Green Cars Adoption and the Geography of Supply of Alternative Fuels

Giulia Pavan*

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Abstract

Easy availability of stations serving alternative fuels is an obvious concern for customers considering to buy a "green" car. Yet, the supply of fuel is seldom considered when analyzing the problem of fostering adoption of environmentally friendly vehicles. I develop and estimate a joint model of demand for green cars and supply of alternative fuels. Customers care about the density of stations offering the fuel their car runs on in their market; stations only supply fuels whose stock of circulating car is large enough to cover the fix cost of building an alternative fuel pump. I use this framework to compare the effectiveness of a subsidy to consumers who buy car running on alternative fuels to that of a subsidy to gas station installing alternative fuel pumps. Counterfactual simulations suggest that subsidizing fuel retailers to offer alternative fuels is an effective policy to indirectly increase low emissions cars sales and is more cost-effective than car prices' subsidies.

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*Department of Economics and Finance, University of Rome "Tor Vergata", Rome, Italy. E-mail: pavan.giulia@gmail.com. I am grateful to my advisor Andrea Pozzi for his advise and encouragement. I would also like to thank Paul Grieco, Cristian Huse, Ryan McDevitt, Laura Nurski, Franco Peracchi, Mathias Reynaert, Margaret Slade, Otto Toivanen, Tommaso Valletti, Jo Van Biesebroeck, Frank Verboven, Michael Waterson, conference participants at EARIE 2014, VII VPDE Workshop, EIEF-Unibo-IGIER Fourth Workshop in Industrial Organization, 6th ICEEE and seminar participants at University of Tor Vergata, CES-KU Leuven and IRVAPP for useful comments. I gratefully acknowledge financial support from the University of Tor Vergata and EIEF and the hospitality of KU Leuven. The usual disclaimers apply.

1 Introduction

Fostering the use of more environmentally friendly fuels, like Liquified Petroleum Gas (LPG) and Compressed Natural Gas (CNG), is named consistently as a policy priority across advanced economies. The implementation of such strategies must act simultaneously on two fronts: prompting consumers to buy cars running on alternative fuels and increasing the number of refill stations offering such fuels.[1] Although the interdependence of these two goals has obvious implications for the effectiveness of alternative fuel adoption policies, the role of fuel availability in green cars demand is seldom considered.

This paper develops and estimates a joint model of demand for cars and supply of fuels. On the demand side, I model consumers' demand for cars with particular emphasis on the choice of the type of fuel the car runs on. On the supply side, filling stations must decide whether to install alternative fuel pumps on top providing gasoline and diesel. The link between the two sides of the model is given by the fact that customers care about refilling cost. Hence, they take into account the price and the density of stations offering the type of fuel utilized when choosing their car. At the same time, filling stations will only be willing to install alternative fuel pumps if there are enough customers driving cars powered by alternative fuels in the area. This unified framework allows for the joint analysis of the effect of different environmental policies. In a counterfactual exercise, I compare the effectiveness of subsidizing the cost of installing LPG and CNG pumps (supply push) to that of

[1]For example, in Europe Directive 2009/28/EC of the European Parliament and of the Council sets a market share target of 10% of renewables in transport fuels. See European Directive (2014) which "sets out minimum requirements for the building-up of alternative fuels infrastructure, including recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and hydrogen". In the USA, 1990 Clean Air Act, CAFE standards (2002) and Energy Independence and Security Act (EISA) of 2007.

supporting the adoption of green cars (demand pull).

The setting for this study is the Italian market in 2012, which is characterized by an high share of new LPG and CNG cars and a heterogeneous dislocation of filling stations among provinces. I assemble a novel dataset which is uniquely suited to study the question, merging information from several sources. I collect data on car sales price, fuel type and other characteristics for newly purchased cars by private holders and I combine them with information on location and range of fuels offered by the universe of the filling stations active in 2012 in Italy.

The empirical analysis consists of two steps. First, I set up a standard discrete choice demand model, assuming that car choice depends, among other things, on fuel cost and filling station density. I specify a nested logit, considering cars with the same fuel-type version closer substitutes than other vehicles. Next, I model gas stations' decision to add alternative fuel pump as an entry decision in the spirit of Bresnahan and Reiss (1987) and Berry and Waldfogel (1999). The number of alternative fuel retailers arises as the outcome of an entry game of complete information, where variable profits accrued to a firm depend on the estimates of the demand side of the model.

