Contents lists available at ScienceDirect

Transport Policy

journal homepage: www.elsevier.com/locate/tranpol

Housing rent and road pricing in Milan: Evidence from a geographical discontinuity approach $\stackrel{\scriptscriptstyle \succ}{\scriptscriptstyle \propto}$

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ARTICLE INFO

Article history: Received 14 January 2015 Received in revised form 7 June 2015 Accepted 17 July 2015 Available online 30 July 2015

JEL classification: Q51 R21 R41 C21 C23

Keywords: Road pricing Housing markets Rent Milan Regression discontinuity

1. Introduction

Road pricing is becoming an increasingly popular policy measure for curbing pollution and congestion in cities. The introduction of a charge for using given roads is meant to internalize external costs through an increase in transport costs and depending on the elasticity of demand, a reduction in traffic flows.

Expected outcomes of such measures are in terms of air quality, health, accidents and speed. Variations in pollution concentration, congestion and transport costs are particularly important in an urban context, because of their impact on individual well-being and ultimately, on housing prices (Eliasson, 2009).¹

Milan, along with London, Stockholm and Singapore, is one of

ABSTRACT

To cope with severe problems of pollution and congestion, a road pricing scheme (the Ecopass) to enter the city centre was introduced in Milan in January 2008. This paper assesses the impact of such a policy measure on the housing market in terms of variations in rent within the treated area. To this end, we adopted a geographical difference-in-discontinuities approach, which allowed us to control for area specific factors and to identify the effect of road pricing at the boundary of the treated area. By using detailed data from 55 zones over the period 2007–2012, we found that the Ecopass has had a small and positive impact on housing rent, equal to +0.75%.

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the few metropolitan cities that have implemented an urban road charging scheme. In January 2008, the "Ecopass" was launched in order to reduce pollution through a reduction in the number of highly polluting vehicles in circulation.

The Ecopass programme was applied within a designated restricted traffic zone corresponding to the central "Cerchia dei Bastioni" area of 8.2 km². The amount of the charge depended on the vehicle's engine emissions standard and fees varied from \notin 2 to \notin 10, from 7:30 to 19:30 on weekdays. Free access to the zone was granted to motorbikes, to several types of alternative fuel vehicles and to conventional fuel vehicles compliant with the European emission standards Euro 3 and Euro 4 or better.

Several papers have already analyzed the effect of road pricing in Milan. Rotaris et al. (2010) proposed a cost-benefit analysis in which the Ecopass passed the test by about €6 million per year. However, the analysis was carried out using descriptive statistics on pollution concentration, in which the identification of the policy effect was particularly weak. To deal with this issue, Percoco (2013) proposed the use of a regression discontinuity design and found that the charge significantly decreased the concentration of some pollutants (especially carbon monoxide and particulates),





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^{*}We would like to thank Tommaso Nannicini and Barbara Chizzolini for their invaluable suggestions. Special thanks to Davide Rossi and Riccardo Fino for their help and assistance. All errors are ours and follow a random path.

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¹ For a review of works relating housing prices and environmental amenities, Colwell and Dilmore (1999).

but only in the short run, as one week after its implementation, pollution had returned to its pre-treatment levels. By using a regression discontinuity design and a synthetic control method, Percoco (2014, 2015) found that the charge increased the usage of motorbikes, hence potentially worsening environmental conditions in the city.

Whether the Ecopass has had an impact on housing prices in Milan has long been and remains a popular topic in public debates and in newspapers.² In 2009, the urban government commissioned a study to evaluate the impact of the charge on the housing market. Pragma (2009) aimed at investigating the effect of the pollution charge on the housing market a year after the introduction of the Ecopass by interviewing real estate agents. The survey led to the conclusion that a small or null effect was expected on house prices and that the sign of the effect was uncertain. While being somewhat informative at the time, the analysis was based on the personal opinions of real estate agents who may have been biased or not necessarily aware of all the details of the Ecopass.

From a theoretical perspective, the impact of road pricing on housing rent is not clear a priori, since two opposite forces may be operating in this context. The reduction in external costs in terms of pollution and congestion may in fact increase rent. On the other hand, an increase in transport costs induced by a second-best tax may reduce the willingness of individuals to pay and hence, rent will decrease. Consequently, it is an empirical matter whether the former or the latter force prevails.

In this paper, we assessed the causal impact of the Ecopass on housing rent. To this end, we adopted a geographical differencein-discontinuities approach, i.e., a regression discontinuity design with two running variables (time and space), which allowed to account for area-specific unobserved variables. Our method relaxed the strong smoothness in the covariates assumption of a classic regression discontinuity approach, as well as the common trend assumption of difference-in-differences models. Our method therefore identified the short run impact of the policy at the boundary of the treated area.

