Departament d'Economia Aplicada

How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain

Javier Asensio,
Andrés Gómez-Lobo,
Anna Matas

DOCUMENT DE TREBALL

13.03

UAB

Universitat Autònoma de Barcelona

Facultat d'Economia i Empresa

How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain[1]

Javier Asensio[2]   Andrés Gómez-Lobo[3]   Anna Matas[4]

January 31, 2013

[2]Department of Applied Economics, Universitat Autònoma de Barcelona (UAB) and Institut d'Economia de Barcelona (IEB): javier.asensio@uab.es.

[3]Department of Economics, University of Chile: agomezlo@econ.uchile.cl. This work was partially undertaken while this author was visiting the IEB.

[4]Department of Applied Economics (UAB) and IEB: anna.matas@uab.es.

Abstract

Using a panel of 48 provinces for four years we empirically analyze a series of temporary policies aimed at curbing fuel consumption implemented in Spain between March and June 2011. The first policy was a reduction in the speed limit in highways. The second policy was an increase in the biofuel content of fuels used in the transport sector. The third measure was a reduction of 5% in commuting and regional train fares that resulted in two major metropolitan areas reducing their overall fare for public transit. The results indicate that the speed limit reduction in highways reduced gasoline consumption by between 2% and 3%, while an increase in the biofuel content of gasoline increased this consumption. This last result is consistent with experimental evidence that indicates that mileage per liter falls with an increase in the biofuel content in gasolines. As for the reduction in transit fares, we do not find a significant effect for this policy. However, in specifications including the urban transit fare for the major cities in each province the estimated cross-price elasticity of the demand for gasoline –used as a proxy for car use– with respect to the price of transit is within the range reported in the literature. This is important since one of the main efficiency justification for subsidizing public transit rests on the positive value of this parameter and most of the estimates reported in the literature are quite dated.

1   Introduction

In late February 2011 the Spanish government announced several permanent and temporary measures to reduce fuel consumption in the transport sector, which were then included in an "Energy savings and efficiency plan" dated March 4th.[1] The ultimate aim of these measures was to reduce the high dependency of the Spanish economy on imported oil at a time of rising international prices.

Among the measures announced was a reduction in the maximum speed limit from 120 km/hr to 110 km/hr in the highway network. In 2011, 59% of vehicle-kilometers traveled in Spain were in high-speed roads ('autopistas', 'autovías' and double lane highways) subject to this change in the speed limit.[2] This policy was applied from March 7th 2011 until June 30th of the same year. The government expected a reduction of 15% in gasoline consumption and 11% of diesel consumption from this measure alone, although it did not present any technical studies to substantiate these claims.

The second measure announced by the government was an increase in the biofuel component of fuels used by the transport sector. Spain sets yearly minimum requirements on the percentage of biofuels to be used in transport as well as, since 2009, specific separate requirements for petrol and diesel. Prior to the analyzed policy change the minimum overall percentage set for 2011 was 5.9%, with at least 3.9% both for diesel and for gasoline. The new policy increased the overall figure to 6.2% and that of diesel to 6.0%, while leaving the gasoline limit unmodified.[3]

The final measure was a transitory reduction of 5% in regional and commuter train (*Renfe*) fares across the country, applicable from March 7th to June 30th 2011. Shortly after this measure was announced it became apparent that the reduction would be difficult to implement in those transport systems operating with

---

[1]See a summary of the Government's announcement at http://www.lamoncloa.gob.es/idiomas/9/gobierno/news/2011/25022011energybill.htm. The details of the plan are available (in Spanish) at http://www.lamoncloa.gob.es/consejodeministros/ referencias/_2011/refc20110304.htm and then following the link 'Eficiencia Energética' [accessed January 24th, 2013].

[2]Anuario Estadístico (Statistical Yearbook), Ministerio de Fomento, Spain.

[3]Although the minimum biofuel content for gasoline was not changed, below we will show that there was an observed increase in the biofuel content of gasolines after the policy announcement; possibly as a reaction to the increase in the overall minimum requirement for fuels used in the transport sector.

integrated fares and negotiations ensued with the transit authorities of several cities and provinces. In the end, the reduction in fares was applied to all public transport services (including metro, train and buses) in two metropolitan areas (Barcelona and Asturias) for a period of three months (April to June 2011). However, in the rest of the country only *Renfe* fares were reduced. In the case of one the most important metropolitan areas (Madrid) this measure had only a limited impact on overall public transport prices as will be discussed below. Only 10 of the other provinces had *Renfe* commuting train services where this measure could be expected to have an impact.

It is important to note that the national authorities explicitly stated that the fare reduction measure was aimed at reducing gasoline consumption and car use. Press reports cite an expected savings of 5.9 million liters of gasoline and a reduction in 2.2 million car trips in the largest cities, according to the *Ministerio de Fomento*'s calculations cited in the press.[4]

In this paper we use monthly data across 48 Spanish provinces to estimate gasoline demand equations in order to infer the impact of the three measures just described. This includes all provinces in Spain except the two that are part of the Canary Islands, which have a particular tax regime that strongly affects petrol prices and consumption.

All else constant the reduction of the speed limit in the high speed network system would be expected to reduce fuel consumption for both gasoline and diesel, although the focus of this paper is on gasoline consumption. Our results confirm this prediction although we find that the impact was much lower than what was originally announced by the authorities.

The question of the performance of fuels used in transport when mixed with different shares of biofuels has been addressed by engineering researchers in various studies.[5] The results they reach vary according to the performance measure employed, as well as on the type of biofuel considered and variables such as engine and vehicle design, driving conditions, load factors, among other (Bayraktar, 2005; Cataluña et al., 2008; Crookes, 2006). In the case of the type of biofuel employed

---

[4] "El billete T-10 costará 7,85 euros entre el 1 de abril y el 30 de junio", *El Periódico*, March 10th, 2011.

[5] See Rutz and Janssen (2007) for an introductory review to the technical issues related to the different types of biofuels available.

in Spain and the EU (ethanol obtained from different biomass sources, technically known as ethyl tert-butyl ether, or ETBE), Kowalevicz and Wojtyniack (2005) report that "because ethanol contains approximately 60 per cent of the energy content of gasoline, it takes more ethanol to get the same mileage as a similar gasoline vehicle" (page 111). Taking that percentage as a reference value, an increase of 1% in the biofuel content of gasoline from its average share during the sample period used in this paper should lead to a 0.41% increase in the total consumption of (blended) gasoline. We test this proposition below with a gasoline consumption model and find values that are in accordance with that result. As far as we are aware, this is the first empirical confirmation of this effect that to date has only been documented based on experimental and laboratory conditions.

As for the third measure introduced –the reduction in public transit fares– we exploit the variation in policy treatment across the different regions and metropolitan areas of the country –that is the 5% reduction in overall transit fares in Barcelona and Asturias vis à vis slight or no reduction in other areas– in order to estimate the effects of transit prices on car use. Since gasoline is almost exclusively purchased by private automobile owners, we take this consumption as a proxy measure of private car use after controlling for other variables affecting fuel demand. As mentioned above, one of the explicit policy aims of this measure was the reduction in car use. Given the above description of the implementation of this policy, we would expect gasoline consumption to fall in Barcelona and Asturias relative to other regions of the country when transit fares were reduced in April 2011 and to increase when this policy was reversed at the end of June 2011.

