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NEW CAR TAXATION AND ITS UNINTENDED ENVIRONMENTAL CONSEQUENCES

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New car taxation and its unintended environmental consequences[1]

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Abstract

In Italy, in 2011 the *Superbollo* tax was introduced for newly registered cars exceeding 185 kW. Although the aim of the tax was not to reduce CO_2 emission as it was actually aimed at increasing government revenues during the economic crisis, we show that it had significant and unexpected impacts on buyers' behavior. Using data related to the universe of vehicles registered between 2008 and 2017 and by using a difference-in-difference framework, we find that the *Superbollo* had a significant role in reducing CO_2 emissions and in increasing the car share with low CO_2 emissions. In particular, we show that the introduction of the *Superbollo* shifted consumers towards greener cars, not necessarily ecological (e.g. electric), with a subsequent reduction in the emission of CO_2 per kilometer traveled of an order of magnitude of 5 to 7%.

Keywords: Car tax reforms, *Superbollo*, CO_2 emissions.

Declarations of interest: none.

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1. Introduction

The transport sector is identified as a serious cause for concern by policymakers due to its unsustainable dependence on oil and its negative environmental impacts (Hennessy et al., 2011). Transport accounts for about 23% of the energy-related carbon dioxide CO_2 emissions (Sims and Schaeffer, 2014), and it accounts for 15% of global greenhouse gas emissions (Blanco et al., 2014). According to the European Union, cars are responsible for around 12% of total EU emissions CO_2[2]. The entity of car's emissions grows as the age of the car fleet increases, since older cars produce higher emissions without taking advantage of environmentally friendlier technologies. To curb this problem, in fact, in 1995, modified in 2011, the European Union developed a strategy to reduce CO_2 emissions of new cars sold in Europe with the aim of reducing the greenhouse gas emissions by 60% by 2050 compared to 1990 levels (European Commission, 2011).

The strategy was based on three cornerstones. The first was aimed at car manufacturers, lowering the target of polluting quantities emitted by the new cars produced to 130gCO_2/km by 2015 and 95gCO_2/km by 2020. Thanks to this new strategy, the average emissions of a new car produced and sold in 2017 was 118.5g of CO_2 per kilometer, significantly below the 2015 target of 130g. The second cornerstone aimed to promote a fuel efficiency information for buyers of new cars. The last strategy adopted, aimed to influence the buyer's vehicle choice, increasing taxes on fuel-inefficient cars compared to the fuel-efficient ones. The amount of car taxes is decided on a national level. In 2005, an attempt to harmonize vehicle taxation at a European level, but this proposal was rejected by the member states.

2 https://ec.europa.eu/clima/policies/transport/vehicles/cars_en

According to the European Environment Agency (EEA), emissions of carbon dioxide from new cars exhibited a decreasing trend throughout the years 2011-2015, both in Italy and in the whole European Union.

The weighted average of the emissions in Italy fell from 132.7g/km in 2010 to 129.5g/km in 2011, reaching five years in advance the European target set for 2015, and further improving in subsequent years: 126.2g/km in 2012, 121.1g/km in 2013 and 118.1g/km in 2014. In 2015 the level of emission was 115.4g/km. For the first time in 2017, the average CO_2 emissions from new cars sold in the EU were greater than in the previous year: 118.5gCO_2/km in 2017 versus 118.1gCO_2/km in 2016. The European countries with the most vehicle registrations (France, Germany, Italy, Spain and UK) are the main contributors to the trend in CO_2 emissions from newly registered passenger cars in the EU-28. Compared to 2016, average emissions increased in all countries excluding Italy: from 0.2gCO_2/km in Germany to 1gCO_2/km in the UK (EEA, 2018).

Various might be the cause of this performance. In this paper, we focus on the analysis of a property tax on new vehicles with engine power larger than 185kW, introduced in Italy in 2011. In particular, this tax, often referred to as *Superbollo*, was applied to new car purchased from 2012 onwards, with the aim of raising tax revenues in a period of severe fiscal stress for the country. This tax was introduced by Decree-Law 6 July 2011 (Article 23, paragraph 21 No. 98) subsequently amended by Decree Law no. 201/2011 (Article 16, paragraph 1).

The effects so far analyzed on the *Superbollo* did not concern the consequences of the tax on CO_2 emissions. Media and trade associations noted that it did not generate the expected revenue increase for the state coffers, leading instead to a contraction of the luxury car market segment. In fact, instead of generating greater tax revenues, quantified at around 168 million per year, it ended up depressing a profitable market not only for the manufacturers, but also for the Treasury. In fact, the decline was of 120 million each year, considering the recovery of VAT on new registrations, road tax, etc. (Unrae, 2017).

The aim of the research is to estimate the impact of the *Superbollo* on the composition of car sales. By using a unique dataset consisting in the universe of circulating cars, we prove that, contrary to the first expectations, the tax increased the share of cars with lower CO_2 emissions. This result is robust across specifications and amounts to 5-7%.

