Much ado about nothing: A failed case for banning combustion vehicles*

Mucho ruido y pocas nueces: el fallido caso de la prohibición de los vehículos de combustión

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Abstract

The Balearic Islands (Spain) passed a regional law in 2019 banning the registration of diesel and petrol vehicles from 1 January 2025 and 1 January 2035, respectively. This law was heavily criticised before and during its implementation and was finally abolished after six months. This paper analyses the effect of this law on the registrations of both types of vehicles, as well as the registration of non-polluting vehicles. Both the synthetic control method and the difference-in-difference estimator show that the ban had no impact on any type of vehicle, not even on those that are non-polluting. Although the Balearic Islands' regional government sought to pioneer implementation of this policy, the incorrect specification of the law, the uncertainty surrounding its approval and its short-term effects and may have reduced its effectiveness.

Key words: *Combustion vehicles; Climate change; Synthetic control method.*

JEL Classification: *L90; Q40; Q58.*

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Resumen

El Gobierno de las Islas Baleares (España) aprobó una Ley regional en 2019 por que la impedía las matriculaciones de vehículos diésel y de gasolina desde el 01 de enero de 2025 y 2035, respectivamente. Esta Ley fue duramente criticada antes y durante su implementación y, finalmente, abolida tras seis meses de vigencia. Este artículo analiza los efectos de esta Ley en las matriculaciones de ambos tipos de vehículos, así como de otros menos contaminantes. Tanto el método de control sintético como el de diferencia-en-diferencias muestran que la prohibición no tuvo impacto en las ventas de ningún tipo de vehículo. Aunque el gobierno regional de las Islas Baleares intentó ser pionero en la aplicación de esta política, la incorrecta especificación de la Ley, la incertidumbre que rodeó su aprobación y sus efectos a corto plazo pueden haber reducido su eficacia.

Palabras clave: *Vehículos de combustión; Cambio climático; Método de control sintético.*

Clasificación JEL: *L90; Q40; Q58.*

1. Introduction

Road transport contributed to almost 21% of total EU emissions of carbon dioxide (2016), the main greenhouse gas, as well as to air pollution in cities and associated health issues. Thus, reducing transport needs, promoting public transport, and moving away from fossil fuels are examples of policies that should be implemented to reduce both emissions and pollution. In this context, it is relevant to evaluate which public policies can be most successfully implemented. In particular, one question to ask if it is a good strategy to ban combustion vehicles, and how consumers will adapt? The main objective of this paper is to assess econometrically the causal effects of a ban on the registration of combustion vehicles in a region. The results will indicate how (not) to define the political economy of climate change.

Following the EU's environmental objectives and the 2015 Paris Agreement on Climate Change (which acknowledges the importance of commitment at all levels of government and for all relevant actors), and given its special vulnerability to climate change as an island territory, the Spanish regional government of the Balearic Islands approved Law 10/2019, of 22 February, on climate change and energy transition.[1]

[1] The text, in Spanish, can be found here: https://www.boe.es/boe/dias/2019/04/13/pdfs/BOE-

It should be noticed that in Spain, as Pérez (2013) explains, the Constitution considers that the national government and the autonomous communities share responsibility for environmental policy. Basic legislation and general rules are designed at the national level, while their development and concrete implementation is a competence of the region to the extent defined in its corresponding Statute of Autonomy.[2]

In this context, the aim of the 2019 Balearic law was to help address climate change by adopting specific mitigation policies and move towards a sustainable, decarbonised, efficient and renewable model. Thus, the Balearic Islands aimed to have an emission-free vehicle fleet by 2050.

To achieve this objective, one of the new law's key measures was to ban diesel vehicles in the Islands from 1 January 2025, and of petrol vehicles from 1 January 2035. Unlike other more common policies that, for example, incentivise (through subsidies or tax rebates) the purchase of less polluting vehicles or restrict the circulation of only the most polluting, this was considered a very radical measure, as it directly banned the circulation of all polluting vehicles. As expected, the change was heavily criticised by both manufacturers and the national government and, in fact, the government threatened to appeal against the law to the Constitutional Court.[3]

From an economic point of view, two clear criticisms quickly emerged. First, the law could have pre-emptive effects. While it was passed in February 2019 and implemented in May 2019, the draft law was presented in August 2018, and had been under discussion since February 2018.[4] In addition to this uncertainty, the law was stalled in November 2019 until the national level climate change law was implemented.[5] This timing is relevant, and will be considered in detail in our econometric analysis later. Although the autonomous community of the Balearic Islands may be a pioneer in the implementation of this policy, the uncertainty surrounding its approval may have detracted from its effectiveness. Secondly, the law had a clear limitation: it established that 'although the circulation of combustion vehicles after the deadlines was prohibited', there were exceptions 'for reasons of public service' or 'for vehicles registered prior to these dates'. Implementation deficiencies in the measure, coupled with uncertainty about a possible reversal by the courts, suggests that it is unlikely to have generated any effect on the purchase of vehicles, at least

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2 Jaria-Manzano and Cocciolo (2020) review the competences of the Autonomous Community of Balearic Islands in relation to climate change.

3 https://www.diariodemallorca.es/mallorca/2019/07/20/balears-topa-sanchez-2857885.html

4 http://partidoequo.es/presentada-la-ley-de-cambio-climatico-de-illes-balears/

5 https://www.abc.es/sociedad/abci-baleares-paraliza-veto-diesel-previsto-para-2025-201911191407_ noticia.html

in the short term.

