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THE EFFECTS OF ROAD PRICING ON TRAVEL BEHAVIOUR. THE CASE OF MILAN

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ABSTRACT

Among the policies for achieving urban sustainable mobility, road pricing, usually declined in the form of cordon pricing around the most congested areas, has proved to be quite effective (Anas and Lindsey, 2011). Nonetheless, this measure is perceived as radical and difficult to be accepted both by motorists and, *a fortiori*, by decision-makers (Gaunt et al. 2007, Glazer 2012, Hamilton 2012). As a result, very few cases of urban road pricing do exist in Europe, mainly in the North. In Italy, since 2007, a road pricing measure has been adopted in the city of Milan; this policy, formerly a pollution charge ("Ecopass"), explicitly became a congestion charge in 2011 ("Area C"), following the results of a public referendum.
Within this context, the present paper aims at investigating the impact of the introduction of road pricing on citizens/residents' mobility behaviour by means of descriptive statistics and econometric analysis – multinomial logit model (Train 2003, Marcucci, 2011). The model includes several explanatory variables: socio-economic variables, travel behaviour data, and green attitude variables.

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1 Introduction

Transport negative effects often overcome positive ones in urban areas, thus affecting the largest part of the world population now living in the cities. In particular, road congestion provokes great negative externalities not only in terms of higher costs (time delays and fuel waste) for motorists, but also by increasing air and noise pollution, natural resources, landscape and energy depletion, greenhouse gas emissions, mortality and morbidity from accidents and reducing accessibility and public space (Small and Verhoef, 2007).

Many attempts have thus been made to achieve a radical shift towards a sustainable mobility, trying to reduce congestion levels and to lower the preference for private car use. In order to face congestion costs there are two possible solutions: more space or less vehicles. In urbanized areas road construction is not very feasible, due to space, environmental and budgetary constraints (Anas and Lindsay, 2011); on the contrary, many strategies can be adopted for reducing the number or the length of trips: technological advances (e-commerce, e-working and ICTs); land use planning (denser or more mixed use cities and neighbourhoods); alternatives' supply (Local Public Transport or vehicles' sharing, for example). Nevertheless, to a certain extent these regulation measures can enhance additional driving (Anas and Lindsey, 2011). Following welfare economics theories, tolls are better than command-and-control policies like bans, for example (Varian, 1992). Actually, they make motorists perceiving the real collective cost of their driving inside the city, thus selecting them according to their willingness to pay. Therefore, since congestion is a classic case of externality, it can be corrected by introducing a Pigouvian tax: a congestion charge, then, appears the best solution/measure to reduce urban congestion. Moreover, as every toll, road pricing is not very popular among citizens' and, *a fortiori*, among decision-makers.

As a result, very few measures of urban road pricing have been adopted, specifically in the Northern European cities like London, Stockholm, Oslo, Bergen, and Gothenburg. Nevertheless, since 2007, a road pricing policy has been undertaken in Italy, too. It is the "Ecopass" pollution charge, introduced in Milan in 2007, and that became in 2011 a congestion charge ("Area C") according to the results of a public referendum.

In this paper the effects of the "Area C" road pricing measure on the mobility behaviour of the Milan citizens are investigated. The data come from the Green Move project conducted in 2012 among the inhabitants of the municipality of Milan (Beria and Laurino, 2013). The *database* consists of 1,198 observations, and includes demographic variables (gender, age, education and skills), respondent's address, variables related to the number of owned cars and typology, individual travel patterns, etc.

The impact of "Area C" on the respondents' travel behaviour has been investigated by means of descriptive statistics and econometric analysis – multinomial logit model – (Train 2003,

Marcucci, 2011). The model includes several explanatory variables: socio-economic variables, travel behaviour data, and green attitude characteristics. The paper is structured into seven sections. The introduction is followed by the literature review on the European experiences of urban road congestion pricing. The case of Milan is presented in Section three. Data and methodology are presented in Section four, while the empirical analysis – descriptive statistics and econometric model – is described in Sections five and six. Policy recommendations are put forward in the last section.

2 Literature review

Due to the growing interest on the topic among policy makers and scholars, literature on road charging is increasing. In particular, the main objects of these studies are: on one side, the level of acceptability of the regulation; on the other side, the effectiveness of the toll in terms of congestion and/or pollution decreasing. If the first analyses are mainly conducted *ex-ante* for testing the feasibility of a toll introduction, the impact of road charging can be measured only *ex-post* in the few cities where it has been introduced.

The present section includes a brief review of existing road charging experiences, which mainly refer to Europe, followed by a focus on two specific aspects: acceptability and response determinants of drivers and citizens to the charging.

2.1 Road pricing experiences

The idea of road pricing has been firstly introduced by Vickrey (1963) and Kain (1972)[5].

The first measure for facing congestion took place in Singapore, in June 1975. It proved to be effective in reducing congestion, increasing speed, and shifting traffic to less congested roads, to off-peak hours or to public transport, that actually doubled in share (Phang and Toh, 2004).

Following Singapore's path, other road pricing schemes were later adopted in the three biggest Norwegian cities, namely Bergen (1986), Oslo (1990) and Trondheim (1991). The goal of these schemes, however, was not to control over congestion (which is negligible in these contexts), but to raise finance to implement transport investments, mainly roads. Later on, in 2001, also Stavanger introduced a toll specifically focused on congestion control.

The most famous case of urban road pricing is the London one, adopted in 2003. The effects (Leape, 2006) of the charging were significant: a 33% reduction in private car trips in Central London during peak hours (65-70,000 car trips avoided). Congestion, in terms of minutes of delay, dropped an average 30% in one year while traffic around the cordon increased between 2% and 6%.

[5] For a theoretical introduction see Rouwendal and Verhoef (2006).

Later on, in 2006 even the city of Stockholm introduced a toll system as part of a broader policy package (Kottenhoff and Brundell-Freij, 2009). Differently from other experiences, Stockholm charged cordon includes the majority of city inhabitants (2/3). Revenues are earmarked to road investments. The effects in terms of traffic reduction and speed increase have been widely studied (Eliasson *et al*., 2009 and Börjesson *et al*., 2012).
Finally in 2013 also Gothenburg is introducing a road pricing with the main purpose of raising funds for supporting rail investments.