The rest of the paper is organized as follows. Section 2 reviews the main literature available on fiscal policy in the car sector. Section 3 describes the institutional settings. Section 4 introduced the methodology, based on difference in difference approach and the variables used in the analysis. Section 5 presents the results of the econometric analysis. Section 6 concludes.

2. Review of the literature

Different policies have been adopted by governments to reduce car polluting emissions. In recent years, a growing number of scientific articles have studied the effects of tax policies on the sale of new cars.

Fiscal policies, in fact, are considered a strong instrument to influence the final consumers' choice and are more effective than annual road tax policies. In fact, as proved by different studies (Greene et al., 2005; Kilian and Sims, 2006; Greene et al., 2013), car buyers who are more price-sensitive tend to see the advantages in terms of fuel savings for the following three years so that tax policies on purchased vehicle are more pervasive in direct consumers' buying decisions (Brand et al., 2013; Gallagher and Muehlegger, 2011). However, these policies have led to unexpected results. Indeed, in Ireland, as shown by Hennesy and Tol (2011) and Leinert et al. (2013), after the introduction of a differentiation in fiscal policies between purchase and sale taxes according to CO_2 emissions intensities, an increase in the sale of diesel cars has been registered instead of an increase in sales of the small cars. This has led to a reduction in CO_2 but also to a negative increase in NOx emissions (Leinert et al., 2013). It is important to note, however, that in terms of CO_2 emissions, diesel cars are superior than petrol cars due to their higher fuel efficiency. In fact, despite the introduction of turbo and direct injection, diesel engine produces higher NO_x emissions and particulates (North et al., 2006). Similar effects occurred in Norway in 2007 where, following the introduction of a vehicle acquisition tax reform, there was an increase in sales of diesel cars with a drop in CO_2 emissions (Ciccone, 2014). Differently in Denmark, in 2007 the tax reform produced a higher registration of fuel-efficient vehicles. Verboven (2002), examining Belgium, France and Italy diesel tax policies in the period between 1991 and 1994, found that the differentiated tax rates led to price discrimination in diesel car market. He observed that, when controlling engine size, the annual mileage is the main determinant factor on fuel choice decision. He remarked how the excise applied on fuel per liter, affected, directly and indirectly, emissions and efficiency level of new cars purchased. Moreover, Mabit (2014) proved that the technological improvement increased sales of fuel-efficient cars much larger than fiscal policies applied by governments.

Other researchers have analyzed the role of taxation in the purchase of new vehicles, such as high tax rates for high-emission vehicles and lower taxes for less polluting vehicles. Several European states such as France, Finland, Sweden, Netherlands, Denmark, Germany and Sweden have adopted these policies. At the beginning, these taxes were structured as “fee bates”, e.g. the revenues received by the most polluting vehicles were used to finance vehicles with lower emissions (Anderson et al., 2011). In Italy the scheme of *bonus/malus* has been applied since March 2019[3].

Other studies have focused on car scrapping programs and their effects on CO_2 emissions. The underlying idea is that new cars have lower emissions than older ones and that the latest technologies further reduce the level of car emissions (Baltas and Xepapadeas, 1999). These works include Dill (2004) and Allan et al. (2010) for the USA, Van Wee et al. (2000) for Netherlands and Miravete and Moral (2009) for the Spanish program. All these studies prove a small but positive effect of scrappage schemes in terms of emissions reductions, in particular when applied to densely populated area. Greater effects are found when clunkers with no emission control technologies are substituted by new cars equipped with catalytic converters (Böckers et al., 2012).

An important aspect for policy achievement is played by the citizens awareness in the presence of a fiscal program in determining individual choices. There are several factors that affect the awareness of a public policy such as limited information, few awareness programs and other behavioral failures. Consequently, only individuals who are aware of public policy can take into account its effects during their decision-making process and then respond to its introduction. In fact, Cerruti et al. (2019), investigating the case of vehicle taxes on consumers' choices in Switzerland in 2018 (*bonus/malus* system), found out how policy awareness plays a crucial role in achieving policy goals. Specifically, if people ignore the policy, it loses its effectiveness while the awareness of the policy leads to a great impact on individuals' vehicle choices.

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[3] The system is directly linked to the average CO_2 emissions of the vehicles, so its logic is to support the choice of vehicles with very low environmental impact. As for the malus, instead, it will be divided into four segments with relative polluting emissions with a range that goes from 1100 to 2500 euros per car from 161-250g / km.

The aforementioned literature has found a positive, although heterogeneous, effect of taxation in modifying preferences and shifting consumer towards less polluting cars. In this paper, we focus on a tax that has at least two peculiarities:

a) The *Superbollo* was introduced with the aim of raising revenues and as such it was applied to a class of vehicles (the ones with kW > 185), whose buyers, should be less sensitive to taxation-induced cost changes;
b) The tax was applied on the basis of the engine power and not on the basis of emissions, in order to have smaller contractions in the demand for charged cars, hence maximizing tax revenues.