The main objective of this paper is to analyse whether the ban on the registration of polluting vehicles affected both the purchase of diesel and petrol vehicles and the purchase of non-polluting vehicles. Our main contribution lies in both the type of policy considered for evaluation and its focus on the short-term and anticipatory effects under uncertainty. To this end, vehicle registrations in 50 Spanish provinces (excluding Ceuta and Melilla) have been collected for the period 2011-2019. The synthetic control method has been applied to obtain a control group for the treated unit. Our results show that implementation of the policy had no impact on diesel and petrol vehicle registrations, and neither did it increase the purchase of non-polluting vehicles. Furthermore, we show that the announcement of the policy did not produce significant anticipation effects either.

Following this introduction, the next section summarizes the literature on measures taken to restrict the circulation of polluting vehicles. Then, the data and the empirical strategy are presented, followed by the results obtained. The study concludes with some policy recommendations.

2. Literature Review

As explained, pollution, mainly in large cities, is a serious problem that significantly affects the health of people living in those areas. Road traffic is one of the main generators of pollution, for which there have been various measures introduced with the aim of reducing pollution levels and improving air quality. These measures can be divided into two broad groups: those that seek to restrict the movement of vehicles via quantities, and those that seek to do so via prices.

Regarding the restrictive measures to the movement of vehicles via quantities, one of the most frequently implemented measures is the restriction of driving depending on the vehicle registration number. In these types of restrictions, the vehicles cannot circulate on certain days, depending on the last number of the registration car. Despite the fact that these types of restrictions have recently been implemented in European cities such as Madrid and Lyon (usually only on days when certain levels of contamination are exceeded), they are more widely implemented in Latin America, where it is sometimes permanent.

The policy implemented in Mexico City in 1989 called "Hoy No Circula" stands out. As Fageda and Flores-Fillol (2018) point out, drivers cannot circulate one day per week depending on the number in which their registration number ends. This restriction covers the entire metropolitan area between 5 in the morning and 10 at night. The result of the program is analysed by Davis

(2008) who does not find any type of impact on air quality levels. In fact, the author does not find any decrease in fuel consumption, nor any significant increase in the use of public transport. In fact, what you see is a significant increase in the number of vehicles. Later Gallego et al (2013) show how in the short term (one month after program implementation) carbon monoxide levels decreased between 5 and 13%, while in the long term they increased, to around 11%. This result is due to the fact that a proportion of citizens (especially middle and high income) acquire a second vehicle to travel; which in some cases is even more polluting. Hence, as Fageda and Flores-Fillol (2018) point out, these types of measures are traditionally inefficient, ineffective in the long term, and regressive, since low-income people have difficulty avoiding the restriction. Similar results are found in Santiago, Chile, where De Grange and Troncoso (2011), show very insignificant reductions in the flow of cars (just 5%) in times of emergency, and not significant in normal periods. It should be noted that the efficiency of some of these quantitative measures depends on their good design. There are examples where the setting of more restrictive emission standards has led to the manufacture of more efficient vehicles (Voltes-Dorta et al., 2013), or restrictions on the circulation of polluting vehicles has led to people substituting their polluted car for a more efficient one (Barahona et al., 2002).

In fact, articles that analyse implementation of the measure in Beijing (China) show significant reductions in pollution levels. Thus, Viard and Fu (2015) detail how the levels of particulate matter 10 micrometers or less in diameter (PM10) decreased in this city by between 18 and 21% thanks to the restriction of circulation. Gu et al (2017) show that pollution reduction is due to the transfer of movements from private vehicles to public transport and not to a reduction in the number of movements. In addition, they observe how this substitution does not occur in high-income families with more than one private vehicle, nor on short trips, where it is possible to violate the regulation with low risk of being detected.

The latter outcome does not coincide with Zhang et al (2019) who show how Chinese cities that have implemented restrictions by registration do not generate a significant increase in public transport. Only cities that combine this type of restriction with other driving restriction programs generate increases in the demand for public transport (between 20 and 30%).

Low Emission Zones (LEZ) is one of the restrictions via quantity. There are many European cities that have implemented these types of restrictions, where entry to a certain geographical area is limited to vehicles that do not meet certain pollution standards. We can see how various cities in Germany, Italy and Greece, or large cities like Lisbon, London and Paris have implemented these types of restrictions. In Asia it is also a relatively popular measure in cities such as Beijing, Tokyo, Shanghai and Hong Kong.

As Fageda and Flores-Fillol (2018) indicate, the most analyzed case is Germany, due to it being implemented earlier, since its legislation dates back to 2007. In this country, it is allowed to define a geographical area as LEZ, and limit access to vehicles with a certain badge, since they are classified according to three types of colors: green, yellow and red (the most polluting ones do not have a label). This restriction was significantly extended by Germany, with 48 LEZ's involving 76 cities, in 2018.

Malina and Scheffer (2015) analyze the impact of this measure on PM10 levels. The result shows that it effectively manages to significantly reduce the levels of this type of pollutant. In fact, the impact is greater as the program is more restrictive, when access by fewer polluting vehicles is allowed. On average, this type of restriction managed to reduce PM10 levels by 13%. This result is similar to that found by Wolf (2014), on average. However, this paper also observes how the impact of this type of measure is not significant in small cities and reaches levels of reduction of 15% in large cities such as Berlin. Another interesting result of this paper is that it does not find any increase in pollution in the areas bordering the LEZ.