With respect to this last policy change, our estimation results when controlling for the transit fare change applied between April and June 2011 show that the magnitude of the discount (5% of established fares) had no effect on consumption in the affected provinces. This could be due to the limited time period and geographical extension where this policy was applied (3 months and only two provinces). The robustness of this result is checked with the inclusion of public transport fares in the gasoline consumption equation. In this specification we find evidence of a cross price effect implying that car use and public transport are substitutes.

We believe that the evidence provided in this paper is very relevant to current policy discussions in Europe. Although higher fuel taxes and/or congestion tolls could be used to reduce car use and gasoline consumption, these policies are often difficult to implement due to political opposition and other restrictions; particularly

3

in Europe where fuel taxes are relatively high by world standards. In this context, alternative policies to reduce gasoline consumption in order to limit negative externalities or in the pursuit of other policy aims —such as saving foreign reserves in the face of rising international fuel prices— may be of interest. Evaluating the speed limit policy change in Spain or the impact of changes in the biofuel content of fuels used in the transport sector provides relevant information regarding these less conventional policy instruments.

As regards public transit fares, determining whether transit fares affect car use is important. One of the main efficiency justification for subsidizing public transport is that lower transit fares reduce private car use and the associated externalities related to this transport mode.[6] For example, Parry and Small (2009) in their detailed study of optimal transit subsidies in Los Angeles, Washington D.C. and London conclude that this second-best argument justifies increasing subsidies in these cities particularly during peak-periods.

Considering how ubiquitous and large transit subsidies are around the world, it is curious to note how little research there is concerning the cross elasticity of transit fares on car use. Although we review the existing evidence for Spain and other countries below, it is interesting to note that even careful studies such as Parry and Small (2009) need to rely on quite weak evidence on the cross elasticity of demand to arrive at their results. In fact, the parametrization of their model comes from just three studies that measure the diversion ratios between car use and public transport, all of them from the mid-70's; that is, more than 40 years old. For Europe they do not present any evidence and use the parameters estimated in the US in their empirical analysis for London. Litman (2012) in a recent review of transport elasticity studies also notes that many of the estimates of transport demand elasticities are quite dated.

Furthermore, the economic crisis is forcing transport authorities to review their services, cost structure and fares as fiscal constraints become increasingly tighter. In this scenario, it will be important to analyze to what extent public transport subsidies should be maintained or reduced. In Spain transit subsidies cover on average 50% of operating costs. However, a significant dispersion can be observed. Subsidies are larger in the big metropolitan areas with a better quality of public transport. Measuring the effects of transit fares on private car use is crucial in order to evaluate

---

[6]The reasonable assumption being that private car users do not face the full social cost they impose on society through congestion, pollution and accidents and that first-best congestion charges or tolls are not feasible.

the economic justification of current levels of public transport subsidies. The results of this paper are mixed but we do find some evidence of a substitution effect that would justify some level of subsidy to transit services.

In addition, our cross-price elasticity estimates of transit fares on car use are within the range reported in the earlier studies. Therefore our results provide a more up to date estimate of this key parameter that does not differ excessively from older ones.

The paper is organized as follows. In the next section we present more details of the methodological approach used to measure the impacts of the policy changes described above, followed by a section describing the data. We then present the empirical specifications and the results of the analysis followed by a comparison of our cross-elasticity estimate with those found in the literature. The paper concludes with a section summarizing our results and a brief discussion of distributional issues regarding public transit subsidies.

2   Methodology and data

As mentioned above the policy changes we want to analyze in this paper were announced by the Spanish government in February 2011. They comprised a reduction in the speed limit in the highways system, an increase in the biofuel content in fuels and a reduction of 5% in the fares for *Renfe* commuting services (*Renfe cercanías*) and inter-regional services.

In order to measure the impact of these changes we estimate several gasoline demand equations to isolate the effects of each policy. We use monthly data on gasoline consumption in each of 48 provinces from January 2008 to December 2011 provided by CORES (the institution responsible for the management of strategic fuel reserves in Spain).[7] Each province may be very different in a variety of ways and our estimation strategy has to take this into account. The advantage of our data is that we observe gasoline consumption for all provinces both before, during and after each policy was applied. Therefore, we can control for unobserved heterogeneity among provinces using panel data estimation methods. In addition, we have a set of observable variables for each province including gasoline price, vehicle stock, employment

---

[7]CORES, 'Consumos de gasolinas, gasóleos y fuelóleos por provincias y comunidades autónomas' (various years), available at www.cores.es (accessed on January 21st, 2013).

levels among others, that can be used to control for determinants of gasoline demand across the different regions.

Gasoline consumption is expressed in tons and includes the consumption of 95 octane and 98 octane fuel. We also have information on the average monthly price of 95 octane gasoline per province (expressed as cents of one Euro per liter) for the same period.[8] These prices have been deflated by the consumer price index of each province. Since retail gasoline prices may be endogenous, some of the models presented below are estimated by instrumental variables. We use the international price of oil (Europe Brent Spot price FOB in U.S. dollars per barrel taken from the U.S. Energy Information Administration database) and the Euro-Dollar exchange rate (from the European Central Bank) to instrument the retail price of gasoline in these estimations.

Gasoline demand is estimated conditional on the vehicle stock, so they are short-run consumption equations. We use information on the stock of vehicles that use gasoline (from January 2008 to December 2011) for each province. The available information is disaggregated by automobiles, motorcycles and other vehicles and was obtained from the Dirección General de Tráfico, the governmental agency responsible for traffic management in Spain.[9]

We also have macro variables per month and province, such as the unemployment rate and the number of workers affiliated to the social security regime (formal dependent workers), to control for idiosyncratic economic shocks in each area that may affect gasoline consumption.

We also define a dummy variable for the month in which the Easter holiday occurred each year. Although month fixed effects should control for other seasonal patterns in gasoline consumption, Easter is unique among holidays in that it can fall on different months each year and so needs to be controlled for directly. Differences in the relative importance of tourism at the provincial level in Spain lead to very different seasonal patterns of petrol consumption. Therefore, both the monthly sea-

---

[8]The price data comes from the Ministerio de Industria, Energía y Turismo. It would have been ideal to use a weighted average price for 98 octane and 95 octane gasoline, but only the latter data was available. However, since 98 octane gasoline represents only around 10% of total gasoline consumption and the price for this fuel is highly correlated with the price for 95 octane gasoline, this omission is probably immaterial. In any case, the results of the paper are unchanged if the models are estimated using only the consumption of 95 octane gasoline.

[9]See http://www.dgt.es/portal/es/seguridad_vial/estadistica/ (accessed January 21st, 2013).

sonal effects as well as the Easter effect are allowed to differ by province

Regarding the policy change on the use of biofuels, it is important to recall that the government did not modify the required minimum contents in gasoline, but only did so for diesel and for overall fuel consumption in the transport sector. This fact does not prevent us from evaluating the impact of modifying the share of biofuels on gasoline consumption since the effective biofuel content in gasoline does not seem to be determined by the minimum value set by the government. Figure 1 compares the evolution of the minimum annual requirement and the effective contents, showing that latter is not constrained by the former, and evolves almost independently.[10] This makes it possible to empirically measure the impact of variations in the relative weight of biofuel on gasoline consumption, and thus evaluate the effectiveness of policy measures aimed at modifying such share.