2.2 The determinants of the attitude towards road pricing

Road charging measures face significant problems of acceptability from the citizens' point of view (Santos, 2008). This explains the little number of applications, especially in urban contexts, if compared to the number of the cities where the debate started (Ison and Rye, 2005; May et al., 2010; Hårsman e Quingley, 2010).
Literature often focused on the topic; there are many factors which proved to influence the acceptability of urban road pricing.
At the roots, there is the value citizens give to individual car use (in terms of flexibility/independence and status) and the consequent frequent use. Psychological and personal factors turned out to affect the answers more than the policy-specific ones; in particular social norms are the dominant factor, followed by personal expectations (Schade and Schlag, 2003).
Aside to the effectiveness of the measure, further elements like fairness and clarity of the political decision-making process are also perceived, especially if they do not infringe on personal mobility freedom, (Jakobsson et al., 2000; Fujii et al., 2004). In particular, the way charges are redistributed is crucial (Marcucci and Marini, 2003). In this context, uncertainty plays a role: as concerns individuals, it increases the acceptability, while the *ex-ante* political uncertainty about the use of revenues contributes to threat the experiment, especially if revenues are for investments other than public transport (De Borger and Proost, 2012).
Finally, also public transport and transport alternatives in general play a key role, despite they are rarely studied and from different viewpoints (Kottenhoff and Brundell-Freij, 2009; Hårsman e Quingley, 2010; Rentziou et al., 2011; Beria and Boggio, 2013; Russo, 2013).
In general, the more public transport is available, the higher is the acceptance of the measure.

2.3 Empirical works on the determinants of drivers and citizens behaviour

Although with different points of view and trying to answer to different research questions, several econometric studies on road charging have been developed. They mainly aim at identifying the individual characteristics which influence the citizens' attitude towards

possible or hypothetical road pricing schemes or the motorists' behaviour, in case of existing road charging measures. Therefore, the first are mainly conducted before the introduction of the measure, and can help in the decision process for adopting the strategy, while the second typology has to be carried out *ex-post* in the few cities where the road pricing experience is available.
In the following Table 1 and ***Table 2*** the main results have been classified, in order to make them comparable and to provide a background for the analysis in Section four.

Concerning the attitude towards road charging policies, despite the spatial and temporal differences, some variables appear to be constantly shaping the attitude of interviewed people. Gender (male) results significant and positive, while the condition of "households with children" is less significant. Education seems to influence positively the attitude towards road charging policies, but this is not always constant. As expected, instead, car ownership (or car number) is always decreasing the acceptance of road charging. Income seems to be negative, but the effect, if significant, is always negligible. Both value of time and environmental concern, on the contrary, are positively influencing the attitude. The first is explained by the willingness to pay by high valued travellers to experience less congestion. Similar is the effect of perceived congestion. The second because road charging is seen as a mean to improve the environment. The effect of the place of residence is ambiguous and heavily depends on city characteristics, making this information hardly exportable among studies. Although studied just in one paper, the fact of being a car commuter makes road pricing negatively perceived. This can be explained with the expectation of an unavoidable economic burden in case the pricing is introduced.

Table 1. Studies on road charging attitude determinants

		Kim et al. (2013)		Hamilton (2012)			Eliasson, Jonsson (2011)	Harrington et al (2001)	Odeck and Brathen (1997)
	stage	ex-post	ex-ante	ex-post	ex-ante	ex-ante	ex-post	ex-ante	ex-post
	City/area	London	New Jersey	Stockholm	Helsinki	Lyon	Stockholm	Southern California	Oslo
	y =	yes vote existing charging	yes vote introduce charging	yes vote existing charging	yes vote introduce charging	yes vote introduce charging	positive attitude to charge	positive attitude to charge	positive attitude to charge
individual	gender (female)	n.s.	n.s.	-	n.s.	n.s.	-		n.s.
	age								-
	children (yes)			-	-	-			
	household size							+	
	education (more)			n.s.	n.s.	+	+	-	+
	car ownership (yes or +cars)	-	n.s..	-	-	-	-	-	
	income			n.s.	n.s.	-		-	o
	value of time			+	+	+			
	environmental concern			+	+	+	+		
	equity concern			n.s.	n.s.	-			
	student								
	full time employee								
residence	inner city (vs. suburbs)						-		n.s.
	city (vs. suburbs)						+		n.s.
trip	travel time								
	schedule flexibility								
	distance								
	congestion (yes)							+	
mobility habits	car to work / commuters (yes)						-		-
	trip frequency (more)								
	PT satisfaction (yes)						+		
scheme	perceived as effective (yes)						+		

+: positive sign; -: negative sign; n.s.: analysed, but not significant

Looking at studies on travel behaviour changes (Table 2), their different research questions are less comparable. Gender seems not significant or constant across studies. Age is instead often significant and negative: the older is the respondent, the less car use is reduced/changed. The presence of children in the family is ambiguous: negative in Texas (families with children do not modify the trip) and positive in Sweden, showing probably the existence of the possibility of rescheduling a trip. Flexibility, in fact, has a positive sign. Both car ownership and income are ambiguous. Variables like job or place of residence are studied just once.

However, fixed jobs (students and full time employees) and commuting in general reduce the possibility of rescheduling, as well as living in a far suburb.

Table 2. Studies on trip change determinants due to road charging[6]

		Odeck and Brathen (1997)	Rentziou et al (2009)	Karlstrom, Franklin (2009)	Kockelman Kalmanje (2005)	Karlstrom, Franklin (2009)
	stage	ex-post	ex-ante	ex-post	ex-ante	ex-post
	city	Oslo	Athens	Stockholm	Austin	Stockholm
	y =	yes reduce car use	Stop using car	switch to public transport	modifying trip due to charge	rescheduling of trip
individual	gender (female)	-		+	n.s.	n.s.
	age	n.s.	-	-	-	
	children (yes)				-	+
	household size					
	education (more)	+				
	car ownership (yes or +cars)			+	-	
	income	+	-	n.s.	-	n.s.
	value of time					
	environmental concern					
	equity concern					
	student				-	
	full time employee				-	
residence	inner city (vs. suburbs)	+				
	city (vs. suburbs)	+				
trip	travel time			-		
	schedule flexibility			+		+
	distance			-	-	
	congestion (yes)		+		-	
mobility habits	car to work / commuters (yes)	-				
	trip frequency (more)		-			
	PT satisfaction (yes)					
scheme	perceived as effective (yes)					

+: positive sign; -: negative sign; o: analysed, but not significant

Recently, a study has been carried out in the year 2011 in Dresden, with the aim to investigate the effects of differentiated road pricing schemes (Francke and Kaniok, 2013). The questions concerned: respondents' travel behaviour, gender and age, the cost of car and public transport use, the involvement in road pricing, tariff structures, and transport and environmental problems. It resulted that people proved to be more flexible if they are younger, female and not-frequent drivers. These results are quite coherent with those presented in Table 2.

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[6] With respect to original papers, signs have been switched in order to answer to the same question: did (would) road charging modify the car use habits?

3 The case of Milan

3.1 The history of the policy

In 2007 the city of Milan studied a measure to face the increasingly worrying environmental problems, in particular the PM10 pollutant. Despite the higher concentrations of PM10 with respect to similar cities are caused by the particular geographical context, the large number of diesel cars was seen as one of the main sources of the pollutant to be reduced.