The main takeaway of the demand model is that consumers are sensitive to fuel availability and this effect is especially strong for alternative fuels. That is, the effect of raising 1% density of filling stations for alternative fuels increases demand for green cars by 0.78% and 0.84% for LPG and CNG cars respectively. The impact of a similar variation on the density of traditional fuels on diesel and gasoline cars is 0.36 % and 0.5%.

On the gas station side, estimation implies that the fixed cost of adding an LPG pump is €40,028, an estimate that is consistent with values reported by experts of the sector.

Lastly, I use the demand and entry estimates to simulate the effects of two alternative policies to boost alternative fuel cars adoption: A 5% rebate on the price of LPG cars and a 10% subsidy to the installation of LPG pumps.

Subsidizing consumers would increase the share of LPG cars by 8.9%, leading to a 0.8% increase in the density of LPG filling station. Subsidizing gas stations would increase the availability of LPG by 10% which increases LPG cars share by 9.2%. These results suggest that subsidizing fuel retailers to offer LPG is an effective policy to indirectly increase LPG vehicle sales and it is more cost-effective than policies acting directly on car prices, although market differences should be taken into account. This is the first paper to propose a full-fledged demand and supply model to study the incentives to alternative fuel adoption. Shriver (forthcoming) considers a similar framework but with a more stylized demand model, where price does not play a role. Huse and Lucinda (2014) estimate a rich model for car demand, including fuel type among the relevant characteristics. However, they do not consider the role of fuel availability and do not model filling station decisions. Furthermore, this is one of the first papers to consider fuel availability as a determinant for the demand of cars. Langer and McRae (2013) provide compelling evidence that this dimension plays a key role in the alternative fuel car segment.

The policy question this paper addresses relates to a vast literature that studies government intervention to limit fossil fuels consumption and promote green fuels. For instance, Bento et al. (2009) examine the gas-tax impact on fuel consumption, distinguishing changes in fleet composition and vehicle miles traveled. Goldberg(1998) and Austin and Dinan(2005) examine the effect of the CAFE standards on new cars adoption while Jacobsen (2013) studies the impacts in the used car market. Closer to my research question, Beresteanu and Li (2011) investigate the effects of federal income tax incentives on demand for hybrid vehicle.

The paper is organized as follows. In Section 2 I provide information on the green car market in Italy and present data sources. Section 3 and 4 discuss the model and the econometric specification. Section 5 shows the results and counterfactual analyses. Section 6 concludes.

2 Data and background

2.1 Data

I combine data from multiple sources to construct two main databases used in the analysis. The first contains information on quantities, prices and characteristics of all the cars sold in Italy in 2012; the second one includes details on location and fuel offer for Italian gas stations in the same year.

Automobile sales, prices and characteristics

I obtain car sales at the province level from the vehicle registration database maintained by ACI (vehicle registration is mandatory in Italy). I focus on private purchases and drop corporate car purchases, this leaves 882,641 cars sold in 2012. Prices and other characteristics have been collected from industry publications ("*Quattroruote*" and "*Panoramauto*"). The price information includes the list price, the registration tax (IPT) and the amount due for the annual circulation tax. The latter two components introduce variation across provinces in overall cost of buying a car. Moreover, IPT and registration tax are usually lower for alternative fuel tax. The other car characteristics I consider are: horse power, engine size, type of fuel, fuel consumption, length, tank capacity and weight.

Since the databases report data at different level of aggregation (sales data are not broken down by optionals). I match cars' sales with price and characteristics of the

standard equipment.[2]

Gas station

The location and characteristics of filling stations were provided by *prezzibenzina.it*, an Italian website which offers information about retail gasoline prices and location as posted by website visitors and verified by the staff. Since 2009 their database coverage percentage was above 90% of Italian filling stations. For the 19,892 filling stations active in Italy in 2012, I observe the fuels they offer, their location, I use the date in which they entered/exit in the database as a proxy of the entry/exit in the market. I cross check these data with the ones provided by *www.ecomotori.net*, which lists all the station offering alternative fuels and those reported in the Italian Competition Authority Investigation on off-brand conventional fuels filling station (AGCM, 2013).

