Cost distribution and the acceptability of road pricing: evidence from Milan's referendum [1]

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Abstract

Road pricing schemes are increasingly adopted by local governments to curb transport externalities in the forms of pollution and congestion. Several factors may influence the acceptance of road users: voter expectations, awareness of the relevance of the policy, familiarity with the road pricing debate, perceived fairness, environmental concerns, car dependence, and the value of a trial. In this paper we argue that the skewness in the distribution of cost is an important factor in the policy acceptance. By using data from the 2011 referendum on Milan road pricing, we find support for the relevance of cost heterogeneity

Keywords: Road pricing, political economy, referendum, cost heterogeneity, Milan.

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1 Introduction

Road pricing schemes are increasingly adopted by local governments to curb transport externalities in the forms of pollution and congestion. The London Congestion Charge, introduced in 2003 and then modified to extend the treated area, is probably the most known and studied example (Banister, 2003; Givoni, 2012; Ison and Rye, 2005; Prud'homme and Bocarejo, 2005; Quddus et al., 2007; Santos and Bhakar, 2006; Santos and Fraser, 2004; Santos and Shaffer, 2004). Other examples of such policy are Hong Kong (Ison and Rye, 2005), Singapore (Santos, 2005), Stockholm (Eliasson et al., 2009), several Norwegian cities (Ieromonachou et al., 2006), Milan (Percoco, 2013a; 2013b; 2014; Rotaris et al., 2010).

Interestingly enough, some of the aforementioned road pricing schemes have been subject to referenda and only in the case of Stockholm and Milan, those measures were approved by the majority, whereas in the case of Edinburgh and Manchester the majority of votes were against road pricing. Li and Hensher (2012) indentify several factors influencing the perception of voters on road pricing: voter expectations, awareness of the relevance of the policy, familiarity with the road pricing debate, perceived fairness, environmental concerns, car dependence, and the value of a trial. Furthermore, uncertainty associated with the effectiveness of the policy and the lack of clear information on the scheme as well as its implementation details are considered as the two most important reasons why road pricing was rejected by referenda in Edinburgh and Manchester. By making use of a survey conducted before the introduction of the congestion charge in Stockholm and after the referendum which took place in 2006, Schuitema et al. (2010) point at the individual perception and experience with the tax as an important factor of acceptance. Similarly, Eliasson and Jonsson (2011) find that perceived environmental effectiveness was crucial to increase acceptability. Harsman and Quigley (2010) propose an empirical model of voting behavior at precint level in Stockhlom in which elements of transport costs and political economy are explicitly taken into account. They find that time savings and increases in transport cost are among the most important determinants of acceptance by voters.

From a theoretical perspective, De Borger and Poost (2012) propose a political economy model of road pricing in which uncertainty about the use of revenues plays a crucial role in explaining rejection through referenda. Russo (2013) also studies the political economics of urban transportation policies and finds that the institutional setting and preferences of voters for the car are among the determinants of road pricing approval.

In this paper, we consider the case of Milan, where a charge was introduced in January 2008 and a referendum took place in 2008 in which 79% of voters approved the tax. Although the majority was extremely high, a great spatial variation characterized the vote. By assembling a dataset on 767 sub-urban areas, we stud the determinants of road pricing acceptance, with particular focus on cost heterogeneity. In fact, by using a pre-treatment origin-destination matrix, we propose a methodology to estimate the distribution of user costs related to the introduction of road pricing for each area. This allows us to estimate area-specific average and median costs and to build an empirical model based on the distance between the two quantities.

Empirical evidence confirms that the larger the distance between average and median costs (i.e. the higher heterogeneity), the larger the share of votes supporting road pricing. The remainder of the paper is organised as follows. In section 2, a brief description of the Milan road pricing scheme is given; section 3 sets our main research hypothesis. Section 4 shows the methodology to estimate the distribution of costs which is subsequently used in the empirical analysis in section 5. Section 6 concludes.