On January 2nd, 2008 a first attempt to introduce urban road charging was implemented by the municipality of Milan through the use of a pollution charge called "Ecopass" (Rotaris et al., 2011). The Ecopas*s* area was around 8 square kilometres in the central sector of the town delimited by the so called *Cerchia dei Bastioni*. The area is actually very small compared to the total city surface (181 square kilometres) and moreover to the metropolitan area. It includes approximately 78,000 inhabitants out of 1.4 Millions, but hosts 37% of total Milan workers (2001 census) with average densities during the working hours of 40,000 persons/km2. Also from the commercial viewpoint the area is the core of Milan, with 23% of total commercial activities (Bedogni et al., 2011).

As the effectiveness in traffic reduction was declining, the Ecopass measure has been put into reconsideration at the end of the trial period. To do that, a technical-political commission has been established by the Mayor to evaluate the measure. In the meantime, a group of associations and parties promoted a referendum on the topic, which took place on 12th June 2011. At the end of the commission's work, the need for consultation was accepted and promoted also by the right-wing city Mayor Letizia Moratti. Before the referendum, actually, nearly all political parties were directly or indirectly supporting the revision of the measure, or at least not explicitly opposing it.

The "Ecopass" measure ended in December 31st, 2011, when it was substituted by a more conventional congestion charge, called "*Area C*", applied to the very same zone. The scope of this new charge was more similar to those in London (started in 2003) and Stockholm (implemented in 2006), i.e. to control congestion costs and only eventually to reduce pollution.

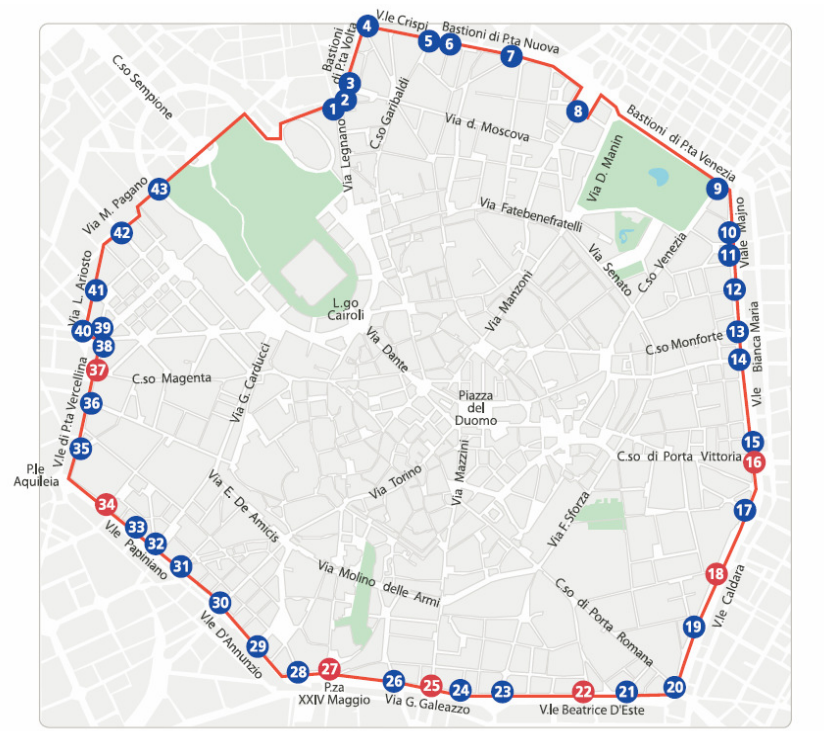


Figure 1 - The Milan cordon and the entrance points; in red those dedicated to public transport. Source: www.areac.it.

The new measure applies a different charging, as outlined in ***Table 3***.

Table 3. Structure of Milan Area C charges

Category	*Charge, per day*	*Notes*
Residents	2€	40 free entrances per year
Service vehicles	3€	Vehicles associated to shops, etc.
Authorised vehicles	0€	Buses, police, taxi, etc.
Other vehicles	5€	
Diesel Euro 0-3, Gasoline Euro 0	No entry	

3.2 The effects of the policy

During the first year, Area C proved to be effective in reducing car trips inside the cordon. Official measures report an average decrease of 41000 vehicles/day between 2011 (with the previous Ecopass pollution charging) and 2012 (the first full year with Area C congestion charging), corresponding to -31%. The autumn months performed slightly worse, -27%, probably due to the Milan citizens getting more used to the charging and to the increase of residents trips, once understood that the 40 free entrances were sufficient. Traffic decreased slightly also in the rest of the city (-7%).

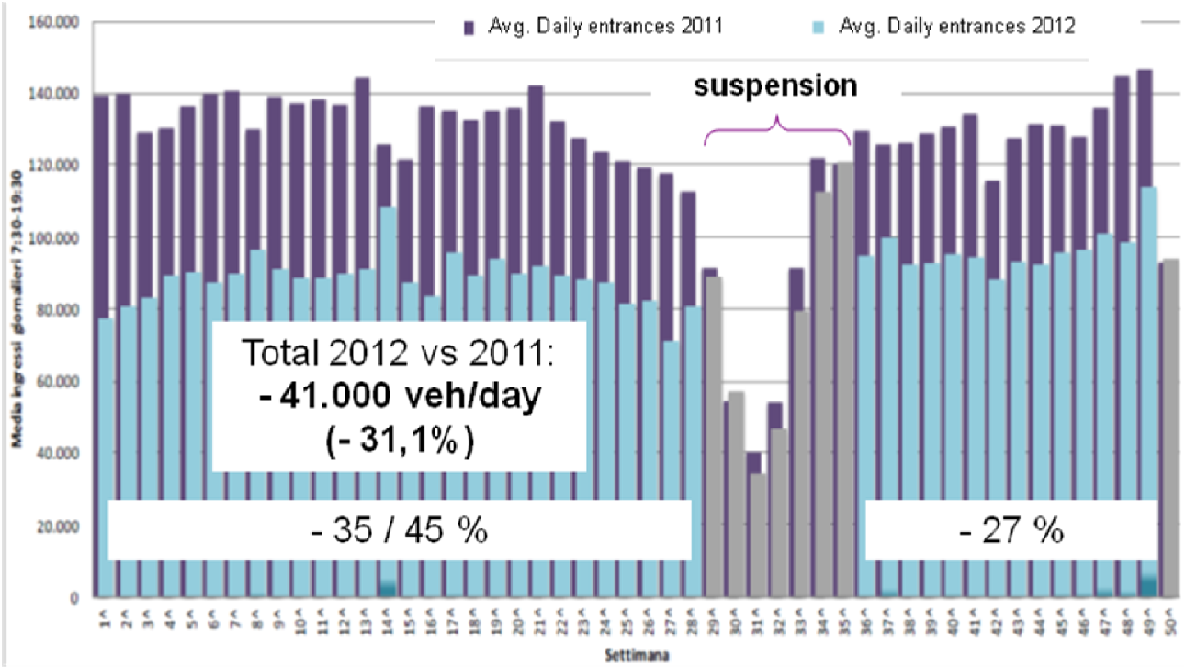


Figure 2. Comparison of 2011 and 2012 traffic measures in Milan centre

Source: AMAT, 2012

It is worth noting that in August – mid of September, the tribunal suspended the pricing for a dispute. During these weeks, not corresponding at all to holiday break, traffic got back exactly to 2011 values, suggesting that the decrease was almost totally due to the pricing itself.