2.2 Italian Green Cars and Alternative Fuels Market

Alternative fuels (AF) include, among others, ethanol, biodiesel, compressed and liquified natural gas, electricity and hydrogen. I focus on Compressed Natural Gas (CNG), or methane, and on Liquefied Petroleum Gas (LPG), or autogas, which represent the bulk of the market in Italy. Italy represents a very interesting market, since the share of AF cars (Figure 1), as well as the number of filling stations offering alternative fuels, is increasing. Although AF are different in nature and in their environmental impact, most of them not only produce much less tailpipe pollution and CO2 emissions, but they can also be significantly cheaper to run. The market share of these types of cars is historically higher in Italy than the rest of Europe: 77% of CNG European cars and 26% of LPG ones are registered in Italy. Further, Italian

[2]Performance characteristics are the same for all the equipments since the engine is the same.

industry sector accounts for excellence both in engine transformation and in storage and distribution. Finally, there has been a significant legislative activity both on the supply of alternative fuels, with the liberalization of the retail fuel market,[3] and on the green car market, which benefited for generous incentives in 2009.[4]

[Figure 1 about here.]

The left panel in Figure 1 shows the share of cars sold in Italy from 2002 to 2012 by fuel type. The share of AF cars (LPG and CNG) shows a positive trend, in particular after 2006. Looking at the right panel in Figure 1, which displays quantities, it is clear that the increase in the share of AF cars is due to both an increase of the total quantity sold in the market and to a decrease of new car registrations in the Italian market since 2007. The peak registered in 2009-2010 could be explained by the scrappage scheme described above. The incentive, in fact, could be claimed for purchases up to the first quarter of 2010. Although the whole sector was subsidized, only the additional incentives dedicated to AF cars seems to affect the quantity of new cars and the effect on the LPG is much stronger than the one on the CNG. This evidence is particularly interesting in order to study the role of the diffusion of filling pumps. As a matter of fact, it could be claimed that LPG cars were more reactive

[3] Constitutional act 18 ottobre 2001, n. 3. Fuels retailing is not considered a public service any more and jurisdiction in regulating filling stations entry is issued to regions.
Law 6 Agosto 2008 n. 133 removed bureaucratic barriers to entry.
The most recent regulation of the sector is the decree "Urgent provisions for competition, development of infrastructure and competitiveness" GU n. 19, 24 April 2012. It further liberalizes the sector and provides for the obligation of a decree to be issued by the Ministry of the Interior to "modernize" and amend the regulations pertaining to self-service and natural gas multi-dispensers.

[4] Dl 10 febbraio 2009, n.5 "Misure urgenti a sostegno dei settori industriali in crisi" - GU n. 34 11 febbraio 2009.
It introduced a scrappage scheme for Euro4 new cars (€1,500) for traditional fuels. This incentives could be combined with purchase incentive of at least €1,500 for a new car running on LPG, CNG, electricity or hydrogen.

to price incentives since their filling stations density was higher.[5]

The drop in volumes for AF cars in 2011 can be linked to the scheme that likely caused intertemporal substitution of demand due to the widespread belief that the incentive was temporary. In order to better understand the role of fuel price in the choice of green cars, Figure 2 shows the fuel cost per 100 km for an average "compact" car in order to make prices comparable (fuel prices cannot be compared: CNG is not sold in liters and fuel efficiency varies per fuel). CNG is the cheapest fuel, however LPG is still cheaper than gasoline. Moreover, gasoline and diesel price show an increasing trend, wile AF price trend is more stable. Therefore, through time the convenience motive to buy an AF car gets stronger.

[Figure 2 about here.]

Figure 3 shows the diffusion of alternative fuel cars over the country (considering only private owners). We can see that LPG cars are sold all over the country while CNG cars are particularly concentrated in some regions.

[Figure 3 about here.]

Fuel price differences across regions do not seem to play a role in explaining this heterogeneity since alternative fuel prices are not disperse (the LPG and CNG price in 2012 were respectively 0.83€/liter and 0.98€/kilogram with a standard deviation of 0.053 and 0.037).[6] Geographical differences seem to play a stronger role in the heterogeneous development of AF networks. Namely, highlands are not covered by the networks and South and Island never developed a CNG network. Further, the

[5] See Appendix A, Table A.3.