2 Road pricing in Milan and the referendum

Milan is among the most polluted cities in Europe (Percoco, 2010). To curb pollution, a charge to enter the city center was introduced in January 2008. The so-called "Ecopass" was implemented in an area of 8.2 squared kilometers on weekdays between 7:30 am and 7:30 pm (figure 1). The amount of the charge depended on the vehicle's engine emissions standard and fees vary from 2 euros to 10 euros. Residents in the treated area were also charged , although at lower fees.

Rotaris et al. (2010) have proposed a cost-benefit analysis in which the Ecopass passed the

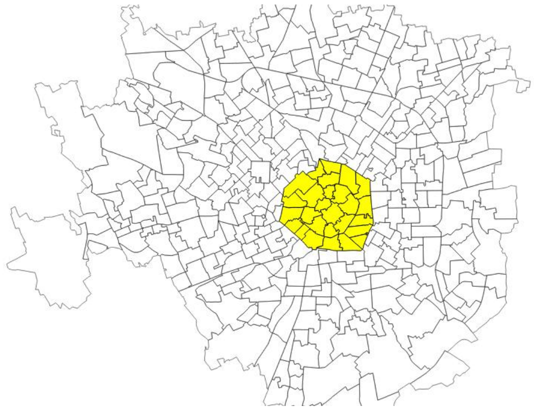

Figure 1: Milan and the treated area

test by about 6 million euros. However, the analysis was carried out by using descriptive statistics, in which the identification of the policy effect was particularly weak. To deal with this issue, Percoco (2013) has proposed the use of a regression discontinuity design to analyse the effect of the Ecopass on the concentration of pollution. It was found that the charge decreased significantly the concentration of some pollutants (especially carbon monoxide and particulates) but only in the short run, while one week after its implementation, pollution returned to its pre-treatment levels. The reason for such poor effect in the long run can be found in the sharp increase in motorbike usage, an unpriced type of vehicle (Percoco, 2014). Finally, Percoco (2012) made an attempt at estimating the effect of road pricing on housing price by using a difference-in-difference approach, finding that the charge significantly decreased home prices in the treated area and hence indicating that the negative effect of an increase in transport costs offsets the benefits from a reduction in external costs such as congestion and pollution.

In a public consultation on June 13 2011, the vast majority of voters (79%) approved the introduction of the Ecopass, which was re- established on January 16 2012 under the name of Area C. Area C started as an 18-month pilot program with the objective to reduce traffic, to promote sustainable mobility and public transport, and to decrease the levels of pollution. Area C was definitively approved on 27 March 2013.

Data we make use of are from the 767 sub-urban areas for which we have data on origin and destination flows for passengers. Figure 1 highlights the 27 sub-urban areas subject to the charge.

3 Cost heterogeneity and road pricing acceptance

In this paper we aim to estimate the impact of the skewness in the distribution of costs related to the introduction of the Ecopass. The rationale for the relevance of the shape of the distribution of costs relies on the vast literature in the political economics of redistributive taxation, highlighting the importance of locating the majority of voters on the cost curve (Persson and Tabellini, 2000).

Under mild concavity assumptions in the cost function, it can be proven that a road pricing scheme is approved by the majority of voters if the marginal cost of the median voter is higher than the marginal cost of the average voter and if the benefits are equally distributed among voters. The rationale for this is rather simple and shown in figure 2 which depicts the cost-benefit analysis faced by voters when deciding on wheter or not to vote for a road pricing scheme.

