Transport Policy 47 (2016) 105–118

Contents lists available at ScienceDirect

Transport Policy

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

Evaluation of subsidies programs to sell green cars: Impact on prices, quantities and efficiency ☆

Juan Luis Jiménez [a,*,1], Jordi Perdiguero [b], Carmen García [c]

[a] Departamento de Análisis Económico Aplicado, Universidad de Las Palmas de Gran Canaria, Facultad de Economía, Empresa y Turismo, Despacho D. 2-12, 35017 Las Palmas de Gran Canaria, Spain
[b] Universitat Autònoma de Barcelona, Departament d'Economia Aplicada, Research Group of "Economia Aplicada" (GEAP), Spain
[c] European University Institute, Italy

ARTICLE INFO

Article history:
Received 17 September 2015
Received in revised form
17 November 2015
Accepted 8 January 2016
Available online 22 January 2016

JEL Classification:
H23
L52
L62
Q58

Keywords:
Subsidies
Automobile sector
Difference-in-difference estimator
Green policies

ABSTRACT

During the recent period of economic crisis, many countries have introduced scrappage schemes to boost the sale and production of vehicles, particularly of vehicles designed to pollute less. In this paper, the authors analyze the impact of a particular scheme in Spain (Plan2000E) on vehicle prices and sales figures as well as on the reduction of polluting emissions from vehicles on the road. They considered the introduction of this scheme an exogenous policy change and because they could distinguish a control group (both non-subsidized vehicles and the same vehicles in Slovenia) and a treatment group (subsidized vehicles), before and after the introduction of the Plan, the authors were able to carry out their analysis as a quasi-natural experiment. The study reveals that manufacturers increased vehicle prices by 600 € on average. In terms of sales, econometric estimations revealed that the Plan would not cause any increase in sales. With regard to environmental efficiency, comparing the costs (invested quantity of money) and the benefits of the program (reductions in polluting emissions and additional fiscal revenues) and it has been found that the Plan would only be beneficial if it boosted demand by at least 30%.

1. Introduction

The automotive industry is widely considered one of the most important manufacturing sectors in the economy of automobile manufacturing countries. Its high level of production and its labor demand make it a visible sector in any economy. The current economic crisis experienced by Western economies starting in 2008 has significantly impacted this industry, particularly in terms of automobile sales.

Reduced sales resulting in increased unemployment in the sector coupled with demands to meet targets for the reduction of greenhouse gas emissions – a result of the United Nations Copenhagen Climate Change Conference and the Kyoto Protocol – has led many Western governments to introduce special programs aimed at increasing vehicle replacement through new purchases.

These programs were essentially designed to fulfill two objectives: increase automobile sales (thereby minimizing redundancies), and reduce greenhouse gas emission levels generated by the vehicles on the road.[2] These policies were implemented in countries such as Germany, Italy, France, the United Kingdom and the United States during 2008 and 2009.

Although there were many countries that introduced these programs and approved their costs in governmental annual budgets, little attention has been paid to their effect on economies and, as far as the authors know, there are no studies into their effect in Europe. Nor are there any studies into the impact of governmental aid on prices set by industry.[3]

One governmental aid program in the United States that has been extensively analyzed called for the adoption of a hybrid vehicle.[4] The

☆Authors thank comments and suggestions by Daniel Albalate, Javier Campos, Aday Hernández, Héctor Rodríguez, Pilar Socorro, Ancor Suárez, members of Departamento de Teoría e Historia Económica of Universidad de Málaga and two anonymous referees. We also thank collaboration in database by María Montesdeoca. Nevertheless, all errors are ours.
* Corresponding author.
E-mail addresses: juanluis.jimenez@ulpgc.es (J.L. Jiménez), jordi.perdiguero@uab.cat (J. Perdiguero).
[1] Tel.: +34928458191.

[2] Hensher (2002) exposes that this is only one of the tools to influence in the transport behavior and hence in the levels of CO_2.
[3] Sallee (2011) analyzes the effect of subsidies for the purchase of the Toyota Prius hybrid car in its price. Surprisingly, the effect is zero; prices are not affected by the subsidy. The author considers that the effect of current prices on future sales may explain this result.
[4] A hybrid vehicle combines an electric engine and an internal combustion engine.

http://dx.doi.org/10.1016/j.tranpol.2016.01.002
0967-070X/

program offered a rebate of up to $2,000 and was introduced in 2001. A new version was introduced in 2005, increasing the rebate to $3,400. Diamond (2009) carried out a first estimate of the impact of this program on the sale of certain hybrid car models (Toyota Prius, Honda Civic and Ford Escape) and the results showed an increase of approximately 18%, depending on the model.

Beresteanu and Li (2011) studied public aid and the effect of gasoline prices on the purchase of hybrid vehicles. The results of the study showed that if the price of gasoline had not increased between 1999 and 2006, there would be 37% fewer hybrid vehicles on the roads. In terms of public aid, the authors estimated that the program stimulated a 20% increase in the demand for hybrid vehicles. Gallagher and Muehlegger (2011) analyzed this same program in United States and found a similar result (a 22% increase in demand).

Other studies include a report by Huang (2010) in which he analyzed the "Cash for Clunkers" program introduced in United States. This program was introduced in March 2009 and offered between $3,500 and $4,500 to exchange an old vehicle for a more energy efficient one. If the savings were between 4 and 9 miles per gallon of gasoline, the owner received $3,500, and if the savings were even greater they received $4,500.[5] The study shows how the average amount awarded ($4,224) boosted demand for more energy efficient vehicles by between 25% and 30%.[6]

Other papers like Mian and Sufi (2010) or Li et al. (2011) show that the global effect of the program was zero. Both papers find that after the initial increase in sales, they decrease in the months after the program. After few months the accumulative sales return to the normal level and the effect of the program is not really different from zero.

Giblin and McNabola (2009) study the carbon-based tax system for new vehicles implemented in Ireland in 2008. Using a car choice model, they predict that carbon-dioxide emissions will be reduced by 3.6–3.8%. While the annual tax revenues are expected to decrease, they argue that the cost savings of reductions in carbon-dioxide emissions may outweigh this loss. Rogan et al. (2011) analyze this policy one year after being implemented, showing that it was successful: emissions of new cars fell by 13% and there was a significant shift to diesel cars. However, as expected, there was a revenue loss. On the other hand, Hennessy and Tol (2011) conclude that despite the increase of market share for diesel cars, carbon dioxide emissions fall but only modestly, or even minimally once the rebound effect of people driving more is accounted for. Moreover, the cost to the revenue per tonne of carbon dioxide avoided is high.

Given that most studies focus on the effects on vehicle sales (and not the impact on prices), the objective of this study is to analyze the impact of a program that promotes pollution reducing vehicles (Plan 2000E in Spain) from three different perspectives: firstly, on the prices set by automobile manufacturers (the effect of subsidy on price); secondly, its effect on the sales of automobiles in a European market, and thirdly, on the viability of the program in terms of environmental benefits (measured by assessing empirical evidence).

The present study contributes to the literature surrounding this issue in the following ways: firstly, as far as the authors know, the impact of public assistance on prices set by manufacturers in the conventional cars has not been previously analyzed. Secondly, studies that analyze European cases are not available in the literature. Thirdly, it is provided evidence on the environmental viability of the program, by comparing its costs and the environmental benefits.

The difference-in-difference analysis reveals that the manufacturers' response to the introduction of the Plan was to significantly increase the prices of the subsidized vehicles, thereby keeping a part of the funds. The fact that automobile manufacturers (hereinafter manufacturers) received one part of the credit by increasing vehicle prices illustrates that the effect of the Plan on the sales and on pollution reduction levels is actually quite low, which significantly reduces the efficiency of the Plan. Econometric results showed that the impact of the program on the sales of automobiles was around 0%. Results also indicate that the costs of the program far exceed the resultant environmental benefits, and as such Plan 2000E not only turned out to be inefficient, but probably was socially undesirable too.

After this introduction the rest of the paper is organized as follows: Section 2 describes the characteristics and the implementation of Plan 2000E in detail and Section 3 focuses on the data used in the empirical study, which is presented in Section 4 for both objectives (effects and environmental efficiency). Conclusions are given in Section 5.

2. Plan 2000E

The manufacture of automobiles and bicycles in Spain during 2009 was valued at approximately 40 billion euro and employed 145,645 workers that same year. These figures accounted for 11.5% of total production and 7.2% of employment in all manufacturing sectors.[7] These figures demonstrate the importance of this sector in the Spanish economy, and explain why this industry has received so much media attention during the ongoing economic crisis.

To put Spanish automobile manufacturing into an international perspective, Spain was the eighth largest manufacturer in the world and third largest in Europe in 2009. Despite this, there is evidence that starting at the end of 2007, the economic crisis was starting to affect the sector, and by 2009 the sector had reached an alarming level of suffering, with a reduction in year-on-year manufacturing of almost 20% for motor vehicles in businesses with more than two hundred employees, and 35% in the remaining businesses.[8]

This negative evolution in the sector in 2008 and 2009 led the Spanish Government to take action (as did other countries with similar problems)[9] by introducing a scrappage scheme that would reactivate sector activity, called Plan 2000E. This Plan would subsidize the replacement of an old vehicle for a new one, with specific characteristics, and was co-financed by the National Government (who contributed 500€), the Autonomous Communities (who contributed 500€) and manufacturers (who contributed 1000€) with the aim of providing a total subsidy of 2000€.

Only specific vehicles with the M1 classification could be subsidized (motor vehicles with at least four wheels, designed and manufactured for the transport of passengers) and those with the N1 classification (vehicles designed for the transport of merchandise, whose gross vehicle weight did not exceed 3.5 t). A list of vehicle requirements is shown in Table 1.

Consumers could benefit from the subsidy by exchanging an M1 or N1 classified vehicle, which was at least 10 years old or with

[5] An extensive explanation of the "Cash for Clunkers" program is available in Cooper et al. (2010) and Yacobucci and Canis (2010).

[6] Alberini et al. (1995) present a theoretical model in order to determine user participation in vehicle substitution programs. Nevertheless, the participation ratios estimated from the model are quite distant from those confirmed in empirical studies, reaching 78% by offering only $2,000.