In Portugal we can also observe empirical papers that analyze the impact on air quality of these types of restrictions. Thus, Dias et al (2016) note how LEZ implementation in the city of Coimbra generated a significant decrease in the levels of PM10 and NO_2 emitted by vehicles, specifically at 63 and 52% respectively. However, the impact on the city's air quality is very small as emissions from other activities increased and the air quality worsened. These results are similar to those found by Santos et al (2019) for the city of Lisbon. In this case, the authors find decreases of 30.5% in PM10 and 9.4% in NO_2, within zone 1 (basically the historic center of the city), while for zone 2 (the rest of the city) the decreases are 22.5% and 12.9% for both types of pollutants. This result occurs despite the fact that the restriction is stricter in zone 1, where Euro-3 criteria are required to access, than in zone 2, where access with Euro-2 technology is allowed. On the other hand, the article does not find any type of effect on PM2.5, nor on NOx, an outcome that leads the authors to conclude that the criteria for access to the LEZ should be tightened.

As we have seen in previous papers, in general the implementation of the LEZ causes a significant decrease in pollution in the short term. However, as Fageda and Flores-Fillol (2018) point out, these measures may cease to be efficient in the medium and long term as more drivers replace their old vehicle and can access the LEZ. As traffic (and sometimes congestion) increases, pollution levels rise again. In addition, it can be considered a regressive measure, since it is the high-income drivers who have the least difficulty changing cars and getting around the restriction.

Precisely to facilitate the renewal of the car park in many countries, public aid programs have been implemented. In these initiatives, owners receive a subsidy by replacing their old vehicles for a new, less polluting one. These types of programs, known as "Cash for Clunkers", have generated a great deal of controversy about their efficiency in reducing pollution levels, especially if we consider the possible rebound effect (because cars consume less fuel, drivers tend to perform a greater number of displacements, which is why they end up generating more contamination). While some studies show that this type of program would generate a significant decrease in pollution levels by replacing polluting vehicles with more efficient ones (Diamond, 2009; Beresteanu and Li, 2011; or Gallagher and Muehlegger, 2011), others show that in the medium term, they do not have a significant impact on the composition of the vehicle fleet, so contamination levels would not be affected (Huang, 2010; Mian and Sufi, 2010; or Li et al., 2013).

The key, as shown by Adda and Cooper (2000) in the case of France, is that drivers strategically postpone or advance the purchase of the new vehicle to be eligible for the plan, causing a decrease in car sales before and after its application. Therefore, in the medium term the number of new lesser polluting vehicles is the same, and the impact on air quality is near to zero. Licandro and Sampayo (2006) find a similar result for the case of Spain. In fact, Lenski et al (2013) show how the value of tons of CO_2 saved (90 million dollars) plus the increase in consumer surplus (about 2 billion) was less than the cost of the program in the United States (3 billion dollars), meaning that the program would generate social welfare losses.

Spain has a long tradition of applying this type of initiative, called Renove or PIVE plans, with controversial results. Thus, Cantos-Sánchez et al (2018) observe that the PIVE plan increases the probability of buying a vehicle, although in a very limited way, of about 10,400 vehicles. Laborda and Moral (2019), for their part, found a greater impact of the PIVE program, estimating an increase of 676,463 vehicles from 2012 to 2016. The authors find this result after applying duration models, where the scrapping rate depends on the age of the vehicle, as well as other factors related to the business cycle, as well as the transport sector. This increase in sales would have generated savings of 6.03 tons of CO_2. On the contrary, Jiménez et al (2016) found no impact on sales, but on prices. Manufacturers take advantage of the plan to increase prices and grab a portion of the program grant. This fact means that the program is not efficient in reducing CO_2 levels, unless there had been a 30% increase in the demand for new vehicles, which did not happen.

As a whole, restrictive measures via quantities, as already indicated by Fageda and Flores-Fillol (2018), can be effective in the short term to reduce pollution, but they are ineffective, inefficient and even regressive in the medium and long term. However, in our case the measure supposes the total prohibition of circulation by any internal combustion vehicle, so the impact on air quality is supposed to be positive. What has not been previously analysed is how drivers react to these types of restrictions on the vehicle fleet. One possibility is that they change their internal combustion vehicles for less-polluting vehicles (hybrids) or non-polluting vehicles (mainly electric and hydrogen vehicles), although there is also the possibility that they will not change their vehicle and decide to move to public transport at the time of application of the program.

Compared to these measures via quantities, there are measures via prices; basically the application of entrance tolls to cities. In contrast to the above, it allows access for those consumers with a greater willingness to pay, making it efficient. By reducing the number of vehicles, it facilitates the reduction of pollution, and is therefore an effective measure; and to the extent that the toll price is low, it is not regressive. There is considerable empirical evidence on the operation of this type of measure. In Singapore, the speed of circulation increased from 19 to 36 kilometers per hour (Phang and Toh, 1997), as the number of vehicles decreased, both during rush hour (45%) and with respect to the entry of automobiles into the city (70%) (Willoughby, 2000). In the case of London, there is consensus on the effectiveness of the toll, although different studies vary in calculating the social benefit generated by it (Prud'homme and Bocarejo, 2005; and Mackie, 2005). Eliasson (2009) finds a similar result for the application of the Stockholm toll, which generates an increase in social welfare. In the case of Milan, Rotaris et al. (2010) and Percoco (2013) show that the access toll reduces pollution levels, generating an increase in social welfare; which is a similar result to that found in Gothenburg (Andersson and Nässén (2016); and Börjesson et al. (2016).

