THE ROLE OF TRANSPORT SUPPLY IN THE ACCEPTABILITY OF POLLUTION CHARGING EXTENSION. THE CASE OF MILAN

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ABSTRACT

In the beginning of 2008 a pollution charging in the central area of Milan was introduced. It initially had a large impact on traffic volume, but in some years its effect worn off, as the citizen of Milan started to change their cars. This is why in June 2011 Milan citizens were consulted in a referendum for its extension to all cars, resulting in a strong support to the policy extension.
We initially describe and contextualize the Milan experiment within the main European experiences on urban road charging in order to have a better understanding of the acceptability of this kind of measures.
The paper then attempts to study, through a revealed preferences exercise, which are the determinants of the highly positive vote in favour of the extension to a road pricing scheme. In particular we are focusing on: ideological orientation, socio-economic variables, distance from the city centre, public transport provision. Differently from existing literature, we put particular interest in the latter, as we want to assess the relationship between policy acceptability and neighbourhood accessibility, to verify if public transport was essential to the successful implementation of road charging.

JEL classification: H23, D72, R48.
Keywords: transport, acceptability, pollution charging.

INTRODUCTION

In 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". The Ecopass 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. The "Ecopass" lasted until 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.

At the end of the trial period of *Ecopass*, before taking any decision on its extension or elimination, the former (right-wing) city Mayor announced a referendum on the topic (promoted by a group of associations), which took place the 12th June 2011 and will be described in the following.

In the present paper we study, through a revealed preferences exercise, the determinants of the vote of the citizens of Milan in the Ecopass extension referendum (i.e. the measured level of acceptability of pollution charging); in particular, we test the importance that the supply of public transport available in the neighbourhood had on the referendum votes, also taking into account the local political orientation and some socio-economic variables.

This aggregated revealed preferences approach appears to be seldom used; in fact, literature generally concentrates on models or stated preferences surveys describing the behaviour or the acceptability of users of an entire area, or on the ex-post measured or perceived effects of the policy. Nowhere else in consulted literature (with the relevant exception of Hårsman and Quigley, 2010, analyzing a similar situation in Stockholm), the differences of acceptability among neighbourhoods were analyzed and explained empirically, with particular respect on public transport.

We match data from various sources to investigate the determinants of a positive vote to the enlargement of the Ecopass area, and the model results seem to be in line with our predictions. Basically, the political ideology and environmental attitude are among the main determinants of the vote. However, also other variables matter in explaining the referendum results, such as the position of the cordon, the public transport supply in the neighbourhood and a limited number of land use and socio-economic characteristics.

The paper is structured as follows. Section 2 recalls the main European experiences on urban road charging, focusing on their acceptability. Section 3 is devoted to the description of the case of Milan, Section 4 explains the empirical framework, and Section 5 discusses the results. Section 6 concludes.

URBAN ROAD CHARGING EXPERIENCES

The first application of the apparently simple idea of road pricing[1] to control congestion took place in Singapore, in June 1975. It proved to be effective in reducing congestion, increasing speed and shifting traffic on less congested roads, time of the day or public transport, that actually doubled in share (Phang and Toh, 2004).

Following Singapore's path road pricing schemes were adopted later in the three main Norwegian cities, namely Bergen (1986), Oslo (1990), Trondheim (1991) to enter in the respective central areas. Actually, the effect in terms of traffic reduction is negligible. The goal of the policy, however, was essentially to raise finance and implement transport investments, mainly roads. In general, the charge, despite being reinvested, is not welcomed by the population, that considers it as an extra tax, that actually is since is not devoted to traffic reduction. Later on, in 2001, also Stavanger introduced a toll, this time more focused on congestion control.

The most famous case of urban road pricing is that of London, adopted in 2003. The effects (Leape, 2006) of the charging are 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 and traffic around the cordon increased between 2% and 6%. On the other side, the running costs are very high and drain up 2/3 of benefits. So, the financial break-even is based on fines, as revenues are not sufficient (Mackie, 2005)[2].

Finally, also the city of Stockholm introduced a toll system in 2006 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 City of Stockholm used the term "environmental charge", but its effects (Eliasson et al., 2009 and Börjesson et al., 2012) were more related to traffic. Travel times decreased, due to the less congestion; public transport modal share increased; car modal share decreased, even if only part of the effect is attributable to the charging (Kottenhoff and Brundell-Freij, 2009). The costs of the system are lower than London ones, but still significant, accounting for 25% of the total revenues (May et al. 2010).

The mentioned cities are not the only ones that took into consideration the introduction of a road pricing scheme. Some of them did not limit to political debate or public consultations (like in New York, San Francisco, West Midlands and some other European cities), but organized referenda to ask citizens the electoral confirmation of the policy. Among the cities in which a referendum took place, the most interesting cases are: Stockholm (with the aim to confirm or reject after a trial period the existing charging scheme); Milan (the question was about the extension of an existing policy and the result was positive); Edinburgh and Manchester (which both drove to a rejection).

[1] It is not the place here for a full discussion of road pricing theory, firstly introduced by Vickrey (1963) and Kain (1972). For a theoretical introduction see Rouwendal and Verhoef (2006).

[2] But May et al. 2010 report costs accounting for 48% of revenues. In any case, it is the largest share among charging schemes in use.

The acceptability of road charging. A literature review

Road charging measures face significant problems of acceptability from the citizens' point of view (Santos, 2008). Many cities, initially in Europe and USA and now also in Asia, took into consideration the idea of implementing this kind of measure (Ison and Rye, 2005; May et al., 2010; Hårsman e Quingley, 2010). However, with the relevant exception of few cases around the World, these ideas remained as such, due to the difficulty to make this policy acceptable.
The factors influencing or determining the acceptability of urban road pricing are numerous. At the roots, there is the value citizens give to individual car use (independence, status) and the deriving frequent use. This determines a difficulty to change the car users' behaviour, which in turn depends not only of the mentioned "psychological" elements, but also on the level of their elasticity of demand.
Exogenous elements also appear to be very relevant. Psychological and personal factors are found to be dominant in explaining the answers than the policy-specific ones; in particular social norms are the most influential factor, followed by personal expectations Schade and Schlag (2003). Further elements, aside to the effectiveness of the measure, are perceived fairness and clarity of the political decision-making process, especially if not implying significant infringements 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, the uncertainty plays a role: uncertainty of individuals increases the acceptability and the ex-ante political uncertainty about the use of revenues contributes to threat the experiment, especially if revenues are not reinvested in public transport (De Borger and Proost, 2012).
A number of stated preferences based models exist, to examine respondents' attitude toward traffic congestion and investigate the effects of endogenous and exogenous characteristics of schemes (Jaensirisak et al., 2005; Mattsson, 2003; Rentziou et al., 2011). These usually are: the mechanism applied, the specific aspects of implementation (toll, timing, area, discounts, etc.), urban structure, mobility and socio-demographic characteristics, perception of the problem, ideology, etc. Usually, however, these models ignore the geographical dimension, for example the differences among neighbourhoods.
Another body of literature, more policy-oriented, looks at problems and differences among implemented or dropped schemes, in order to explains success or failure of them. They found the factors more easily explaining the policy acceptability: existence of congestion problems, a clear communication of objectives, the reinvestment of revenues, the scheme design and simplicity, the opposition to new taxes, the perceived effectiveness and fairness, the existing vehicle taxation (Ison and Rye, 2005; Ieromonachou et al., 2006; May et al., 2010; Eliasson and Jonsson, 2011).
Despite intuitively relevant, public transport provision and accessibility are not included explicitly in literature among the elements shaping acceptability. Rentziou et al. (2011) quote a limited number of studies (few of which recent) in which the "availability of alternative modes of transport" affects acceptability. DfT (2005) reviews a number of contributions, but accessibility is only indirectly measured by the few models taking into account the generalized costs into the main behavioural model (like, for instance, in Eliasson and Mattsson, 2006), and this is often done in an aggregated manner. Theoretical contributions, such as Marcucci et al. (2005) and Russo (2012), study the effect of public transport users