Our analysis hence contributes to the literature by providing evidence on the price sensitivity of high-income buyers (or buyers of cars of greater power) as well as on the potential environmental benefits of general fiscal policy.

3. The institutional setting

The Italian car market is one of the largest in the world, after the US, Japan and Germany since it accounts for about 2 million cars sold each year (Schiraldi, 2011). Significant changes have occurred over the years. The 2017 Report of the *Unione Nazionale Rappresentanti Autoveicoli Esteri* (Unrae)[4] states how the Italian market has been characterized by three deep crises over the last 35 years. In 1983, due to economic stagnation and a high rate of inflation, the market had a sudden drop of 400,000 units (-21.6%). Ten years later, in 1993, there was a more acute crisis, concomitant with the devaluation of *lira* currency (Italian currency before the euro introduction), the forced withdrawal on current accounts and the crisis in the tertiary sector, caused a market

[4] http://www.unrae.it/files/Book%20UNRAE%202017_5a81843af099e.pdf

decline of 686.000 units (-28.8%). After this crisis, the market remained substantially stable for 11 years over the 2,250,000 registered cars. The last crisis took place in 2017. The worst impact on car registrations was achieved in 2013, with a reduction of 1,190,000 new car registrations (-48%) (Unrae, 2017). The economic crisis and the increase in fuel prices have pushed buyers towards alternative fuels and engines: consequently, the weight of petrol engines has been gradually reduced. In fact, in 2010 they represented 36.2% (710,810 units) of the total number of sold car, but at the end of 2013 they fell to 30.8% (401.579 units). On the other hand, during the last 30 years, the weight of diesel cars has recorded an increase. After the two crises, the market started to grow again, accelerating in 2015 and 2016. The market in the 2017 closed at 1,970,000 registrations (+7.9%), a level of sales more in line with the potential of the Italian market. The 2017 saw the overtaking of hybrid cars on Compressed Natural Gas (CNG). With a volume growth of 71.2%, the hybrid cars reached 3.4% of market share, with a progressive expansion of the supply that attracts all buyers, especially families (+90%). Electric cars are on the upswing: + 42.7% in 2017, with almost 2,000 cars registered and a share reaching 0.1% (Unrae, 2017).

In Italy, all car owners are subject to a tax (with a few exceptions listed in the sector legislation[5]). This ordinary car tax, named *Bollo* is a local tax, levied on vehicles and motor vehicles registered in Italy, whose payment is in favor of the Italian Regions of owner's residence. The main source of the tax is the law *D.P.R. 5 Febbraio 1953 n. 39*

[5] The law provides these exemptions for the payment of *Bollo* car tax:

- petrol vehicles with a cylinder capacity of no more than 2000 cm3 and diesel vehicles with a displacement of no more than 2800 cm3 owned by people with disabilities;
- specific environmentally-friendly cars (but only for the first 5 years after purchase), identified by each Region regulations;
- zero-emission cars;
- CNG vehicles in the Lombardy Region and the Piedmont Region (in the rest of Italy the stamp duty is reduced to 25%);
- cars with an age greater than or equal to 30 years.

("*Testo unico delle leggi sulle tasse automobilistiche*"). Ownership is presumed by registration in the Public Automobile Register (PRA - *Pubblico registro automobilistico*), even if proof to the contrary is admitted (i.e. vehicle sales, etc.). The tax amount is defined on the basis of the polluting emissions reported on the registration certificate to determine which directive the vehicle complies with (Euro 0, 1, 2, etc.) and multiply the corresponding value for each kW of engine power. Owners can use the ACI (*Automobile Club d'Italia*) or Revenue Agency (*Agenzia delle entrate*) website, where by entering information of the vehicle and the region of residence it is possible to know directly the exact amount to be paid. Intuitively, so much less it will be the pollution class (*euro class*), the more owners will pay.

Differently, cars owners must pay an additional tax *Superbollo*, if their vehicles engine power is above a specific threshold. Specifically, the tax is defined as follows:

- 10 euros for each kilowatt of engine power exceeding 225kW for 2011;
- 20 euros for every kilowatt of engine power exceeding 185kW from 2012.

The tax is reduced after five, ten and fifteen years from the date of vehicle construction, respectively to 60%, 30% and 15%, and is no longer due after twenty years from the date of construction. These periods are calculated from the 1st January following the construction of the car. If motorists are not required to pay the ordinary car tax, they are not even required to pay the *Superbollo* tax. Otherwise, those who are the owners of the vehicle for the Public Automobile Register, upon expiry of the fee payment period, are required to pay the *Superbollo*. For vehicles with a leasing or usufruct contract, are required to pay those who are users or usufructuaries', respectively (Decree Law no. 201/2011, article 16, paragraph 1). In case of omitted or insufficient payment of

Superbollo the fine is equal to 30 % of the amount not paid (Article 13 of Legislative Decree 18 December 1997, n. 471).