With respect to the speed limit reduction, we do not have data to control for this variable directly. However, if other control variables affecting gasoline consumption are included in the regressions, then the average impact of this measure across provinces can be approximated by including a discrete variable marking the period in which said policy was applied. To this end, a dummy variable was created taking a value of one for the months the speed limit reduction was applied. It must be noted that the highway network in Spain remained mostly unchanged in the 2008-2011 period so that the province fixed effects will control for the relative size of this network in each region. Unfortunately, we cannot control for changes in the flow of vehicles in each region. However, we expect the provincial level macro variables mentioned above to control for these effects.

Finally, in order to study the effects of the reduction in public transit fares on car use we assume that car use is directly proportional to gasoline consumption. Although gasoline consumption represents only 19% of all fuel consumed in the transport sector (gasoline plus diesel), it is almost exclusively used by private automobiles and motorcycles. In contrast, diesel consumption will be affected by demand from trucks, buses and other vehicles whose behavior is probably not affected by transit fares. Close to 47% of the stock of private automobiles run on gasoline, while the rest run on diesel. Thus, any decrease in gasoline consumption as a result of the transit fare reduction applied in 2011 will probably underestimate the total reduc-

---

[10]Monthly data on the actual percentage of biofuel in gasoline is provided by CORES in the publication 'Informe resumen anual del boletín estadísticos de hidrocarburos' (various years). This information is at the national level and does not vary by province.

Figure 1: Observed and minimum required biofuel content in gasoline (%)
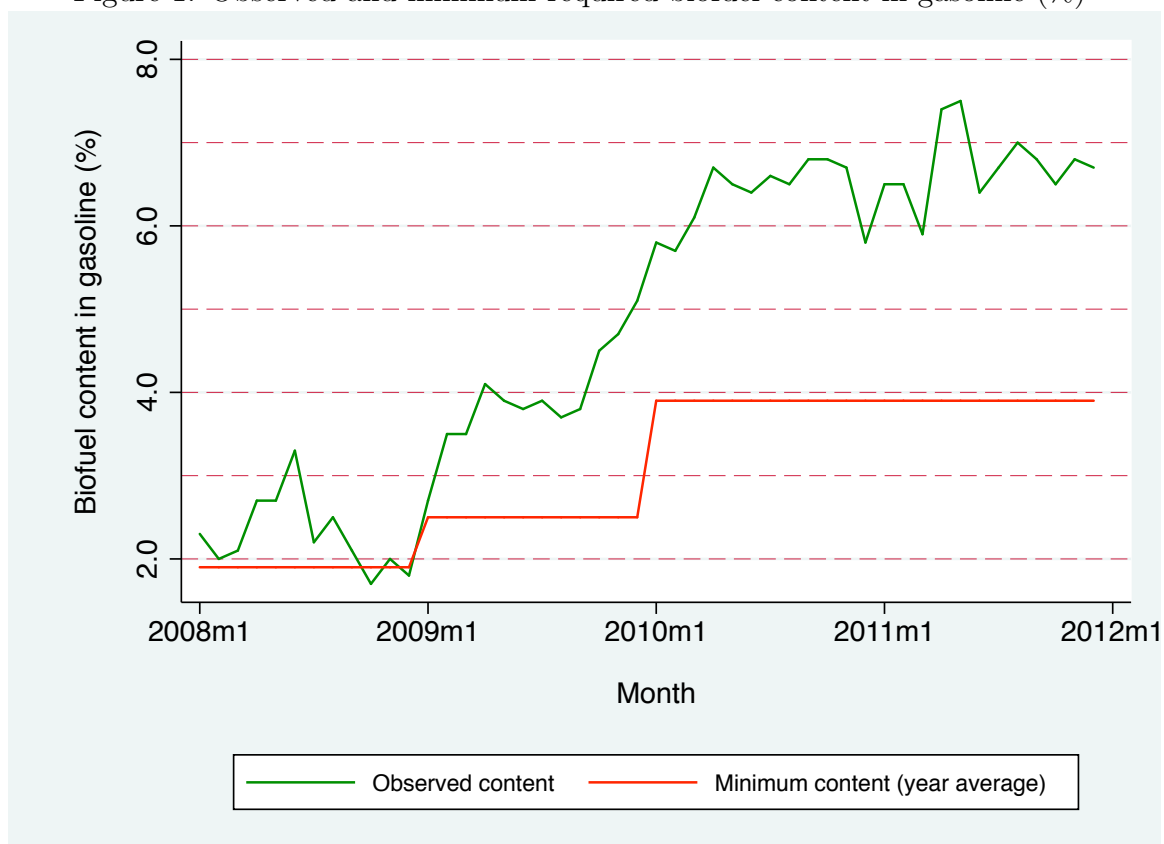
tion in car use. However, it seems unlikely that this policy would only affect diesel consumption. Therefore, if this policy change effectively had an impact on private car use, we would expect to find some measurable effect on gasoline consumption.

When it made the announcement to reduce *Renfe* fares, the central government did not seem to realize that in the two major metropolitan areas and in one province services are integrated, and it did not have the power to apply the policy without the consent of the metropolitan transport authorities. In those three areas, negotiations between central government and the metropolitan transit authorities resulted in an across the board reduction of 5% on all public transit services (train, metro and bus) in Barcelona and Asturias. However, in Madrid the decision was taken not to reduce transport fares except for tickets issued by *Renfe*.

Furthermore, most passengers using *Renfe* commuting service in Madrid use a travel pass valid for all public transport modes, whose price was not affected by the reduction in *Renfe* fares. Since only 26% of Renfe passengers in Madrid use single-trip or multi-ride tickets and Renfe accounts for 12.2% of public transport trips in the area, just 3.2% of public transport users in Madrid were affected by the policy.[11] We therefore assume that it had a minimal impact compared to Barcelona and Asturias, where the reduction was applied to all fare-integrated public transport modes. This provides an interesting variation since Madrid can be used as a control group to examine the effects of the policy on the two other metropolitan areas with integrated services.

In Madrid and the other provinces with railway commuting services (Valencia, Sevilla, Vizcaya, Cádiz, Málaga, Guipúzcoa, Murcia, Alicante, Santander, and Zaragoza) the 5% reduction in train fares applied from March 7th to June 30th. In Barcelona and Asturias, the 5% reduction on all public transport fares applied from April 1st to June 30th.

In the rest of the provinces for which we have data, the policy was irrelevant as there were no *Renfe* commuting services. The fare reduction of *Renfe* inter-regional services was probably not very relevant either since inter-regional passengers were only 16,4 million in 2011, compared to 422,6 million passengers in the case of *Renfe* commuting services.[12] Therefore, besides comparing the effect of the public tran-

---

[11]Data comes from Consorcio Regional de Transportes de Madrid, Demanda de transporte público colectivo, 2011

[12]This last figure of commuting passengers is highly concentrated in two provinces, Madrid with

9

sit fare reduction on gasoline demand between Asturias and Barcelona, on the one hand, and Madrid, on the other, it is also possible to compare consumption between provinces where this policy was applied with provinces where this policy was irrelevant.

Finally, data on the level of urban public transport fares was gathered for the capital city of each province.[13] We were able to collect data for 46 provinces from bus operators' sources. The fare used as a reference is that of the most frequently used ticket that, except for Madrid, corresponds to multi-ride card. In the case of Madrid a monthly pass that allows for unlimited travel was selected.[14]

Table 1 presents the average monthly value of gasoline consumption for the twenty largest provinces in terms of this variable. All other provinces are grouped together in the "Other" category. It can be seen that Madrid and Barcelona are the two largest provinces with a similar scale in terms of gasoline consumption. The rest of the provinces are smaller. In particular, Asturias is ranked 14th in terms of gasoline consumption.