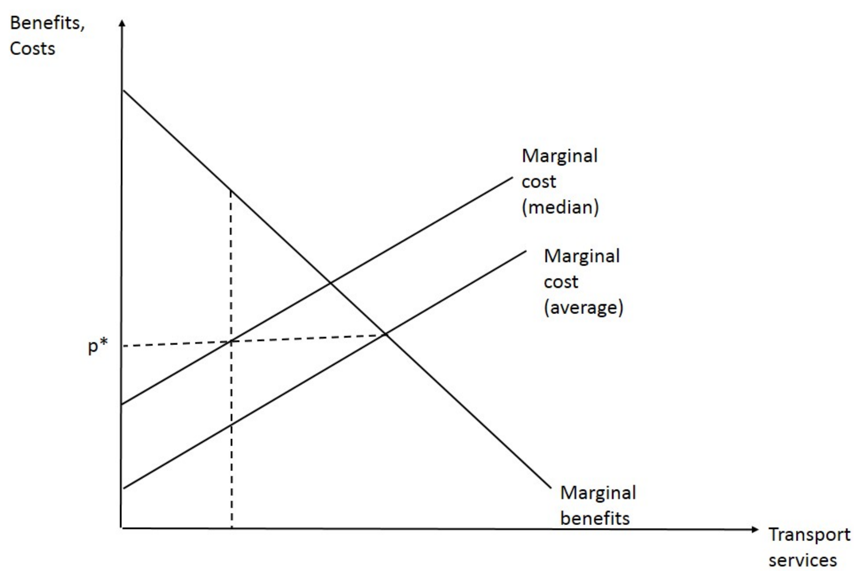

Figure 2: Cost heterogeneity and voting decision

In particular, let us consider a voter in a given area making the decision on whether or not to vote for the referendum on road pricing on the basis of a simple benefit-cost comparison. Let us also assume a local government setting a second-best charge, $p*$, equaling marginal benefit and cost of the average voter. Figure 2 shows this choice graphically. The heterogeneity in the impact of the tax is modeled by means of two different marginal cost functions, of for the average voter and one for the median voter. In the case of a charge equal to $p*$the majority of voters will vote for the tax in the case the marginal cost of the median voter is larger than the marginal cost of the average voter. In such case, a tax equal to $p*$ will result for a median voter in a positive benefit-cost comparison and hence the charge will be approved. This implies, that the larger the difference between the median and average marginal cost, the larger the majority voting in favor of the charge.

In other words, the skewness in the distribution of costs is the fundamental determinant of the success of the charge in the referendum.

In our analysis (and also in the empirical evidence) we have not considered eventual heterogeneity in the distribution of benefits. The rationale behind such assumption relies on the fact that improvement in the environmental quality is a non-rival non-excludible public good whose consumption is equal across individuals. It should be noted that as we are analysing acceptance of road pricing across sub-urban areas the homogeneity of the benefits holds only within a given area and does not necessarily hold across areas. This implies that we are not assuming eventual benefits in terms of environmental quality or congenstion are equally distributed across the city, buth rather that benefits may vary across areas but are equally distributed among the voters in each area.

Given this theoretical rationale, the estimation of the distribution of marginal costs for each sub-urban area in our dataset is crucial for the empirical analysis aiming at veryfing the positive correlation between the diference between median and average marginal costs and the probability of the charge to be approved.

4 Estimating the distribution of costs

In the previous setion we have argued that the distribution of costs within each area is a determinant of acceptance of road pricing schemes. To estimate such distribuion function we make use of information on the origin and destrination of daily commuters. It is in fact useful to think at the source of heterogeneity in terms of traveed path and distance chose by the voter. In the case of a fixed second best tax, in fact, the charge per traveled kilometer varies by changing the quantity of kilometers traveled. This further implies the centrlity of the geography of paths as a crucial determinant of the distribution of charge-related costs.

Data on O-D of passengers, are used in this paper to construct a measure of cost at area-level. In particular, let us consider the shortest path distance between the area i and area j, D_{ij}, and the line connecting the centroids i and j as L_{ij}, then the cost for each pair (i,j) relative to the introduction of the road pricing is defined by:

$$C_{ij} = \begin{cases} 0 & otherwise \\ \frac{5}{D_{ij}} & \forall j \in A^{RP} \\ \frac{5}{D_{ij}} & \forall j : L_{ij} \cap A^{RP} \neq \emptyset \end{cases} \tag{1}$$