vs. car users in terms of vote and political support. However, the importance of public transport for the citizens is evident in people acceptability of road charging (Kottenhoff and Brundell-Freij, 2009), also considering that one way to make more acceptable the scheme is re-investing the revenues in improving and expanding the existing transport system (Banister, 2003).
The most significant contribution on the topic is by Hårsman and Quigley (2010), which also differs from others from the methodological point of view. While the majority of studies on acceptability uses a stated preferences method, they used a revealed preferences method based on the results of the confirmation referendum held in Stockholm after a trial period. Their model has a strong spatial dimension, combining the referendum results in the different neighbourhoods with an existing transport – residential simulation model to calculate costs and simulate the effects of charging. Results, despite differently obtained, are in line with the rest of literature. They underline the importance of political tendency in referendum results. However, other factors remain important, namely the neighbourhood of residence (e.g. inhabitants in the cordon area were more willing to accept the pricing) and the size of time saving, that is strictly related with the effectiveness of public transport alternatives. Our paper applies a similar methodology with the aim of verifying if public transport has a role in explaining the acceptability of Milan road charging scheme.
An interesting aspect pointed out in some contributions is the fact that the attitude towards these schemes varies over time. The general tendency is that acceptance, compared to the early ideation phases, is decreasing during the implementation phase, while it rises after its completion as shown by attitude surveys in Bergen and Trondheim (Odeck and Bråthen, 2002), Stockholm, (Schuitema et al., 2010), and London (Dix, 2005). This is because the potential advantages (time saved) are still unsure before and are perceived only after full implementation, while the negative effect (the toll) is ready to become reality, and is often associated to practical problems (Jones, 2003; Schade et al, 2004; May et al, 2010), and both are often overvalued in their dimension (Henriksson, 2009). Literature is then aligned defining the acceptance vs. time curve as u-shaped in the three phases of ideation, implementation, and post-implementation (Jones, 2003; Rentziou et al., 2011).
Thus, the success of the Stockholm and Milan experiments can lay in the fact that the citizens had time to become familiar with the scheme, understand the mechanisms behind, and appreciate the benefits before being asked an opinion that would have been, otherwise, uninformed and dominated only by personal beliefs and expectations.

MILAN EXPERIMENT

The city of Milan, in 2007, 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.

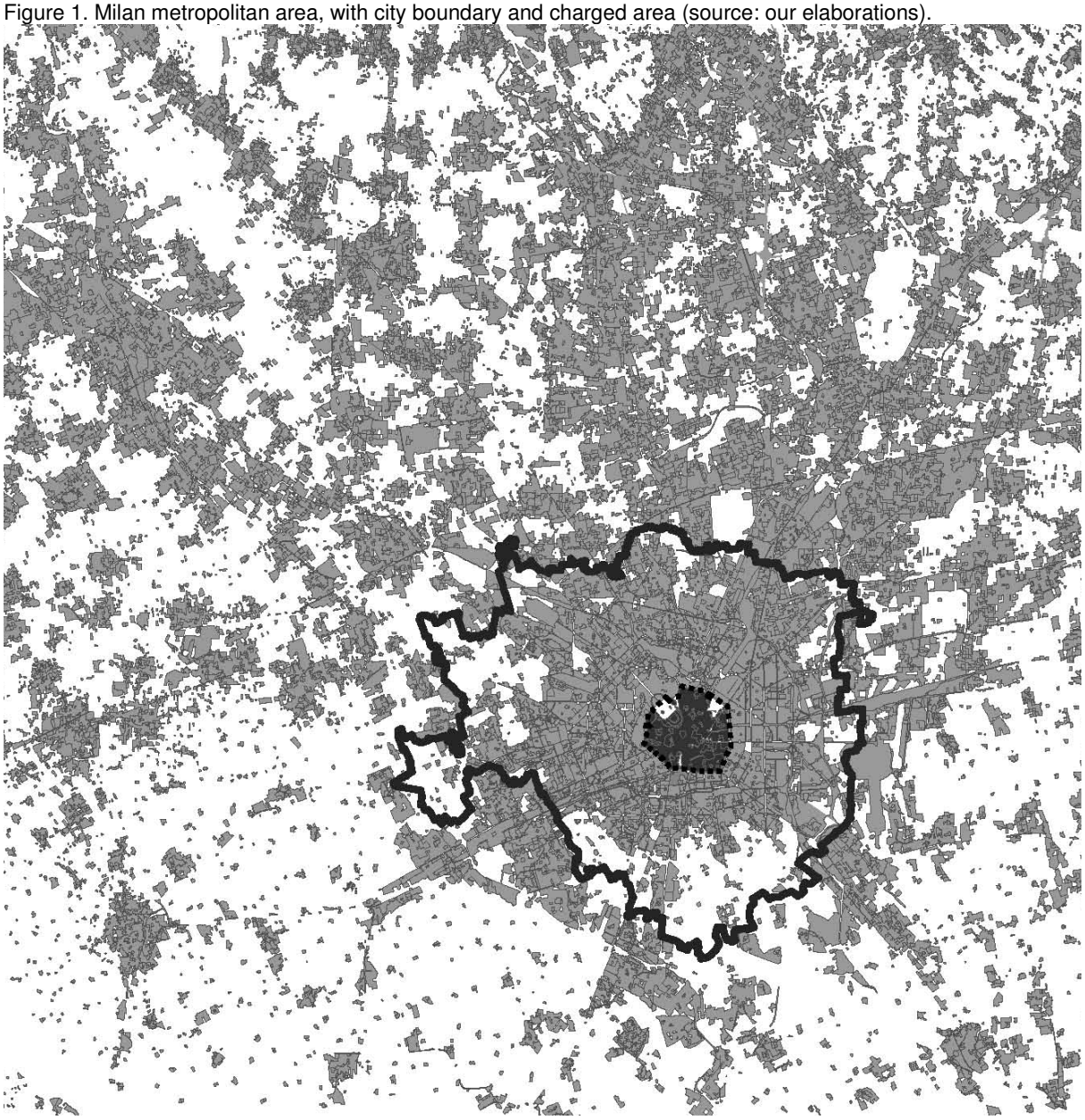
The former pollution charging measure ("*Ecopass*")

The new measure, called "*Ecopass*", started experimentally in January 2nd, 2008. It was explicitly aimed at introducing the "polluters pay principle" through a variable daily entrance toll to be paid by vehicles entering the city central area from Monday to Friday and from 7.30 am to 7.30 pm. The toll was differentiated according to the emission class of the vehicle. Older cars were instead totally banned, while innovative engines (natural gas, LPG, electric, etc.) were allowed for free. Of course, the effect of Ecopass was not limited to pollution, as it acted like a rough congestion charging toll. For a complete discussion of the Ecopass scheme, including full rules and detailed charges please refer to Rotaris et al. (2010).

The area subject to control was 8 square kilometres wide in the central sector of the town delimited by the so called *Cerchia dei Bastioni*, corresponding to the XVI century city walls. It corresponds to the 4,5% of Milan city area (much less considering the larger metropolitan area, as shown in

Figure 1). 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/km^2. Also from the commercial viewpoint the area is the core of Milan, with 23% of total commercial activities (Bedogni et al., 2011).