Table 2 provides descriptive statistics for the explanatory variables used in the gasoline consumption equation for the first and last year in the sample. As can be observed, gasoline prices increase on average by 12.2% in real terms between 2008 and 2011. There is some price dispersion across provinces, although of a small degree. In 2011 there was a 3.4% difference between the maximum and minimum prices. Regarding the employment data, the fall of more than 10% between 2008 and 2011 reflects the severe economic crisis affecting the Spanish economy during the sample period. The decrease in employment has affected all provinces, although with different intensities. The stock of vehicles consuming gasoline shows a slight increase of 4.2%, which is explained by a significant increase in the number of motorcycles (+14%) and a decrease in the remaining vehicles (mostly cars). These changes may be partially explained by the increasing use of motorcycles that has been observed in urban areas since the beginning of the economic crisis. Average public transport fares have increased by 6.6% in real terms. The level of dispersion across provinces is quite large, with the highest fare almost trebling the lowest.

234.3 million passengers in 2011 and Barcelona with 106.2 million passengers.

[13]Except for the province of Pontevedra where the fares from Vigo were used.

[14]The average price per trip is computed dividing the cost of the pass by the average number of monthly trips per pass (84).

Table 1: Mean values for the 20 largest provinces in terms of gasoline consumption

Province	Gasoline consumption (tons per month; 2008-2011)
Madrid	54,574
Barcelona	49,883
Valencia	23,105
Alicante	21,694
Baleares	18,874
Málaga	16,729
Sevilla	15,632
Gerona	13,219
Murcia	13,176
Cádiz	11,259
Coruña	10,362
Tarragona	9,885
Pontevedra	9,759
Asturias	9,733
Zaragoza	9,195
Vizcaya	8,788
Granada	8,378
Navarra	7,030
Badajoz	6,943
Toledo	6,864
Other	4,061

Table 2: Descriptive statistics (annual values across provinces)

	2008	2011	$\Delta 2011/2008$
Gasoline price (euro cents, 2011)			
Mean	117.1	131.4	12.2%
Std. Dev.	1.50	1.46	
Min.	115.0	128.6	
Max	120.4	133.0	
Employment			
Mean	289,143	260,013	-10.1%
Std. Dev.	454,624	412,126	
Min.	29,651	28,708	
Max	2,548,574	2,336,801	
Number of vehicles			
Mean	271,354	282,803	4.2%
Std. Dev.	369,146	387,355	
Min.	27,550	28,972	
Max	1,873,463	1,959,734	
Number of motorcycles			
Mean	48,316	55,095	14.0%
Std. Dev.	75,851	84,421	
Min.	3,364	4,018	
Max	463,290	515,858	
Public Transport Fare (euro cents, 2011)			
Mean	57.4	61.2	6.6%
Std. Dev.	12.7	13.5	
Min.	34.1	35.0	
Max	88.6	97.5	

3 Model specification and results

3.1 Empirical specification

We estimate a series of equations for gasoline consumption of the following form:

$$ln(Q_{pt}) = X'_{pt}\beta + \delta \cdot D_{3-6/11} + \rho \cdot Bio_t + \gamma \cdot D_{A,B} + \psi_p + \epsilon_{pt} \qquad (1)$$

where Q_{pt} is gasoline consumption in province p in month t, X_{pt} is a vector of explanatory variables for fuel demand, including the vehicle stock, gasoline price, month dummy variables, among others, and β is a vector of conformable parameters.

The main parameters of interest of the model are δ, ρ and γ. The first is associated with the dummy variable $D_{3-6/11}$ that takes a value of one from March to June 2011 and zero otherwise and is common to all provinces. Therefore, δ will measure any effect on gasoline consumption that affected all provinces during this period, including the reduction in the maximum speed limit in highways. The variable Bio measures the content of biofuels in gasolines in month t and will control for changes in fuel consumption due to changes in this proportion.

The variable $D_{A,B}$ is a dummy variable that takes a value of one from April 2011 to June 2011 for Barcelona and Asturias. Since this is the interaction of the 'treatment' group (Barcelona, Asturias) with the period under treatment (April to June 2011) the coefficient associated with this variable (γ) will be the difference in difference estimator of the effects of the treatment ('reduction of public transit fares').[15]

All specifications include a province fixed effects, ψ_p, to control for unobservable time invariant characteristics of each province. All specifications also include monthly fixed effects and Eastern effects to control for seasonal variations in gasoline demand. All these seasonal effects are allowed to vary by province.

Finally, ϵ_{pt} is an error term. Below we test for first order autocorrelation of this error term and present estimations considering panel specific autocorrelation and heteroskedasticity.

---

[15]This is not precisely true since the 'treatment' period variable included in the regression is $D_{3-6/11}$ which takes a value of one from March 2011 to June 2011, but including a variable from April 2011 to June 2011 instead of $D_{3-6/11}$ of has no discernible effects on the results.

Figure 2: Gasoline consumption in Asturias, Barcelona and Madrid, 2009-2011
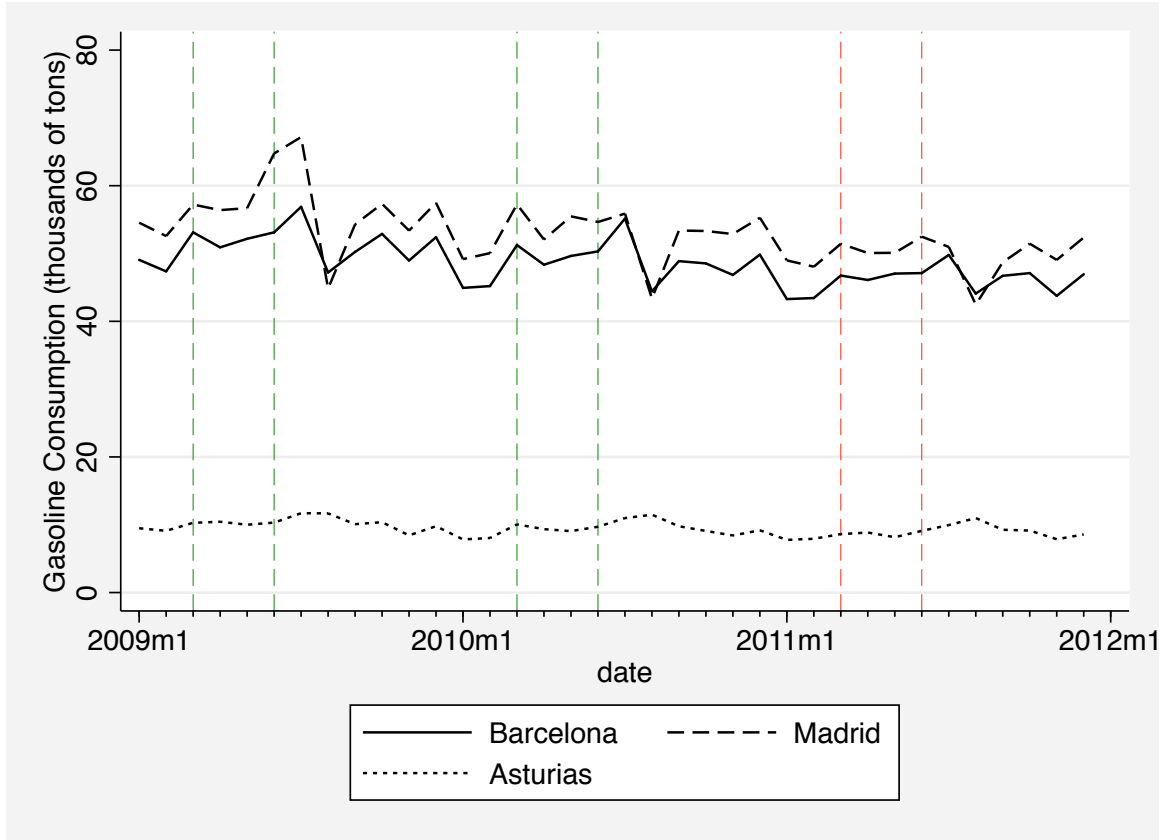
3.2 Results