[7] MITYC (2011). *Estadística de Fabricación de Vehículos Automóviles y Bicicletas*.

[8] Fundación SEPI (2009). *Las empresas industriales en 2009: Encuesta sobre estrategias empresariales.*

[9] During 2008 and 2009, public assistance was also provided to purchase of vehicles in Germany (2.500€ per vehicle, with a total of 600,000 vehicles being subsidized), Italy (rebate ranged from 1500€ to 3000€, depending on the vehicle), France (allocation of 1000€, with approximately 400,000 vehicles subsidized), the United Kingdom (2000 GBP, of which the Government contributes 1000, and the manufacturers the rest) and the United States (rebate of $3500 or $4500, according to vehicle fuel consumption).

a minimum of 250,000 km on the clock for a new vehicle that did not exceed 30,000€ (prior to applying the subsidy, with VAT taxes included) and met certain emissions criteria. The scheme could also be used for second hand purchases[10] if the car being scrapped was at least 12 years old and the used was less than 5 years old.

The first stage of Plan 2000E officially began on May 18th 2009 and would end on May 18th 2010, or when the fixed objective was met, which was the financing of 200,000 vehicles. However, the approved budget for Plan 2000E was used up in the first five months, according to data cited from the Ministry of Industry[11] (this is an approximation; the timing is based on the official start date of the program to the end of August).[12] The speed with which the budget was used up caused the government to extend the number of subsidized vehicles by 80,000 in November 2009 (second stage), that is, an additional allocation of 40 million euro.[13] Finally, with the market continuing to report falling annual car registrations and with the government considering that Plan 2000E had a positive and dynamic effect[14] on the economy, it approved the extension of the Plan once again in 2010. In this last stage (the third stage), the Plan was made effective from January 1st 2010 until September 30th 2010, or until the Plan had met its stated quantitative objectives i.e. subsidizing 200,000 vehicles. Plan 2000E officially ended in July 2010. In the first four months of 2010 75% of the allocated vehicles had been accounted for and it was expected that the full budget would be used up by the month of May or June.[15] The sum of all vehicles covered by the Plan (480.000) represents the 2.2% of the total fleet.

Almost all of the Autonomous Communities (hereinafter Communities) that participated in Plan 2000E (including Ceuta and Melilla) had signed up to the Plan by 2009, with Madrid and La Rioja being the two exceptions. Nevertheless, they both offered discounts on registration tax, with Madrid offering 20% and La Rioja between 15% and 38%. Some Communities such as Navarra, Galicia, Valencia and Cataluña offered their own plans, some of which increased the requirements set out by the Government. The rest of the Communities opted to contribute the standard 500€ set by the Government.

In 2010 (during the third stage of the Plan) certain Communities such as Canarias, Asturias, and Islas Baleares were excluded because the funds had been used up. Other Communities such as País Vasco passed legislation in favor of the new Plan, but used up the funds quickly (by March 2010), while Galicia decided not to implement Plan 2000E (although it did subsidize efficient vehicles). We do not show any pattern that explains why some Communities participated in the Plan and others did not. There are different political parties, levels of income, etc, in the two groups.

In the first stage, there was a degree of uncertainty amongst the Communities as to how to react to the Plan; these doubts had increased by the third stage in 2010. Given that it was impossible to obtain detailed information on sales in each of the Communities, it has been measured the average impact of the Plan, i.e. variations in regional responses to the Plan.

Table 1
Requirements and planning.
Source: Own elaboration.

Characteristics	Price	Emissions	Others
Subsidized vehicle	< 30,000 €	< 120 g/km (ecological)	M1
		< 149 g/km (innovative)	M1: Stability control; presence detection
		< 149 g/km	M1: Three way-catalyst; EGR valve
		< 160 g/km	N1
Planning Stage	**Legal period**	**Real period**	**Number of vehicles**
First	May09–May10	May09–Aug09	200,000
Second	Nov09–Dec09	Nov09–Dec09	80,000
Third	Jan10–Sep10	Jan10–Jun10	200,000

Note: The column Number of vehicles refers to the maximum number financed by the Plan 2000E.

The characteristics of the Plan previously indicated allowed us to address this study as a quasi-natural experiment. As pointed out by Lafontaine and Slade (2008), a natural experiment must meet three criteria: (1) that there is an exogenous change in the market; (2) that there is a group affected by the change; (3) that there is a group that is not affected by the change, which fulfills the control group function.

The introduction of the Plan meets these criteria: (1) the introduction of the Plan is a political decision, an agent that does not operate in the market and therefore the change is not produced as a consequence of actions by the active manufacturers in the market. Although the introduction of the plan can respond to the economic crisis, automobile operators could not anticipate the criteria to be subsidized, or the exact moment that it would be implemented; (2) the introduction of the Plan allows the authors to have a group of different versions of vehicles affected by the Plan (those that satisfy the criteria to join the Plan); (3) Plan 2000E creates a set of equal versions (even those found within the same vehicle model) that cannot be included in the Plan and hence represent a potential control group. Another potential control group is these same vehicles in European Union countries that have not implemented any plan.

As the introduction of Plan 2000E meets the criteria of a natural experiment, which allows the application of a difference-in-difference estimator, the authors can estimate the effect of the program on the prices set by the manufacturers in a relatively simple way. Because they take as a control group not subsidized vehicles in Spain, since the two groups were formed after the introduction of the Plan they are not considered random – they were created by the Plan – they had to control their estimations by using characteristics that determine whether a vehicle belongs to one group or another i.e. the pollution level, which was estimated based on the horsepower of the vehicle.

Although there are some positive reviews of the Plan, such as that from The Ministry of Industry, Tourism and Commerce who reported that the Plan generated good results and the Federation of Automobile Dealers Associations (*Federación de Asociaciones de Concesionarios de Automoción*) who were satisfied with the extension of Plan 2000E and the increase in sales reported in some

[10] The specific conditions of the Plan applied to second hand purchases are very restrictive. In consequence, the amounts of sales of this type of cars represent a low percentage of total sales in the market. Moreover, it is quite difficult to obtain the prices and sales of second hand purchases vehicles. This is why this study will not consider the impact of the Plan 2000E in those vehicles.

[11] *"El Plan 2000E ha agotado ya el 75% de sus fondos"*. *Expansión* (14/04/2010).

[12] *"Cien millones en ayudas para el Plan 2000E"*. http://motor.terra.es/ultimas-noticias-actualidad/articulo/cien-plan-2000e-52271.htm

[13] BOE (Núm. 260, de 7 de noviembre de 2009. Págs.: 92952–02053). Real Decreto 1667/2009, de 6 de noviembre, por el que se modifica el Real Decreto 898/2009, de 22 de mayo, por el que se regula la concesión directa de subvenciones para la adquisición de vehículos, Plan 2000 E de apoyo a la renovación del parque de vehículos, y se amplía el número máximo de vehículos a financiar en 80.000 vehículos adicionales.

[14] BOE (Núm. 7, de 8 de enero de 2010. Págs.: 2015–2020). Real Decreto 2031/2009, de 30 de diciembre, por el que se regula la concesión directa de subvenciones para la adquisición de vehículos, "Plan 2000E" de apoyo a la renovación del parque de vehículos durante el año 2010.

[15] *"El Plan 2000E ha agotado ya el 75% de sus fondos"; Expansión* (14/04/2010). "El Plan 2000E cumple su primer año de vigencia a punto de agotar sus fondos"; *Cinco Días* (17/05/2010).

months, there are still criticisms about the uncertainty of the Plan and the delays in the payments received.[16]

The Spanish Competition Authority (*Comisión Nacional de la Competencia, CNC*) has stated their concerns about the effects of the Plan on vehicle prices and that they have reason to believe that the automobile dealers had incentives to increase prices, not only to counteract the discount but to absorb part of the subsidy received by the consumers. According to the Comisión Nacional de la Competencia (2009), it was expected that one result from Plan 2000E would be increased sales, reduced prices paid by the consumer and increases in the price received by the dealer, in a way that the difference between the price paid by the purchaser with the subsidy and the price that would be paid without the subsidy would be less than the subsidy itself (Comisión Nacional de la Competencia, 2009).

3. Data

To achieve the goal of this study, the authors built two databases: (1) A detailed database of all vehicles for sale in Spain. This database will be used when vehicles not subsidized in Spain are the control group. (2) A database at European Union level that will be used as their control group are the countries that have not implemented any plan. Both databases are explained in more detail below.

The first database that was used combine different sources, which included factory price, vehicle sale price to the public[17], vehicle characteristics (security and comfort variables), monthly sales of each brand, as well as annual sales per vehicle model, and some control variables on income evolution (national Gross Domestic Product) and complementary goods prices (international crude price).[18]

The database contained prices for the period between January 2007 and September 2010 (every time that the price for specific versions of a vehicle is modified, not a monthly price) and included vehicles from 35 brands sold in Spain. These prices change usually two or three times a year. This equated to 732 specific versions (289 are subsidized and 443 versions are not subsidized), which had to be available on the market before and after the implementation of the Plan (which is one of the advantages of the average analysis carried out by the CNC, which is done by model). Table 2 shows descriptive statistics for variables in the data set, distinguishing between subsidized and non-subsidized vehicle.

The database includes those vehicles that have a public sale price of less than 50,000€ for two reasons: firstly, Plan 2000E establishes a requirement that the car price be less than 30,000€; secondly, and most relevant, because the competition is diverse between vehicles with very high prices than those with low prices. It is expected that the vehicles that cost more than €50,000 would belong to a distinct product type market and would not directly compete with the identified automobiles in the Plan.

Table 2 shows the average price of vehicles per brand, differentiating between subsidized and non-subsidized vehicles. The prices ranged from approximately 7000€ to 38,000€. 38% of subsidized cars (51% of non-subsidized) used a gasoline engine with 100 horsepower (155) and an average guarantee of 28 months (31 for non-subsidized). The majority of the vehicles had anti-lock braking system (ABS) and power steering. During the study period, the average monthly sales per brand represented 3699 vehicles, and the price of crude ranged from $39.95 to $132.72 per barrel.