An alternative to the congestion toll is to modify the registration tax. Various international experiences have shown how linking the registration tax with the car's level of pollution significantly influences the type of vehicle purchased, especially in Europe. Zimmermannova (2012) already showed through correlations how this type of measure had generated an increase in the number of new vehicles instead of second-hand vehicles, which are more polluting, in the Czech Republic. This fact led to a decrease in the emissions generated by the vehicles. These results have been confirmed in different European countries through different econometric models. In Ireland, a 13% decrease in vehicle emission levels is observed (Rogan et al. 2011); in the Netherlands the decrease is 11% in CO2 levels (Kok, 2015); and in Norway 4.3% (Ciccone, 2018). Klier and Linn (2015) carry out a joint analysis for France, Germany and Sweden, observing a decrease in the number of registered vehicles, and especially in the case of France a change towards more environmentally efficient vehicles.

This result is partly explained by the reduction in the number of registered vehicles (Klier and Linn, 2015), by the substitution in the purchase of more polluting vehicles for others that generate fewer emissions (Ciccone, 2018), and by the increase in market share of diesel vehicles (Rogan et al 2011; and Ciccone, 2018). This effect seems to be greater in company vehicles compared to private consumer vehicles, as shown by Kok (2015) in the case of the Netherlands. Despite the fact that this measure has been shown to be effective in reducing pollution levels from new vehicles, the cost can be high, as shown by Rogan et al., (2011). The introduction of a lower registration tax for the most environmentally efficient vehicles caused a decrease of 33% in Ireland, approximately 166 million euros.

Another possible price measure is to increase fuel prices by increasing taxes. It should be noted that Spain is one of the EU countries with the lowest fuel taxes, only above the eastern countries (Romania, Poland, Lithuania, Hungary, Estonia and Bulgaria) and Luxembourg. The other 20 countries have higher diesel taxes.[6]

As mentioned, the main purpose of this paper is to analyze the effect of a measure via quantities such as forbidding the registration (nor circulation) of internal combustion vehicles in the Balearic Islands. To our knowledge, this is the first time that the effectiveness of this type of measure has been assessed, although, as we have seen in this section, these types of measures via quantities have not had a high degree of effectiveness in modifying vehicle fleet composition and in significantly reducing pollution levels.

3. Database And Empirical Strategy

We have collected data from three different sources. First, the database is composed by registrations by type of vehicle (diesel, gasoline and non-polluting cars[7]) at province level, from January 2011 to January 2020. A total of 50 Spanish provinces, excluding Ceuta and Melilla, compose the sample. The data has been obtained from the statistic portal of the Spanish General Directorate of Traffic. On the other hand, control variables such as the Gross Domestic Product per capita by province and petrol prices have been obtained from the National Statistics Office (INE) and from the Ministry of Industry, Trade and Tourism (Spanish Government), respectively.

Figure 1 depicts the evolution of vehicle registrations by type of vehicle

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6 Data obtained from the Oil Bulletin of the European Commission in July of 2020 (https://ec.europa.eu/energy/data-analysis/weekly-oil-bulletin_en?redir=1).

7 This category encompasses electric and hydrogen vehicles (the latter shows very low cases). Hybrid cars, those that combine combustion and other type of engine, are not considered in this study due to the low share and the presence of zero monthly registrations.

separately, for the case of the Balearic Islands and the average of the other Spanish provinces. While the data for the Balearic Islands shows seasonality and ups and downs, computing the average for several observations (provinces) smoothens the series. The average monthly registrations of diesel vehicles in Balearic are 1,518 (1,236 for the remaining provinces), and 2,658 for gasoline vehicles (1,027 for the other provinces). However, for the case of the electric and hydrogen vehicles average monthly registrations in the Balearic Islands totals approximately 19 vehicles (16 for the rest of the provinces). Figure 1 shows that the registrations of electric and hydrogen vehicles have increased since mid 2016-beginning of 2017 in the Balearic Islands and, on average, in the remaining provinces included in the sample.[8]

The main takeaway from this figure is that the other Spanish provinces may not be an appropriate natural control group for the behavior of vehicle registrations in the Balearic Islands to apply the difference-in-differences estimator. Moreover, a deeper analysis of vehicle registrations by provinces reveals great differences in the number and the behavior of registrations across provinces.[9]

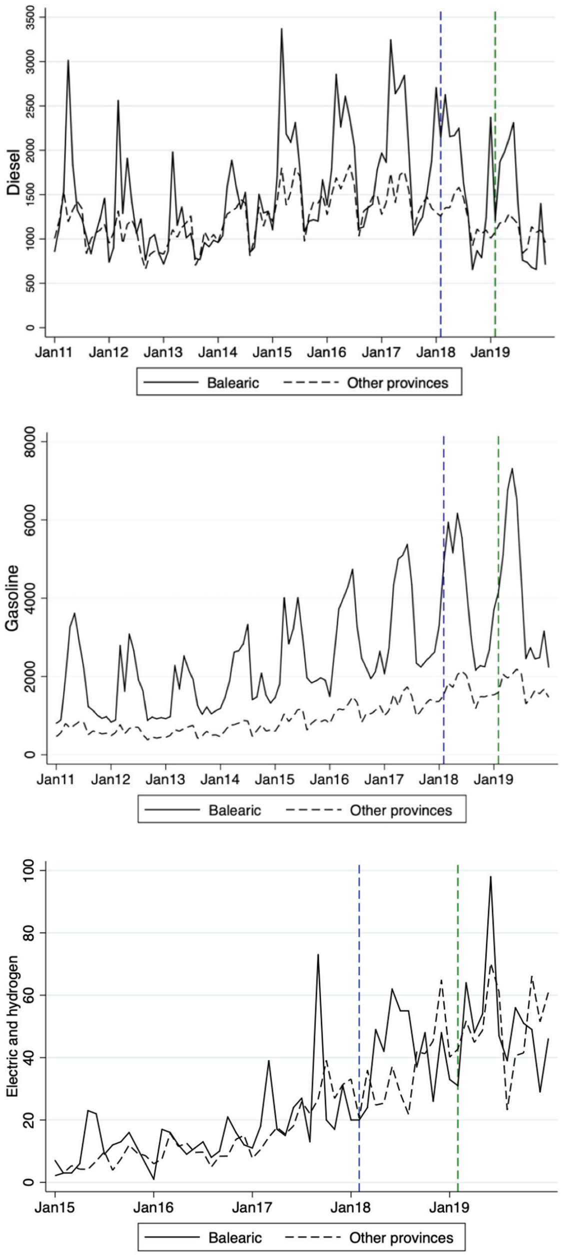
Therefore, we need to look for a control group that approximates vehicle registration of the treated unit before estimating the regression. In order to do so, we have applied the the synthetic control method[10], following Abadie and Gardeazabal (2003). This methodology allows us to approach this problem by comparing the Balearic Islands during the treatment period with a synthetic region, i.e., a weighted combination of other Spanish regions chosen to resemble the characteristics of the treated region (Balearic Islands) in the period previous to the shock (before the Law was implemented). This idea was developed by Abadie and Gardeazabal (2003), who create a vector of weights (a combination of control provinces), which specifically best resemble the treated before the treatment takes place and developed by Abadie et al (2010).