[6] Notice that LPG and CNG are measured respectively in liter and in kilogram. Therefore, it is not possible to compare them directly. However, CNG is usually cheaper per kilometer to run than LPG, as shown above.

maps show first evidence of the strong correlation between AF cars share and the pump density (the black dots are the alternative fuel pump stations operating in 2012), which is also confirmed in Figure 4, where scatterplots between the share of AF cars sold in 2012 and the AF filling stations' density are presented. It already shows the strongly significant positive correlation which will be further investigate in what follows.

[Figure 4 about here.]

3 Empirical Model

The empirical model describes consumer demand for cars and entry choices in alternative fuel retail industry made by filling stations. The model is static and the timing is as follows. The period starts with a given stock of registered cars for each type of fuel in each market. Then, existing traditional fuel stations simultaneously decide whether to add alternative fuel pumps, given the expected local market demand of fuel and the number of competitors. The expected demand of fuel depends both on the stock of already circulating cars and on the number of expected newly registered cars. Lastly, a consumer decides whether to buy a car with a certain fuel, given the number of filling stations in the market at the time in which she undertakes the decision. Consumers behave myopically, that is, they do not form expectations on the evolution of the number of circulating cars and filling stations.[7]

I introduce the model starting from the last stage. Identification of both parts of the

[7]This assumption is dictated by the fact that the model is static.
Myopic behavior when purchasing durable goods that vary in energy costs have been firstly studied by Hausman (1979). Although the focus of this literature is the energy cost and not its availability, the absence of conclusive evidence suggests that this assumption could be considered realistic. For a detailed overview of the literature, see Busse et al (2010)

model is discussed in section 4.

3.1 Demand

Demand is modeled as a standard discrete choice problem with differentiated products. I assume that the consumer maximizes a linear utility, taking into account the characteristics of the vehicles.

I consider $m = 1, ..., M$ local markets (provinces), each with $h = 1, ..., H$ households. For each market I observe the quantity of sold cars; product characteristics for a car model $j = 1, ..., J$, which install a specific fuel f, are the same across markets. I assume that each year households can choose to buy a vehicle among the set of cars available in the market, or not to buy a new car.

Market size is given by the total number of households living in the province, scaled to accommodate for the fact that cars are durable goods.[8] I implement a nested logit model where cars are nested according to the fuel they run on.[9] Products are grouped in $F + 1$ exhaustive and mutually exclusive nests. The utility of the outside good (not buying a car) is normalized to zero. I define the indirect utility of a consumer h in market m from buying a car model $j(f)$, as a function of product characteristics,

[8] I assume that households consider to buy a new car every 4 years, given evidences on Italian car market.

[9] Although alternative fuel cars are mostly bi-fuel, I assume the consumers who choose these type of vehicles are mainly interested in the alternative fuel setting of the car, given the price gap between these fuels and gasoline (see Figure 2).

fuel characteristics and unknown parameters.

$$u_{hj(f)m} = \delta_{j(f)m} + \nu_{hj(f)m} =$$
$$= \alpha p_{j(f)m} + x_{j(f)}\beta + n_{fm}\lambda + \xi_{j(f)m} + \zeta_{hfm} + (1-\sigma)\varepsilon_{hj(f)m},$$
$$h = 1, \ldots, H_m,\ j = 1, \ldots, J,\ m = 1, \ldots, M, f = 1, \ldots, F. \quad (1)$$

Where $\delta_{j(f)m} = \alpha p_{j(f)} + x_{j(f)}\beta + n_{fm}\lambda_h + \xi_{j(f)m}$ is the mean utility; $p_{j(f)m}$ is the price of car model installing fuel f, $j(f)$, in market m [10], $x_{j(f)}$ is a vector of observed car characteristics. n_{fm} is the number of filling stations offering the fuel compatible with the car $j(f)$, $\xi_{j(f)}$ represents unobserved car characteristics.
To capture the correlation in taste across cars with similar fuels, I nest cars by the type of fuel f they run on. The individual specific part of the utility given by car j in market m is $\nu_{hj(f)m} = \zeta_{hfm} + (1-\sigma)\varepsilon_{hj(f)m}$, where $\varepsilon_{hj(f)m}$ is an i.i.d. extreme value term and ζ_{hf} is common to all products in group f and follows distributional assumption of a nested logit which depends on σ (Cardell, 1997).