Fig. 1 shows monthly trends in vehicle sales; the point when Plan 2000E began is highlighted in red. From this date on and after each extension of the Plan, an increase in vehicle sales was observed. Nevertheless, vehicle sales clearly vary depending on the month being observed. After the introduction of Plan 2000E, the only months in which a different pattern was observed comparing the same months in different years were July 2010 (a fall in car sales was observed and the date coincides with the end of the Plan), and November 2010 (an increase in sales was observed, even though Plan 2000E was no longer in place). With regard to the remaining periods when Plan 2000E was in place, the average monthly vehicle sales followed the same trends seen in previous years.

The second database includes information on prices and technical specifications of the vehicle provided by the European Commission.[19] The authors have information from January 2007 to December 2010. With the price and technical specifications they can infer what cars are within the plan for each of the countries.

Given the uncertainty during the application of Plan2000E, the authors wanted to identify whether there were any variations in behavior at the different stages of the Plan so it has been considered the different stages separately and assessed behavior. The first stage under consideration was the first four months after the Plan was officially launched, which ran from May to August 2009. This period saw the maximum availability of funds and maximum interest from the Communities. For the second stage, it has been considered the remaining period for the Plan, which ran from September 2009 to June 2010; this period definitively marked the end of the budget. These months are considered as a single group because of the uncertainty when, during September and October, it was discovered that funds were limited. In addition, there was continued uncertainty when the budget was increased at the end of 2009 and again in 2010.

In the other estimates the authors considered three periods: May to August 2009, September to October 2009 (when funds were limited and in some cases extremely scarce, even though these months continued to form part of the initial stage of the Plan), and November 2009 to June 2010 (because in November 2009 and January 2010 new budgets were established, thus there were additional funds made available during these months to allow Plan 2000E to continue).

In the proposed analysis by the CNC, it is stated that there is reason to believe that behavior varies depending on which price model is in place, *i.e.* subsidized or non-subsidized. Table 3 shows a similar analysis into the average prices for subsidized and non-subsidized vehicles before and after the introduction of the Plan. The analysis was carried out for the different periods highlighted above.

It can be observed in the data that trends in average prices of the subsidized vehicles and non-subsidized vehicles varied. In the first stage, while the prices for non-subsidized vehicles fell 7.7%, there was a slight increase (0.2%)[20] in average prices for subsidized vehicles. In following stages, all of the models saw a drop in prices as a result of the situation in the previous stage and this was more prominent in the non-subsidized vehicles: between September

[16] Press release- FACONAUTO: *"La incertidumbre en las CC.AA respecto al Plan 2000E ralentiza la venta de coches en enero"* (15/01/2010); *"La incertidumbre en los concesionarios sobre el Plan 2000E frena las ventas en abril"* (16/04/2010); *"Las Administraciones públicas adeudan a los concesionarios de automoción 13,9 millones"* (23/06/2010).

[17] The difference between the sale price to the public and the factory price are the registration taxes, indirect taxes and transport.

[18] Price data and characteristics were obtained from the website of Asociación Nacional de Vendedores de Vehículos a Motor, Reparación y Recambios (GANVAM). Market data on monthly vehicle registrations were obtained from the Asociación Nacional de Importadores de Automóviles, Camiones, Autobuses y Motocicletas (ANIACAM). Nominal GDP came from INE and international crude prices from OPEC.

[19] http://ec.europa.eu/competition/sectors/motor_vehicles/prices/archive.html

[20] The authors carried out a test on average differences for each type of vehicle and compared the before with the first stage. In the case of subsidized vehicles the average difference hypothesis is accepted (increase in first stage), while non-subsidized is rejected.

Table 2
Descriptive statistics by type of vehicle.
Source: Own elaboration.

Variables	Mean		Standard deviation		Minimum		Maximum	
	S	Non-S	S	Non-S	S	Non-S	S	Non-S
Manufacturer Price	15557.8	23487.4	4909.5	6547.9	7414.3	6995.9	24345.7	37801.6
Gasoline	0.38	0.51	0.49	0.50	0	0	1	1
Horsepower	99.9	155.4	27.0	38.0	55	60	177	265
Guarantee (months)	28.3	31.3	9.8	12.3	24	24	84	84
Trunk capacity	1007.7	1322.4	439.9	597.1	267	267	2800	3423
ABS	1	0.99	0	0.08	0	0	1	1
Number of airbags	4.3	5.44	1.9	1.6	1	0	8	8
Power assisted steering	0.95	0.94	0.22	0.24	0	0	1	1
Monthly sales per brand	3370.6	2836.1	2603.1	2980.1	160	3	12922	16771
Annual sales per model	8424.4	2781.8	11459.5	7848	18	1	55132	77847
GDP	266691.8		10073.61		251910		280679	
Crude	71.58		25.13		39.95		132.72	
Subsidized	0.39		0.49		0		1	

Note: *S* is subsidized vehicle. *Non-S* is non-subsidized vehicle.

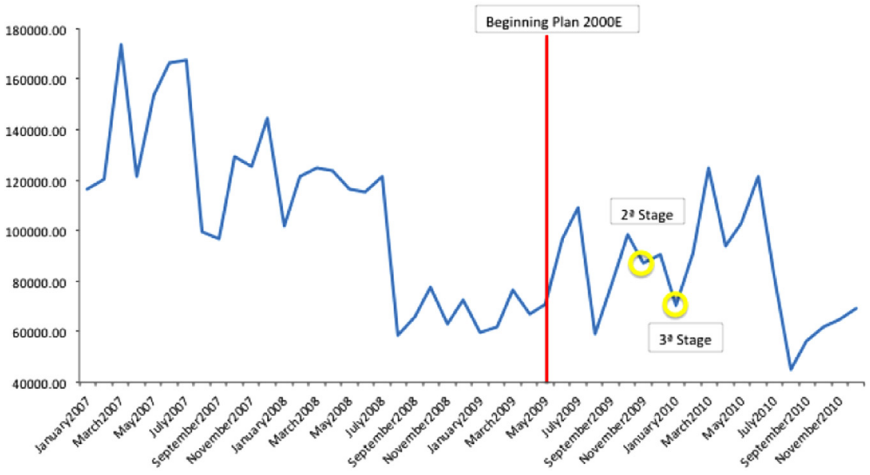

Fig. 1. Monthly automobile sales in Spain. Source: ANIACAM. Own elaboration.

2009 and June 2010, average prices for vehicles in the subsidized group fell 9.5%, while those in the non-subsidized group fell a further 16.7%.

Although these results may reflect an impact of the subsidy that contrasts with what the Government expected, they must be analyzed with caution; being descriptive, they do not account for supply factors (those which affect brand prices) or demand factors (perhaps there is a different behavior in the sales between subsidized and non-subsidized vehicles after the introduction of the Plan) so the authors had to be careful not to report inaccurate conclusions.

An econometric analysis of the prices was carried out to determine whether there was a variation in price trends associated with vehicle type.

4. Empirical strategy, findings and discussion

The present study has two objectives. The first is to analyze the effect that Plan 2000E had on the manufacturing prices of vehicles included in the Plan. Note that the forecasts do not vary considerably if the analysis is carried out with public sale price, given the high level of correlation between the two variables.

For this purpose, it has been created an equation in which vehicle prices are a function of vehicle characteristics, total sales by brand (ideally the authors would like to use exact sales by automobile version, however this data is not publically available), the economic evolution of the country, the official price of crude oil and possible timing effects. These details are addressed in Section 4.1.

A second approach to understand the effects of the Plan on the

Table 3
Average prices (nominal euro) by vehicle and period.
Source: Own elaboration.

	Before	After (1)		After (2)		
		May–Aug09	Sep09–Jun10	May–Aug09	Sep–Oct09	Nov09–Jun10
Subsidized vehicles	15,766.90	15,804.2	14,267.5	15,804.2	15,068.8	13,754.1
Non-subsidized vehicles	24,065.50	22,203.3	20,033.2	22,203.3	18,988.9	21,911.6

prices set by manufacturers can be seen in Section 4.2. In this section the authors use as controls those European Union countries that have not introduced any promotional plan.

Once it has been observed the impact of the program on prices set by the manufacturers, they then set out to determine whether the Plan was viable by estimating the benefits (i.e. the reduction in greenhouse gas emissions and the tax revenue derived from increased sales), and the costs derived from its implementation (i.e. the volume of public resources invested in the Plan). The results are presented in Section 4.3.

4.1. Effect of Plan 2000E on prices

The estimation carried out considered the exact versions of vehicles that were available before and after the introduction of Plan 2000E, which only applied to vehicles with a sale price not in excess of 50,000€. Similarly, given the differences in vehicles within categories, it has been included an option that allowed the authors to carry out a cluster analysis by price and horsepower and thus obtain stronger results.[21] This allowed them to control potential differences in errors according to price bracket.

The estimate by Berry et al. (1995) is the most commonly used for demand estimates and states that vehicle price and characteristics determine their sales. In this study, the characteristics of Plan 2000E meet the criteria of a quasi-natural experiment, meaning it can be estimated the effect of the Plan using a difference-in-difference estimator. This allows the authors to have a control group (the versions of vehicles that are non-subsidized) and a treatment group (the versions of vehicles that are subsidized and meet the criteria for Plan 2000E).

The correct implementation of difference-in-difference estimator requires that the differences between both groups (control and treatment group) are minimal, excepting from the treatment. The availability of versions of vehicles that are non-subsidized and versions that are subsidized in the database allows the implementation of difference-in-difference, being the adherence to the Plan the only contrast between them. If there are differences between groups, the variable responsible for the differences must be controlled. In this study, the only difference between the control group and the treatment group is the pollution level, which must be controlled so that the estimations are not biased. Vehicle horsepower can be used to estimate the pollution level and thus allows us to measure and control this difference between the two groups.

It is important to note that there are no other differences between the two groups with respect to the remaining characteristics because the same versions of cars were used in each group. This type of methodology is frequently used to analyze the effect of public policies. One example is a study by Albalate (2008) who assesses the impact of programs to reduce alcohol levels in European motorists.