Before showing the econometric results we present a graph of gasoline consumption for three provinces. Figure 2 presents the evolution of gasoline consumption from January 2009 to December 2011 for Asturias, Barcelona and Madrid. The periods from April to June of each year are marked in the graph. An examination of this figure does not reveal any difference in the pattern of consumption between April to June 2011 as compared to previous years except for a general downward trend in consumption. Furthermore, there does not seem to be any marked difference in the consumption pattern of gasoline in Barcelona or Asturias in 2011 compared to previous years and compared to Madrid. However, the estimation of the impacts of the policy changes studied in this paper must be based on a formal statistical analysis.

Table 3 presents the results of a series of specifications of equation (1). The first

14

model (column labeled (1)) is a fixed effects panel data regression. It also includes province specific monthly effects and a province specific effect for the Easter holidays. Neither the Easter, month or province fixed effects are reported in the table.[16] The standard errors for this model were calculated using the Huber/White sandwich (robust) variance estimator.[17]

The Wooldridge test statistic for first order autocorrelation presented at the bottom of column (1) indicates that the null hypothesis of no autocorrelation is easily rejected.[18] Although not reported, a Wald test for homoskedasticity of the variance of the errors across different panel groups was also rejected. Therefore, column (2) estimates the model using Feasible GLS considering panel specific autocorrelation of order one (AR(1)) in the residuals and panel specific heteroskedasticity.

Columns (3) and (4) replicate the estimations of column (1) and (2) except that the price of gasoline was instrumented with the international price of oil and the US-Euro exchange rate.

From the table it can be seen that the short-run price elasticity of the demand for gasoline is highly significant and varies between -0.20 to -0.24 depending on the model. As expected, the IV models estimate more elastic price elasticities. These results accord well with prior empirical literature that report inelastic demand elasticities for this fuel.[19]

---

[16]These results are available from the authors upon request.

[17]This implies that observations are assumed to be independent within each panel. If on the other hand the observations are not assumed to be independent within each panel (using the *cve(cluster)* option in Stata) then the standard errors estimated are slightly higher but the results are unchanged.

[18]See Wooldridge (2002) and Drukker (2003) for details of this test.

[19]It must be borne in mind that since the model conditions on the stock of vehicles, this elasticity is a short-run elasticity, in the sense that it does not consider the effects that the price of gasoline may have on future vehicle purchases.

Table 3: Gasoline consumption equation (all provinces)

Estimation technique:	FE	GLS	IV	IV-GLS
	(1)	(2)	(3)	(4)
Ln(Price)	-0.214***	-0.197***	-0.241***	-0.225***
	(0.0187)	(0.0112)	(0.0152)	(0.0106)
Ln(Total vehicle stock)	1.028***	0.941***	0.942***	0.778***
	(0.300)	(0.118)	(0.136)	(0.109)
Ln(Motorcycle stock)	-0.405***	-0.464***	-0.423***	-0.484***
	(0.0881)	(0.0303)	(0.0396)	(0.0276)
Ln(Total employment (dependent))	0.700***	0.579***	0.739***	0.645***
	(0.092)	(0.0353)	(0.0425)	(0.0326)
Dummy 3/11 to 6/11	-0.0299***	-0.0174***	-0.0273***	-0.0195***
	(0.00515)	(0.00321)	(0.00448)	(0.00304)
Biofuel content (%)	0.00771**	0.00377***	0.00898***	0.00616***
	(0.00302)	(0.0013)	(0.00158)	(0.00122)
Barcelona/Asturias 4/11 to 6/11	0.0106	0.00617	0.0111	0.00971
	(0.0104)	(0.0111)	(0.0158)	(0.0105)
Constant	-7.043	-4.420***	-6.530***	-3.030**
	(4.319)	(1.334)	(1.641)	(1.209)
Province fixed effects	yes	yes	yes	yes
Month-Province effects	yes	yes	yes	yes
Easter-Province effects	yes	yes	yes	yes
Panel specific AR(1) errors	no	yes	no	yes
Panel heteroskedastic errors	no	yes	no	yes
Wooldridge AR(1) test (P-value)	0.0028	—	0.0001	—
Observations	2,304	2,304	2,304	2,304
R-squared	0.927	—	0.998	—
Number of Provinces	48	48	48	48

Note: Standard errors in parenthesis, significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The coefficient associated with the vehicle stock indicates that the null hypothesis that gasoline consumption grows proportionally with this stock cannot be rejected in models (1) to (3). However, conditional on the vehicle stock, more motorcycles reduce gasoline consumption. In other words, the per vehicle consumption of gasoline falls with the proportion of motorcycles in the total stock.[20]

Total employment has the expected positive effect on gasoline consumption across all models.

The March 2011 to June 2011 dummy variable has a negative impact on gasoline consumption. Depending on the specification, this effect varies between 1.7% to 3.0%. This effect is common to all provinces and implies that during the period in which the speed limit in highways was reduced and *Renfe* fares were reduced there was an associated fall in gasoline consumption. Therefore, there is some evidence that the two measures did reduce consumption, albeit not by the 15% estimated initially by the government. Unfortunately, we are unable to distinguish the total effect caused by the speed limit reduction from the *Renfe* fare reduction. However, since the *Renfe* fare reduction only affected a subset of provinces and was probably marginal in all but the two provinces where all transit fares were reduced (Barcelona and Asturias) –and for which another variable is included to control for this effect in the model– it is highly probable that the reduction in gasoline consumption observed during these months were due to the speed limit reduction.

The coefficient related to the biofuel content of gasolines is significant and positive. It implies that for each percentage increase in the biofuel content, gasoline consumption increases by 0.4% to 0.9%. These figures are consistent with those reported in the experimental literature mentioned above and, as far as we are aware, provide the first evidence with real world data of the existence of this effect.

Finally, the coefficient associated with the general decrease in public transit fares in Barcelona and Asturias is not statistically significant in any of the models. In addition, the estimated coefficients do not even have the expected sign across all regressions. As mentioned at the beginning of this paper, this negative result would have important consequences for the justification of transit subsidies and therefore we experimented with other specifications below to make sure this result is robust.

---

[20]We tested non-linear effects by including powers of the stock variables but found no evidence of non-linear effects.

