa (Suburban site): 2 km from the city center, reserved parking spaces;
S.Giovanni (Suburban site): 3 km from the city center, reserved parking spaces;
City Center: no reserved parking spaces;
Valmaura (Periphery site): 4 km from the city center, no reserved parking spaces;
Cattinara (Periphery site): 4 km from the city center, reserved parking spaces.

Since most reserved parking spaces are available at Piazzale Europa, the main site of the University of Trieste, an increase in the cost of the annual parking permit would almost exclusively impact the modal split at this location. As reported in Table 4, Piazzale Europa is the location with the highest use of the private car. This proves the positive and strong relationship between car use and cheap parking, as already found by Willson and Shoup (1990) and Willson (1992).
The levy of an hourly parking tariff, instead, would mainly impact the more peripheral sites (Via Valmaura and Cattinara) due to the longer travel time needed to reach these sites by bus and due to longer parking times needed to attend the classes and the training activities offered there.
Reducing the number of parking spaces would impact mode choice especially at S. Giovanni and Via Valmaura, whereas moving the parking facilities farther away from the university sites would impact mode choice also at Piazzale Europa.
A full subsidy of the bus ticket greatly affects all sites, particularly Piazzale Europa. By contrast, increasing the bus ticket has a high impact on bus ridership, again mostly at Piazzale Europa and City Center.
Finally, Policy mix 1 and 2 affect all sites with slightly larger impacts on Via Valmaura and S.Giovanni.

5. Conclusions

Universities, like other types of public and private institutions, when located in a city, have both positive and negative impacts on the area where they are placed. On the one hand, they contribute to the prestige of the area; on the other hand, they are large generators\attractors of traffic. The ability to successfully balance the pros and cons of the urban location of these large traffic-generating institutions is crucial for their success and for the livability of the city.

The aim of the research reported in this paper was to understand: (a) how mode choice decisions are made by the teaching and administrative staff and the students of the University of Trieste at the various locations where academic activities take place, and (b) how they would be affected by 8 different transport management policies. The results obtained, the model developed and the scenario analysis performed could allow the university mobility manager and the city authorities to take decisions on parking and bus pricing policies, to plan the location of the university sites and to forecast their impact on the city traffic.

The literature summarized in Section 2 suggested that subsidizing bus use is highly effective to reduce solo driving (Boyd *et al*., 2003; Akar *et al*., 2012; Barla *et al*., 2012; Zhou, 2012; Whalen et al., 2013). Our estimates confirm this statement: we find that fully subsidizing bus service would raise the bus share from the current, on average, 53% to 61-82% depending on the means of payment.

Conversely, one can increase the parking tariffs to increase bus ridership or active travel, as recommended by Shoup (2005), Toor and Havlick (2004), Barla *et al*. (2012). Our estimates confirm the validity of this suggestion. We find that substantially increasing the monetary parking cost would raise the bus share from 53%, on average, up to 71-77%, depending on the means of payment.

Furthermore, we tested the effectiveness of reducing the size of the parking lots or relocating them further away from the university buildings. The former would increase bus ridership to 56% and the latter to 69%.

The paper estimated also the distributional impact of such policies by user status and by university location. The differentiated impact between students, teaching and administrative staff is in line with our expectations and with previous literature (Akar *et al*., 2012; Barla *et al*., 2012). The impact among locations proved also to be quite differentiated although no clear-cut relationship emerged between the centrality of the location and the effectiveness of the policy. Further analysis would be needed and more data should be collected in order to fully identify how the different policies interact with the characteristics of the urban locations, the supply of public transportation and the available parking facilities.

Finally we tested two differently balanced, and probably more acceptable, policy mixes: the first one, increasing parking price and imposing new parking restrictions, would increase bus ridership to 63% (a 19% increase), the second one, reducing both bus and parking subsidies, would increase bus ridership to 60% (a 13% increase).

The model we have estimated represents a useful tool to predict the effectiveness of the above mentioned policies. Obviously, the university mobility manager should also take into account their efficiency, acceptability and enforceability, as pointed out by an anonymous reviewer. These aspects need to be analyzed in detail in future research efforts. From a technical point of view two improvements could also be implemented: testing for non-linear preferences for the travel time components; and estimating the monetary value of travel time via a choice model specified in the willingness-to-pay space.

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