Figure 1. Milan metropolitan area, with city boundary and charged area (source: our elaborations).



The effects in terms of absolute pollution reduction were not revolutionary: -15% of total PM10 emitted inside the central area (Bedogni et al., 2011), but clearly much less when considering the total emissions of the whole city area. Recently, a different measure of PM has been introduced (the black carbon instead of the mass), more effective in catching the traffic reduction (Invernizzi et al., 2011). In this case the measure shows better its effectiveness. However, in general the measure revealed to be more effective in forcing the substitution of the more polluting vehicles than in reducing the direct emissions: the number of newer and less polluting vehicles entering in the area increased by 478% in 4 years and this result, of course, is reflected also on the rest of the city. Commercial vehicles substitution ratio was even larger (1400%).

Not only a benefit in terms of congestion reduction has been measured, with -16% traffic inside the tolled area (that, however, must be depurated from exogenous effects, giving a -

6% to -7%, but also an increase in commercial speed, patronage of public transport safety (Bedogni et al., 2011).
The main drawbacks of the former Milan pollution charging were:

1. A progressive reduction of effectiveness, once older vehicles are substituted: in 2010 only 14,4% of vehicles entering the tolled area were paying, while all the rest were exempted.

2. Some boundary effects on the viability and especially on the demand for parking around the cordon.

3. The lack of clarity on the way revenues, approximately 6M€/year (Papathanasopoulou and Antoniou, 2011), were reinvested.[3]

The referendum

As the effectiveness 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 question of the referendum (too long to be totally reproduced here) is:

> *Do you want that the Municipality of Milan adopts and realises a plan of interventions to empower the public transport and the "clean" mobility alternative to cars, through the extension to all vehicles (excluding the zero emissions ones) and the progressive broadening of the cordon charging, with the goal of halving traffic and pollution?*

Followed by a list of specific measures (e.g. doubling of pedestrian areas, extension of night metro opening, etc.) to be financed by the mentioned extension of the cordon (and park) pricing.
As one can see, the topic was presented in a rather generic way (who does not want a better environment?). The referendum refers to a situation quite blurred, in which citizens were asked an opinion to generically extend the existing measure.[4] In particular, they were not asked explicitly about a "congestion charging". However, the debate made clear to the electors that the main point was a yes/no about the future of *Ecopass* and in particular on its

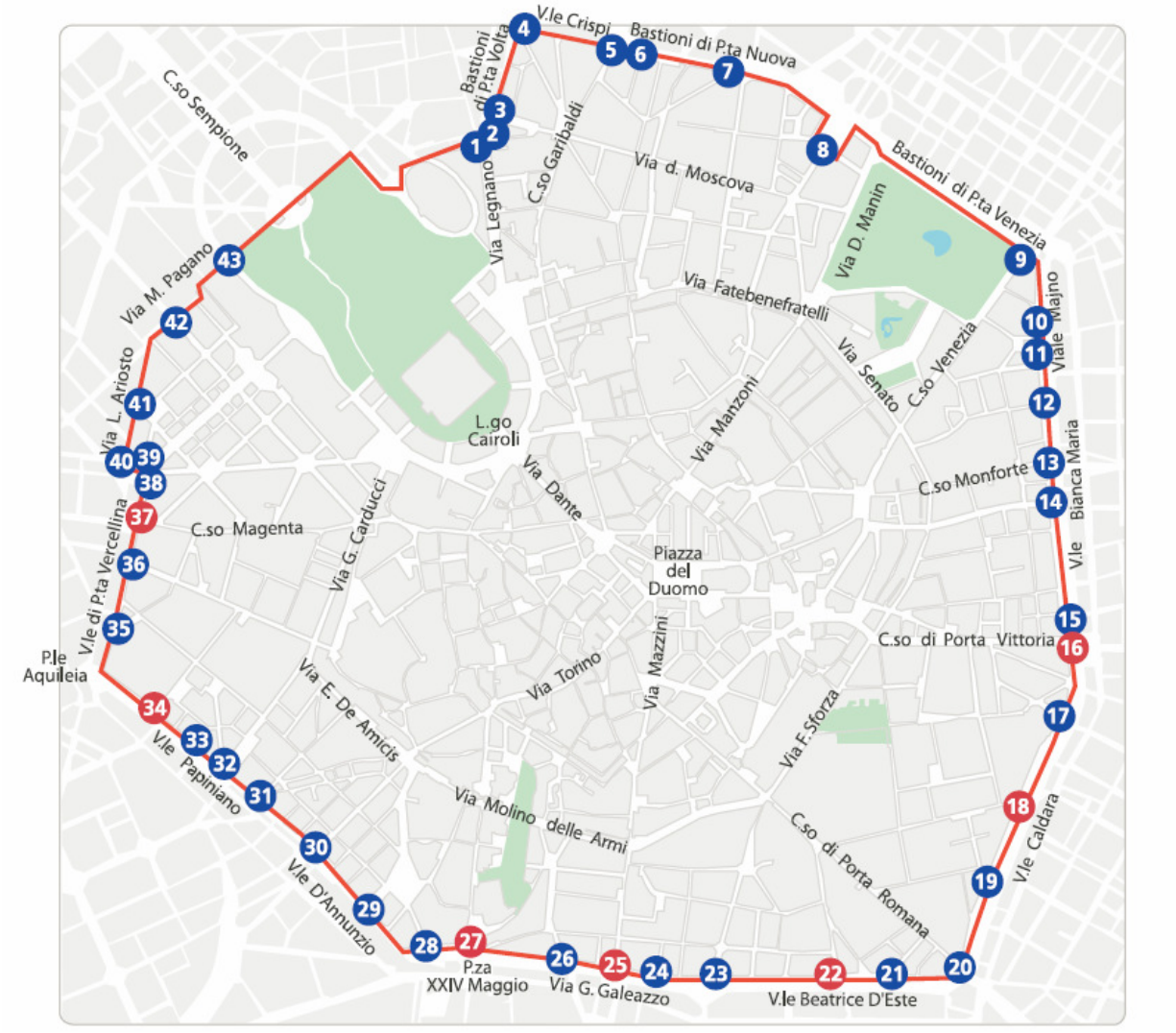
[3] However, one must say that the total resources invested in public transport in those years were many orders of magnitude larger.
[4] It is worth mentioning that, differently from Stockholm, where an information campaign on charging effectiveness took place (Hårsman e Quingley, 2010), in Milan the level of information to citizens, journalists and scholar was definitely less satisfying. No full report with detailed results was available before the referendum, but only before the new measure was implemented, thanks to the different attitude of new Mayor.

spatial and temporal extension. So, those voting "no" were clearly affirming that they did not want the Ecopass anymore, while those saying "yes" generally affirmed that Ecopass was to be extended to improve other forms of mobility.
The result was clearly positive, with a "yes" rate of 79.12%. We will widely discuss the results and the differentiations of results according to the zone in the rest of the paper.

The new congestion charging measure ("AreaC")

The referendum provided the necessary political enforcement to evolve the previous scheme towards a more traditional congestion charging scheme.

Figure 2 - The Milan cordon and the entrance points; in red those dedicated to public transport. Source: www.areac.it.