Revenues from tolls accounted, in 2012, for 20.3 Millions Euro. Of these, approx 10 were used to operate the system and the remaining to finance public transport increase (10 millions) and new bike sharing stations (3 Millions). The administration committed itself to spend the totality of net revenues into sustainable mobility and public transport.

It is also interesting to check which categories are more influenced by the policy. Analysing the distribution of entrances of the five users categories (***Figure 3***), we see that "other" cars (i.e. all those not belonging to specific categories) are those with the most occasional behaviour. For example, 48% entered just once in a year and 88% entered less than 10 times. To the opposite, residents are (among paying users) those entering more times in a year: 30% of them entered more than 40 times, corresponding to the threshold of free entrances. The rest did not pay because below the threshold and 7.5% of them did not even pass the cordon one time in a year.

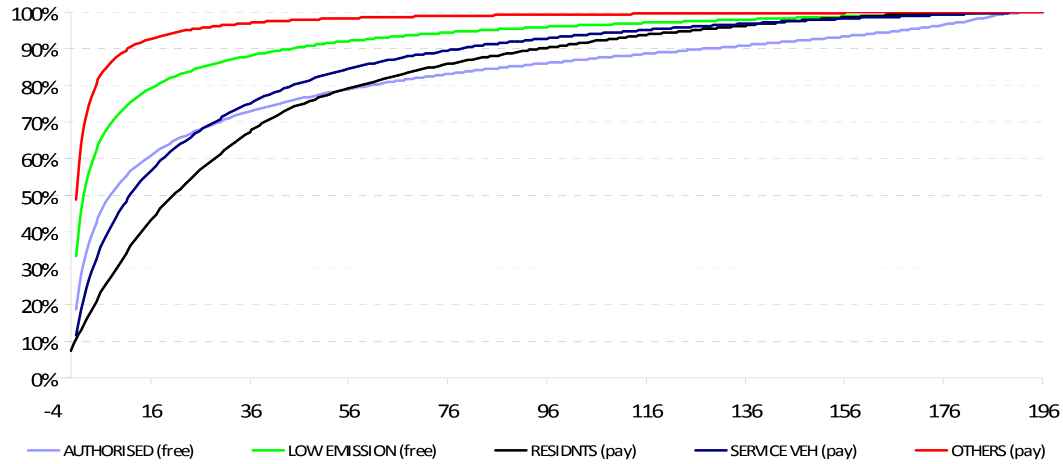


Figure 3. Cumulated number of entrances in 12 months, for users categories
Source: authors' elaboration on AMAT, 2012

These figures explain that citizens well accepted the policy: actually few residents were affected by the measure or had just to adapt their behaviour to remain below the 40 free entrances. Other cars and vehicles pay sporadically, few times in a year. Less than 1% of each category vehicles enters in the cordon every day. With the exception of some residents, the main resistances to the policy are concentrated among the owners of the shops, which claim a negative effect on sales. However, it is possible to demonstrate that the number of city users entering in the city centre (i.e. taking into account those entering both by car and public transport) decreased only of 4-5%.[7]

4 Data and methodology

In order to investigate the effects of Area C on the citizens' travel behaviour, data are collected in the year 2012 among the inhabitants of the municipality of Milan[8]. The database consists of 1,198 observations[9], and includes demographic variables (gender, age, education and skills), respondent's address, variables related to the number of owned cars and typology, individual travel patterns (Table 4) (Beria and Laurino, 2013).

The probability of the respondents to reduce the use of the car because of the Area C introduction is investigated by means of descriptive statistics and econometric analysis – multinomial logit model – (Train 2003, Marcucci, 2011). Specifically, according to the above commented literature review, several explanatory variables have been taken into consideration: demographic variables, variables related to the number of owned cars, their

[7] Authors' estimation on AMAT (2012) and on other official documents on public transport patronage.
[8] The database comes from "Green Move" project, carried out by the Politecnico di Milano and sponsored by Regione Lombardia (see Beria and Laurino, 2013).
[9] Of which 1,129 are used. For a discussion on database cleaning see Beria and Mariotti (2013).

value and fuel-typology, the district of residence, the respondents' green attitude, the perceived increase in oil prices, etc.

Table 4: Explanatory variables

Variable	Description
Socio-economic variables	
Gender	Dummy variable: "1" if male, "0" if female.
Age	Age of the respondent. Continuous variable
Education	Dummy variable: "1" if the respondent achieved a bachelor degree (ISCED[10] 6 at least), "0" otherwise
Skilled worker	Dummy variable: "1" if the respondent is a skilled worker, "0" otherwise
Car change	Change in the number of owned cars in the last five years. Dummy variable: "1" if increase, "0" if decrease or steady.
Oil price	Dummy variable: "1" if the respondent has changed his/her travel patterns due to the oil price's increase, "0" otherwise.
District of residence	Represents the district where the respondent lives. Dummy variables.
Travel behaviour	
Modal choice: - LPT - Bike - Foot - Motorcycle - Car (driver) - Car (passenger)	Six dummy variables suggesting the main modal choice adopted by the respondent.
Daily travel by car for: - reaching the workplace - reaching the LPT stop - moving within the neighbourhood - moving outside the neighbourhood - leisure in the city - other motives (i.e. tourism outside the city)	Six dummy variables underlying why the respondent uses the car daily or very often.
Car use	Dummy variable: "1" if the respondent uses the car not often, "0" otherwise
Green attitude	
Car sharing member	Dummy variable: "1" if the respondent is or has been member of car sharing services in Milan (Guidami and E-Vai), "0" otherwise.
Peer-to-peer	Dummy variable: "1" if the respondent is favourable to become a member of a future peer-to-peer car sharing service, "0" otherwise
Share LEV	Share of low emission vehicles owned by the respondent over the total number of owned cars. Continuous variable

The question about the effects of Area C on travel behaviour presented a set of five answers (Table 5).