8 We do not consider registrations of these types of vehicles between 2011-2014 due to more than 65% of provincial data being zero (i.e. there were no registrations of electric and hydrogen vehicles).

9 Graphical analysis by provinces is available upon request to authors. They have not been included for simplicity.

10 It should be noted that the matching estimator has also been applied to obtain the control group. However, the optimally selected provinces do not properly replicate the behavior of vehicles registrations in the Balearic Islands.

FIGURE 1
REGISTRATIONS BY TYPE OF VEHICLE. BALEARIC VS. OTHER PROVINCES (AVERAGE)



Source: Own elaboration.

Notes: Blue dashed line: February 2018, when the Law was announced; Green dashed line: February 2019, when the Law was passed.

In our case, the synthetic control method considers not only monthly registrations but also the average monthly rate of registrations, the quarterly rate of registrations, the gross domestic product per capita and the average hydrocarbon price. All of them are predictors in our model. The synthetic control method provides a control unit much more similar to the Balearics than the average of all other Spanish regions.

The synthetic control method has been applied separately for each type of vehicle. Moreover, we have distinguished between *two different* treatment periods. Taking into account the process of discussion and passing of the law (see Introduction section), we have considered three different stages: *stage 0* refers to the control period, before the law was discussed/presented, from January 2011 to January 2018[11]; *stage 1* refers to the period between the discussion and presentation of the law but before its passing, from February 2018 to January 2019; and *stage 2* considers the period when the law was passed and implemented, from February 2019 to November 2019. As noted, the law was passed in February 2019 but came into force in May 2019. Given that the period between the approval of the law and its implementation is short, we have considered both treatments together.

We have applied the synthetic control method and estimated regressions considering stage 2 as the treatment period first (it starts in February 2019 and lasts until November 2019), and then used stage 1 as the initial treatment period (it starts in February 2018 and lasts until November 2019). This strategy allows us to estimate the policy's potential anticipation effects.

TABLE 1

AVERAGE REGISTRATIONS (AND VARIATION RATE)

	Diesel			**Gasoline**			**Electric and hydrogen**		
	St. 0	St. 1	St. 2	St. 0	St. 1	St. 2	St. 0	St. 1	St. 2
Treated (Baleares)	1240	1682	1374	1716	4003	4329	7	42	51
Variation rate St 0		36%	-25%		133%	19%		500%	129%
Variation rate St t-1			-18%			8%			21%
Synthetic control (Announcement)	1249	1296	1218	1665	4267	4626	14	90	97
Variation rate St 0		4%	-6%		156%	22%		543%	50%
Variation rate St t-1			-6%			8%			8%
Synthetic control (Law was passed)	1566	1626	1539	2644	7584	8202	13	96	110
Variation rate St 0		4%	-6%		187%	23%		638%	108%
Variation rate St t-1			-5%			8%			15%

Source: Own elaboration.

Notes: St. 0: Stage 0 (before). St. 1: Stage 1, announcement. St. 2: Stage 2 (Law was passed).

11 Excepting electric and hydrogen vehicles, which was between January 2015 to January 2018.

Table 1 summarizes the average registrations, and its variation rates, by vehicle type, distinguishing between the Balearics and observations of the synthetic control. It can be seen that the registration of diesel vehicles increased by 36% in the Balearic Islands in stage 1 with respect to stage 0, while they decreased in the second stage in comparison with the stage of reference. Registrations of the remaining vehicles increased in the Balearic Islands during the analyzed stages. However, these figures should be compared with vehicle registrations in the synthetic control group, which follow the same pattern, although the quantities of variation are slightly different.

4. Results

Figures 2 to 4 depict the behavior of the different types of vehicles for the province of the Balearics and for the synthetic province. All these figures separately represent the two treatments or starting points considered: the month in which the policy was announced (February 2018) and the month in which the policy was passed (February 2019). Especially in the cases of diesel and gasoline vehicles, it can be seen how the control group now behaves similarly to the treated unit, in comparison with the raw data (previous Figure 1).

For each analysis (by type of cars, announcement and passing Law), the synthetic method uses different unit weights among control regions, in order to create the synthetic Balearic Islands. All are included in Table 2.