3.2 Entry

The entry model regards the choice of filling station selling traditional fuels to enter the alternative fuel market adding a pump for LPG or CNG. I model this choice as a game of complete information in the spirit of Bresnahan and Reiss (1991). I consider alternative fuel market as a homogeneous good industry[11] and assume that all the gas station operating in 2012 are potential entrants in the alternative fuel market. Post entry profits accruing to firm i from offering a type of fuel in market

[10] price is indexed by m because the precence of local taxes makes it market specific
[11] Alternative fuels are not differentiated in regular and premium fuel as traditional ones.

m take the following form:

$$\Pi_{im} = \underbrace{(p_{im} - c_i) l_i(p_{im}, p_{-im}, n_m)}_{VP_i(n_m)} - F_{im} \tag{2}$$

where p_{im} represents the price per liter at which the firm sells the fuel and c_i is the marginal cost. The residual demand faced by the filling station is denoted by l_i (since it measures the liters sold) and depends on the price set be the firm, those chosen by its competitors and the number of firms in the market.

In order to enter the market firms must pay a fixed cost F_{im} (independent from the number of firms in the market) to cover installation of new infrastructure.

In order to identify the parameter of post-entry profits I make the further simplifying assumptions (Berry and Waldfogel, 1999):

- Within markets, firms have identical marginal and fixed costs.[12]
- Drivers split their fuel consumption equally across gas station[13] in a given market so that demand for fuel faced by a generic station in market m is:

$$l(n_m) = \frac{1}{n}[k_m(q(n_m) + Q_m)] \tag{3}$$

where k_m is the average fuel consumed by a car compatible with the fuel offered by the station (ex. LPG) and Q_m and $q(n_m)$ are, respectively, the stock of already circulating cars consuming the fuel sold by the station and the number of newly registered cars consuming the fuel. The latter, as illustrated in the

[12]Marginal costs are strongly related to international fuel prices and are set by large companies at national level. Fixed costs are mostly related with building costs and new infrastructures are built by specialized firms.

[13]These assumptions are coherent with both Salop(1979) circle competition and with Cournot competition, which are the two way of modeling competition in this market.

demand model, will depend on the number of filling stations selling the fuel in the market.

Hence, I can rewrite profits as

$$\Pi_{im} = (p_m - c)l(n_m) - F_m = vp_m(n_m) - F_m \tag{4}$$

4 Identification and Estimation

4.1 Demand

In order to estimate the mean utility parameters in (1), α, β and λ, I follow Berry (1994). I obtain a linear estimating equation for the logarithm of the market share of car j relatively to the market share of the outside good:

$$\ln\left(\frac{s_{jm}}{s_{0m}}\right) = \alpha p_{jm} + x_j\beta + n_{fm}\lambda + \sigma \ln s_{j|fm} + \xi_j \tag{5}$$

where $s_{j|fm}$ is the market share of product j within the nest f and p_{jm} is the price of the model j in the market m. In the demand specification I include both physical characteristics, such as length, size of the tank and performance characteristics, such as the ratio of power over weight and the power over the engine size. The only time varying characteristic is the fuel cost for 100km computed as the product of time-invariant fuel efficiency (kilometers per liter) of the car and the price of the fuel the car runs on, which instead varies in time. I also include month, province and brand fixed effect as well as model fixed effect.

I take into account the endogeneity of price and market share of product j within the group f. As it is standard in the literature (Berry et al., 1994), I use as instruments

the sum of the characteristics of cars used in the regression produced by the same firm and produced by other firms.[14] Given the timing of the model and the characteristics of the filling station entry decision (it takes more than one year to open a new filling station), I consider the density of filling station as an exogenous variable. In Appendix C I perform check of the robustness of my results to this assumption.

4.2 Entry

Given the assumption made in section 3.2, the zero profit condition implies that we will observe n_m filling station selling a particular fuel in market m if and only if $F_m = vp(n_m)$. I exploit several data sources to quantify the variable profit components so that I can treat them as data. I will instead assume that fixed entry costs are not observed. The entry model is estimated exclusively for LPG because data on CNG wholesale price are not available.

I use data from the *Automobile Club d'Italia* on the stock of existing cars by fuel in each province (Q_m in equation (3)) and information provided by the Ministry of Economic Development on average LPG consumption per provinces (k_m). Retail price (p_m) is provided by ISTAT and LPG wholesale price (c) is provided by specialized magazine "*Staffetta Quotidiana*" combining data on price of butane, propane and US dollar euro exchange rate, then I added taxes as provided by "Agenzia delle dogane e dei monopoli". Lastly, I compute the quantity of new cars ($q(n_m)$) given the functional form specified in the demand model.