The new measure, now called "AreaC", applies to the very same zone and uses the same technological infrastructure of Ecopass. What is changed is the structure of charges. Older and polluting vehicles cannot circulate anymore, while all the rest are admitted paying an undifferentiated fare of 5€/day, whatever is the vehicle. "Service vehicles" have a discount, while residents obtained a package of 40 free entries per year, plus a discount on the

exceeding ones. Detailed analyses on the impact of such charges have been conducted and published before the new measure was introduced. For example, it has been shown that 50% of residents enter in the cordon less than 40 times/year (Bedogni et al., 2011). Similar analyses have been published after implementation confirming the expected impacts and demonstrating that the number of heavily burdened citizens is exiguous (Nuccio and Tosi, 2012). Reports about traffic, emissions and public transport speed have been published regularly and a summary of first year financial results and use of revenues has been issued.

EMPIRICAL FRAMEWORK

Milan is an important case of implemented road pricing (and also the first one in Italy) and the referendum provides an interesting dataset to analyse the determinants of the vote. The present and next sections will be devoted to study these determinants: we analyse the forces behind the (positive) vote to Ecopass extension, with the help of a linear regression model.

Data

To perform the analysis we build a unique database. From the Statistics Bureau of the Municipality of Milan, we collect data of the 286 voting precincts in Milan.[5] In particular, we gather the results of the Ecopass referendum, which took place the 12th and the 13th of June, 2011 (number of citizens with voting rights in the district, number of voters, valid votes, and the percentage of favourable answers). We also have, from the same source and with the same composition, the results of the other referendum of June 2011 (public water, nuclear power, etc.) and the detailed results of the last local elections (14th and 15th of May, 2011). We refer mainly to the results of the nuclear referendum and on the percentage of left(right)-wing results in local elections.
We merge these data with socio-economic, demographic and land use information built from other sources. These data are referred to larger zones (55 zones for the Agenzia del Territorio databases and 88 city districts from Milan Municipality databases). In addition, we calculate the distance of each voting place[6] with the Duomo square (i.e. the city centre), as a proxy of the average distance of voters from the priced area, which is round shaped exactly around the Duomo. We also categorise the zones as internal to the priced area (*central*) or external, divided in three circles (*crown, peripheral* and *suburban)*.

Table 1. List of variables and their description.

Type of variable	Variable name	Description	Unit	Source
Independent	***yes***	N. yes to Ecopass out of n. valid votes	%	A
	ecopartic	Participation rate to Ecopass referendum	%	A
Demographical	***Average_income***	Average zone income	k€	B
	PC_female	Percentage of female population	%	C

[5] Actually, the electoral precincts are more than 300, but include also hospitals, prisons, etc, which we excluded from our observations.
[6] In Italy, citizens in each precinct usually go to vote in an primary school in electoral area.

	PC_foreign	Percentage of non-Italian population	%	C
	PC_fam_with_sons	Percentage of families with sons	%	C
	PC_18-34yearsold	Age class: 18-34 years	%	C
	PC_35-64yearsold	Age class: 35-64 years	%	C
	PC_over65yearsold	Age class: over 65 years	%	C
Geographical	***Distance***	Distance electoral precinct - city centre	km	calc.
	Distance_sq	Distance squared	km	calc.
Scheme characteristics	***Cordon_inside***	Central zone, inside cordon	dummy	C
	Cordon_crown	Zones surrounding the cordon	dummy	C
	Cordon_periphery	Periphery zones, outside cordon	dummy	C
	Cordon_suburban	Suburban zones, outside cordon	dummy	C
Ideology	***Nuclear_participation***	Participation rate to the nuclear referendum	%	A
	Left_rate	Left-wing out of valid votes at local elections	%	A
Public transport	***Metro***	N. of metro or urban rail lines in the precinct	n	calc.
	Tram	N. of tram lines in the precinct	n	calc.
	Bus	N. of bus lines in the precinct	n	calc.
	Stops_density	Density of bus/tram stops in the area	Stops/ha	C
Land use	***Density***	Inhabitants density	Inh/km2	C
	PC_houses	Share of houses in the zone (surface)	%	C
	PC_offices	Share of offices in the zone (surface)	%	C
	PC_comm_industry	Share of commerce and industry (surface)	%	C
	PC_services	Share of services in the zone (surface)	%	C

Sources. A: electoral database of Milan municipality, B: Brambilla et al., 2011, C: Comune di Milano, 2012

Finally, we also compute public transport "accessibility indexes": for each voting precincts we compute, respectively, the number of metro (plus urban rail), tram and bus lines and the average density of bus and tram stops. These are actually measures of supply and not strictly of accessibility. However, in the case analysed and for our purposes, we think that this proxy is acceptable from a transport viewpoint. Milan public transport network is very homogeneous: lines of each transport means (metro, tram, bus) have pretty similar characteristics (frequency, capillarity, commercial speed), the network is strictly hierarchical (buses are often feeder lines to metro or tram lines). Moreover, given these characteristics, the measure of accessibility in terms of "lines" is easy and does not need to introduce subjective measures of relative weights.
We also considered numerous other variables (zones inhabitants, quality of life index, extra urban buses), finally excluded from the regressions because not statistically relevant.

Descriptive statistics

In Table 2we provide the summary statistics of the main electoral results. The same data are represented in the following
Figure 3,
Figure 4 and Figure 5. In particular, looking at the electoral data, the average response to the referendum query has been a very positive one (79.2%), but lower than the contextual referendum about nuclear power. The participation rate to the Ecopass vote is around 50%, quite high for a local referendum. Few months later, during local administrative elections, the majority of population voted for the left[7], and the participation rate was even higher than during the Ecopass referendum.

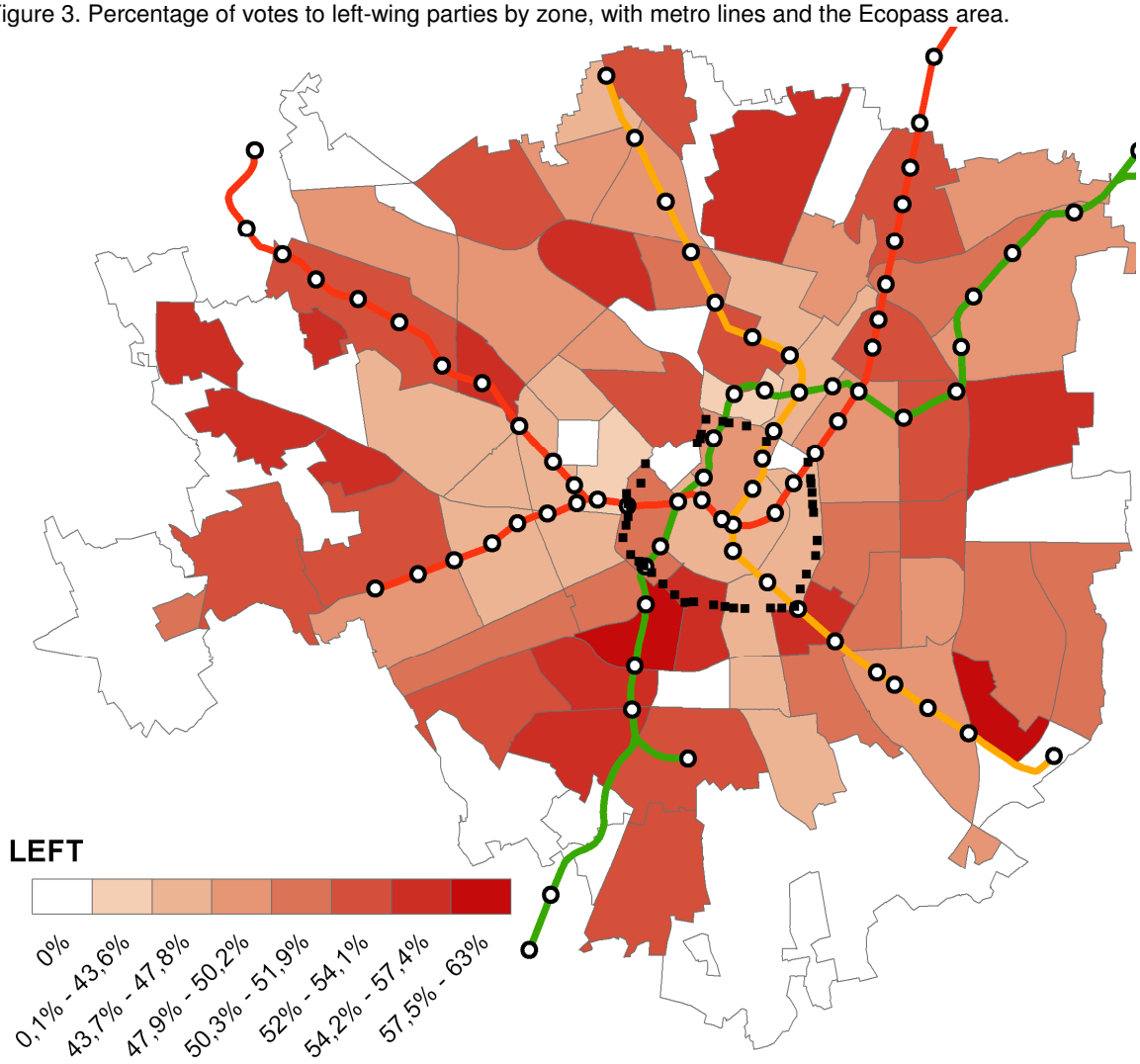
Table 2. Descriptive statistics for the main electoral variables in the model