4. Methodology and the data

The aim of the research presented in this article is to estimate the impact of the *Superbollo* on the composition of car sales. To this end, we exploit the features of the measure in terms of types of cars actually charged as well as in terms of the timing of the implementation of the tax.

In particular, we have adopted a difference-in-difference approach in which the counterfactual is defined by the period before the introduction of the *Superbollo* and by the types of vehicles not charged. Data are collected from Italian Ministry of Infrastructure and Transport for the years 2008-2017[6]. The dataset contains information relating to vehicles registered in the National vehicle archive, managed by the Italian Driver & Vehicle Licensing Agency (*Direzione Generale per la Motorizzazione*). Data was downloaded for all regions and assembled into a single dataset. In Table 1 we summarize the definitions for the variables used in the empirical analysis.

Our baseline specification takes the following form:

$$y_{ipt} = \alpha + \beta Post_t + \gamma Superbollo_i + \delta Superbollo_i * Post_t + \tau Trend_t + \rho Controls_{ipt} + \varepsilon_{ipt} \quad (1)$$

[6] The Ministry of Infrastructure and Transport makes the dataset "vehicle and motor vehicle park" public and open in the following link: http://dati.mit.gov.it/catalog/dataset/parco-circolante-dei-veicoli.

Where the dependent variable measures either *kW* or *CO_2* emissions for vehicle *i* registered in province *p* in year *t*, *Post* is an indicator variable measuring the post-2011 period, *Superbollo* is a dichotomous variable indicating whether vehicle *i* has power greater than 185kW. It should be mentioned that to increase the comparability across types of vehicle, we have restricted the analysis to the cars with 150<kW<200. Finally, we include a temporal trend (needed to identify the impact of the policy) and a series of control variables, such as age and gender of the buyer, engine capacity, fixed effects for engine Euro type[7] (Euro 0- Euro 6), engine fuel type, and a series of province-specific fixed effects. Finally, equation (1) was estimated in logarithms, so that estimates of δ can be interpreted as elasticities. Standard errors have been clustered across provinces.

In our econometric analysis, we relax also many assumptions behind equation (1) and in particular, we test the robustness of our results across several specifications.

Table 2 reports descriptive statistics of several outcome and control variables. Columns (2) and (3) are useful to verify the balancing properties of our sample. Interestingly enough, it emerges that for almost all of the considered control variables the treated and the control groups show small differences, whereas substantial differences are evident for our outcomes of interest, that is kW and CO_2 emissions.

Table 3 reports a more structured analysis of the outcome variables by considering the mean of kW and of CO_2 emissions of new cars before and after the introduction of *Superbollo* for the treatment and for the control groups. In both cases, the implicit non-parametric difference-in-difference estimator is negative, althought relatively small in size as it points to a decrease by 11.7mg for CO_2 and by 2.6kW.

[7] The legal framework consists of a series of directives, which modify what was originally regulated by Directive 70/220 / EEC. These directives set the stringent standards for exhausting vehicles of the European Union and EEA member states.
For details: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31970L0220&from=EN

Although these results point at a clear balancing in our sample between the treatment and the control group, a further test for the common trend assumption is needed to reinforce the argument for the use of the difference-in-difference approach. To this end, figure 1 provides a graphical representation of the common trend characterizing the treatment and the control group with a substantial change in the trend occurring in correspondence of the introduction of the *Superbollo,* although it seems less apparent in the case of kilowatts[8].

5. Results

We start the presentation of our results by considering kW as an outcome variable. Table 4 shows several versions of regression (1). Models (1)-(3) differ for the inclusion of fixed effects at province and class of the engine level. In particular, model (1) reports an estimate of the coefficient associated to *Superbollo*Post* equal to -0.01, an order of magnitude that is maintained also when controlling for fixed effects in models (2) and (3). In model (4), we include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type and a series of province-specific fixed effects. In this case, the estimated parameter of interest increases to -0.04, an estimate that is confirmed also when we consider symmetric time window over the years 2008-2015.

[8] It should be noted that the drop in our outcome variables of interest begins only apparently in 2010, whereas the entire decrease is due to the changes occurring in vehicles purchased 2011. This apparent mismatch is only due to the graphics. Nevertheless, this 2011 drop can be interpreted as an anticipation effect, although in our econometric analysis we will keep 2012 as the first year of activity of the policy. Furthermore, table A1 in the Appendix reports a more structured test of the common trend assumption with leads and lags of the treatment variable, that is interactions between year dummies and the indicator variable *Superbollo*. In the case of kW as a dependent variable, the interaction is always not significant before 2011, whereas starting from that year it becomes negative and statistically significant. A similar pattern is observed for CO_2 emissions, although in the pre-2011 period the interaction is marginally significant in two cases, although with a positive sign.