I then assume that the logarithm of the fixed cost of entry in market m is:

$$ln(F_m) = \gamma W_m + \omega \nu_m \tag{6}$$

[14]Instead of fuel cost, fuel efficiency is used for computing the instruments, since it is constant across markets.

where γ and ω are the parameters we would like to estimate and ν_m is a standard normal. W_m is a vector of market specific observable cost shifters. Namely, I include dummies which identify the presence of a regional law imposing the supply of one alternative fuel and geographical dummies. Equation (6) implies that n_m entrants in market m are consistent with the following inequalities.

$$\frac{ln(\widehat{vp_m}(n_m+1)) - \gamma W_m}{\omega} \leq \nu_m \leq \frac{ln(\widehat{vp_m}(n_m)) - \gamma W_m}{\omega} \tag{7}$$

Where $\widehat{vp_m}(n_m)$ are the variable profits quantified using data sources mentioned above.

The distributional assumption on ν_m allows me to write the following likelihood for the event that n gas station decide to offer LPG in the market m.

$$\mathcal{L}(\theta) = \sum ln\left(\Phi\left(\frac{ln(\widehat{vp_m}(n_m)) - \gamma W_m}{\omega}\right) - \Phi\left(\frac{ln(\widehat{vp_m}(n+1)) - \gamma W_m}{\omega}\right)\right) \tag{8}$$

The parameters of fixed cost function (γ) are retrieved as those that maximize the likelihood.

5 Empirical Results

5.1 Demand

In Table 1 I report the coefficients estimated using a standard OLS logit regression, an IV logit and IV nested logit.

[Table 1 about here.]

The potential market is defined following Berry, Levinsohn and Pakes (1995), who consider the number of households as potential purchasers. Here, I divide it by 48, since I have monthly data and assuming that households buy a new car every 4 years. I also tried different specifications, assuming households consider whether to buy a car every 5 or 6 years and results are in line with the ones presented.
Price has a significant and negative impact on consumers' mean utility. In particular, it is -3.12 in the nested logit, which is in line with other estimates of European cars' market (Goldberg and Verboven, 2001).
The ratio of power and weight and the length have a positive and significant effect on the mean utility, while the effect of tank dimension and the ratio of power and engine volume have a less clear effect. The estimate of fuel costs parameter is positive and significant, suggesting that one possible rationalization of this puzzling result is that consumers are more sensitive to the reduction of costs related to deviations from their optimal route than fuel cost saving.
This is further confirmed by the analysis of the coefficients on filling stations availability. I include pump density interacted with fuel dummies in order to allow for a different relationship between fuel availability and cars demand. This specification would possibly capture an S-shaped relationship between fuel availability and cars demand, given that density of filling station is mostly homogeneous among markets, keeping the linearity of the mean utility. All density parameters are positive and significant in the three specifications (the additional effect of diesel is negative but the overall effect is positive). However, increasing density of LPG and CNG has a positive effect, greater in magnitude with respect to the traditional fuels one. In the nested model, the effect of rising by 1% the density of filling stations for alternative fuels increases demand for green cars by, respectively, 0.78% for LPG cars and 0.84% for CNG cars, while the impact of the same variation in the density of traditional

fuels on diesel and gasoline cars is respectively 0.36 % and 0.5%.
The nesting parameter is significantly different from zero and satisfies the restrictions for consistency with random utility maximization in a nested logit ($0 < \sigma < 1$). The results imply that consumer preferences are more strongly correlated across vehicles with the same fuel-type. However, the small nesting parameter, equal to 0.3, still allows substitution patterns across fuels.
Table 2 lists the average own and cross-price elasticities of demand. Note that along the main diagonal are reported the average price elasticities of demand for the same fuel, which are higher than cross fuel elasticity. That is, consumers perceive cars with the same fuel closer substitutes than cars with different fuels, which is particularly true for alternative fuel cars (the elasticities within nests are higher for AF cars).

[Table 2 about here.]

5.2 Entry

Table 3 reports estimates of the parameters of an ordered probit obtained by exploiting post-entry information on variable profit, holding demand estimates fixed. The constant term parameter represents the logarithm of the mean of the distribution of the fixed costs and ω is the estimated standard error of the logarithm of fixed costs. Therefore, the implied mean fixed cost is $40,028$€, which is about half the actual fixed cost reported by experts of the sector for adding a new pump offering LPG.[15] ω is equal to 0.35, which implies a fixed cost variance depending on market characteristics greater than one-quarter of the mean fixed cost. Geographical location does not to play a crucial role in the determination of fixed costs.