Election	Variable	Mean	Standard deviation	Max	Min
Ecopass referendum	***yes (%)***	79.14	3.30	89.19	71.68
	ecopartic (%)	48.41	6.13	60.83	7.72
Municipal election	***Left_rate (%)***	50.52	5.37	63.94	23.33
	localpartic (%)	66.64	7.44	77.56	14.49
Nuclear referendum	***Nucl_yes (%)***	89.90	3.60	60.00	98.08
	nuclpartic (%)	49.65	5.79	37.44	80.45

The first
Figure 3 represents the percentage of votes to the winning left-wing party. The pattern is not strictly radial. Left parties perform better in the periphery and some central areas. However, right-wing remains strong also in some low income peripheral or semi-central areas in southern and northern parts of the city. As one would expect, the more conservative areas are those with higher income, which in Milan are the city centre and the western semi-central districts.

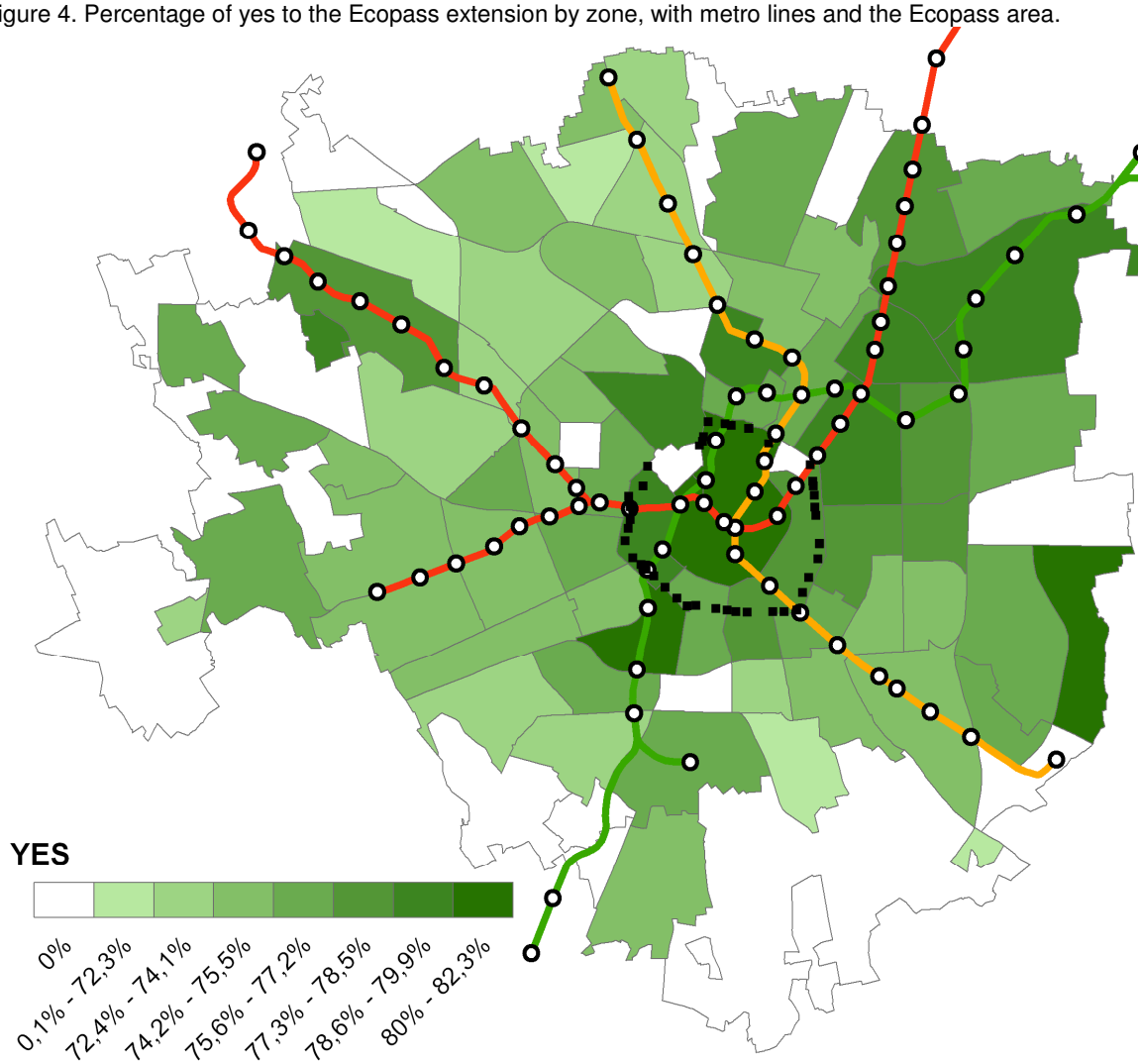
[7] These votes express only a slight preference for left-wing parties; however, after the ballot in the last weekend of May the present Mayor won with a strong majority. It is worthwhile to note that it was the first time after 20 years of conservative governments that the left won administrative elections in Milan. Nevertheless, broad differences among zones still exist.

Figure 3. Percentage of votes to left-wing parties by zone, with metro lines and the Ecopass area.