TABLE 2

REGIONS AND WEIGHTS CONSIDERED BY SYNTHETIC

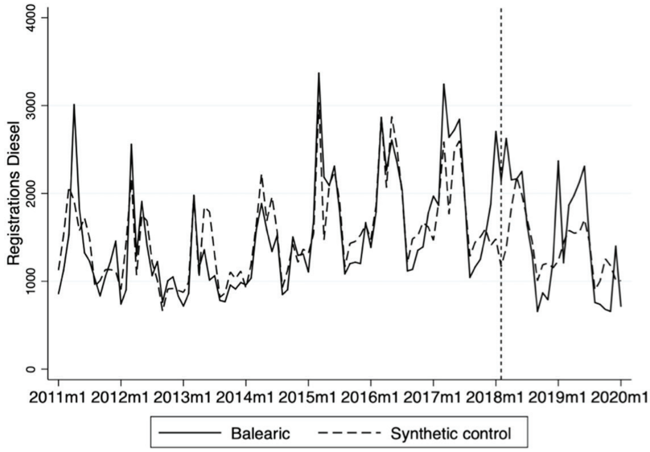
	Diesel	**Gasoline**	**Electric and hydrogen**
Announcement	Málaga (38.1%), Castellón (31.1%), Alicante (20.1%) and Ourense (10.7%)	Málaga (57.7%) and Alicante (42.3%)	Cádiz (0,2%), Girona (9,7%), Madrid (3,8%), Cuenca (6,3%), Alicante (43,5%), Álava (32%), Bizkaia (2,1%) and Gipuzkoa (2,4%)
Law	Málaga (50.6%), Castellón (36.7%) and Alicante (12.7%)	Málaga (53.7%) and Alicante (46.3%)	Cádiz (1,2%), Girona (18,5%), Tarragona (29,8%), A Coruña (47,5%) and Madrid (3%)

Source: Own elaboration from synthetic control estimations described in Figures 2 to 4.

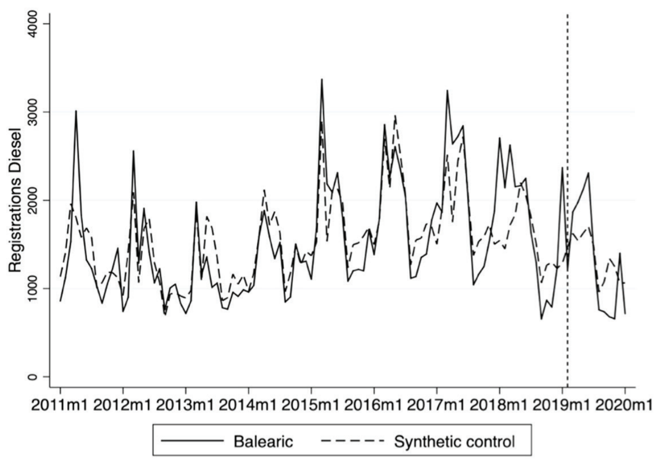
At this time, it should be highlighted that considering two different starting points affects the control group used in the estimation. This is a relevant question for the emerging electric and hydrogen vehicles market, but not for the combustion vehicle, which is a mature market. In fact, as Figure 1 shows, non-polluting vehicle registrations did not take off until mid-2016, two years before the law was announced.

FIGURE 2
DIESEL. SYNTHETIC CONTROL

A: STARTING POINT: FEBRUARY 2018 (ANNOUNCEMENT)



B: STARTING POINT: FEBRUARY 2019 (LAW)

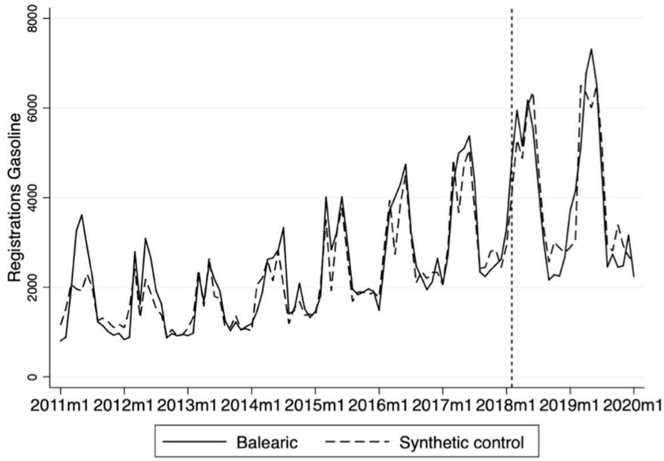


Source: Own elaboration.

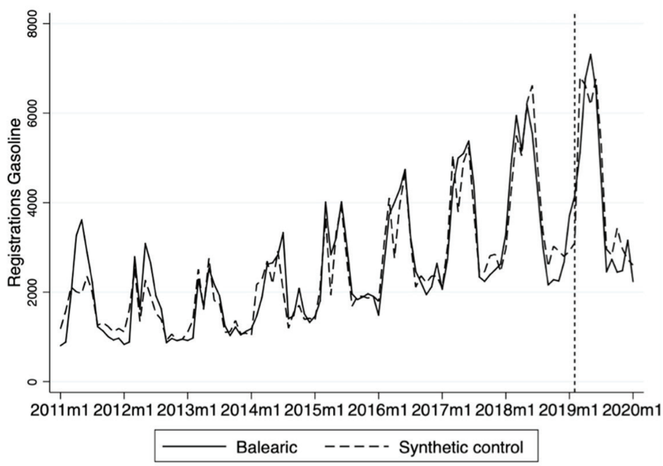
FIGURE 3

GASOLINE. SYNTHETIC CONTROL

A: STARTING POINT: FEBRUARY 2018 (ANNOUNCEMENT)