[10] *International Standard Classification of Education*

Table 5: Dependent variable

Answers	***Multinomial logit***
Yes, I reduced the use of the car to enter Area C zone	1
Yes, I use less the car for all my trips	2
Yes, I do not use the car anymore for my trips	
No, I pay the ticket and I did not change my travel behaviour at all	0
No, I'm limitedly affected by Area C	

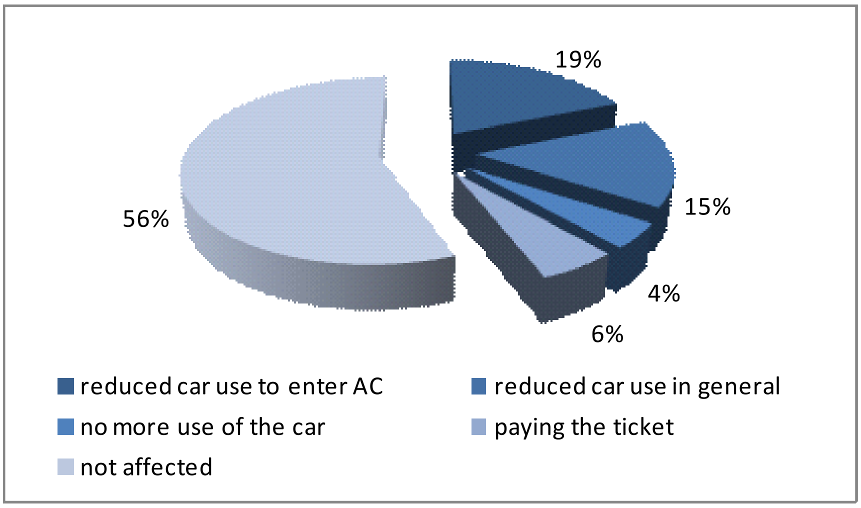
Question: "Have you changed your travel behaviour due to Area C"

The differences in travel behaviour as a consequence of the Area C introduction are modelled by means of a multinomial logit estimation, relating the probability to have reduced the use of the car or not,for entering in Area C or in general to a set of explanatory variables x_i.
We computed a multinomial logit to see whether the difference between the respondents' travel behaviours are significantly different from zero and random utility components are assumed to be independent identically Gumbel (extreme value) distributed (Greene, 2003).
The analysis has been conducted by considering multiple answers (Table 5); therefore, we applied a multinomial logit model where the dependent variable assumes "0" value if no change of travel behaviour occurred (i.e. the respondent trips are not affected by the introduction of the toll, because not influenced by the cordon or because the driver is willing to pay the toll); "1" value in case of car use reduction for entering in Area C; and "2" value if car use has been reduced, in general, or ceased at all. The meaning of this classification is to distinguish between those whose travel behaviours did not change significantly (comparison Group), from those which are affected somehow. The characteristics of these groups are studied, with respect to the unaffected. The explanatory variables, which capture the difference in travel behaviour are described in Table 4. Besides, district dummies (in Table 4, as well) are added to the model in order to control for fixed effects.

5 Descriptive statistics

According to the results of the survey, the impact of the "Area C" in terms of trip change can be represented in Figure 4.
More than the 60% of the respondents has not changed habits due to the toll introduction: most of them (56%) are not affected by the toll, while 6% nis willing to pay the ticket for keeping on entering in area C.
As concerns people who changed their own travel behaviour, the most of them has changed it only for entering into the area (19%), a still significant part is using less the car in general for all its movements (15%), while about 4% of the whole sample has decided not to use the car anymore.

Figure 4 – The impact of "Area C" in Milan in terms of trip change



Source: authors' elaboration

In the next paragraphs some variables will be considered in order to better understand their possible influence on respondents' reaction to the introduction of the Area C toll. In particular, variables have been divided into three categories (Table 4) according to the following features: socio – demographic variables, both individual (age, gender, education, job, place of residence), and car fleet characteristics (number of cars owned by the family and its recent changes, impact of fuel price increase); travel behaviour (modal choice, driven distance and car use frequency); and green attitude, concerning propensity to car sharing services, both traditional and peer-to-peer, and the preference towards low-emissions vehicles (hereafter LEVs).

5.1 Socio-demographic variables

Males and females do react in a similar way to the toll introduction, except for the decision to reduce or stop car use: in this case women are 20%, that is more than the men (17%).

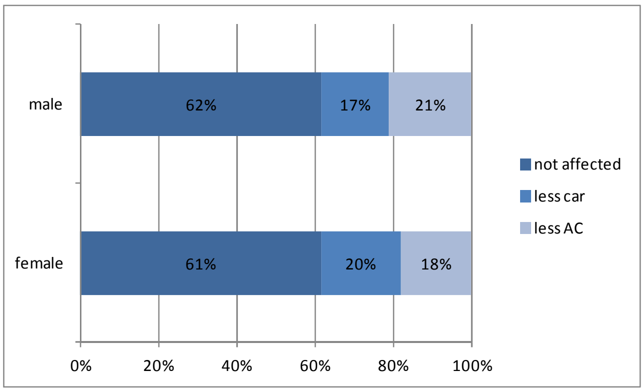


Figure 5 – The impact of "Area C" in Milan - gender
Source: authors' elaboration

Among those who have reduced their car use in general or even stopped it, people between 30 and 49 years old constitute 60%; 20% of them are under 29, while the left 22% belongs to the "eldest" class (50-59). The youngest, instead, are about a quarter of those whose car use for entering in Area C is now lower, but they are only the 19% of the not affected.
A quarter of the youngest (18-29) respondents (24%) has reduced his/her car use for entering Area C, while people aged 40-49 seem more reluctant to change their habits: if affected, they prefer to pay the toll (41%).

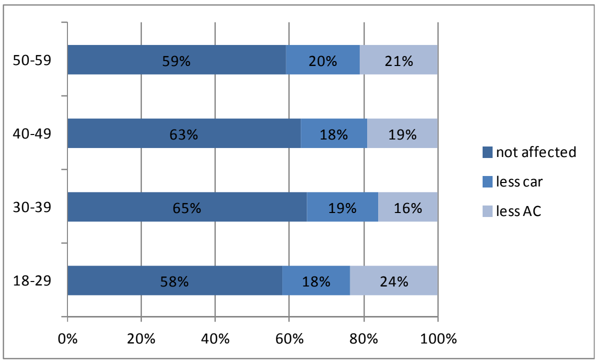


Figure 6 – The impact of "Area C" in Milan – age
Source: authors' elaboration

Educated people (ISCED[11] 2011 more than 6), i.e. people who have at least a bachelor degree, (one third of the sample) are approx. the 30% of each category of respondents.
Among them, the 60% is not affected while the affected ones are equally divided into the two categories of those reducing their car usein general orfor Area C entry. The quote of affected is then 41%, that is a little bit more than the 38% of affected respondents' who do not have a bachelor degree.
As expected, due to the correlation between ISCED levels and workers' expertise, not even skill seems a key driver for reducing car use after the introduction of the "Area C" measure, since the quote for each category (about a quarter) clearly reflects the percentage of skilled workers on the total of the sample (25%). Furthermore, skilled people reducing their car use (both in area C and elsewhere) are 41% compared to the unskilled affected by the toll (37%).
The same can be said for not working people (including retired, students, unemployed and housewives/homemakers); due to the high employment level in Milan, 80% of respondents are active on the labour market and the same quote is present in each frequency class. In this case unemployed reducing their car use are 44% compared to the "affected" quote of employed (37%).

[11] See footnote 10.