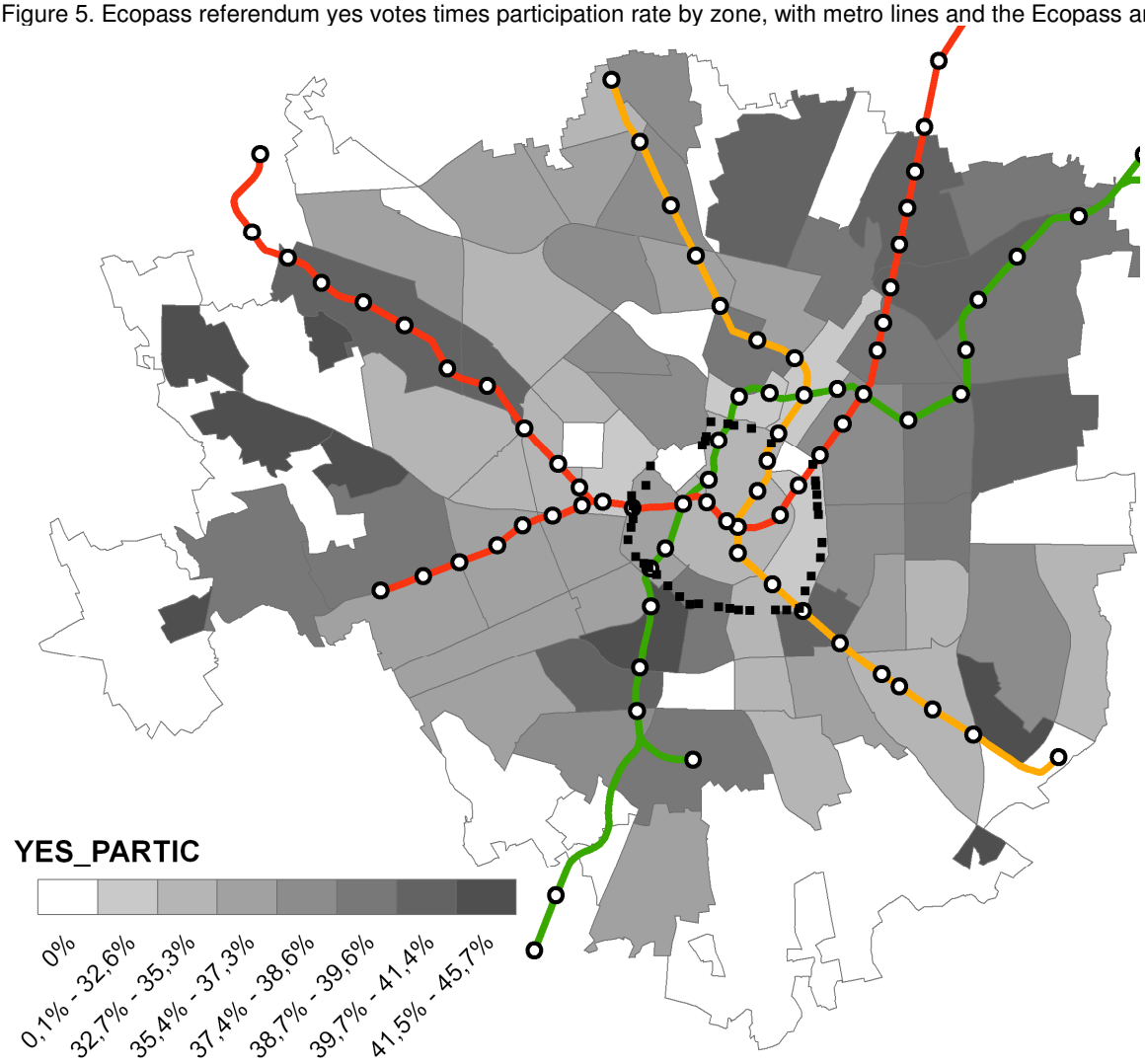
Looking in Figure 4 at the referendum result (yes/valid votes) we see a stronger favour in the city centre and in the eastern districts.

Figure 4. Percentage of yes to the Ecopass extension by zone, with metro lines and the Ecopass area.



Weighting the yes votes with the participation rate, as depicted in Figure 5, we obtain the absolute number of “yes” in the city (yes/citizens). This takes into account that participation rate is relatively low (less than 40%) in the central (here we also have the lowest participation rate in local elections) and semi-central zones. The zones with an average participation rate (between 40% and 50%) are the peripheral or suburban ones, and are particularly concentrated in the North and East parts of the town. The outcome is that the better results for the referendum are no more in the centre, but in the north and east peripheries, together with some specific zones in the west and south. It is also quite clear that the more enthusiast zones external to the cordon are those better served by metro lines.

Figure 5. Ecopass referendum yes votes times participation rate by zone, with metro lines and the Ecopass area.



From Table 3 we can infer the precincts average accessibility in 2011. More than a half of the precincts (55%) have no metro or *Passante* (i.e. light rail); tram is available in 54% of zones, while bus guarantees the full coverage of the city (is absent in only 3.5% of cases, probably central areas served by other means).

Table 3. Frequency and percentage of precincts with number of transport lines of a given transport mode in 2011

N. of lines	Metro or *Passante*		Tram		Bus	
	Freq.	%	Freq.	%	Freq.	%
0	156	54.55	131	45.80	10	3.50
1	104	36.36	64	22.38	42	14.69
2	25	8.74	51	17.83	72	25.17
3	1	0.35	22	7.69	88	30.77
4	-	-	13	4.55	59	20.63
5	-	-	1	0.35	11	3.85
6	-	-	-	-	4	1.40
7	-	-	-	-	-	-
8	-	-	4	1.40	-	-

Model, variables and hypotheses

The goal of this study is to check the determinants of the referendum results. To do that, we correlate the percentage of votes favourable to the Ecopass extension (both the *yes* and the *yes* times *participation*) with the distance from the Ecopass area, the ideological orientation, the socio-economic characteristics of the neighbourhood and the amount of public transport services available in the district.
The database includes 286 observations. Electoral and accessibility data are referred to this zoning, while socio-demographic information is referred to larger zones, as more detailed figures do not exist.
To perform the estimation, we use the Ordinary Least Squared method applied to two models. We hypothesize that the number of votes favourable to the Ecopass extension (*yes* or *yes*participation*) in each electoral precinct (y_i) depends on a constant term (α), a series of characteristics (x'_i) related to each electoral district, plus some measures of accessibility (z'_i), and an error term (ε_i).

$$y_i = \alpha + x'_i\beta + z'_i\gamma + \varepsilon_i$$

where i=1, 2, ..., 286 represents the electoral precinct.

The characteristics (x'_i) are the ones mentioned above and summarised in Table 1.

RESULTS AND SENSITIVITY ANALYSIS

Base regression

We initially run two base regressions for both models, as reported in Table 4. Both signs and values show that the two models behave differently for the majority of independent variables. We comment the two models together.

Table 4. OLS regression for the determinants of Ecopass referendum, base model

		(A) *yes*ecopartic*		(B) *yes*	
Demographics	***Average_income***	9,77	**	-0,04	
	PC_female	-841,84	**	5,85	*
	PC_foreign	-178,03		-0,92	
	PC_fam_with_sons	15,19		-8,71	
Geographics	***Distance***	299,39	***	-2,66	***
	Distance_sq	-23,46	***	0,25	***
Scheme	***Cordon_inside***	247,66	*	-0,43	
	Cordon_crown	183,99	***	-1,03	
Politics	***Nuclear_participation***	41,63	***	-0,004	
	Left_rate	35,99	***	0,08	**
PTransport	***Metro***	40,45	*	0,48	*

	Tram	28,17	*	0,11	
	Bus	43,69	***	0,2	
Land Use	***Density***	0,01	*	0,0001	**
	PC_offices	1929,41	**	25,79	***
	PC_comm_industry	-157,69		-2,54	
	PC_services	817,35		30,52	**
	constant	-753,42	*	79,21	***
	R^2	0,986		0,265	

P-value: *=p<0.15; **=p<0.1; ***=p<0.05. N=286.