In table 5, we split the sample into macro-geographical areas (North, Center and South) to verify eventual spatial heterogeneity in the effectiveness of the policy. In estimating the same model as in column (4) in table 3, it emerges that the introduction of *Superbollo* has decreased kW of new car purchased by 4% in the North and in the Center, and by a slightly lower amount, 3%, in the South.

Turning to consider the other outcome variable, that is CO_2 emissions, table 6 reports the same models as table 3. In this case, we have estimated a 5% reduction in CO_2 emissions in the baseline model in column (1) and in the specification with province fixed effects is estimated, whereas it decreases to 3% when using also class of the engine fixed effects. In the models in columns (4) and (5), we introduce control variables and we restrict the temporal window, obtaining an estimate of -5% and -6% respectively. These estimates are also confirmed in table 7, when splitting the sample in three areas.

Our empirical analysis points at a significant effect of the *Superbollo* on kW and on CO_2 emissions, however, our results in terms of the environmental impact of the policy may be driven by the steadily diffusion of ecological cars. In table 8, we report the outcome of the analysis carried out excluding ecological cars, defined as vehicles with engine fuel type with a lower environmental impact (lpg (liquefied petroleum gas), methane, petrol/ethanol, electric, petrol/lpg, petrol/methane, petrol/wank, hybrid petrol/electric, hybrid petrol/electric). Also, in this case, results are confirmed at -5%, with an increase to -7% in the symmetric time window case.

Finally, if the results in terms of emissions were driven by *Superbollo*, then we should observe the emergence of the reduction of CO_2 emissions in correspondence of the 185kW threshold only after the introduction of the policy, that is only after 2011.

To test for this possibility, we have estimated routinely, for each year in the sample, the following regression inspired to the Regression discontinuity design:

$$CO_i = \alpha + \gamma Superbollo_i + \delta f(kW) + \rho Controls_{ip} + \varepsilon_{ip} \quad (2)$$

Where *f(kW)* indicates a 5^{th} order polynomial in the forcing variable kW.

Regression discontinuity analysis can be used to estimate program impacts in situations in which individuals are chosen for treatment based on whether their value, for a numeric rating, exceeds a designated threshold. Specifically, this approach is characterized by a treatment assignment that is established on whether an applicant falls beyond or below a cut-point on a rating variable, causing a discontinuity in the probability of treatment receipt at that point (Jacob et al., 2012). The main idea is that individuals with scores just below the cutoff are suitable comparisons to those just above the threshold. If variation in the treatment near the threshold is approximately randomized, then it follows that the baseline characteristics should have the same distribution just beyond and just below the threshold. Consequently, the baseline covariates are used to test the validity of the regression discontinuity design (Lee and Lemieux, 2010).

Figure 2 plots the coefficients of interest across models and it emerges an interesting heterogeneity behind the point estimate of -5%, as the negativity of the coefficient clearly emerges after 2011 (with the sole, odd, exception of 2012), with a convergence towards a -10% estimate.[9]

[9] It should be mentioned that these point estimates are slightly larger than the ones of the difference-in-difference models, however, it should be also noted that in the RDD we do not control for the (declining) time trend and for its break in 2011. These estimates should be taken only as indicative of the causal impact of the *Superbollo*.

As a final robustness check, in column (3) in table 8 we control also for kW and province-specific time trends, obtaining an elasticity of -6%, hence in line with our previous estimates.

6. Conclusions and Policy Implications

Fiscal policy effects have been widely recognized as relevant in reducing CO_2 emissions. The literature has found positive effects, although differentiated, between the various European countries implementing fiscal policies in the car sector. The primary consequence of most of these measures is a change in the final consumer preferences in favor of more eco-friendly cars. By using a difference-in-difference method, in which the counterfactual is defined by the years before *Superbollo* introduction and the types of vehicles to which the tax is not applied, we estimate the impact of this tax on the composition of vehicle fleet. Specifically, we consider in the analysis a temporal trend, a series of control variables and a geographical (province-level) fixed effects. Our results reveal a significant effect of *Superbollo* on CO_2 emissions and kW (engine power of vehicles expressed in kilowatts). As a robustness check, we excluded from the analysis the ecological cars that, notwithstanding their small share of the market, could have played an important influence in terms of environmental impact. The outcome is confirmed: *Superbollo* is negative and significant in all the estimates. Consequently, we can state that the introduction of a car tax can lead to a reduction of CO_2 emissions, only if the consumers avoid buying cars with higher engine power. These effects occur although the primary objective of the tax is not the environmental one. We also demonstrate how *Superbollo* has played an important role in determining the number of circulating vehicles and in reducing larger-capacity cars in a consistently way among the various Italian geographical areas.