Table 4: Gasoline consumption equation (only thirteen provinces with *Renfe* commuting services)

Estimation technique:	FE	GLS	IV	IV-GLS
	(5)	(6)	(7)	(8)
Ln(Price)	-0.222***	-0.197***	-0.238***	-0.219***
	(0.0336)	(0.0185)	(0.0307)	(0.0188)
Ln(Total vehicle stock)	1.101*	0.794***	1.076***	0.700***
	(0.5980)	(0.2120)	(0.2540)	(0.2010)
Ln(Motorcycle stock)	-0.617***	-0.551***	-0.625***	-0.571***
	(0.1580)	(0.0558)	(0.0820)	(0.0544)
Ln(Total employment (dependent))	0.519**	0.578***	0.547***	0.624***
	(0.2200)	(0.0702)	(0.0957)	(0.0675)
Dummy 3/11 to 6/11	-0.00993	-0.0122**	-0.00826	-0.0125**
	(0.0066)	(0.0057)	(0.0080)	(0.0054)
Biofuel content (%)	0.00922*	0.00458**	0.0102***	0.00643***
	(0.0051)	(0.0022)	(0.0031)	(0.0022)
Barcelona/Asturias 4/11 to 6/11	0.00161	0.00679	0.00141	0.00824
	(0.0150)	(0.0123)	(0.0170)	(0.0118)
Constant	-3.598	-0.955	-3.301	0.0313
	(7.495)	(2.543)	(3.258)	(2.404)
Province fixed effects	yes	yes	yes	yes
Month-Province effects	yes	yes	yes	yes
Easter-Province effects	yes	yes	yes	yes
Panel specific AR(1) errors	no	yes	no	yes
Panel heteroskedastic errors	no	yes	no	yes
Wooldridge AR(1) test (P-value)	0.0643	—	0.0304	—
Observations	624	624	624	624
R-squared	0.896	—	0.997	—
Number of Provinces	13	13	13	13

Note: Standard errors in parenthesis, significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4 presents the results of similar specifications to that shown above but using data only for the thirteen provinces with *Renfe* commuting services. The reason for limiting the analysis to this set of provinces is that they may be very different to other provinces in terms of urban or social characteristics (usually larger cities).

The results indicate that the estimated price elasticities of gasoline demand are very similar to those estimated with the full sample. Gasoline consumption seems to be proportional to the vehicle stock. This is seen most clearly in models (5) and (7), although the null hypothesis of an elasticity of fuel demand to vehicle stock equal to one cannot be rejected in models (6) and (8).

Conditional on the total vehicle stock, more motorcycles reduces fuel consumption as expected. Also, total employment increases fuel consumption.

The March to June 2011 dummy variable has a negative coefficient in all models. However, the size of this coefficient is smaller than the comparable coefficient estimated with the full sample. In addition, they are statistically significant only in the GLS regressions. Although the Wooldridge test for first order autocorrelation indicates that the null hypothesis of no autocorrelation cannot be rejected in the fixed effects regression, this hypothesis is rejected in the IV regression. Therefore our preferred model is the IV-GLS shown in column (8). In this case, there is a decrease of 1.3% in gasoline demand during the months in which the speed limit reduction and the *Renfe* fare reduction were in place. For the same reasons espoused above for the model estimated with the full sample, we believe most of this reduction is due to the speed limit reduction.

A possible explanation for a lower decrease in the petrol consumption derived from the reduction in speed limit is that provinces with *Renfe* commuting services are provinces with high level of urban population and, as a consequence, higher congestion levels. Thus, the percentage of kilometers traveled on motorways at uncongested speeds –and hence subject to speed limit– may be lower than in the remaining provinces.

The increase in the biofuel content increases gasoline demand in all the models presented in Table 4 and this impact is slightly higher than the corresponding estimates using the full sample.

Finally, the dummy for Barcelona and Asturias from April to June 2011 is not

19

statistically significant in any of the models shown in Table 4. In addition, the sign of the estimated coefficient is positive when a negative effect is to be expected if the decrease in transit fares reduces car use and therefore gasoline consumption. This implies that there is no evidence that gasoline consumption in these two provinces decreased more than the equivalent consumption of the other provinces during the same period.

This last result, taken together with the similar effect observed in the models of Table 5, would imply that the reduction in public transit fares had no significant effect on gasoline consumption. An extensive robustness analysis of the above models was undertaken –for example, excluding some variables, separating the treatment on Barcelona and Asturias into two different dummy variables, dividing the sample in other ways and an assortment of other specifications– and in all cases no evidence was found of an effect on gasoline consumption of the reduction in fares in Barcelona and Asturias. This result would imply that one of the main arguments for subsidizing public transport disappears.

However, before making such as sweeping conclusion alternative explanations for the results must be considered. The main one is that the reduction of transit fares that we analyze affected only two provinces and did so only for three months. This constitutes a very reduced treatment group making it difficult for the data to identify the policy effect. Moreover, the fact that when the policy was announced it was explicitly defined to be a temporary measure implies that no long-run effects can be expected since only consumers able and willing to switch modes for a predefined limited time period would reduce their gasoline consumption. Finally, the identification of the policy impact in the above model using a difference-in-difference estimator (the dummy variable for the two provinces during the three-month treatment period) relies on the assumption that all other factors not included in the model specification remained constant during the time when the policy was applied. The validity of this assumption may be particularly doubtful in the case of public transport fares which –based on our data on the median fare of the major city of each of 46 provinces– seemed to have evolved differently in each province during our sample period.

In order to control for these effects we include an additional explanatory variable that measures the level of public transport fares at each province. Although this requires dropping the dummy variable that captures the effects of the policy change in Asturias and Barcelona, the advantage of this specification is that it makes it possible to estimate the actual value of the cross elasticity of gasoline consumption

with respect to transit fares. By directly identifying whether there is a significant modal substitution effect we can determine the effectiveness of policies aimed at reducing gasoline consumption with changes in public transport fares that do not have a limited and temporary design.

Table 5: Gasoline consumption equation including transit fares (all provinces)

Estimation technique:	FE	GLS	IV	IV-GLS
	(9)	(10)	(11)	(12)
Ln(Price)	-0.200***	-0.185***	-0.227***	-0.212***
	(0.0202)	(0.0113)	(0.0158)	(0.0109)
Ln(Transit fare)	0.116	0.0791***	0.106***	0.0673***
	(0.0703)	(0.0191)	(0.0271)	(0.0183)
Ln(Total vehicle stock)	1.076***	1.054***	0.997***	0.933***
	(0.309)	(0.115)	(0.138)	(0.107)
Ln(Motorcycle stock)	-0.379***	-0.440***	-0.397***	-0.462***
	(0.0932)	(0.0308)	(0.0409)	(0.0283)
Ln(Total employment (dependent))	0.732***	0.612***	0.766***	0.659***
	(0.103)	(0.0368)	(0.0449)	(0.0340)
Dummy 3/11 to 6/11	-0.0306***	-0.0177***	-0.0281***	-0.0192***
	(0.0052)	(0.0031)	(0.0044)	(0.0030)
Biofuel content (%)	0.00582*	0.00289**	0.00718***	0.00533***
	(0.0030)	(0.0013)	(0.0017)	(0.0013)
Constant	-8.296*	-6.319***	-7.693***	-5.177***
	(4.586)	(1.323)	(1.692)	(1.223)
Province fixed effects	yes	yes	yes	yes
Month-Province effects	yes	yes	yes	yes
Easter-Province effects	yes	yes	yes	yes
Panel specific AR(1) errors	no	yes	no	yes
Panel heteroskedastic errors	no	yes	no	yes
Wooldridge AR(1) test (P-value)	0.0047	—	0.0003	—
Observations	2,208	2,208	2,208	2,208
R-squared	0.927	—	0.998	—
Number of Provinces	46	46	46	46

Note: Standard errors in parenthesis, significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

With the above assumptions it is possible to estimate models analogous to those shown in Table 3 and 4 but including the logarithm of the public transit fare. The results are shown in Table 5. In these regressions, the Dummy variable for Barcelona and Asturias from March to June 2011 has been excluded since we are controlling for the level of public transit fares directly. In addition, a Durbin-Wu-Hausman test for endogeneity of the public transit fare failed to reject the null hypothesis that this variable was exogenous.[21] Therefore, in the results shown in Table 5 the public transit fare was not instrumented.