B: STARTING POINT: FEBRUARY 2019 (LAW)

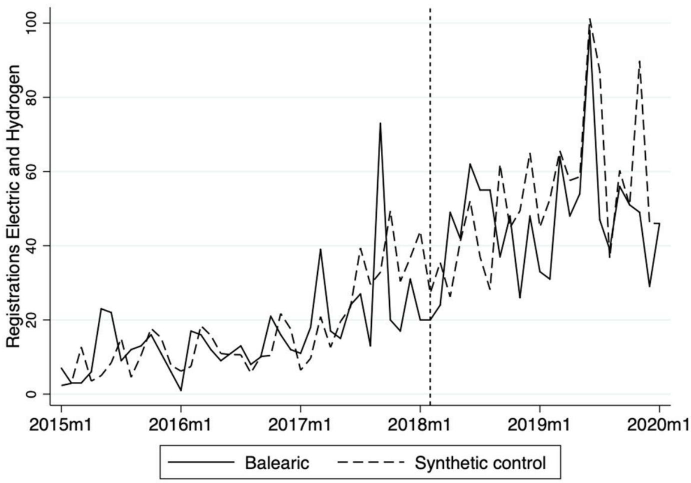


Source: Own elaboration.

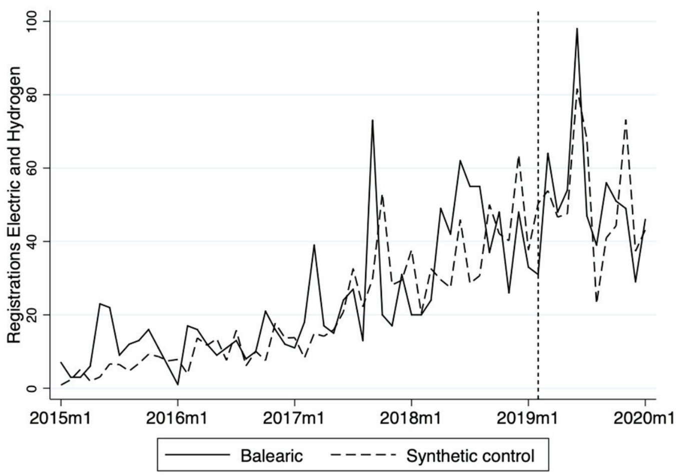
FIGURE 4

ELECTRIC AND HYDROGEN. SYNTHETIC CONTROL

A: STARTING POINT: FEBRUARY 2018 (ANNOUNCEMENT)



B: STARTING POINT: FEBRUARY 2019 (LAW)



Source: Own elaboration.

These figures show how policy has changed registrations in diesel, petrol and electric and hydrogen cars. As can be seen, no relevant or notable increase or decrease has been found. In order to quantify the impact of the policy, a difference-in-difference analysis (hereinafter DiD) has been implemented using the synthetic province as a control group. In each type of vehicle, we consider only two types of observations in all periods: registrations of vehicles in the Balearic Islands versus the synthetic control group. And we also consider the treatments of the announcement of the law and the passing of the law, respectively.

Specifically, the Ordinary Least Squares method was applied in order to estimate these causal effect, robust to heteroscedasticity, following equation (1):

$$R_{it} = \beta_0 + \beta_1 \text{Treated}(\text{Balearic})_i + \beta_2 \text{Stage2}(\text{After Law was passed})_{it} + \beta_3 \text{DiD}_{it} + \alpha_i + u_{it} \quad (1)$$

where R_{it} is the number of registrations of the region's vehicles (*i*, Balearic vs. synthetic group) at month (*t*); $\text{Treated}(\text{Balearic})_i$ takes value 1 if the region (*i*) is the Balearic Islands and 0 otherwise (synthetic control countries); $\text{Stage2}(\text{After Law was passed})_{it}$ takes value 1 for the months in which the policy was passed in the Balearic Islands and 0 in other cases; DiD_{it} is the interaction of both previous binary variables, so it takes value 1 for the Balearic Islands after the Law was passed, and 0 in all other cases. This represents the average effect of this policy. Finally α_i represents individual fixed effects (month and year effects); and u_{it} is the error term. In order to estimate potential different effects due to the Law being announced or once the Law was passed, we split both Stage and DiD into two variables. Stage 1 was the announcement while Stage 2 was the passing of the Law.

TABLE 3

DIFFERENCE IN DIFFERENCE ESTIMATIONS. REGISTRATIONS. STARTING POINT: FEBRUARY 2019 (LAW WAS PASSED)

	Diesel	**Gasoline**	**Electric and hydrogen**
Treated(Balearic)	-0.0471*	-0.0019	0.5447***
	(0.03)	(0.02)	(0.10)
Stage 2(after Law was passed)	-0.4859***	-0.2023	-0.5044
	(0.15)	(0.13)	(0.41)
DiD Stage 2	-0.0761	-0.0719	0.0491
	(0.09)	(0.07)	(0.23)
Month effect	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Observations	214	214	118
R^2	0.76	0.92	0.78

Standard errors in parentheses. Endogenous variables are measured in natural logarithms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 and Table 4 summarize the results of the difference-in-differences estimator. They show that the law's implementation had no impact on the registrations of diesel, gasoline vehicles or electric and hydrogen (Table 3). The same conclusion is obtained when the announcement of the law is considered as a starting point (Table 4). Additionally, we can rule out the existence of anticipation effects.