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Table 1. Definition of variables and data sources.

Variable	Description
CO2 Emission	Vehicle CO2 emission measured in grams per kilometer.
Age of owner	Age of the vehicle holder.
Gender	Equal to 1 if the male, 0 female.
Engine capacity	Engine size measured in cubic centimeters (cm3).
kW	Engine power of a vehicle expressed in kilowatts.
Euro class	Polluting classes of vehicles identified by European directives.
Euro 0	Vehicles registered before 31/12/1992;
Euro 1	Directives for vehicles registered after 01/01/1993;
Euro 2	Directives for vehicles registered after 01/01/1997;
Euro 3	Directives for vehicles registered after 01/01/2001;
Euro 4	Directives for vehicles registered after 01/01/2006;
Euro 5	Directives for vehicles registered after 01/01/2008;
Euro 6	Directives for vehicles registered after 01/09/2015.
Superbollo	Equal to 1 if engine power is more than 185 kilowatts, 0 otherwise.
Post	Equal to 1 if the years 2012-2017 are considered, 0 otherwise.
Province	Province of residence of the vehicle owner.

Table 2: Descriptive statistics

	(1) Whole sample	(2) Treated	(3) Control
Age of owner	52.21	51.71	52.26
	(13.57)	(14.68)	(13.46)
Male gender	0.811	0.808	0.811
	(0.391)	(0.394)	(0.391)
Engine capacity	2,782	2,821	2,779
	(415.0)	(620.5)	(389.9)
kW	169.4	194.9	167.0
	(12.76)	(4.054)	(10.46)
Euro class	4.510	4.565	4.505
	(0.535)	(0.550)	(0.533)
CO_2 Emission	204.7	217.4	203.5
	(35.71)	(46.09)	(34.33)
Superbollo	0.0862		
	(0.281)		

Table 3: Before-after comparison

	(1) Control Before	(2) Control After	(3) Treated Before	(4) Treated After	Implicit Diff-in-Diff
CO_2 Emission	204.1	162.4	217.5	164.1	-11.7
	(35.16)	(32.18)	(48.27)	(50.93)	
kW	167.6	167.7	194.9	192.4	-2.6
	(10.36)	(13.61)	(4.09)	(4.24)	

Notes: All the coefficients are statistically different from 0 at 1%.

Table 4: Difference-in-difference estimates with kW Outcome

	(1) Whole sample	(2) Whole sample	(3) Whole sample	(4) Whole sample	(5) Symmetric time window
*Superbollo**Post	-0.01***	-0.01***	-0.01***	-0.04***	-0.04***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Superbollo	0.15***	0.15***	0.15***	0.14***	0.14***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Post	0.01***	0.01***	-0.01***	0.02***	0.03***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Observations	151,275	151,275	151,275	90,909	75,564
R-squared	0.378	0.381	0.400	0.598	0.602
Province FE	NO	YES	YES	YES	YES
Class FE	NO	NO	YES	YES	YES
Controls	NO	NO	NO	YES	YES

Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Difference-in-difference estimates with kW outcome across areas

	(1) North	(2) Center	(3) South
*Superbollo**Post	-0.04***	-0.04***	-0.03***
	(0.004)	(0.003)	(0.003)
Superbollo	0.14***	0.14***	0.13***
	(0.002)	(0.003)	(0.002)
Post	0.02**	0.00	0.02***
	(0.008)	(0.003)	(0.004)
Observations	56,538	16,334	18,037
R-squared	0.592	0.604	0.622
Province FE	YES	YES	YES
Class FE	YES	YES	YES
Controls	YES	YES	YES

Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1. Regions in the "North" are Piemonte, Lombardia, Liguria, Veneto, Trentino Alto Adige, Friuli Venezia Giulia, Emilia Romagna. Regions in the "Center" are Toscana, Lazio, Umbria, Marche. Regions in the South are Campania, Puglia, Basilicata, Abruzzo, Molise, Calabria, Sicilia, Sardegna.

Table 6: Difference-in-difference estimates with CO_2 emission outcome

	(1) Whole sample	(2) Whole sample	(3) Whole sample	(4) Whole sample	(5) Symmetric time window
*Superbollo**Post	-0.05***	-0.05***	-0.03***	-0.05***	-0.06***
	(0.005)	(0.004)	(0.005)	(0.006)	(0.006)
Superbollo	0.06***	0.07***	0.06***	0.00	0.00
	(0.006)	(0.006)	(0.005)	(0.004)	(0.004)
Post	-0.03***	-0.27***	-0.07***	-0.03***	-0.04***
	(0.004)	(0.003)	(0.006)	(0.004)	(0.004)
Observations	148,467	148,467	148,467	88,843	73,946
R-squared	0.379	0.391	0.472	0.638	0.593
Province FE	NO	YES	YES	YES	YES
Class FE	NO	NO	YES	YES	YES
Controls	NO	NO	NO	YES	YES

Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Difference-in-difference estimates with emission outcome across regions

	(1) North	(2) Center	(3) South
*Superbollo**Post	-0.05***	-0.05***	-0.05***
	(0.008)	(0.009)	(0.009)
Superbollo	0.00	0.00	-0.00
	(0.005)	(0.007)	(0.007)
Post	-0.03***	0.01*	-0.04***
	(0.006)	(0.005)	(0.008)
Observations	55,133	15,967	17,743
R-squared	0.622	0.654	0.678
Province FE	YES	YES	YES
Class FE	YES	YES	YES
Controls	YES	YES	YES

Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1. Regions in the "North" are Piemonte, Lombardia, Liguria, Veneto, Trentino Alto Adige, Friuli Venezia Giulia, Emilia Romagna. Regions in the "Center" are Toscana, Lazio, Umbria, Marche. Regions in the South are Campania, Puglia, Basilicata, Abruzzo, Molise, Calabria, Sicilia, Sardegna.

Table 8: Impact of *Superbollo* on ecological car sales

	(1) CO_2 emissions excluding ecological cars	(2) CO_2 emissions excluding ecological cars and symmetric time window	(3) CO_2 emissions excluding ecological cars, symmetric time window, year dummies and province time trends
*Superbollo**Post	-0.05***	-0.07***	-0.06***
	(0.006)	(0.006)	(0.006)
Superbollo	0.00	0.00	-0.01***
	(0.004)	(0.004)	(0.004)
Post	-0.05***	-0.05***	
	(0.005)	(0.005)	
kW			0.13***
			(0.014)
Observations	87,132	72,459	72,433
R-squared	0.625	0.581	0.587
Province FE	YES	YES	NO
Province time trends	NO	NO	YES
Class FE	YES	YES	YES
Controls	YES	YES	YES

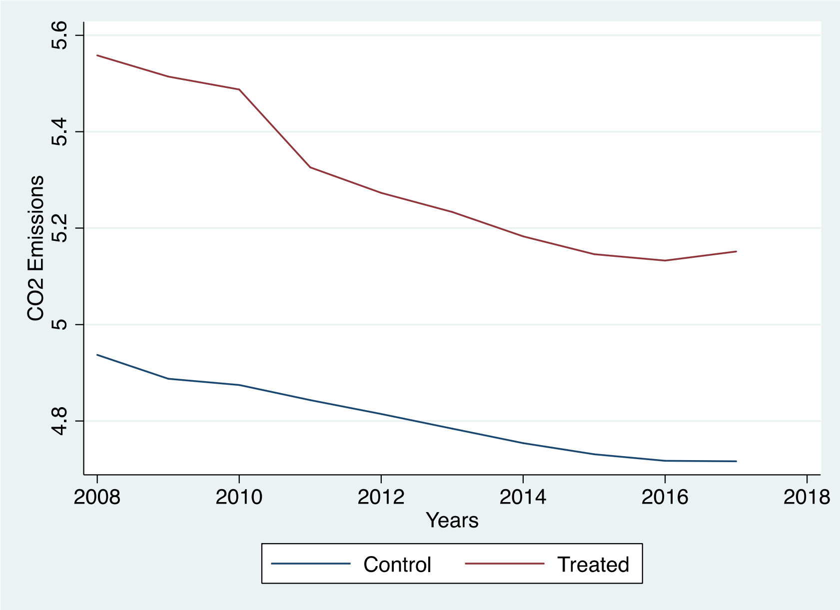
Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1.

Table A1: Test of common trend assumption (Symmetric time window)

	(1) KW	(2) CO emissions
Year 2009	-0.01***	0.02***
	(0.001)	(0.002)
Year 2010	-0.01***	0.03***
	(0.001)	(0.003)
Year 2011	-0.00**	0.03***
	(0.001)	(0.003)
Year 2012	0.00*	-0.01***
	(0.002)	(0.003)
Year 2013	0.01***	-0.01***
	(0.002)	(0.003)
Year 2014	0.03***	-0.03***
	(0.003)	(0.003)
Year 2015	0.03***	-0.05***
	(0.005)	(0.005)
Superbollo	0.15***	0.04***
	(0.002)	(0.007)
2008**Superbollo*	0.00	0.00
	(0.000)	(0.000)
2009**Superbollo*	-0.00	0.02**
	(0.003)	(0.007)
2010**Superbollo*	0.00	0.01*
	(0.003)	(0.008)
2011**Superbollo*	-0.02***	-0.12***
	(0.003)	(0.010)
2012**Superbollo*	-0.05***	-0.05***
	(0.002)	(0.009)
2013**Superbollo*	-0.05***	-0.13***
	(0.003)	(0.010)
2014**Superbollo*	-0.06***	-0.12***
	(0.003)	(0.012)
2015**Superbollo*	-0.06***	-0.13***
	(0.003)	(0.011)
Observations	75,564	73,946
R-squared	0.603	0.600
Province FE	YES	YES
Class FE	YES	YES
Controls	YES	YES