[Table 3 about here.]

[15] The figure was reported by an expert of Kalorgas s.p.a.

5.3 Counterfactual: car price rebates vs. filling station subsidies

I use the estimated parameters to compute the effect of different policy incentives to adopt alternative fuel vehicles. I perform policy counterfactuals to compare the effectiveness of supporting the adoption of green cars by offering car price rebate (demand pull) to that of subsidizing the cost of installing LPG pumps[16] (supply push). First, I consider the effect of a 5% price reduction of LPG cars on their market share. The price rebate of 5% is in line with other rebate programs in Europe (Huse and Lucinda, 2013). I distinguish between a "direct effect" (keeping fixed the number of filling stations) and its "indirect effects", which concerns the effect of the increased market share on the entry choice until a new equilibrium is reached.

I compare this outcome with that from reducing the fixed costs (γ_0) by 10%. I considered a reduction by 10% since it is applied to a small number of firms. Therefore, the total expenses would result comparable to the previous policy. In this exercise, the equilibrium number of LPG cars filling stations is the smallest integer value which satisfy condition (7) where $\widehat{vp}(n)$ is computed using (12). I refer to this as the "direct effect". I determine the "indirect effects" by computing the estimated quantity of alternative fuel cars given the effect of the higher number of filling stations $q_{mf}(n)$[17] and then the number of filling stations which satisfy condition (7) implied by the new quantity of cars, until a new equilibrium is reached.

Notice that, computing the counterfactuals, I consider as the status quo the cars quantity and filling station number implied by the model in order to isolate the variation due to the policy from the variation implied by the estimating error. Ac-

[16] I limit counterfactual analysis to LPG cars, since data availability only allows to estimate entry of LPG stations.

[17] See Appendix B, equations (11) and (12)

cordingly, the outcomes of the counterfactuals I am interested in are changes, not levels.

Table 4 reports the mean percentage difference between the estimated market shares under the baseline model and price reduction of alternative fuel cars by 5%.

[Table 4 about here.]

The "direct effect" of the policy implies an increase in LPG market share by 7.9%. The effect of the policy on other fuel type cars market share is negligible and mirrors the substitution patterns showed in Table 2. That is, the extra market share of LPG cars comes mainly from the outside good. The small size of the "indirect effect" of the policy suggests that the change in demand is not followed by an increase in filling stations availability.

Table 5 reports the variation in the estimated number of pumps per square kilometers under the baseline situation and after a decrease of the fixed costs by 10%. This type of incentive would increase the density of pumps by 9.2% on average. The "indirect effect" of the policy on the share of LPG cars is in line with the previous policy (9.2% increase of the market share under this policy, against an increase by 8.9% under the previous policy). This second policy implies feedback effectiveness: the increasing number of filling stations implied by the "direct effect" affects LPG vehicles market share, which further push the filling station entry. This is a crucial difference with the previous policy, which "direct effect" on the car market has small effect on filling station entry.

[Table 5 about here.]

Lastly, I perform a back-of-envelope calculation to compare the cost effectiveness of the two policies. Given the price rebate "direct effect", there would be about

120 thousands cars eligible for subsidies. Since the average price of LPG car is 16.5 thousands of euros, a 5% price rebate program would cost about one 98.5 million euros in government revenue.

The estimated number of filling station would be equal to 3320, namely 8.1% more than the existing one. Subsidizing the whole retailing sector would cost about 12 million euros. Subsidizing only the new filling stations would cost about 1 million euros. Therefore, this policy would be significantly less expensive for the government. Although the mean effect of the second policy is slightly higher and the feedback effectiveness could suggest a stronger long-run effect, geographic heterogeneity of these effects is an important issue that should be taken into account. In order to visualize the heterogeneous effects of the two policies, I report in Figure 5 the total average effects of the two counterfactuals LPG market share in each Province.[18] The maps show that price subsidies have a more homogeneous effect all over the country, while the subsidies to filling stations have very strong effect in some provinces and almost no effects in other provinces.

[Figure 5 about here.]