The first part of the methodology is to estimate the following equation:

$$\begin{aligned} \textit{Manufacturer price}_{it} &= \beta_0 + \beta_1\,\text{Subsidized}_i + \beta_2\,\text{First stage}_{it} + \\ &\beta_3\,\text{DID First stage}_{it} + \beta_4\,\text{Second stage}_{it} + \beta_5\,\text{DID Second stage}_{it} + \\ &\beta_6\,\text{Monthly sales}_{it} + \beta_7\,\text{Gasoline}_i + \beta_8\,\text{Horse power}_i + \beta_9\,\text{Guarantee}_i + \\ &\beta_{10}\,\text{Trunk capacity}_i + \beta_{11}\,\text{ABS}_i + \beta_{12}\,\text{Number of airbags}_i + \\ &\beta_{13}\,\textit{Power assisted steering}_i + \varepsilon_{it} \end{aligned} \tag{1}$$

Manufacturer price$_{it}$ is the wholesale price for each version of vehicle i at moment t. The following exogenous variables have been used to try to explain what affects it:

1. *Subsidized$_i$:* binary variable that takes value 1 if the version is a subsidized one, i.e., if the vehicle is included in the Plan.
2. First stage$_{it}$: binary variable that takes value 1 if wholesale price belongs to any of the four months of the first stage: May, June, July and August 2009. General effects on prices in this stage are captured by this variable, without differentiating between subsidized and non-subsidized vehicles.
3. DID First stage$_{it}$: this takes value 1 for subsidized vehicles in the first four months of first stage. It is the product by two latter binary variables (1 and 2). It is the difference-in-difference estimator for the first stage of the Plan. A positive estimation of this variable indicates that prices of subsidized vehicles have increased compared to non-subsidized vehicles.
4. Second stage$_{it}$: binary value that takes value 1 for the rest of the months in which the Plan is valid. It spans September 2009 to July 2010. This variable includes some of the first stage (two months in which the funding was over: September and October 2009), the second and third stage of the Plan together.
5. DID Second stage$_{it}$: It is the difference-in-difference estimator for the latter variable (second stage). Its interpretation is the same as variable number 3.
6. Monthly sales$_{it}$: this variable covers monthly sales (in units) of each brand during the period in question. Some endogeneity problems arise because these sales are influenced by the price set by manufacturer. For this reason it has been used a two-step estimator (Two Stage Least Minimum Squares) where the instruments are the Spanish GDP from 2007 to 2010 (measured on an annual basis in millions of current euro), two temporal variables (year and summer[22]) and crude oil (Brent crude oil price, measured in dollars per barrel).
7. *Gasoline$_i$*: binary variable that takes value 1 if the vehicle uses gasoline. It takes value 0 if the vehicle uses diesel.
8. *Horsepower$_i$*: the horsepower of the vehicle.
9. *Guarantee$_i$*: the length of guarantee offered by the wholesaler (expressed in months).
10. Trunk capacity$_i$: it measures the capacity of the trunk and is expressed in liters.
11. *ABS$_i$*: binary variable that takes value 1 if the vehicle has the ABS braking system.
12. Number of airbags$_i$: it is the number of airbags included in the car.
13. Power assisted steering$_i$: binary variable that takes value 1 if the car has power assisted steering.

In addition, the following equation was also estimated:

$$\begin{aligned} \text{Manufacture price}_{it} = {} & \beta_0 + \beta_1\,\text{Subsidized}_i + \beta_2\,\text{First stage}_{it} \\ & + \beta_3\,\text{DID First stage}_{it} + \beta_4\,\text{Sept oct}_{it} \\ & + \beta_5\,\text{DID sept oct}_{it} + \beta_6\,\text{Nov 09 june 10}_{it} \\ & + \beta_7\,\text{DID Nov 09 june 10}_{it} \\ & + \beta_8\,\textit{Monthly sales}_{it} + \beta_9\,\text{Gasoline}_i \\ & + \beta_{10}\,\textit{Horse power}_i + \beta_{11}\,\text{Guarantee}_i \\ & + \beta_{12}\,\text{Trunk capacity}_i + \beta_{13}\,\text{ABS}_i \\ & + \beta_{14}\,\text{Number of airbags}_i \\ & + \beta_{15}\,\text{Power assisted direction}_i + \varepsilon_{it} \end{aligned} \tag{2}$$

The new variables considered are:

[21] The cluster analysis used *K-means* methodology to create groups. Calinski-Harabasz pseudo F-statitisc has been implemented to determine the optimal number of groups, seven in this case. See Calinski and Harabasz (1974).

[22] It is a binary variable that takes value 1 for July and August. It is included due to seasonality of sales in summer period.

1. $Septoct_{it}$: binary variable that takes value 1 if price is for the period between September and October 2009.
2. DID $septoct_{it}$: difference-in-difference estimator for September and October 2009.
3. $Nov09june10_{it}$: this variable takes value 1 for this range of months. It comprises the second and third stages of the Plan.
4. $Didnov09june10_{it}$: difference-in-difference estimator for months included in the second and third stages.

The results from the forecasts in Eqs. (1) and (2) are shown in Table 4. In both cases the dependent variable is the manufacturer price from version *i* in period *t*.[23]

The explanatory capacity of the model (measured by R^2) was approximately 78% and the *F*-tests were accepted at 1% in all of the cases.

With respect to the explanatory variables, the quantity of vehicles sold is significantly low, which explains the inverse relationship between price and quantity. Recall that this variable is instrumented based on GDP, price of crude, year and summer.[24] Some characteristics of the vehicles are significant and determine that diesel vehicles, with greater horsepower or larger trunks, are factors that increase the vehicle manufacturer price. It is interesting to observe that the vehicles with longer guarantees have lower prices. A test was carried out on some brands that are found in lower market segments, and revealed how they offered a longer guarantee in this period.[25]

Nevertheless, the parameters of greatest interest in the study are difference-in-difference estimators. Both forecasts gave the same result: during the application of the first stage of the Plan, subsidized vehicle prices increased by approximately 1000 euro compared to non-subsidized vehicles. So it can be concluded that during this period (from May to August 2009), a positive effect was observed on the prices of subsidized vehicles.

Diamond (2009) indicated that manufacturers could incorporate public aids funds in their price structure and thus establish a higher price for vehicles. Incorporating this concept into the present study, it can be said that a large part of the subsidy could go directly towards subsidizing the manufacturers without significantly influencing the adoption of new vehicles, which would work against the program objectives. However, the report by the Comisión Nacional de la Competencia (2009) indicated that Plan 2000E would probably result in an increase in the nominal and effective price received by the dealer by about 1000 euro, since they have incentives in maintaining the same price prior to the introduction of the Plan.

One aspect that the authors want to discuss is the possibility that consumers buy subsidized cars rather than non-subsidized vehicles. In this case the control group would be affected by the Plan and the difference-in-difference estimator would be biased upward. Therefore, the coefficient of the D-i-D estimator would not reflect an increase in the prices of subsidized vehicles but the increase in the price difference between subsidized and non-subsidized vehicles. This increase in the price difference would be partly explained by the increase in prices of subsidized vehicles (ownership of part of the grant by firms) and the effect of sales on prices.

Table 4
Price equations estimations[a](unsubsidized Spanish models as a control group).

Explanatory variables	Equation 1	Equation 2
Subsidized	−1894.25(1269.83)	−1917.48 (1243.63)
First Stage	352.59 (382.24)	352.46 (389.41)
DID First Stage	**938.36* (522.79)**	**1012.67** (530.33)**
Second Stage	1032.42 (583.81)	
DID Second Stage	**−1112.71 (1140.61)**	
Sept-Oct		874.42 (1047.08)
DID Sept-Oct		**−2268.85 (1556.67)**
Nov09-June10		1435.84 (933.35)
DIDNov09-June10		**−422.10 (1515.64)**
Monthly Sales	−0.49*** (0.18)	−0.54*** (0.16)
Gasoline	−3532.98*** (613.03)	−3460.9*** (653.59)
Horsepower	112.28*** (9.62)	111.04*** (8.54)
Guarantee	−99.50*** (20.54)	−103.09*** (18.74)
Trunk capacity	0.20 (0.31)	0.27 (0.34)
ABS	618.09 (3046.6)	725.28 (3149.01)
Number of airbags	217.22 (173.75)	232.19 (185.19)
Power assisted direction	829.46 (1068.32)	842.52 (1106.32)
Constant	9330.71*** (3479.00)	9432.54*** (3458.07)
Observations	904	904
R^2 (centered)	0.78	0.78
F-test	1.1e+08***	1.1e+09***

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.
Note 2: Monthly sales by brand have been estimated using the following instruments: GDP nominal, year, summer and crude price.

[a] In these equations it has been included fixed-effects by car model. All results remain but there are two main changes: firstly, the difference-in-difference estimator in first stage is significant and it reaches 480 €; secondly, the coefficient of guarantee turns into positive.

4.2. Effect of Plan 2000E on prices: European countries as a control group

As it has been noted the use of non-subsidized vehicles as control group may bias the estimates since this group may have been indirectly affected by the plan. If users were not buying vehicles unsubsidized to buy a subsidized vehicle due to the plan, estimates of the previous section would be biased upward.

To try to solve this issue the authors analyze in this section the possible impact on the prices of car manufacturers using as control group a Euro zone country that have not implemented any plan to promote the sale of vehicles on this period: Slovenia. To check if this country is a good control group or not they follow the approach of Albalate (2008). The same model is estimated incorporating only dummy variables for years prior to the Plan, different for every country. The econometric result indicates that it cannot be rejected even 10 percent that affected group (Spain) and the control group (Slovenia) behaves in the same way before the introduction of the plan. Results of these econometric estimations can be seen in Table A1 of the Annex. An alternative way to check if Slovenia is a good control group is to analyze the evolution of unsubsidized vehicles. If the evolution of the vehicle prices has behaved similarly in Spain and Slovenia, we should not observe significant differences in the prices of unsubsidized vehicles, so the difference-in-difference estimator for this group of vehicles would not be significant. As can be seen in Tables A2 and A3 of annex the difference-in-difference estimator is not significant in any case for non-subsidized vehicles. Finally, it was conducted a “Placebo Test”

[23] As suggested by Albalate (2008), the authors estimated the same model incorporating dummy variables for years prior to the Plan, differentiated for the car's versions affected and unaffected by the Plan. The econometric result indicates that both groups follow the same trend before the Plan, so the result of the difference-in-difference estimator would reflect the specific effect of the Plan and not the previous evolution of both groups. The Chi2 is equal to 1.58 and it cannot be rejected the null hypothesis that the trend of affected and unaffected versions follow the same trend at 45.49%.