The results for the own-price elasticity of demand for gasoline are very similar to the previous results. This parameter is quite stable across all specifications and sub-samples presented in this paper, which is reassuring.

The public transit fare coefficient is not significant in the fixed effects regression (column labeled (9)). However, it is significant in the other three cases and implies a cross-price elasticity of between 0.07 and 0.11 depending on the estimation method. This parameter also indicates that gasoline demand (as a proxy for car use) and public transit are substitutes, albeit not very strongly. We will discuss these results further below.

As for the other variables, they are very similar to the earlier estimates. The demand for gasoline grows roughly proportional to the total vehicle stock but, conditional on this stock, falls with the number of motorcycles.

With respect to the March to June 2011 dummy, the estimated coefficient is negative and of similar magnitude as that shown in Table 3. However, since in these latter results we are controlling for urban transport fares, it is reasonable to assume that the effect of the *Renfe* fare reduction is to some extent controlled for by this variable. Therefore, we can be more confident that the results for the March to June dummy variable are mostly measuring the impact of the speed-limit reduction policy.

As for the biofuel content of gasoline this variable is again significant and implies an increase in gasoline consumption as the proportion of biofuel increases. The magnitude of this effect is similar to those of Table 3, implying that an increase in 1% points in the biofuel content of gasoline increases total gasoline demand by 0.3% to 0.7%. The estimate of 0.41% derived from the technical literature lies within these

---

[21]The same variables used to instrument the price of gasoline were used to instrument the transit fare: the exchange rate and the international price of oil.

two extremes.

4 Cross-elasticity of the demand for gasoline

As argued in the introduction one of the main efficiency justification for subsidizing public transport is that lower transit fares reduce private car use and the associated externalities related to this transport mode. Our results indicate that this elasticity is between 0.07 and 0.11 when we estimate the model using the average transit fare of the capital city of each province. How do these estimates compare to the available evidence reported in the literature?

Hensher and Brewer (2001) report the elasticity estimates shown in Table 6. They summarize this evidence by stating that "The findings are rather limited. (...) The average cross-elasticity of car demand with respect to bus fares is 0.09 (±0.07) and with respect to train fares 0.08 (±0.03)." (pages 83-84). It must be noted that most of these estimates are from studies using data from the early 70's or even earlier. However, these values are very close to those estimated in this paper.

Litman (2012) updating an earlier study (Litman, 2004) also reviews the existing estimates of transport elasticities. Based on this review Litman (2012) suggests that cross-price elasticities between transit fares and car use are of the order of 0.03 to 0.10 in the short-run and between 0.15 and 0.30 in the long-run (average over all time periods). It is remarkable to note that the our short-run elasticity estimates within the bounds or very close to the short-run elasticity range suggested by this author.

Furthermore, Litman (2012; page 1) notes that "Commonly used transit elasticity values are largely based on studies of short- and medium-run impacts performed decades ago when real incomes where lower and a larger portion of the population was transit dependent. As a result, they tend to be lower than appropriate to model long-run impacts." However, our estimates would suggest that this elasticity has not changed significantly in the last decades, at least using evidence from Spain. Obviously, more comparable evidence from other countries needs to be garnered before a more definite conclusion can be made regarding this point.

Table 6: Elasticity of car use with respect to transit fares)

Context	Transit fare	Trip type	Result	Data type	Reference
London 1970-75	bus	peak work	0.06	Time series	Glaister and Lewis (1978)
London 1970-75	bus	off-peak work	0.06	Time series	Glaister and Lewis (1978)
Boston 1965	bus	peak work	0.14	Cross-section	Kraft and Domencich (1972)
Illinois 1961	bus	peak work	0.21	Cross-section	Warner (1962)
San Francisco 1973	bus	peak work	0.12	Cross-section	McFadden (1974)
San Francisco 1973	bus	off-peak work	0.13	Cross-section	McFadden (1974)
Melbourne 1964	bus	peak-work	0.19	Cross-section	Shepherd (1972)
Sydney	train	peak work	0.09	before and after	Hensher and Bullock (1979)
Sydney	bus and train	peak work	0.06	Cross-section	Madan and Groenhout (1987)

Source: Hensher and Brewer (2001), Chapter 4.

Elasticity estimates for Spain are more limited in number. However, Matas (1991), using a discrete choice model, estimates a cross-price elasticity of car choice with respect to public transit fare for the Barcelona metropolitan area of 0.07. Asensio (2002), using data from Barcelona, reports an elasticity estimate of 0.008 of car use with respect to bus fares and of 0.023 with respect to train fares.

Our estimates are very close to Matas (1991) although somewhat higher than those reported by Asensio (2002). However, it must be noted that these studies only estimate the elasticity for one city while our estimates are an average across the country.

Finally, using our cross-elasticity estimate and data for the Barcelona metropolitan area we can calculate a diversion ratio between car use and public transport demand. In 2010, there were 4.815.000 public transport trips and 7.744.000 private transport trips in this city. Litman (2012) suggest that the transit short-run own-price elasticity should be between -0.2 and -0.5. Assuming a value of -0.35 for this parameter, our cross price elasticity estimates of 0.07 to 0.11 imply a diversion ration between car use and public transit between 0.32 and 0.50. These values are somewhat smaller than those used by Parry and Small (2009) but within the same order of magnitude.

5   Conclusions

In this paper we empirically analyzed a series of policies implemented in Spain between March and June 2011. The first policy was a reduction in the speed limit in highways from 120 km/hr to 110 km/hr. The second policy was an increase in the biofuel content of fuels used in the transport sector. The third measure was a reduction of 5%in commuting and regional train fares that resulted in two major transport systems reducing their overall fare for public transit.

Using a panel of 48 provinces with monthly data for four years, we analyzed empirically the impact of these policies on fuel consumption. We find evidence of a decrease of around 2-3% in gasoline consumption during the period in which train fares and the maximum speed limit was reduced. Unfortunately, we cannot untangle the impact attributable to each of these two policies. However, we suspect that most of the impact is coming from the speed limit reduction because most of the 48 provinces do not have commuting train services and regional train services account for only a small proportion of trips in the country. Therefore, it is unlikely that

the reduction in train fares would have had an important impact at the national level. Furthermore, in the specifications where transit fares are included directly –and therefore include the reduction in train fares– the coefficient associated with the period in which the speed limit reduction was in place remains significant and in the same value range.

We also find evidence that the biofuel content of gasolines does affect gasoline consumption. An increase in 1% point in the biofuel content in gasoline increases gasoline consumption by 0.3% to 0.7%. This result is consistent with experimental evidence that indicates a decrease in fuel efficiency as more biofuel is added to gasolines. As far as we are aware this is the first paper where non-experimental evidence is presented with respect to this effect.

Finally, we find a positive cross-price elasticity of gasoline demand with respect to transit fares of about 0.07 to 0.11. Although this implies that there is some degree of modal shift between public and private transport users, we do not find evidence of any effect on gasoline consumption of the fare reduction applied to all transit modes in two major public transport systems (Barcelona and Asturias). The fact that the policy was applied only temporarily and during a relatively short period of time is, in our opinion, the most likely explanation for this result.