Notes: Controls include a series of control variables, that is age and gender of the buyer, engine capacity, fixed effects for engine Euro type, engine fuel type. Clustered standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Common trend between treated and control groups



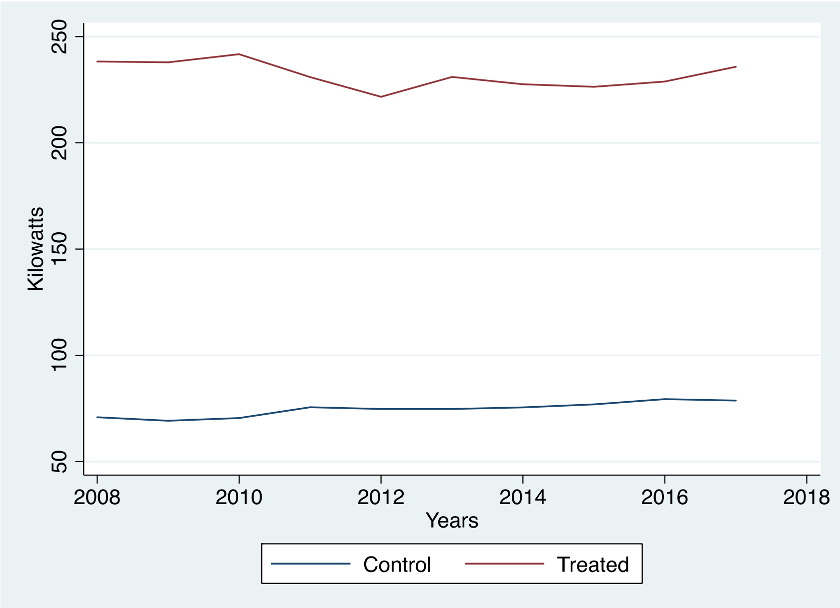
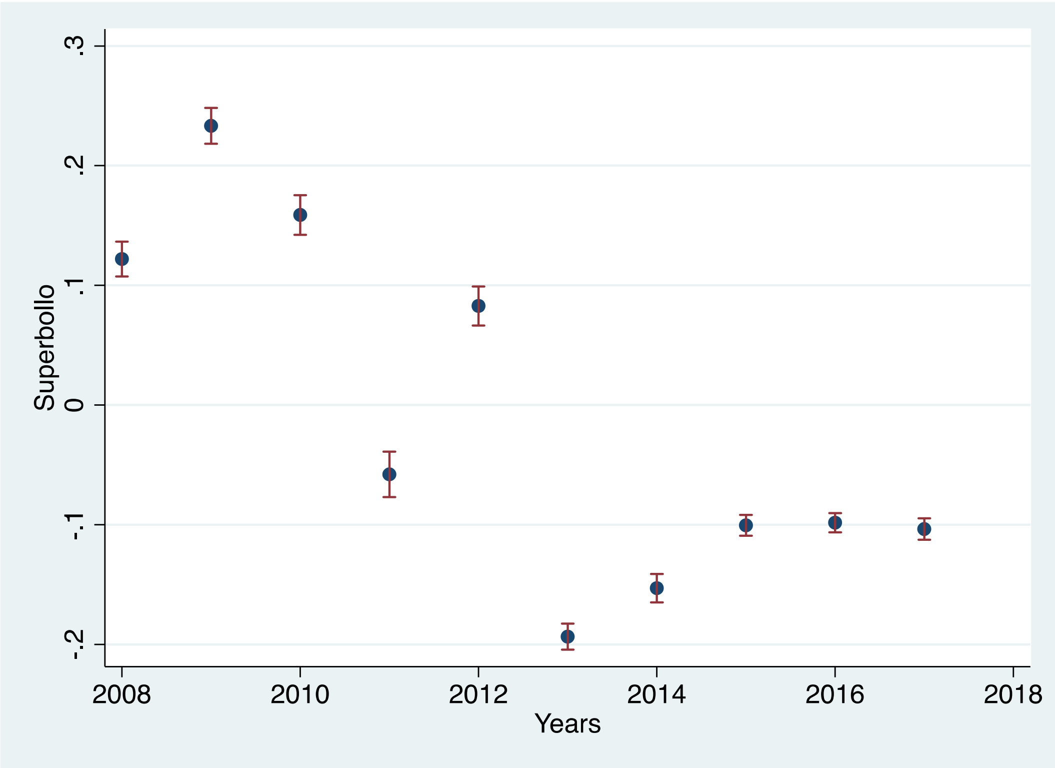


Figure 2: *Superbollo* coefficient for regression discontinuity with 5th order polynomial



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