[24] The Kleibergen-Paap and Stock-Yogo statistics indicate that these instruments do not properly solve the problem of endogeneity of the monthly sales by brand variable. This fact can make the coefficient of this variable be biased towards zero, so the effect of sales on price could be greater.

[25] In fact, the longest guarantee was given by KIA (84 months). Nissan offered 36 months; Seat, 24.

to verify that the effect shown by the difference-in-difference estimator is due to the change introduced by the Plan in 2009. So in order to construct the two "Placebo Test" it was assumed that the change in the market occurred in 2008 and 2010 respectively (years where no significant legislative change occurs in the market). The results can be seen in Tables A5 and A6 of annex 1. The results show that the difference-in-difference estimator does not find significant effect on these two approaches as expected. So, this country is a good control group and so the difference-in-difference estimator reflects in a correct way the effect of the Plan in the manufacturer's prices.

The empirical approximation can be observed in the following equation:

$$\text{Manufacturer price}_{it} = \beta_0 + \beta_1 \text{Period of Plan}_t + \beta_2 \text{DID}_{it} + \beta_3 \Delta \text{GDP}_{it} + \varepsilon_{it} \quad (3)$$

where:

1. $Manufacturerprice_{it}$ is the price before taxes fixed by the manufacturer in the country i at the time t.
2. $PeriodofPlan_t$ is a dummy variable that takes value 1 for the years affected by the plan and 0 otherwise for all the countries.
3. DiD_{it} is the difference-in-difference estimator and is generated by the multiplication Country affected$_i$*$PeriodofPlan_t$.
4. The authors introduced as a control variable the percentage change in gross domestic product. The reason for introducing this variable is the possibility that a different trend in the gross domestic product could generate differences in willingness to buy durable goods such as a vehicle.[26]

The estimation includes fixed effects by model, country and year. In this case it has also been examined whether the plan has different effects for 2009 than for 2010, and whether the vehicles in different price bands (less or more than 15,000 euro) were influenced differently. Results can be observed in the following tables:

As shown in Table 5a and b, the difference in difference estimator concludes that prices in Spain increase around 650 euro as a consequence of the plan.[27] It checks the possibility that the effect would be different for the two years of the plan. Like can be seen in the second column (Model 2) the coefficient of the diff-in-diff estimator are very similar, coefficients do not show a statistically significant difference, so it can be concluded that the effect are similar during all the plan period. It should be noted that this is the price increase made by the manufacturer, notwithstanding that the retailer can increase the price appropriating another part of the grant. Unfortunately the authors do not have information on prices that dealers charge so they cannot analyze the impact of the plan on retail final prices.

However, the recent antitrust cases in Spain against major manufacturers in which they collude not only in prices but also in other strategic information suggests that this is not a competitive market (see for example files S/0486/13, S/0487/13, S/0488/13, S/0489/13 in www.cnmc.es)

The authors have not found any other analysis in the literature that focuses on the impact of public assistance in established manufacturer prices of conventional vehicles, except the paper of Kaul et al. (2012) (Sallee, 2011, focus in the effect on the Toyota Prius hybrid car). In this paper authors do not found in average any effect of the plan in the price fixed by the dealers in the German market. Authors showed like the cheapest subsidized cars (up to 12,000 euro) suffered an increase in prices around 200 euro, meanwhile the more expensive car segments (more than 32,000 euro) received an extra-grant of 1100 euro.

To account for the possibility that the effect of the plan would be different for vehicles of different price bands, column 3 and 4 presents estimations for cars priced less than 15,000 euro and for those who are between 15,000 and 30,000 euro respectively. The results show that the price increase for the cars priced less than 15,000 euro like the case of Germany.

The result means that consumers are appropriated in the best 1350 euro of aid, 65%. This result is similar to that obtained by Busse et al. (2006) which showed as consumers obtained between 70% and 90% of the discounts offered directly to consumers, while the discounts offered to the vehicle dealers only reached 30% or 40% of consumers. The authors believe that the information asymmetries are responsible for these differences.

Therefore it can be concluded that in the first stage of the Plan by increasing their prices by 650 euro for the subsidized versions of certain vehicles, the manufacturers "collected" this amount rather than passing it on to the consumer. At this point it is not possible to determine the effect of different prices on different types of vehicles, likely due to the uncertainty created by the Plan. In summary, half of the fixed 2000€ subsidy in the Plan was taken by the manufacturers and thus in reality the Plan consisted of a 1350€ subsidy paid to the consumer upon replacement of an old vehicle, and 650€ paid to the manufacturers. The part of the Plan that ended up being the subsidy to the manufacturers obviously does not create or reduce pollution levels nor does it increase vehicle sales; thus the efficiency and effectiveness of the Plan are unclear.

4.3. Environmental efficiency of Plan 2000E

To estimate the benefits of the program, the authors calculated the benefits of reduced greenhouse gas emissions generated by the vehicles included in the Plan and the tax revenue generated from increased sales. It is not the authors' objective to perform a Cost-Benefit analysis, since they do not have information on the reduction in claims due to new vehicles or the time reduction displacement that could occur due to the improvement in their technical characteristics, elements that would improve the benefits from the Program. In addition it is assumed a fixed price for emitted CO_2 and that all variables increase at the same interest rate.

To quantify the benefits of reduced greenhouse gas emissions it has been assumed that the Plan replaced cars with average greenhouse gas emission levels of 1990 indicated by the European Union (180 g de CO_2/km) with less polluting cars i.e. those included in the subsidized range of vehicles described in Plan 2000E (133.92 g of CO_2/km) like are proposed in Hahn (1995) (see Table 7).

After calculating the reduction in pollution production per kilometer, they multiplied these savings by the number of kilometers that the car would travel after one year (24,000 km),[28] by the number of years this car could expect to run (15 years)[29] and by the number of cars included in the Plan (461,838 vehicles). This allowed the authors to determine the number of tons of CO_2 emissions that would be avoided as a result of the Plan, which

[26] In any case we can check in Fig. A1 of the annex like the evolution of the gross domestic product in the two countries are very similar.

[27] The statistical results are available to the reader upon request.

[28] It is being assumed that both old and new vehicles would perform the same kilometers, meaning that there would be no rebound effect. If users do more miles on a new car with an old one as indicated by Binswanger (2001) and Herring and Robin (2007) emissions savings would be lower and the results of the plan would be more negative.

[29] Following the European Commission et al. (1999), the average lifetime of a vehicle is between 9 and 10 years, with exceptions that can reach 15.

Table 5a
Price equations estimations (Slovenia as a control group).

	Model 1	Model 2	Price < 15000	15000 < Price < 30000
Constant	13637.53*** (66.931)	13641.11*** (68.653)	10855.41*** (49.817)	18416.57*** (202.254)
Period of plan	−176.220 (157.792)	−176.220 (158.438)	−148.090 (115.435)	−228.389 (522.606)
DiD estimator	**538.246** (210.786)**		**413.116** (157.860)**	**702.615 (657.040)**
DiD estimator 2009		**552.906** (219.288)**		
DiD estimator 2010		**505.666** (247.089)**		
Observations	285	285	180	105
F-Test	3.98** (0.0213)	2.65* (0.520)	3.85** (0.0254)	0.80 (0.4574)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table 5b
Price equations estimations (Slovenia as a control group).

	Model 1	Model 2	Price < 15000	15000 < Price < 30000
Constant	13753.58*** (104.242)	13758.35*** (105.961)	10983.64*** (74.259)	18340.77*** (334.646)
GDP gr	−28.308 (19.558)	−30.527 (21.089)	−32.891** (14.418)	17.311 (60.291)
Period of plan	−445.673* (243.561)	−466.799* (255.261)	−446.659** (172.549)	−53.549 (808.194)
DiD estimator	**681.973*** (232.105)**		**564.915*** (167.551)**	**602.938 (752.892)**
DiD estimator 2009		**675.538*** (234.107)**		
DiD estimator 2010		**732.583** (291.624)**		
Observations	285	285	180	105
F Statistic	3.38** (0.0209)	2.53** (0.0442)	4.44*** (0.0062)	0.55 (0.6549)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table 6
Estimations of annual sales by model.

Explanatory variables	**(1)**	**(2)**	**(3)**	**(4)**
Subsidized	5507.2*** (1,633.7)	3017.7 (2,838.2)	3438.7** (1,637.8)	1400.3 (3,118.1)
Subsidized period	−1914.6*** (658.3)	−3409.5*** (1,246.6)	−1733.4*** (624.4)	−2502** (1,139.2)
DID Subsidized period	**730.4 (1,326.4)**	**281.6 (2693.7)**	**61.6 (1,243.7)**	**−1458.3 (2,605.1)**
Manufacturer price		−0.06* (0.03)		−0.03** (0.01)
Constant	3590*** (919.9)	8396.9*** (2451.1)	3,075.6*** (998.8)	4592.6*** (1,534.9)
Observations	602	299	602	299
F-test	5.74*** (0.0023)	3.98*** (0.0100)	19.65*** (0.0000)	17.25*** (0.0000)
Hansen J Statistic		8.379 (0.1365)		9.418 (0.1514)
Cluster	Yes	Yes	No	No
Fixed effects	No	No	Yes	Yes
% increase in sales	9.2	3.6	0.8	−18.5

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

could then be translated into a monetary value. This was achieved by multiplying the number of tons of CO_2 by the average price of emission rights of a ton of CO_2 in the market during 2010 (€14.32).[30]

The other element of Plan 2000E that brought benefits was the increase in tax collected from the sale of automobiles. The sale of any type of vehicle generates revenue for the public treasury from Value Added Tax (VAT) and vehicle registration tax (IM). In this case, since a 2000 euro subsidy was available for the purchase of a vehicle, the Treasury Department would receive additional revenue, since the subsidy would be included as an income increase and thus be declared in individual income tax filings (IRPF).