Socio-economic and demographical variables show that only income and percentage of women are significant. The composition of the households and the percentage of foreigners living in the neighbourhoods are not significant, as well as age composition (considered in other model specifications and omitted from Table 4). The *income* variable is positive and significant in determining the *weighted yes* (A), but not in the *yes* (B): the more a neighbourhood is high income, the more the participation to the referendum. Women share is negatively correlated with weighted yes (A) and positively with yes (B): women voted less, but voted yes.

Distance is always significant and u-shaped, but with different convexities. Concerning the *yes* (B), the negative effect of distance increases up to a certain point, where the relation is reversed. So, the semi-central areas are those where “yes” votes are the lowest. However, the *weighted yes* (A) shows the opposite: the share of “yes” out of total number of citizens increases with distance and decreases only in peripheral areas.

The fact of being inside (*Cordon_inside*) or around the cordon (*Cordon_crown*) has a positive and significant impact on *weighed yes* (A): citizens of the central area are the most favourable, as they enjoy the largest benefits of an uncongested centre, and citizens living just outside the cordon are positive, but to a lower extent. Probably, this takes into account the lower car dependency, with a positive effect, and the discomfort of border effects, with a negative effect. Citizens living in the rest of the city are, consequently, less in favour of Ecopass/AreaC.

The political orientation in the local administrative elections is significant in both specifications. *Left-wing* voters and *nuclear* referendum are positively affecting the *weighted yes* (A). In model (B), instead, *nuclear* results are not significant.

The supply of *public transport* is, again, positive and significant for model (A): the more a neighbourhood is supplied, the more their citizens will accept the road pricing, as they have better alternatives to car use. The effect is however less visible in the model (B) (only metro is significant), showing that the public transport supply mainly affects participation rate.

Finally, the group of land use variables show scarce significance. Only the presence of *offices* is positive and significant in both models. As in Milan the central area has an high density of offices, we interpret this with the will of central area citizens to reduce the negative effects of commuters.

Further regressions: the differentiation of internal and external areas

We perform a second group of regressions, all referred to the sole *weighted yes* model. The results are in

Table 5.

Table 5. OLS regression, model with differentiation of internal and external areas.

		(C) TOTAL *yes*ecopartic*		(D) INSIDE CORDON *yes*ecopartic*		(E) OUTSIDE CORDON *yes*ecopartic*	
Demographics	***Average_income***	11,35	***	7,74		18,11	***
	PC_female	-1104,85		Insuff. data		-1066,37	
	PC_foreign	-935,07	*	-5483,63		-1353,37	***
	PC_fam_with_sons	339,49		11178,23	*	577,99	
	PC_18-34yearsold	5121,63	**	-27628,4	*	5983,7	***
	PC_35-64yearsold	-1263,96		Insuff. data		-1313,78	
	PC_over65yearsold	221,49		-42657,7	**	49,5	
Geographics	***Distance***	330,47	***	1341,38		329,51	***
	Distance_sq	-25,29	***	-591,95		-24,83	***
Scheme	***Cordon_inside***	208,82					
	Cordon_crown	137,58					
	Cordon_periphery	-35,91					
Politics	***Nuclear_participation***	41,62	***	96,74	***	41,73	***
	Left_rate	33,64	***	-5,84		31,95	***
PTransport	***Metro***	30,06		14,01		50,35	*
	Tram	18,45		35,88		47,53	**
	Bus	48,39	***	21,85		45,21	***
	Stops_density	397,82		-14043,7	*	554,53	*
Land Use	***Density***	0,01		0,17		0	
	PC_offices	1871,47	*	17213,6		1168,83	
	PC_comm_industry	22,8		-4623,92		20,6	
	PC_services	792,32		Insuff. data		278,75	
	constant	-1003,05	**	11866,97		-1157,25	**
	R2	0,987		0,979		0,987	

P-value: *=p<0.15; **=p<0.1; ***=p<0.05. N=286.

In this case we differentiate the regressions between observations inside the cordon (D) and outside (E), to test if there is a difference between the consideration of the variables between the two part of the city.
The analysis shows that few of the variables are significant inside the cordon (D), except *nuclear* and some demographic variables. This means that neither the *distance* nor the *public transport* supply affected the result in the centre. This is reasonable, because public transport supply is very high and it is already the best option. So, for the city centre, the main determinant is that of being “inside”.

To the contrary, outside the cordon, both *distance* and accessibility become extremely significant. In particular, *public transport* supply is always positive and with similar coefficients. Neighbourhoods with higher accessibility are thus more willing to accept the road pricing especially if located midway between centre and periphery. For them, in fact, the car dependency remains low and the relationships with city centre are higher and better served with public transport. Instead, in peripheral areas, supply is less dense, but citizens are less dependent from the city centre and thus less sensitive to the road pricing.

CONCLUDING COMMENTS

In our paper we initially address the issue of acceptability of urban road charging policies. Literature shows that a number of factors determine how people react to this kind of measure, with different weights according to the context. The perception of the problem, of the solutions available and the way they are communicated play a role in overall acceptability, but in this case geographical dimension is irrelevant. Also social norms and beliefs play a role, both positively (e.g. the “green” attitude of citizens) and negatively (e.g. the importance of personal mobility). Clearly also the socio-economic environment and the land use may have an influence on the acceptability. More recent literature shows also that acceptability changes over time and, consequently, the moment in which it is “measured”, for example in a referendum, may change results.

We focus on the Milan case because it is the second world experience of a referendum confirming the road charging and because the availability of data on electoral results allows us to make an empirical analysis of revealed preferences on factors influencing acceptability. At first sight, the Milan application confirms what happened in Stockholm, where the approach “introduce first, get acceptability later” (Eliasson and Jonsson, 2011) revealed to be effective in preventing the negative attitude of population due to the ignorance on the actual extent of the measure: population is more familiar with benefits and costs of the measure on their daily life and is then more realistic in judging the scheme. The response of Milan through the referendum of June 2011 for the extension of the existing pollution charging measure (“Ecopass”) was in fact extremely positive.

In our analysis we focused on spatial differences among neighbourhoods using some spatial variables, like the average income, the public transport accessibility, the local political attitude, the distance from the priced area, etc.

Data shows that PT accessibility played a role in shaping referendum results: the more a zone is accessible by PT, the more the inhabitants will be prone to accept the road charging, as they have effective alternatives to reach the priced area. The relation with distance is similar: the maximum of acceptability (*weighted yes*) is inside the priced area, where benefits are the greatest. Outside it is bell-shaped: lower around the cordon, where the traffic problems concentrate, then increasing, showing that relations with centre become rarer, and then decreasing again in remote areas, where car dependency is unavoidable and possible benefits disappear.

Other variables confirm the previous findings of literature: the ecological and political attitude of citizens is very relevant. Also income and office density in the area are positively related with the acceptance of charging measures: poor, remote and residential districts suffer more from the charging and, in change, have no direct benefits.

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REFERENCES

Banister, D. (2003). 'Critical pragmatism and congestion charging in London'. *International Social Science Journal*, 55(2): pp.249-264

Bedogni, M., Pulpito, A., Tosi, L. (2011). *Valutazione nuovi scenari di regolamentazione degli accessi alla ZTL Cerchia dei Bastioni*. Agenzia Mobilità Ambiente e Territorio. Comune di Milano, Milano, Italy

Börjesson, M., Eliasson, J., Hugosson, M. B., Brundell-Freij, K. (2012). 'The Stockholm congestion charges – 5 years on. Effects, acceptability and lessons learnt'. *Transport Policy*, 20: pp.1-12

Brambilla, M.G., Michelangeli, A., Peluso, E. (2011). 'Equity in the City: On Measuring Urban (Ine)Quality of Life'. *DISCE - Quaderni dell'Istituto di Economia e Finanza* ief0101, Università Cattolica del Sacro Cuore.