The rationale behind expression (1) is that all flows from area i having destination within the treated area, A^{RP},manifest a unitary increase in transport cost by 5 euros. A similar increase affects all flows from area i to area j whose line representing the theoretical minimum distance cross the treated area. On this point, it should be mentioned that the expression for C_{ij}in the third line of (1) is an equilibrium condition relying on the fact that an individual needing to cross area A^{RP} with destination outside the area has two options: paying the charge (5 euro) or avoiding roads in the area, possibly increasing the path to destination. In equilibrium, the cost of the two options is the same and equal to $\frac{5}{D_{ij}}$. In general, given the monocentricity of Milan, $C_{ij}|_{j\in A^{RP}} > C_{ij}|_{j:L_{ij}\cap A^{RP}\neq \emptyset}$, that is the maginal unitary cost of the introduction of the charge is larger for individuals with destination inside the treated area as the traveled distance is shorter, i.e. $D_{ij}|_{j\in A^{RP}} > D_{ij}|_{j:L_{ij}\cap A^{RP}\neq \emptyset}$. According to data presented in Rotaris et al. (2010), we assume 5 euros to be the average charge paid by road users.

Let $G = (V,R)$ be an undirected graph representing the road network of Milan (figure 3) consiting of V vertices and R roads. Each road has a cost function approximated by its length L_r with $r \in R$. To be noted is the fact that as we work with areal data, the length is calculated from the boundary of the origin (i.e. where the road intersects area boundary) and to boundary of destination. The total cost of a path from i to j is given by $C_{ij} = \sum_{r\in R|R_{ij}} L_r$, where $R_{ij}$is a partition of R representing all possible routes from i to j. The shortest path hence minimizes total cost, i.e. it

Table 1: Summary statistics

	Whole city	Treated area	Non-treated area
Cost (mean)	0.804	0.820	0.722
Cost (median)	0.930	0.981	0.786
Cost (Median-Mean)	0.126	0.161	0.064
Cost (Skewness)	-0.799	-0.811	-0.702
Cost (St. Dev.)	0.357	0.231	0.323
Yes (mean)	0.791	0.829	0.758
Yes-No (mean)	0.582	0.658	0.516

solves the problem:

$$\min_{r \in R_{ij}} C_{ij}$$

Minimization of of total cost can then be solved by using the Dijkstra (1959) algorithm.

Figure 3: Road network in Milan

For each area i it is hence possible to compute the aveage marginal unitary cost according to the N destinations as $E[C_i] = \sum_j w_{ij} C_{ij}$ where w_{ij} is a weight representing the share of total out-flows

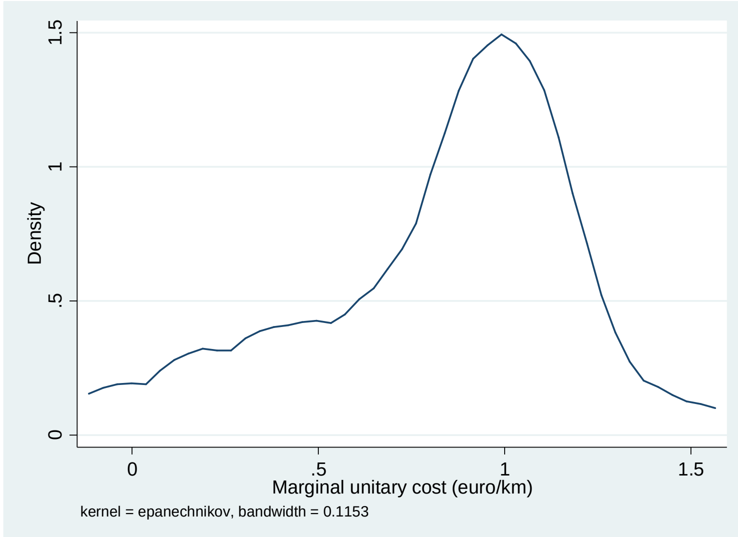

Figure 4: Kernel density of marginal unitary cost

from area i directed to area j. Similarly, it is possible to define the median of the area-specific cost distribution.

Results of the 2011 referendum have been provided by the Office of Elections of the Municipality of Milan and contain information on number of voters, number of votes classified into "Yes" and "No", corresponding to the approval or rejection of road pricing. We have data on 1251 electoral sections of the 2011 referendum, which have been aggregated to match transport sub-urban areas.