The policy has not had an effect during the period of the data. But specifically it had two main results: first, both synthetic and DiD shows that the policy has not been effective at discouraging the purchase of polluting vehicles; second, it has not incentivized the acquisition of non-polluting vehicles.

Uncertainty around the passing of the law (there were many discussions during the draft process) together with the fact that it is not clear in the law whether any diesel or gasoline vehicle can circulate, or whether the vehicles already registered could circulate ("prohibition of circulation except for reasons of public service or previous establishment in the autonomous community"), could explain these results.

Table 4 shows that the coefficient of the difference-in-difference estimator is not significant for these types of vehicles in stage 1 (announcement of the policy). Regarding the electric and hydrogen vehicles, no significant impact of the law's implementation has been found.

TABLE 4

DIFFERENCE IN DIFFERENCE ESTIMATIONS. REGISTRATIONS. STARTING POINT: FEBRUARY 2018 (ANNOUNCEMENT)

	Diesel	**Gasoline**	**Electric and hydrogen**
Treated (Balearic)	-0.0371	0.0248	0.0182
	(0.03)	(0.02)	(0.10)
Stage 1 (Law announcement)	-0.6793***	-0.2439*	-0.7965***
	(0.15)	(0.13)	(0.38)
Stage 2 (after Law was passed)	-1.1998***	-0.5122***	-1.4407**
	(0.22)	(0.19)	(0.59)
DiD Stage 1	0.1148	-0.0628	-0.0609
	(0.08)	(0.07)	(0.20)
DiD Stage 2	-0.0483	-0.0758	-0.2263
	(0.08)	(0.07)	(0.22)
Month effect	Yes	Yes	Yes
Year effect	Yes	Yes	Yes
Observations	214	214	118
R^2	0.79	0.92	0.81

Standard errors in parentheses. Endogenous variables are measured in natural logarithms.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These results are related to and may also be explained by the findings obtained by Rubio et al. (2020), who surveyed 2,290 participants in Spain to analyse their support for three potential policies to combat climate change, which included prohibiting the use of polluting light-duty vehicles from 2029. The results show that only 27% of the directly affected respondents (those who have a vehicle) and 35.7% of the non-directly affected respondents would support this policy. Moreover, the authors analyse which of the five considered factors could explain support from respondents, namely: i) perceived effectiveness of the policy; ii) self-perceived individual responsibility to act against climate change; iii) self-perceived capacity to change own behavior; iv) resistance to change; and v) the distance with which the effects of climate change are perceived.

5. Policy Recommendations And Conclusions

Climate change has become one of the leading economic problems at global level. Road transport is among the most polluting sectors, and for this reason different countries have implemented measures to reduce pollution by internal combustion vehicles. Despite the existence of empirical evidence in favor of the implementation of measures via prices (mainly the introduction of toll access to the main cities), many countries continue implementing measures via quantities.

This paper analyses the introduction of one of these measures via quantities, specifically the prohibition of diesel and gasoline registration vehicles in the Balearic Islands from 2025 and 2035 respectively, and its impact on the registration of new vehicles today. However, a weakness of the law is that it prohibited the registration from the indicated date, but not the circulation of vehicles of these types registered in advance. This fact generated significant rejection by vehicle manufacturers, which included a legal appeal to the European courts.[12] In addition, the central government of Spain considered that the measure exceeded regional powers and warned the Balearic Islands' government if it did not withdraw the measure, it would appeal to the Constitutional Court.[13] This paper is about the very short-term effects of the policy taking into account the fact that by the very nature of the policy short-term effects can be modest.

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12 https://www.abc.es/motor/economia/abci-fabricantes-coches-denuncian-gobierno-balear-ante-bruselas-plan-para-vetar-motores-combustion-201901161044_noticia.html#vca=mod-sugeridos-p1&vmc=relacionados&vso=los-fabricantes-de-coches-denuncian-al-gobierno-balear-ante-bruselas-por-su-plan-para-vetar-los-motores-de-combustion&vli=noticia.foto.sociedad&ref=

13 https://www.abc.es/sociedad/abci-baleares-paraliza-veto-diesel-previsto-para-2025-201911191407_noticia.html

This opposition by both agents is still surprising when economic rationality indicates that these types of measures are not specific to significantly modify the fleet of vehicles, and therefore the levels of pollution emitted by them. The results obtained in this paper confirm this result, showing how the measure did not generate any significant change in the vehicle fleet: neither a significant decrease in the registration of gasoline and diesel vehicles, nor an increase in the registration of non-polluting vehicles. Allowing the circulation of previously registered diesel and gasoline vehicles beyond 2025 and 2035 meant that drivers had no incentive to change their vehicle for a non-polluting one before then. The approval of these types of measures is completely ineffective unless the circulation of previously registered vehicles is also prohibited and the entry into force date is close. The possible reversion of the policy and the short-term horizon of the data may also explain why we do not find a relevant effect. A better design and implementation of these types of regulatory measures would improve its efficiency significantly.

An alternative to quantity measures, even when implemented efficiently, are price measures. The price mechanism is tremendously powerful to efficiently modify the individual decisions, so introducing access tolls to main cities, increasing registration taxes on the most polluting vehicles and/or significantly increasing fuel taxes, could significantly help to modify the vehicle fleet, by encouraging the introduction of non-polluting vehicles. Furthermore, this type of measure generates additional resources for the public sector, which can be used to increase investment in public transport, which is key to reducing the number of vehicles in circulation.

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