A second noteworthy class of variables analyses the car fleet of the surveyed people.
Half of the sample owns only one car, while another 42% have two; only 9% owns at least a third car, for a total amount of 1,819 cars. The share of cars for 1,000 inhabitants (548) is consistent with the urban level of motorization for the area (Istat, 2011).
Car fleet has been steady during the last five years for a great majority of citizens (75%), and only the 17% of the respondents have increased the number of their cars.
In particular, among those affected in entering Area C, the percentage of those who have reduced the number of their own cars during the last 5 years is 12%, more than 8% among the not affected and those who have reduced their car use in general.
An exogenous variable has also been considered. Respondents were asked about their being affected by the fuel price increase. About 73% of people affected by Area C declares also to be affected by the higher prices of fuel, which made them using less the car and preferring other travel modes. Among those who reduced their entrances in "area C", the quote of affected by the oil price increase grows up to 86%.
Even in this case, people who were influenced by the fuel price increase and changed their travel behaviour after the Area C introduction are much more (47%) than those reducing car use (23%).

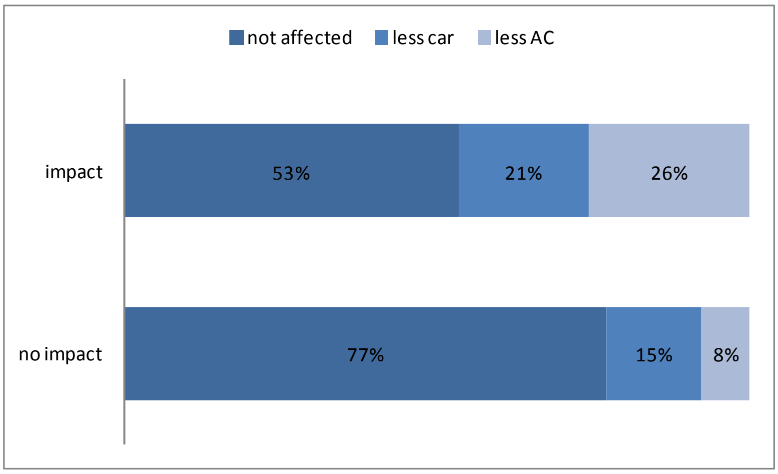


Figure 7 – The impact of "Area C" in Milan – fuel price increase impact
Source: authors' elaboration

Finally, a focus has been placed on the geographical areas of Milan. The city is divided into 9 zones, where the zone n°1 (Central district) is totally inside the Area C, and people living there have got some partial exemption from the toll[12]. As expected, in this district, the quote of those paying the toll is the highest (22%).

[12] See Table 3.

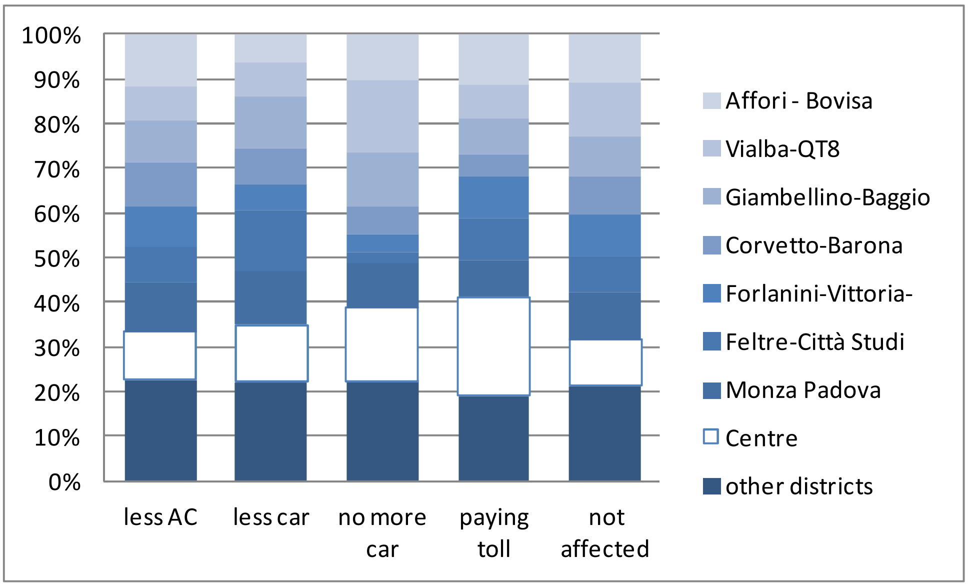


Figure 8 – The impact of "Area C" in Milan – place of residence
Source: authors' elaboration

5.2 Travel - behaviour variables

Moving to the respondents' travel choices, variables about distance and motivation of the journey are here considered. More than half of the sample covers less than 10,000 km per year (54%), 31% travels for 10,000 up to 20,000 km, and only the 2% covers more than 50,000 km.

As concerns the covered distance, the sample has been divided into "frequent driver" (those who use car daily or often) and others. Following this distinction it is possible to note that frequent users have reduced more their trips by car into the Area C (15%) than those elsewhere (8%). By the way, irrespective of their driving frequency, the 80% of the sample have to cope with the Area C toll.

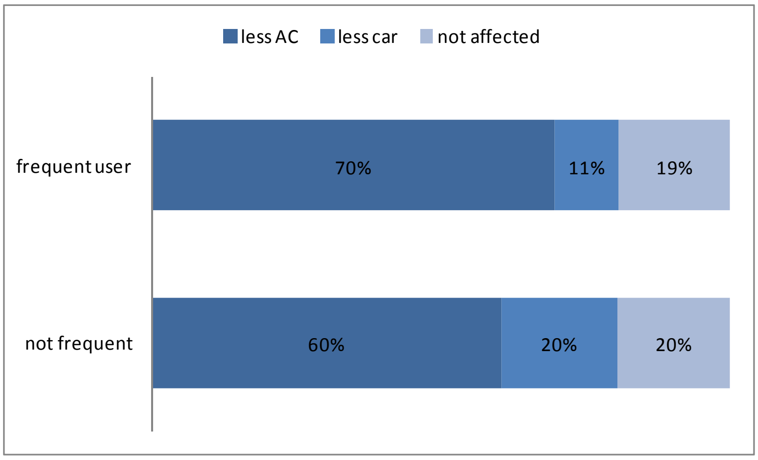


Figure 9 – The impact of "Area C" in Milan – travel frequency
Source: authors' elaboration

Focusing on the different transport means chosen by respondents, it's not surprising the majority (59%) of preferences for the car as a driver (all respondents have got the driving licence and have at least one car at their disposal in the family.