City of Stockholm, (2006). *Stockholmsförsöket: Facts and results from the Stockholm trials*, first version. Congestion Charge Secretariat, Stockholm.

Comune di Milano (2012). Piano di Governo del Territorio. Piano dei Servizi. Allegato 3. Schede NIL. Comune di Milano.

Daunfeldt, S. O., Rudholm, N., Rämme, U. (2009). 'Congestion charges and retail revenues: Results from the Stockholm road pricing trial'. *Transportation Research Part A*, 43(3): pp.306-309

De Borger, B., Proost , S. (2012). 'A political economy model of road pricing'. *Journal of Urban Economics*, 71(1): pp.79–92

DfT, (2005). Transport and Land Use Interaction in the Context of Road Pricing. DISCUSSION PAPER. Department for Transport (UK)

Dix, M. (2005). *Central London Congestion Charging Scheme*. Presentation at the Impacts - 9th Annual Conference, 17 March 2005

Eliasson, J., Jonsson, L. (2011). 'The unexpected "yes": Explanatory factors behind the positive attitudes to congestion charges in Stockholm'. *Transport Policy*, 18(4): pp.636-647

Eliasson, J., Hultkrantz, L., Nerhagen, L., Smidfelt Rosqvist, L. (2009). 'The Stockholm congestion – charging trial 2006: Overview of effects'. *Transportation Research Part A*, 43, (3): pp.240-250

Eliasson, J., Mattsson, L. G., (2006). 'Equity effects of congestion pricing. Quantitative methodology and a case study for Stockholm'. *Transportation Research Part A*, 40: pp.602–620

Fujii, S., Gärling, T., Jakobsson, C., Jou, R.C. (2004). 'A cross-country study of fairness and infringement on freedom as determinants of car owners' acceptance of road pricing'. *Transportation,* 31: pp.285–295

Hårsman, B., Quigley, J.M. (2010). 'Political and Public Acceptability of Congestion Pricing: Ideology and Self-Interest'. *Journal of Policy Analysis and Management,* 29(4): pp.854-874

Henriksson, G. (2009). What did the Stockholm trial mean for Stockholmers?. In: Gullberg, A., Isaksson, K. (Eds.), Congestion Taxes in City Traffic. Lessons learnt from the Stockholm Trial. Nordic Academic Press

Invernizzi, G., Ruprecht, A., Mazza, R., De Marco, C., Močnik, G., Sioutas, C., Westerdahl, D. (2011). 'Measurement of black carbon concentration as an indicator of air quality benefits of traffic restriction policies within the Ecopass zone in Milan, Italy'. *Atmospheric Environment*, 45(21): pp.3522-3527

Ison, S., Rye, T. (2005). 'Implementing Road User Charging: The Lessons Learnt from Hong Kong, Cambridge and Central London'. *Transport Reviews*, 25(4): pp.451–465

Jaensirisak, S., Wardman, M., May, A. D. (2005). 'Explaining Variations in Public Acceptability of Road Pricing Schemes'. *Journal of Transport Economics and Policy*, 39, Part 2: pp.127–153

Jakobsson, C., Fujii, S., Gärling, T. (2000). 'Determinants of private car users' acceptance of road pricing'. *Transport Policy*, 7: pp.153–158

Jones, P. (2003). Acceptability of Road User Charging: Meeting the Challenge. In Schade, J. and Schlag, B. (Eds, 2003), Acceptability of Transport Pricing Strategies, pp. 27-62. Oxford: Elsevier

Kain, J. F. (1972). 'How to improve transportation at practically no cost'. *Public Policy*, 20: pp.335–352

Kottenhoff, K., Brundell-Freij, K. (2009). 'The role of public transport for feasibility and acceptability of congestion charging. The case of Stockholm'. *Transportation Research Part A*, 43(3): pp.297-305

Leape, J. (2006). 'The London Congestion Charge'. *Journal of Economic Perspectives*, 20(4): pp.157–176

Mackie, P. (2005). 'The London Congestion Charge: A Tentative Economic Appraisal. A Comment on the Paper by Prud'homme and Bocajero'. *Transport Policy*, 12(3): pp.288-290

May, A., Koh, A., Blackledge, D., Fioretto, M. (2010). 'Overcoming the barriers to implementing urban road user charging schemes'. European Transport Research Review, 2(1): pp.53-68

Marcucci E., Marini M. A., Ticchi D. (2005). Road pricing as a citizen-candidate game. European *Transport \ Trasporti Europei*, No. 31 (2005): 28-45

Marini, M., Marcucci E. (2003). *Individual uncertainty and the political acceptability of road pricing policies.* In: Schade J. and Schlag B. (eds.) *Acceptability of transport pricing strategies*: MC-ICAM conference on acceptability of transport pricing strategies, Dresden, 2002. Elsevier, Amsterdam, pp. 279-297. ISBN 9780080441993

Mattsson, L.G. (2003). *Modelling Road Pricing Reform in Stockholm*. IMPRINT-EUROPE seminar: Implementing Pricing Policies in Transport: Phasin, Leuven, Belgium

Nuccio, D., Tosi, L. (2012). *Primi risultati a due mesi dall'attuazione di Area C. Traffico e composizione del parco veicolare*. Agenzia Mobilità Ambiente e Territorio. Comune di Milano, Milano, Italy

Odeck, J., Bråthen, S. (2002). 'Toll financing in Norway: the success, the failures and perspectives for the future'. *Transport Policy*, 9(3): pp.253–260

Papathanasopoulou, V., Antoniou, C. (2011). *Assessment of Congestion Pricing Prospects for Athens, Greece*. Paper presented at 90th TRB Annual Meeting. Washington, USA

Phang, S.Y., Toh, R. S. (2004). 'Road congestion pricing in Singapore: 1975 to 2003'. *Transportation Journal*, 43: pp.16–25

Rentziou A., Milioti C., Gkritza K., Karlaftis M. G. (2011). 'Urban Road Pricing: Modeling Public Acceptance'. *Journal of Urban Planning and Development*, 137(1): pp.56-64

Rotaris, L., Danielis, R., Marcucci, E., Massiani, J. (2011). 'The urban road pricing scheme to curb pollution in Milan, Italy: Description, impacts and preliminary cost–benefit analysis assessment'. *Transportation Research Part A,* 44(4): pp.359-375

Russo, A (2012). *Voting on Road Congestion Policy*. TSE Working Papers 12-310, Toulouse School of Economics (TSE)

Rouwendal, J., Verhoef, E.T. (2006). 'Basic economic principles of road pricing: From theory to applications'. *Transport Policy*, 13(2): pp.106–114

Santos, G. (2008). *London Congestion Charging*. Brookings-Wharton Papers on Urban Affairs, pp.177-234

Schade J., Schlag, B. (2003). *Acceptability of Transport Pricing Strategies*. Elsevier, Oxford

Schade, J., Seidel, T., Schlag, B. (2004). *Cross-site-evaluation of acceptability indicators*. Working paper CUPID project

Schuitema, G., Steg, L., Forward, S. (2010). 'Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm'. *Transportation Research Part A*, 44(2): pp.99–109

Vickerman, R. (2005). *Evaluating the Wider Economic Impacts of Congestion Charging Schemes: The Limitations of Conventional Modelling Approaches*. Paper presented at the 45th European Regional Science Association Congress, Amsterdam, Netherlands, 23-27 August

Vickrey, W. C. (1963). 'Pricing in urban and suburban transport'. *American Economic Review*, 52: pp.452–465