By using data pertaining to 55 areas in Milan over the period 2007–2012 with a bi-annual frequency, we found that the Ecopass has increased housing rent by 0.75% and that this effect was robust across several specifications.

Percoco (2014b) recently estimated the impact of Ecopass on housing prices by using a difference-in-differences model and finding a negative effect of the policy. The research presented in the present paper differs from Percoco (2014b) in two important ways. First, we made use of housing rent instead of prices, as we believe that housing prices revealed by market transactions adjust slowly to structural policies, whereas the rental market is less small and hence, rent may react promptly to an event such as the introduction of the Ecopass. Second, we made use of a geographical difference-in-discontinuities model that allowed us to obtain precise estimates of the effect at the boundary of the treated area. The assumptions needed for this identification were more realistic than those needed for the identification of policy parameters in a difference-in-differences model.

Besides the literature on the effects of road pricing, this paper is also related to the growing literature on the causal impacts of transport policies (mainly rail innovations) on housing markets. We think that the closest study is the one by Gibbons and Machin (2005), in which the authors present results of difference-in-differences models to estimate the impact on housing prices of the Jubilee Line in London. The spatial extent of the impact was also analyzed by Ahlfeldt (2013) by combining quasi-experimental evidence with numerical calibration. A difference-in-differences approach was also used by Grimes and Young (2013) in the case of the Auckland Western Line. Hongbo and Mulley (2006) and Mayor et al. (2012) are also recent studies exploiting the spatial dimension to estimate the impact of improvements in rail transport.

The paper is organized as follows. Section 2 presents a description of the structure of the Ecopass. Sections 3 and 4 present the applied methodology and data, respectively, whilst results of the econometric analysis are provided in Section 5. Section 6 concludes the study.

2. Road pricing in Milan

Milan is Lombardy's primary city and with 1.3 million inhabitants, is the second most populated city in Italy. Its metropolitan area extends broadly around the inner city and is estimated to host some 5.2 million people. More than 2.3 million vehicles move within and into the inner urban area every day, half of them arriving from outside the urban area (AMMA, 2008; AMAT, 2012a).

The city was (and still is) characterized by a high motorization rate compared to other European cities; in 2007, there were 558 cars per thousand inhabitants in Milan (Percoco, 2010). The reliance of city users on cars was a major cause of the severe air pollution affecting Milan, prompting a concentration of particulates systematically above that of European standards.

Building on the experiences of other cities, a pollution charge (the so-called Ecopass) was first introduced in January 2008. In January 2012, the Ecopass was substituted by a different scheme, called Area C, in the form of a pollution charge, following a radical improvement in the emission factors of circulating vehicles due to car renovations induced by the Ecopass. The Ecopass' rationale drew upon the "polluter-pays principle", contained in Directive 2004/35/CE, which focused on providing different charges for different emission vehicle classes ("Euro" classes).

A toll area of 8.2 km², roughly identified by a major circular road that encircles the city centre, the so-called "Cerchia dei Bastioni", was identified and monitored using 43 cameras recording car number plates. The area defined by Ecopass' cordon comprised 4.5% of the municipality's breadth and 6% of its population (77,000 inhabitants).

The road pricing scheme was effective from 7.30 to 19.30 during working days and was applied to all vehicles that crossed one of the gates equipped with cameras. By paying the charge, the vehicle obtained full access to the area for the entire day. Vehicles were divided into five categories based on their PM10 emission factors (COPERT IV model). The first two categories (alternative fuel vehicles and new Euro class vehicles) were exempted, while vehicles in the other three categories had to pay a charge, respectively, of \in_2 , \in_5 and \in_{10} . Residents inside the area had the opportunity to subscribe to yearly passes at a price equivalent to 10% of full year access.

At the outset, about 50% of circulating vehicles was potentially subject to the tariff, but the gradual substitution of older and highly polluting vehicles with new cleaner ones progressively reduced this number. AMAT (2012b) reported that the number of vehicles decreased, with respect to the pre-Ecopass period, by 14.6% in 2008 (the year of the introduction of the pollution charge), 15.7% in 2009 and by 12.9% in 2010. In 2011, traffic in the area unexpectedly continued to decrease (-20.0%) due to an economic crisis effect reducing the use of cars. Nevertheless, a progressive shift toward non-paying classes of vehicles raised awareness about the sustainability of the measure. In fact, the share of charged vehicles to exempted vehicles fell from 0.23 in 2008 and 2009 to 0.15 in 2010; in 2011, as few as 14% of accessing

² See for example Mancini (2008) and Viarengo (2012).

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