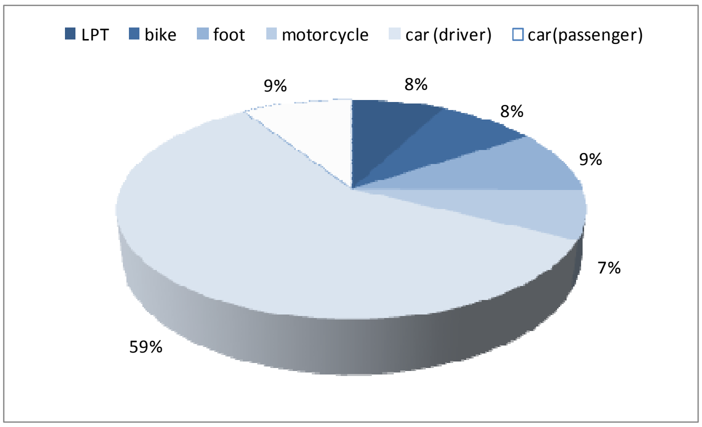


Figure 10 – Travel choices in Milan
Source: authors' elaboration

Finally, as concerns the main motivations for travelling (i.e. daily or often), the most of the people is going to work (21%), while going to the LPT stop is not so frequent (9%), probably to the great diffusion of LPT network and at the consequent being handy of the stops themselves.

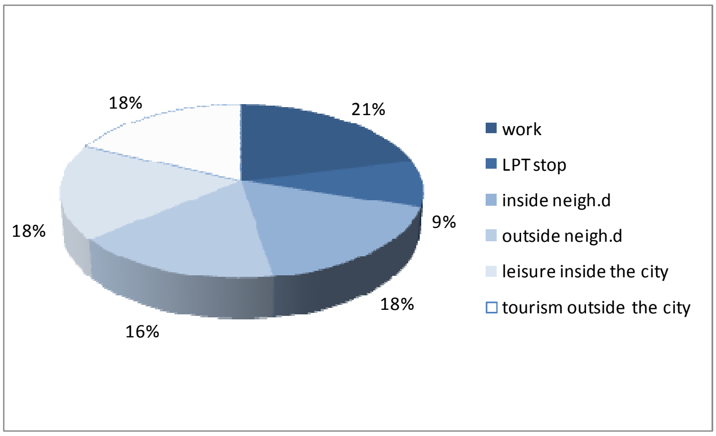


Figure 11 – Travel choices in Milan
Source: authors' elaboration

5.3 *Green attitude variables*

For measuring the "green attitude" of the survey respondents, two kinds of questions have been identified: those concerning the car-sharing (traditional and peer-to-peer) and the propensity (stated or revealed) towards LEVs.

As concerns car-sharing, people were asked if they are (or have been) members of GuidaMI or E-Vai. Among those who use or used these car-sharing services, the most of them (about 80%) has reduced car use facing Area C introduction, compared to 36% of those not interested in the car-sharing services.

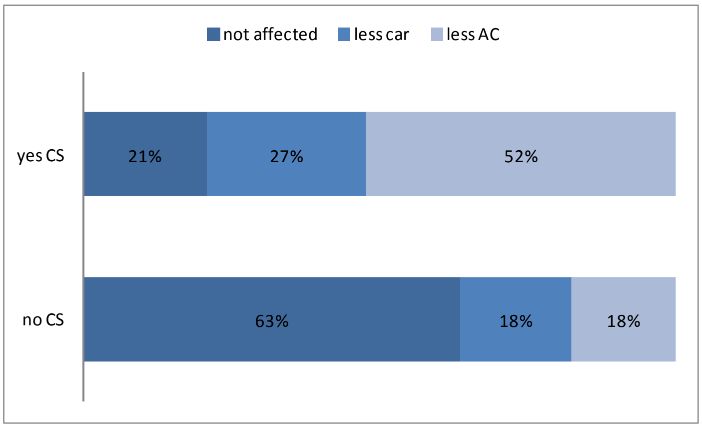


Figure 12 – The impact of "Area C" in Milan – car sharing
Source: authors' elaboration

People willing to share their own vehicle in a peer-to-peer car sharing, are more flexible to the toll introduction: 45% of them reduced car use versus 32% of those who are not willing to share their car.

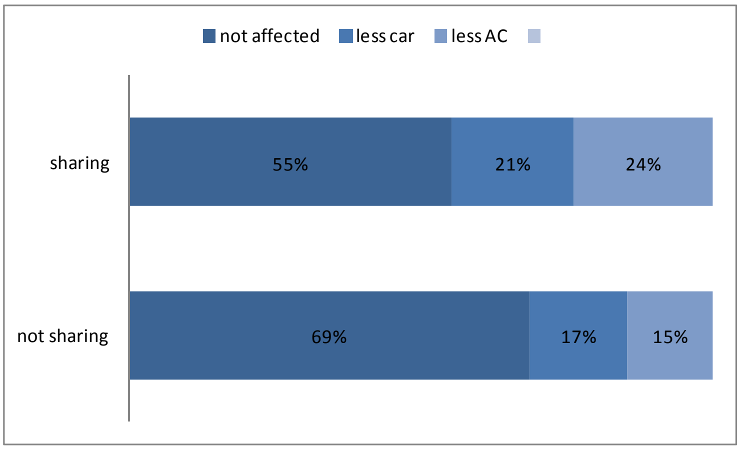


Figure 13 – The impact of "Area C" in Milan – car sharing peer-to-peer
Source: authors' elaboration

Finally, it is worth considering the behaviour of those owing alternative fuelled car fleet (that amounts to 10% of the total). Both revealed preferences for a LEV (i.e. the share of LEVs over the owned car fleet) and declared ones (i.e. the willing to buy a LEV) do not seem to impact on the travel behaviour of the respondents after the introduction of Area C. Actually, the quote of not affected people is about 20% both for "green" and "not green" motorists.

6 Multinomial logit model results

The results of the descriptive statistics have been corroborated by a multinonal logit model, where the comparison group is represented by those respondents that have not changed their travel behavior ("car addicted"). Table 6 presents the results of four models, which differ according to the number of explanatory variables included; in models 2, 3 and 4 dummy district variables have been included to control for fixed geographical effects.

Table 6: Multinomial logit model

	Model 1	Model 2	Model 3	Model 4
Group 1				
Gender	-0.352**	-0.318**	-0.320**	-0.315**
Age	0.012	0.012	0.009	0.010
Skilled workers			0.256	0.253
Increased car number	0.081	0.069	0.079	0.116
Reduced car number	0.015	0.028	0.016	0.025
Oil price	0.575***	0.578***	0.570***	0.575***
LPT	0.924***	0.879***	0.931***	0.924***
Bike	0.800***	0.785***	0.828***	0.836***
Foot	0.396	0.413*	0.479**	0.501***
Motorcycle	0.850***	0.826***	0.831***	0.815***
Car- driver	0.648***	0.604***	0.585***	0.563***
Car-passenger	0.570**	0.500	0.529	0.518
Car use-travel to work	0.466***	0.483***	0.471***	0.475***
Car use to reach LPT stop	0.471***	0.455***	0.480***	0.500***
Move_in neigh			0.323**	0.316**
Move_out neigh			-0.005	0.012
Car use leisure	0.434***	0.423***	0.364**	0.361**
Car use tourism			0.042	0.040
Carsharing member	1.365***	1.333***	1.352***	1.401***
Peer-to-peer	0.252	0.284*	0.277*	0.283*
Share_LEV				-0.716***
_cons	-3.855***	-3.797***	-3.994***	-3.958***
DummyDistrict	no	yes	yes	yes
Group 2				
Gender	0.041	0.044	0.027	0.033