This income is very important, as seen in the report by the Union of Analysts of the Spanish Treasury Department (GESTHA). In this report they estimated that each one of the vehicles generated 2643€ in revenue with the following breakdown: 196€ from income tax, 1958€ from VAT and 489€ from vehicle registration tax. These figures were actually used by the analysts at the Spanish Treasury Department to ensure that Plan 2000E was profitable. The result was estimated revenue of approximately 1.2€ billion, which was greater than the costs of the Plan.

It is important to highlight that these results are only accurate if it is assumed that all users that took part in the Plan would not have changed their vehicle had the Plan not been in place. This assumption is reflected in the first column of Table 7, in which the authors assume that the 461,838 vehicles included in the Plan account for newly created demand.

[30] There are other emissions benefits of retiring older vehicles, as the NO*x* emissions reductions. However there are no market emissions rights for this and it cannot be included.

Table 7
Comparison of revenues and costs for Public Administration derived from Plan2000E, depending on new demand generated.Source: Own elaboration.

	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Pollution old vehicles [a]	180	180	180	180	180	180	180	180	180	180
Pollution new vehicles [a]	133.92	133.92	133.92	133.92	133.92	133.92	133.92	133.92	133.92	1le33.92
Yearly kilometers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Useful life of vehicles (years)	15	15	15	15	15	15	15	15	15	15
Number of car subsidized by the Plan	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838
Avoided tons of CO_2	7,661,338.214	6,895,204.393	6,129,070.572	5,362,936.75	4,596,802.929	3,830,669.107	3,064,535.286	2,298,401.464	1,532,267.643	766,133.821
Price per ton of CO_2 [b]	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32
Savings (€) of avoided CO_2	109,710,363.2	98,739,326.91	87,768,290.58	76,797,254.26	65,826,217.94	54,855,181.62	43,884,145.29	32,913,108.97	21,942,072.65	10,971,036.32
Costs of the Plan	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000
Taxes revenues due to Plan	1,220,637,834	1,107,626,075	994,614,316.8	881,602,558.2	768,590,799.6	655,579,041	542,567,282.4	429,555,523.8	316,543,765.2	203,532,006.6
Results	868,510,197.2	744,527,402.3	620,544,607.4	496,561,812.5	372,579,017.5	248,596,222.6	124,613,427.7	630,632.769	−123,352,162.2	−247,334,957.1

[a] CO_2 emissions in gr/km.
[b] In euro, according to quotation

Nevertheless this data is not reality, so to estimate the effect of the Plan on subsidized vehicle sales they followed Eq. (3). In these forecasts, unlike those shown in Table 4, annual sales by model were used. The authors did this because sales by brand have an associated monthly periodicity, which tells them with greater variability that they are observing a monthly effect of the Plan. However, to distinguish between subsidized and non-subsidized models it was carried out a sales forecast with annual figures by model.

The following equation was used:

$$\text{Annual sales by model}_{it} = \beta_0 + \beta_1 Subsidized_i + \beta_2 Subsidized\ period_{it} + \beta_3 DiD_t + \beta_4 X_{it} + \varepsilon_{it} \quad (4)$$

In Table 6 the authors used the variable *subsidized* as binary. If the corresponding model had 50% or more versions that were subsidized, then the variable takes on a value of 1, otherwise it is zero. In the columns (1) and (2), a cluster error term by brand was used to take into account the heterogeneity of the different brands in the database. In the case of columns (3) and (4) fixed effects by brand were incorporated. In the columns (2) and (4) the authors introduce the variable "manufacturer price", which is considered to be an endogenous variable. In these two cases it has been used a Two Least Squares and the instruments are: GDP of the country, trunk capacity, a dummy variable that take value 1 if the vehicle has a power assisted steering, the number of airbags and the horsepower. Results are shown in Table 6.[31]

As Table 6 shows, the effect of the Plan on sales defined ranges from 730.4 to −1458.3 units. It should be noted that the information is aggregated at annual level, so the empirical estimations have a lot of noise. In any case the authors calculate the percentage of increase in sales derived of the implementation of Plan2000E. Like it can be seen in the last row of Table 6, the percentage ranges from 9.2% to the −18.5%. These results are in average close to that obtained in the analysis performed by the Fesvial and GfK Emer Ad Hoc Research (2009), in which they reported that the Plan "encourages many individuals to buy a vehicle" based on 5% of the survey participants.

This result is not surprising when the duration of the Plan 2000E is considered, over thirteen months. As indicated Mian and Sufi (2010) and Li et al. (2011), the effects of the "Cash for Clunkers" program in United States over the sales are diluted in less than six months, going to have an effect on sales equal to zero. It is possible that the Plan 2000E generated positive effects on sales in the initial months, but unfortunately monthly data on sales were not available to test this hypothesis. In summary, seems clear that the overall effect of the Plan 2000E on sales over its lifetime is effectively zero.

Regardless of the empirical evidence, in the additional columns from the efficiency analysis included in Table 7 it was uncovered new demand generating capacities of the Plan, starting with the previously mentioned 100% to 10%.

In terms of the benefits derived from the reduction of polluting emissions, the benefits depend on the capacity of the Plan to create demand for less polluting vehicles. This survey found that a large percentage of participants would have exchanged their car for a less polluting model even if the Plan did not exist, thus a reduction in pollution levels would have been seen even without the Plan.

As above, the benefits derived from tax revenue depend on the

[31] Like in the price equation it has been tested if the affected and unaffected groups follow the same trend before the Plan. The same result was obtained; it cannot be rejected the null hypothesis that the two groups follow the same trend before the introduction of the Plan. So, the D-in-D estimator shows in an efficient way the effect of the Plan.

Table 8
New demand generated by public subsidies. Source: Own elaboration. Gasoline (gas.), Diesel (die), Short Run (s.r.), Long Run (l.r.).

Article	Country	Year	Type of vehicle	Subsidy quantity	Net effect on sales
Gallagher and Muehlegger (2011)	USA	1999–2006	Hybrid	2000–3400$	22%
Beresteanu and Li (2011)	USA	1999–2006	Hybrid	2000–3400$	20%
Li et al. (2011)	USA	2009	Conventional	3500–4500$	0%
Miravete and Moral (2011)	Spain	1994–1995	Conventional	480–600€	0% gas 27.72% die
Chandra et al. (2010)	Canada	2000–2007	Hybrid	1000–3000$	26%
Huang (2010)	USA	2009	Conventional	3500–4500$	25–30%
Mian and Sufi (2010)	USA	2009	Conventional	3500–4500$	0%
Diamond (2009)	USA	2001–2006	Hybrid	2000–3400$	18%
Fesvial and GfK Emer Ad Hoc Research (2009)	Spain	2009–2010	Conventional	2000€	5%
Licandro and Sampayo (2006)	Spain	1997	Conventional	480€	16% s.r 1.2% l.r.
Adda and Cooper (2000)	France	1994–1995	Conventional	5000FF	5%
Present study (2015)	Spain	2009–2010	Conventional	2000€	0%

capacity of the Plan to create demand. If, for example, 40% of sales came from newly created demand, then 60% of the users would have changed their car anyway and would still have paid VAT and registration taxes. The collection of income tax depends only on joining in the Plan or not. Users welcomed the plan, regardless of whether or not new demand, have to declare the subsidy in their income tax. This is due to the increase in income that is subject to income tax generated as a direct result of the Plan, and without this the increase in personal income tax collection would not have occurred. As we can see, the benefits and therefore the effectiveness of the Plan depend on its capacity to generate new demand.

With respect to the program costs the authors have only taken into account the expenses assumed by the local and national governments. To calculate these costs they multiplied the total number of cars included in the Plan 2000E (461,838 vehicles) by the 1000€ subsidy per vehicle contributed by the local and federal government. The costs do not depend in any case on the capacity that this has to create new vehicle demand since the subsidy is given to all of the users that participated in the Plan, not only those who would have changed their car anyway, but also to those who would not have changed their car without the Plan. Results are shown in Table 7.

Table 8 shows the net effect of Plan 2000E, which strongly depends on the Plan's capacity to create new demand in the market. If it is assumed that the majority of the 461,838 vehicles would not have been sold without the Plan, the large increase in tax revenue from the Plan would have had a net positive effect, that is, the revenues for Public Administration from the Plan would exceed the costs. However, if new demand creation capacity falls below 30%,[32] costs exceed revenues and the plan becomes socially undesirable for Public Administration. This result is very important since it tells us that the Plan is inefficient particularly in that alternative policies with an equivalent cost would further reach better results.

The great majority of costs and revenues considered in Table 7 are income transfers from the Government to producers and consumers, which should be taking into account when performing a Cost-Benefits analysis. Nevertheless, the main objective of this section is to determine whether the Plan 2000E is the most efficient policy (the one in which has to invest less funds) the Public Administration has at its disposal to reduce the emissions of CO_2.

According to the previous estimations, the Plan do not generates a new demand, what means that the consumers who benefit from the subsidy do not change their behavior. As a consequence, reductions of CO_2 are not generated. The amount of CO_2 saved from the new demand creation of 20% (The average effect of the papers that find a significant effect) is about 1,532,267.643 t. When the savings of avoided CO_2 are compared with the net costs of the Plan 2000E that the Public Administration must bear, which are approximately 145 million euro, the authors obtain that the proportion of cost per ton is close to 95€, when the value in the market of these tons is 14.32€. Knittel (2009) estimated a cost per ton of 365–237$ in the "Cash for Clunkers" program of United States, and Li et al. (2011) between 288 and 91 dollars for the same program.

Available information concerning the impact of public assistance on the generation of new demand in the automobile industry seems to show that the results of Plan 2000E are far from the percentage levels that make a Plan beneficial from the perspective of Public Administration. Furthermore, the data clearly indicate that the implementation of the program resulted in a net loss for the Spanish economy. As it was observed in the Introduction of this study, research has shown that the capacity to create new demand based on public assistance is about 20%.