The cross-price elasticities estimated in this paper are consistent with other estimates found in the literature. However, most of the reported estimates are quite dated (mid-70's) so it is encouraging to find that our more recent estimate indicates that this parameter has remained in the range reported by earlier studies, at least for the case of Spain. In addition, using data for Barcelona, our elasticity estimates imply a diversion ration of car use to public transit use of around 0.32 to 0.50 which is not very different from the values used by Parry and Small (2009) in their study of public transit subsidies in Los Angeles, Washington D.C. and London.

We believe that reporting a new estimate of the cross-price elasticity of car use (proxied by gasoline consumption) with respect to transit fares is important since one of the major efficiency arguments for the substantial subsidies that public transit receives in developed countries is based on the assumption that the cross elasticity of car use with respect to transit fares is positive. Therefore, the evidence presented in this paper is important for the evaluation of public transport subsidies particularly as the current economic crisis in Europe and other parts of the world are forcing authorities to reconsider these subsidies.

Finally, it should be noted that public transport subsidies may be justified on distributional grounds and not just with economic efficiency arguments. In particular, public transport users tend to be poorer than average.[22] However, if this is the case then it is not clear that a universal subsidy, as often applied in this sector, is preferred to mean-tested subsidies. Gómez-Lobo (2009) provides an interesting example for the case of Chile where mean tested transfers to compensate for rising public transit fares were applied.[23] Thus, even if distributional issues are important there is still a case for analyzing whether subsidies, as currently applied, are the best policy to deal with these social issues in this sector.

---

[22]Molnar and Mesheim (2010) provide recent evidence on this for the UK outside London.

[23]Serebrisky, et al (2009) discuss the distributional issues related to public transport in more detail.

References

[1] Asensio, J. (2002), 'Transport Mode Choice by Commuters to Barcelona's CBD', *Urban Studies*, 39(10), pp. 1881-1895.

[2] Bayraktar, H. (2005), 'Experimental and Theoretical Investigation of Using Gasoline-Ethanol Blends in Spark-Ignition Engines', *Renewable Energy*, 30(11), pp. 1733-1747.

[3] Cataluña, R., R. da Silva, E. Weber de Menezes, and R. Boeira Ivanov (2008), 'Specific Consumption of Liquid Biofuels in Gasoline Fueled Engines', *Fuel*, 87(15-16), pp. 3362-3368.

[4] Crookes, R. J. (2006), 'Comparative Bio-fuel Performance in Internal Combustion Engines', *Biomass and Bioenergy*, 30(5), pp. 461-468.

[5] Drukker, D. M. (2003), 'Testing for serial correlation in linear panel-data models', *Stata Journal*, (3)2: 168-177.

[6] Serebrisky, T., A. Gómez-Lobo, N. Estupiñan, and R. Munoz-Raskin (2009), 'Affordability of Public Transport: what do we mean, what can be done?', *Transport Reviews*, 29(6), pp. 715-39.

[7] Gómez-Lobo, A. (2009), 'A New Look at the Incidence of Public Transport Subsidies: a case study of Santiago, Chile', *Journal of Transport Economics and Policy*, 43(3), pp. 405-425.

[8] Hensher, D.A. and A.M. Brewer (2001), *Transport: An Economics and Management Perspective*, Oxford University Press: Oxford, New York.

[9] Judson, R.A. and A.L. Owen (1999), 'Estimating Dynamic Panel Data Models: a Guide for Macroeconomists', *Economic Letters*, 65, pp. 9-15.

[10] Kowalewicz, A. and M. Wojtyniak (2005), 'Alternative Fuels and their Application to Combustion Engines', *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, 219, pp. 2103-125.

[11] Litman, T. (2004), 'Transit Price Elasticities and Cross-Elasticities', *Journal of Public Transportation*, 7(2), pp. 37-58.

[12] Litman, T. (2012), 'Transit Price Elasticities and Cross-Elasticities', Victoria Transit Policy Institute, May.

[13] Matas, A. (1991), 'La demanda de transporte urbano: un análisis de las elastici-
dades y valoraciones del tiempo', *Investigaciones Económicas*,15(2), pp. 249-267.

[14] Molnar, J. and L. Mesheim (2010), 'A Disaggregate Analysis of Demand for
Local Bus Service in Great Britain (excluding London) using the National Travel
Survey', Draft, University College London and Institute for Fiscal Studies.

[15] Nickel, S. (1981), 'Biases in Dynamic Models with Fixed Effects', *Econometrica*,
49, pp. 1417-26.

[16] Parry, I.W.H. and K.A. Small (2009), 'Should transit subsidies be reduced?',
American Economic Review, 99, pp. 700-24.

[17] Rutz, D. and R. Janssen (2007), *Biofuel technology handbook*, WIP renewable
energies, München.

[18] Wooldridge, J. M. (2002), *Econometric Analysis of Cross Section and Panel
Data*, Cambridge, MA: MIT Press.

Últims documents de treball publicats

NUM	TÍTOL	AUTOR	DATA
13.03	How effective are policies to reduce gasoline consumption? Evaluating a quasi-natural experiment in Spain	Javier Asensio, Andrés Gómez-Lobo, Anna Matas	Febrer 2013
13.02	Performance in Post-compulsory Education: Evidence from Vocational and Academic Tracks	Cristina Lopez-Mayan	Febrer 2013
13.01	The Impacts of Social Networks on Immigrants' Employment Prospects: The Spanish Case 1997-2007	Luciana Méndez Errico	Gener 2013
12.12	Tax Incentives and Direct Support for R&D: What do Firms Use and Why?	Isabel Busom, Beatriz Corchuelo, Ester Martinez Ros	Desembre 2012
12.11	An Ex-post View of Inequality of Opportunity in France and its Regions	Jean-François Carpantier, Christelle Sapata	Desembre 2012
12.10	An Inquiry into the Use of Illegal Electoral Practices and Effects of Political Violence	Roxana Gutiérrez Romero	Novembre 2012
12.09	Determinants of Spanish Firms' Life Cycle and Job Creation: A Pseudo-Panel Approach	Roxana Gutiérrez Romero	Novembre 2012
12.08	Empirical Approaches to Inequality of Opportunity: Principles, Measures, and Evidence	Xavier Ramos, Dirk Van de gaer	Juliol 2012
12.07	Chaos and order in the contemporary city. The impact of urban spatial structure on population density and commuting distance in Barcelona, 1986-2001.	Ivan Muñiz, Miquel-Àngel García-López	Juny 2012
12.06	Openness and Technology Diffusion in Payment Systems: The Case of NAFTA	Francisco Callado, Jana Hromcová, Natalia Utrero	Juny 2012
12.05	Los límites de la compacidad urbana como instrumento a favor de la sostenibilidad. La hipótesis de la compensación en Barcelona medida	Ivan Muñiz, Daniel Calatayud, Roger Dobaño	Maig 2012
12.04	Economic structure and key sectors analysis of greenhouse gas emissions in Uruguay	Matías Piaggio, Vicent Alcántara, Emilio Padilla	Abril 2012
12.03	"Deuda hídrica y escasez. Análisis MRIO del uso del agua en Andalucía"	Francisco Navarro, Cristina Madrid	Febrer 2012
12.02	Recursos naturales y desarrollo en el Chad: ¿maldición de los recursos o inserción periférica?	Artur Colom-Jaén	Gener 2012
12.01	Construcción de un modelo Multi-Regional Input-Output (MRIO) medioambiental para Cataluña y el resto de España: Estudio del balance en CO2 incorporado en el	Francisco Navarro	Gener 2012