Age	0.018***	0.017***	0.016**	0.017**
Skilled workers			0.116	0.105
Increased car number	0.410**	0.389**	0.393**	0.439**
Reduced car number	0.695***	0.661***	0.628***	0.651***
Oil price	1.404***	1.414***	1.436***	1.447***
LPT	0.572***	0.540***	0.489***	0.486***
Bike	0.440	0.447*	0.407	0.418*
Foot	0.494***	0.448**	0.405**	0.423**
Motorcycle	0.386	0.386	0.363	0.345
Car- driver	-0.282	-0.279	-0.267	-0.288
Car-passenger	0.471	0.468	0.457*	0.436
Car use-travel to work	0.294	0.338*	0.342*	0.349*
Car use to reach LPT stop	0.533***	0.512***	0.534***	0.556***
Move_in neigh			-0.172	-0.181
Move_out neigh			-0.069	-0.054
Car use leisure	0.294	0.314**	0.280	0.282
Car use tourism			0.128	0.128
Carsharing member	1.772***	1.802***	1.794***	1.849***
Peer-to-peer	0.230	0.260	0.254	0.260
Share_LEV				-0.788***
_cons	-4.123***	-4.026***	-3.908***	-3.882***
DummyDistrict	no	yes	yes	yes
n.obs	1129	1129	1129	1129
Log Likelihood	-946.76836	-935.45966	-931.60993	-927.72561
PseudoR2	0.1008	0.1115	0.1152	0.1189

Group 0 (where Y=0) is the comparison group, who did not reduce car use; Group 1 (Y= 1): car reduction to enter Area C zone; Group 2 (Y=2), car reduction for all moves-no car use.

As concerns the socio-economic characteristics, it results that compared to the “car addicted” respondents (comparison group), those who have been affected by the Area C tool (group 1) tend to be female and oil price sensitive. Besides, they tend to use the car as driver, but also to use LPT, bike, foot and motorcycle; specifically, the car is used to travel to work, to reach the LPT stop, to move within the neighborhood where they live and for leisure. Besides, they show a green attitude since they are (or have been) car sharing members, are willing to adopt a peer to peer service, nevertheless, they are less willing to own LEV cars, if compared to traditional cars. The car ownership, in terms of chanes, instead, is not relevant in explaining the travel choices.

The respondents that have reduced the car use for all their trips (Group 2) tend to be older (although the coefficient is small), and they have experienced a change in the number of owned cars in the last five years. Besides, they are oil price sensitive and tend to travel by means of LTP, bike, foot, and only in model 3 they are car passenger. They use the car only to travel to work and to reach the LTP stop. Besides, they are or have been car-sharing members,

while are less willing to own LEV cars, if compared to traditional cars. Overall, they seem to be the economically weaker groups, which reduced car use not only due to AreaC, but also in general, in order to face the economic crisis.
The two groups share, therefore, common patterns: price-sensitiveness, travel behavior, green attitude in terms of car-sharing membership, and are less willing to own LEV cars. This last aspect can partially explain car use reduction: LEV can access Area C without paying the ticket. Differences mainly concern gender (Group 1), age (Group 2), and change in the number of owned cars (Group 2). Besides, the following aspects are never significant: skilled workers, car use to move out of the neighborhood, and for tourism.

7 Conclusions

In this paper the impact of the introduction of road pricing on citizens' mobility behaviour has been investigated. In particular, the characteristics of those who have reduced their car use for entering only in Area C (Group 1) and for all their trips (Group 2) have been observed by means of descriptive statistics and econometric analysis.
Results are quite consistent with those provided by the empirical literature.
As concerns socio-demographic characteristics and travel behaviour it is possible to note that gender is not always significant while, as expected, having a permanent job (proxied by using the car to reach the work place) makes respondents less flexible to car use control policies as road pricing.
Age proved to be significant (again, in Group 2) in explaining the reduction of car use in general, in contrast with the most frequent literature results. This is probably due to the upper limit of 59 present in the survey, that is mainly a still-working condition. As concerns travel behavior, respondents in groups 1 and 2 tend to prefer LPT, and to use the car to reach the LPT stop with respect to Group 0 (those not affected by the charging).
With respect to the comparison group (those who are not affected or those who pay the ticket), affected respondents (groups 1 and 2) share some features like price-sensitiveness, travel behavior, and green attitude.
Owing Low Emission Vehicles, on the contrary, is always negative and significant. This last aspect can partially explain car use reduction, indeed, LEV can access Area C without paying the ticket. Furthermore, LEV are often more expensive than traditional ones, coping with the price-sensitiveness of the respondents as well. These results confirm the effectiveness of the Area C program in car use reduction, but also that the impact is not homogeneously distributed among users groups. For sure, users with better alternatives (those already using public transport, primarily) are those which more easily can reduce car use. At the same time, weaker social groups tend to be more affected due to their price sensitiveness, but this is true to explain general car use reduction and not priced area reduction, showing a certain rigidity

in the drivers' relationship with the priced area. Nevertheless, it cannot be denied that the fuel price increase might have strengthened the positive impact of the tool, since it is visible a clearer correlation for the group which reduced car use in general rather than those driving through the charged area..

In general, as in the other examples of London and Stockholm, the importance of a clear communication of both the goals and the toll revenues future use and the presence of a good LPT service seems to be determinant. Within this context, the relative quality of LPT in Milan can be useful to explain the policy results (Beria and Boggio, 2013). The same can be said about the referendum that was held before the change from Ecopass to Area C, which shows a clear propensity towards citizens' participation (*ibidem*).

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SOMMARIO

Tra le diverse possibili strategie per rendere sostenibile la mobilità urbana, il *road pricing*, che nella maggior parte dei casi consiste nell'imporre una tariffa all'ingresso nelle aree più congestionate, si è rivelata una misura efficace. Ciononostante, i cittadini, e a maggior ragione gli amministratori, considerano impopolare questo strumento di regolazione (Gaunt *et al*. 2007, Glazer 2012, Hamilton 2012). Di conseguenza, in Europa ne esistono poche applicazioni, per lo più nei paesi del Nord. In Italia, a Milano, nel 2007 è stata adottata una politica di *road pricing*, inizialmente nata come tassa sull'inquinamento (Ecopass) che in seguito ad un referendum consultivo si è trasformata nel 2011 in una tassa sulla congestione (Area C).

In quest'ambito, l'articolo si propone di studiare l'impatto del *road pricing* sulle scelte modali dei cittadini tramite una statistica descrittiva ed un'analisi econometrica, e precisamente un modello logit multinomiale (Train 2003, Marcucci, 2011). Il modello considera diverse variabili esplicative, come i dati demografici, le caratteristiche del parco veicolare e la zona di residenza. Sarà inoltre osservato l'effetto di alcune variabili esogene, come l'aumento del prezzo del carburante.