At the time of writing this, there was no academic reference on Plan 2000E in the literature; this was the only study to analyze the impact of automobile demand on environmental efficiency. Nevertheless, as stated earlier, Fesvial and GfK Emer Ad Hoc Research (2009) carried out a survey of 1061 individuals in which they assessed whether Plan 2000E encouraged them to change their car. When faced with the specific question "How much has the new Plan influenced you to purchase a car in 2009?" only 5% answered "a lot" and about 15% replied with "somewhat", while the remaining 80% did not show any intentions of changing their car because of the Plan. Thus, it seems that Plan 2000E at best led to new demand creation of 20%, a figure quite similar to the one obtained for the case of hybrid cars in the North American market. Studies in Spain for previous plans show how the overall long-term effect is small, having only technological impact on the composition of the vehicle fleet (specifically an increase in the percentage of diesel vehicles).

Table 8 shows the results for different studies in addition to the results obtained from the present survey on Plan 2000E.

Therefore, the capacity to create new demand by public assistance programs requires in all cases a figure of about 20%, which is greater than the result of Plan 2000E this leads to the conclusion that Plan 2000E was not socially desirable. With this level of new demand creation, the Plan would have generated social welfare losses of €123 million. Note that at this percentage, the benefits of the Plan do not even cover the public sector expense (€1000 per vehicle). If the impact of the Plan on the generation of new demand is 5% as indicated by the previous forecasts and the survey carried out by Fesvial and GfK Emer Ad Hoc Research (2009), the losses would add up to more than €309 million.

These results are reported despite the very favorable Plan assumptions: 15 year vehicle lifetime, 24,000 km per year use, and

[32] The analysis carried out revealed that a Plan 2000E value of 29% new demand creation would be beneficial for Public Administration, while the authors do not consider income transfers to producers and consumers.

approximately 130 g of CO_2/km recommended by the E.U.; all of which contribute to the avoidance of greenhouse gas emissions. In addition, it has been assumed that the consumers who decided to change to a subsidized vehicle did so because of the Plan (the alternative being not to change at all) when actually it is possible that many consumers changed to cars that are non-subsidized yet less polluting. Thus, also a reduction in pollution has been obtained. It is clear that if the authors changed some of these assumptions the results from the Plan would only worsen social welfare. These assumptions clearly indicate that from an environmental perspective, Plan 2000E was an inefficient policy introduction.

5. Policy recommendations

The previous section shows how prices have increased and demand remains stable after the Plan2000E in Spain. In addition, positive environmental effects were not reached, although the Plan established it as its main aim.

At this stage an alternative to direct assistance programs is needed. There is a growing popularity in the economic literature towards increases in fuel tax and energy efficient vehicle standards.[33] Greene et al. (2005) showed how a tax system in which taxes are fixed on vehicles with energy efficiency below a certain level, and whose revenue serves to subsidize the most efficient vehicles, would significantly increase the energy economy of the vehicles.

Austin and Dinan (2005) compared how the modification of vehicle standards and/or the increase in fuel tax help reduce pollutants. The results of the simulation model highlight that the tax increase caused greater immediate savings than the modification of standards because it introduced individual incentives to drive less and choose more energy efficient vehicles. Linn and Klier (2007) also reported that when faced with an expected increase in fuel prices, driving costs increased for the less efficient cars, creating new demand for more energy efficient vehicles. The authors estimated than an increase in fuel price of one dollar caused an increase in the energy efficiency of new vehicles by 0.5 miles per gallon of fuel.

The capacity to reduce vehicle pollutants by taxes has also been observed by Sterner (2007). In this study the author shows that fuel consumption, and therefore pollution levels, would be much higher if fuel taxes did not exist within the countries in the OECD. This evidence leads the author to conclude that fuel taxes are the most powerful instrument in the fight against climatic change.

Similarly, Ryan et al. (2009) observed that the Road Fund Tax is the most efficient mechanism to reduce pollution levels of the vehicles within the countries of the European Union. Specifically, an increase of 10% in the Road Fund Tax caused a reduction in pollution levels of the fleet of vehicles equal to 0.3 g/km in the short term, which increased to 1.4 g/km in the long term.

Kloess and Müller (2011) show by means of simulations for the car fleet in Austria, that an appropriate policy framework not only promotes the diffusion of efficient cars but can also slow down fleet growth and reduce the distance driven by cars.

To summarize, it seems that tax mechanisms (i.e. fuel taxes and vehicle taxes) have a greater influence on the pollution levels of the vehicles and imply a lower cost for local, regional and national governments.[34]

6. Conclusions

The automobile industry is one of the most important manufacturing sectors for automobile manufacturing national economies. Their high production values and their labor intensity continue to have an important effect on governments, namely that they are traditionally concerned about the development and stability of this industry in its territories.

With the economic crisis affecting many developed countries since 2008, the automobile industry has reported a significant drop in sales, resulting in increased unemployment in the sector. Faced with this situation many governments have introduced programs to stimulate the replacement of old cars for new vehicles through scrappage schemes, with two main objectives: to increase automobile sales and reduce pollution levels.

Even though these programs are important there is an absence of empirical evidence on their effects. Studies on scrappage schemes in the United States have shown how this type of program can lead to an increase in sales of approximately 20%, however, we know nothing about the European market.

At the same time it is not known what effect the programs can have on the prices set by the manufacturers and whether these programs have desirable effects i.e. whether the costs of the program are lesser or greater than the benefits generated.

This study analyzed the effect of the prices fixed by manufacturers in Plan 2000E, which is a Spanish program that offered a subsidy of 2000€ to consumers to replace old vehicles with newer, less polluting ones. It was co-financed by the manufacturers (€1000 euro), National Government (€500 euro) and Autonomous Communities (€500 euro).

Using difference-in-difference the authors observed that the Plan caused an increase of 650€ in the price of subsidized cars, meaning that the subsidy of 2000€ ended up being shared between the consumers, who would only receive a net discount of 1350€, and the manufacturers, who would receive the remaining 650€. It was also concluded that this price increase occurs during the two years of the plan and in all price ranges affected by the plan.

Thus, the success of the Plan in achieving its objectives was limited since part of the fixed subsidy in the program went to the manufacturers and did not generate any type of incentive to the consumer to exchange vehicles for less polluting ones.

In addition to the first estimate of the net effects generated by Plan 2000E it is also clear that the Plan did not generate results for Public Administration. Even though favorable hypotheses were assumed, the result of the forecast was a negligible capacity to generate new demand, compared to the 30% required to make the program efficient.

From the empirical analyses carried out in the United States and the survey of Plan 2000E, the estimated increase in demand capacity was approximately 20%. Assuming this 20% capacity for the generation of new demand, the program leads to losses of more than 123€ million, which would increase if the capacity to create new demand was lower. Losses would be greater than 300€ million with a 5% change in demand.

The results are clearly conclusive: the program is inefficient, subsidizing a large part to the manufacturers directly instead of the consumers. In addition, the high costs of the program and its reduced impact make Plan 2000E undesirable from Public Administration perspective.

If the real objective of government is to reduce the level of

[33] Anderson et al. (2011) highlight fuel economy standards and their costs in US and Europe. They also study the welfare effects of this policy *vs* fuel taxes.

[34] Bento et al. (2009) also show that the distribution of the resources obtained from the tax increase can improve income distribution. If the resources were uniformly distributed, the average households in the last four income percentiles

(*footnote continued*)
would improve their situation. If the resources were shared proportionally to income level, only the highest and lowest percentile would improve their social welfare.

pollution caused by the vehicle fleet, economic literature has shown how other more efficient mechanisms exist and are less costly to the public sector. The increase of fuel taxes or the fixing of more severe energy efficiency standards are examples of alternative mechanisms that can help meet goals in pollution prevention.

Appendix A

Fig. A1

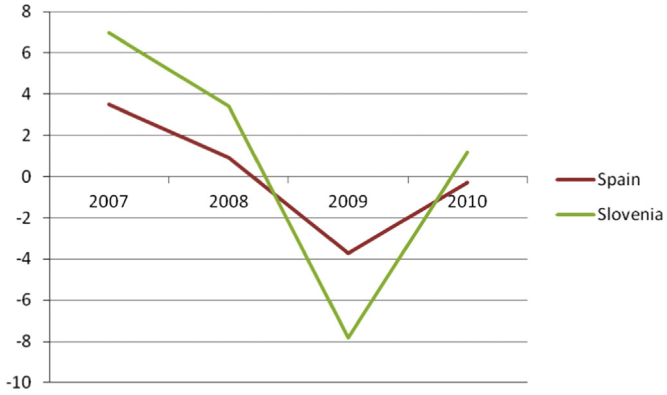

Fig. A1. Percentage of change in the gross domestic product of Spain and Slovenia Source: own elaboration from data of International Monetary Found.

See Table A1–A6.

Table A1
Test for the control group (Slovenia as a control group).

Constant	13809.79*** (56.159)	13819.51*** (62.554)
Spain 2007	−556.769*** (186.344)	−593.414*** (213.163)
Control 2007	−19.832 (183.562)	−65.451 (223.929)
Spain 2008	−255.291 (158.156)	−272.337 (165.734)
Control 2008	−40.266 (252.894)	−62.593 (261.4)
GDP gr		5.706 (15.915)
F−test Spain = Control	**2.19 (0.1167)**	**2.08 (0.1299)**
Observations	285	285
F Statistic	2.30* (0.0631)	1.85 (0.1087)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table A2
Price equations estimations unsubsidized vehicles (Slovenia as a control group).

	Model 1	Model 2	Price < 20000	Price < 20000
Constant	26804.78*** (90.318)	26775.43*** (91.338)	15570.75*** (98.321)	33393.26*** (118.215)
Period of plan	668.333*** (246.728)	668.333*** (244.970)	282.382 (243.841)	1124.404*** (345.424)
DiD estimator	**−23.444 (334.072)**		**−352.589 (359.4)**	**−306.271 (449.494)**
DiD estimator 2009		**−162.403 (341.722)**		
DiD estimator 2010		**373.580 (406.402)**		
Observations	320	320	118	202
F-Test	7.77*** (0.0007)	6.21*** (0.0006)	0.71 (0.4996)	9.34*** (0.0002)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table A3
Price equations estimations unsubsidized vehicles (Slovenia as a control group).