Data on origin and destination flows for passengers are from AMAT, (Agenzia per la Mobilità, l'Ambiente ed il Traffico - the agency for mobility, environment and traffic of the municipality of Milan) and have been collected through several waves of surveys in 2005, hence before the introduction of the road pricing. This feature is of particular relevance since flows between origin and destination can be thought to be the private equilibrium before the treatment and hence an ideal counterfactual to be used in our econometric analysis. In particular, the O-D matrix has been compiled for all 767 sub-urban areas according to the time of the travel, which is divided into three moments of the day: morning, afternoon and evening. We have aggregated flows for the first two periods, corresponding to the timing of charging.

Figure 4 shows the cost distribution in the whole city of Milan, whereas table 1 reports summary statistics for the whole city and for sub-samples related to the treated area and for the control areas.

Both figure 4 and table 1 point at a skewness of the distribution for which the average marginal cost from the introduction of road pricing is lower than the median marginal cost. Interestingly enough, in table 1 it also emerges that the larger the difference between median and mean of the cost distribution, the larger the share of "yes" and the difference between "yes" and "no" in the referendum.

5 Empirical evidence

Our empirical analysis aims to verify the existence of a positive correlation between the median-average marginal cost difference and the public support for the road pricing scheme. To this end, we have estimated the following regression:

$$y_i = \alpha + \beta(Median - Mean)_i + \gamma controls_i + \varepsilon_i \tag{2}$$

where the dependent variable is the difference between the share of "yes" and the share of "no" in area i. The rational for using this type of dependent variable instead of the share of "yes" is that it is a better measure of acceptability at area level as it measures a sort of probability for the charge to pass the referendum. To be noted is the fact that the share of "yes" was majority in all areas, so that discrete choice models cann be used to estimate (2). $(Median - Mean)_i$ is a measure of disallineament between median and the average and may take three types of forms: a simple difference between the mean and the median, an indicator variable taking the value of 1 if the median is higher than the mean, and an indicator variable taking the value of 1 if the precint median is higher than the city-wide median. Among the controls, we consider the distance to the closest subway station, the density of tram stops, share of votes for center-left party in the last election, number of bike-sharing stations, population density, road density.

Our 767 sub-urban areas are also classified by the Municipality of Milan into 9 boroughs. In regression (2) we hence introduce borough-specific fixed effects to account for unobserved heterogeneity at borough level. The source of all our variables is the Municipality of Milan and can be

Table 2: Regression estimates (OLS)

	(1)	(2)	(3)	(4)	(5)	(6)
(Median-Mean)	1.012***			0.921***		
	(0.221)			(0.249)		
$I[E(C_i) > Median_i]$		0.117***			0.101**	
		(0.002)			(0.045)	
$I[E(C_i) > Median_{Milan}]$			0.098***			0.092**
			(0.003)			(0.039)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	Yes	Yes	Yes
Observations	767	767	767	767	767	767
R. sq.	0.567	0.401	0.372	0.625	0.633	0.425

downloaded from its Open Data website.

Table 2 reports our empirical results. In models (1)-(3) we consider specifications with fixed effects and withouth controls, using different measures of cost heterogeneity. In all three specifications, our theoretical rationale seems to be confirmed since our measures of Skewness are all positively correlated to the difference between “yes” and “no”. In particular, if we consider the average cost difference of 0.126 in table 1, we have an expected marginal change in the difference between “yes” and “no” of 12.7% in the case of model (1). This value is 11.7% in model (2) and 9.8% in model (3).

In models (4)-(6) we control also for the distance to the closest subway station, the density of tram stops, share of votes for center-left party in the last election, number of bike-sharing stations, population density, road density. Coefficients of interest decrease marginally, indicating a substantial robustness of our estimates and that the distribution of charge-related costs is an important determinant of road pricing acceptability.

6 Conclusion

Road pricing acceptability by the public is a matter of paramount importance for transport policy making. In this paper we have argued that charge-related cost distribution is a determinant of acceptability.

By considering the case of the 2011 referendum on road pricing in Milan, we have firstly estimated area-specific cost distribution and then related the diference between median and average marginal cost to the outcome of the referendum. Empirical results confirm that cost heterogeneity is a significant determinant of the probability to pass the referendum.

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