	Model 1	Model 2	Price < 20000	Price < 20000
Constant	26844*** (157.038)	26892.75*** (157.582)	15717.64*** (173.237)	33422.76*** (201.234)
GDP gr	−9.604 (31.401)	−30.076 (32.909)	−33.073 (32.125)	−7.664 (42.179)
Period of plan	564.225 (420.912)	342.314 (432.836)	−96.794 (441.615)	1045.728* (555.172)
DiD estimator	**34.315 (384.781)**		**−138.780 (414.864)**	**−263.626 (509.444)**
DiD estimator 2009		**−7.632 (381.582)**		
DiD estimator 2010		**629.045 (493.471)**		
Observations	320	320	118	202
F Statistic	5.17*** (0.0021)	4.86*** (0.0011)	0.82 (0.4881)	6.17*** (0.0008)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table A4
Test for the control group unsubsidized vehicles (Slovenia as a control group).

Constant	27408.81*** (88.164)	27411.26*** (95.993)
Spain 2007	−1051.933*** (251.587)	−1061*** (287.676)
Control 2007	−776.083*** (226.618)	−786.493*** (277.048)
Spain 2008	−334.062 (257.068)	−338.49 (266.700)
Control 2008	−28.802 (344.769)	−32.114 (349.763)
GDP gr		1.448 (21.986)
F-test Spain=Control	**0.40 (0.6716)**	**0.39 (0.6752)**
Observations	320	320
F Statistic	7.70*** (0.0000)	6.11*** (0.0000)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table A5
Placebo Test. Price equations estimations subsidized vehicles (Slovenia as a control group).

	2008 like affected year		2010 like affected year	
	Model 1	Model 2	Model 1	Model 2
Constant	13515*** (102.850)	13497.99*** (104.561)	13715.62*** (55.209)	13715.62*** (55.209)
Period of plan	16.599 (183.142)	82.27 (170.500)	−238.605 (200.093)	−238.61 (200.093)
DiD estimator	**406.99 (249.520)**		**365.22 (265.665)**	
DiD estimator 2008		**147.24 (230.536)**		
DiD estimator 2009		**435.46* (235.917)**		
DiD estimator 2010		**393.74 (266.759)**		**365.22 (265.665)**
Observations	285	285	285	285
F-Test	3.13** (0.0476)	2.12* (0.0834)	0.97 (0.3809)	0.97 (0.3809)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

Table A6
Placebo Test. Price equations estimations subsidized vehicles (Slovenia as a control group).

	2008 like affected year		2010 like affected year	
	Model 1	Model 2	Model 1	Model 2
Constant	13534.67*** (126.663)	13453.74*** (132.369)	13715.82*** (55.259)	13715.82*** (55.259)
Period of plan	−13.55 (215.507)	143.53 (204.323)	−212.34 (202.418)	−212.34 (202.418)
GDP gr	−3.93 (14.632)	8.74 (15.945)	−10.91 (12.214)	−10.91 (12.214)
DiD estimator	**419.906 (255.117)**		**348.52 (266.557)**	
DiD estimator 2008		**113.70 (239.216)**		
DiD estimator 2009		**442.40* (236.990)**		
DiD estimator 2010		**370.07 (271.052)**		**348.52 (266.557)**
Observations	285	285	285	285
F-Test	2.09 (0.1051)	1.74 (0.1307)	0.91 (0.4368)	0.91 (0.4368)

Note 1: ***1%; **5%; *10% significance test. Robust standard errors clustered by model shown in brackets.

References

Adda, J., Cooper, R., 2000. Balladurette and Juppette: a discrete analysis of scrapping subsidies. J. Polit. Econ. 108 (4), 778–806.
Albalate, D., 2008. Lowering blood alcohol content levels to save lives: the European experience. J. Policy Anal. Manag. 27 (1), 20–39.
Alberini, A., Harrington, W., McConnell, V., 1995. Determinants of participation in accelerated vehicle retirement programs. Rand J. Econ. 26, 93–112.
Anderson, S.T., Parry, I.W.H., Sallee, J.M., Fischer, C., 2011. Automobile fuel economy standards: impacts, efficiency, and alternatives. Rev. Environ. Econ. Policy 5 (1), 89–108.
Austin, D., Dinan, T., 2005. Clearing the air: the costs and consequences of higher CAFE standards and increased gasoline taxes. J. Environ. Econ. Manag. 50, 562–582.
Bento, A.M., Goulder, L.H., Jacobsen, M.R., et al., 2009. Distributional and efficiency impacts of increased U.S. gasoline taxes. Am. Econ. Rev. 99 (3), 667–699.
Beresteanu, A., Li, S., 2011. Gasoline prices, government support, and the demand for hybrid vehicles in the United States. Int. Econ. Rev. 52 (1), 161–182.
Berry, S., Levinsohn, J., Pakes, A., 1995. Automobile prices in market equilibrium. Econometrica 63 (4), 841–890.
Binswanger, M., 2001. Technological progress and sustainable development: what about the rebound effect? Ecol. Econ. 36, 119–132.
Busse, M., Silva-Risso, J., Zettelmeyer, F., 2006. $1000 cash back: the pass-through of auto manufacturer promotions. Am. Econ. Rev. 96 (4), 1253–1270.
Calinski, R.B., Harabasz, J., 1974. A dendrite method for cluster analysis. Commun. Stat. 3, 1–27.
Comisión Nacional de la Competencia (2009) II Informe anual sobre ayudas públicas. Madrid.
Cooper, A., Chen, Y., McAlinden, S., 2010. The Economic and Fiscal Contributions of the "Cash and Clunkers" Program – National and State Effects. CAR Research Memorandum.
Chandra, A., Gulati, S., Kandlikar, M., 2010. Green drivers or free riders? An analysis of tax rebates for hybrid vehicles. J. Environ. Econ. Manag. 60, 78–93.
Diamond, D., 2009. The impact of government incentives for hybrid-electric vehicles: Evidence from US states. Energy Policy 37, 972–983.
European Commission, Standard & Poor' s DRI, KULeuven (1999) Auto-Oil II Cost-Effectiveness Study. Part III: The Transport Base Case (Annex B.8). Spain.
Fesvial and GfK Emer Ad Hoc Research (2009) Plan 2000E: Percepción de los conductores españoles. Madrid.
Fundación SEPI (2009) Las empresas industriales en 2009: Encuesta sobre estrategias empresariales. Madrid.
Gallagher, K.S., Muehlegger, E., 2011. Giving green to get green? Incentives and consumer adoption of hybrid vehicles technology. J. Environ. Econ. Manag. 61, 1–15.
Giblin, S., McNabola, A., 2009. Modelling the impacts of a carbon emission-differentiated vehicle tax system on CO_2 emissions intensity from new vehicle purchases in Ireland. Energy Policy 37, 1404–1411.
Greene, D.L., Patterson, Ph.D., Singh, M., et al., 2005. Feebates, rebates and gas-guzzler taxes: a study of incentives for increased fuel economy. Energy Policy 33, 757–775.
Hahn, R.W., 1995. An economic analysis of scrappage. Rand J. Econ. 26 (2), 222–242.
Hennessy, H., Tol, R.S.J., 2011. The impact of tax reform on new car purchases in Ireland. Energy Policy 39, 7059–7067.
Hensher, D.A., 2002. A systematic assessment of the environmental impacts of transport policy. Environ. Resour. Econ. 22, 185–217.
Herring, H., Robin, R., 2007. Technological innovation, energy efficient design and the rebound effect. Technovation 27 (4), 194–203.
Huang E (2010). Do public subsidies sell green cars? Evidence from the U.S. "Cash for Clunkers" program. Energy Technology Innovation Policy Discussion Paper Series #2010-17.
Kaul A., Pfeifer G., Witte S. (2012). The incidence of Cash for Clunkers: an analysis of the 2009 car scrappage scheme in Germany. University of Zurich Working Paper Series ISSN 1664-705X.
Kloess, M., Müller, A., 2011. Simulating the impact of policy, energy prices and technological progress on the passenger car fleet in Austria – a model based analysis 2010–2015. Energy Policy 39, 5045–5062.
Knittel ChR (2009). The implied cost of carbon dioxide under the Cash for Clunkers program. Center for the Study of Energy Markets No. 189.
Lafontaine, F., Slade, M., 2008. Exclusive contracts and vertical restraints: empirical evidence and public policy. In: Buccirossi, P. (Ed.), Handbook of Antitrust Economics. MIT Press, Cambridge.
Li S., Linn J., Spiller E. (2011). Evaluating "Cash for Clunkers". Program effects on auto sales and the environment. Resources for the Future Discussion Paper, No. 39.
Licandro, O., Sampayo, A.R., 2006. The effects of replacement schemes on car sales: the Spanish case. Investig. Econ. 30 (2), 239–282.
Linn J., Klier Th (2007). Gasoline prices and the demand for new vehicles: evidence from monthly sales data. Mimeo.
Mian A., Sufi A., (2010). The effects of fiscal stimulus: evidence from the 2009 "Cash for Clunkers" program. NBER Working Paper, No 16351.
Miravete E.J., Moral M.J. (2011). Qualitative effects of "Cash-for-Clunkers" programs. Unpublished Working Paper.
MITYC (2011). Estadística de Fabricación de Vehículos Automóviles y Bicicletas: Metodología. Madrid.
Rogan, F., Dennehy, E., Daly, H., Howley, M., Ó Gallachóir, B.P., 2011. Impacts of an emission based private car taxation policy – first year ex-post analysis. Transp. Res. A 45, 583–597.
Ryan, L., Ferreira, S., Convery, F., 2009. The impact of fiscal and other measures on new passenger car sales and CO_2 emissions intensity: evidence from Europe. Energy Econ. 31, 365–374.
Sallee, J.M., 2011. The surprising incidence of tax credits for the Toyota Prius. AEJ: Econ. Policy 3, 189–219.
Sterner, Th, 2007. Fuel taxes: an important instrument for climate policy. Energy Policy 35, 3194–3202.
Yacobucci BD, Canis B (2010). Accelerated vehicle retirement for fuel economy: "Cash for Clunkers". Congressional Research Service 7-5700.