Province heterogeneity is exacerbated when the total effect of the policy is taken into account, since the higher is the variation of the demand, the stronger is the effect on the entry choice. The high variance of the results mirrors the huge heterogeneity of Italian provinces already discussed in Section (2.2). In fact, the subsidies to filling stations are more effective where the initial market share and filling station density are higher, while price subsidies effects are uncorrelated with initial conditions.[19]

[18]In appendix D I further investigate this issue.

[19]result that contradicts the hypothesis developed from 2009 evidences. Comparison of policies effects on CNG market would clarify the relationship between initial condition and policy effectiveness.

The main takeaway of this comparison is that the effectiveness of the two policies should be evaluated at the local level.

6 Conclusion

Using a rich database on cars sold and filling stations locations in 2012, I document the importance of fuel stations availability in the choice of adopting alternative fuel vehicles. I use the model to compare two different policies to foster green cars adoption. First, I consider the effect of a price-subsidy on the adoption of alternative fuel cars. Then, I consider fixed costs reduction for new pumps supplying alternative fuels.

These results suggest that subsidizing fuel retailers to offer LPG is an effective policy to indirectly increase LPG vehicle sales, and is more cost-effective than policies acting directly on car prices. Moreover, the feedback effectiveness of this policy would suggest a long-run effect of this policy that could not be expected in the price rebate case given the lack of feedback effects suggested by the counterfactual exercise. However, relevant market heterogeneity suggest that policies comparison should be performed at more local level.

These findings highlight that policymakers ought to take into account the infrastructure availability in the markets they are regulating.

References

[1] AGCM (2013). *Impianti di distribuzione carburanti indipendenti.* (IC44)

[2] Anderson, S.T., Parry, I. W. H., Sallee, J.M., Fischer, C. (2011). Automobile Fuel Economy Standards: Impacts, Efficiency, and Alternatives. *Review of Environmental Economics and Policy*, 5(1), 89–108.

[3] Anderson, S T., Sallee. J.M. (2011) Using loopholes to reveal the marginal cost of regulation: The case of fuel-economy standards. *American Economic Review*, 101(4) 1375-1409.

[4] Austin, D., Dinan, T. (2005). Clearing the air: The costs and consequences of higher CAFE standards and increased gasoline taxes. *Journal of Environmental Economics and Management*, 50(3), 562-582.

[5] Bento, A., Goulder, L., Jacobsen, M., von Haefen, R. (2009) Distributional and Efficiency Impact of Increased U.S. Gasoline Taxes. *American Economic Review*, 99(3), 667-699.

[6] Berry, S. (1994) Estimating Discrete-Choice Models of Product Differentiation. *The RAND Journal of Economics*. 25 (2), 242–262.

[7] Berry,S., Levinsohn, J., Pakes,A. (1995). Automobile prices in market equilibrium. *Econometrica*, 63(4), 841-890.

[8] Berry, S., Waldfogel J. (1999) Public radio in the United States: does it correct market failure or cannibalize commercial stations? *Journal of Public Economics* 71(2): 189-211.

[9] Beresteanu, A., Li, S. (2011) Gasoline Prices, Government Support, and the Demand for Hybrid Vehicles in the United States. *International Economic Review* 52(1) : 161-182.

[10] Bresnahan, T. F., Reiss P. C.(1991). Entry and competition in concentrated markets. *Journal of Political Economy*, 99(51):977–1009.

[11] Busse, M.R., Knittel C.R., Zettelmeyer, F. (2010) Are consumers myopic? Evidence from new and used car purchases. *American Economic Review*, 103(1): 220-256.

[12] Clean Air Act Amendments of 1990. 104 Stat. 2468. P.L. 101-549.

[13] Directive 2005/55/EC of the European Parliament and of the Council of 28 September 2005.

[14] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008.

[15] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009.

[16] Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014. infrastructure (Text with EEA relevance).

[17] Energy Independence and Security Act, 2007. Public Law 110-140.

[18] Goldberg, P. K., (1998) The Effects of the Corporate Average Fuel Efficiency Standards in the US, *Journal of Industrial Economics*, 46 (1), 33.

[19] Goldberg, P. K., Verboven F. (2001) The Evolution of Price Dispersion in the European Car Market. *Review of Economic Studies*. 68(4), 811–48.

[20] Greene, D. L. (1996) Survey evidence on the importance of fuel availability to the choice of alternative fuels and vehicles. *Energy Studies Review*, 8, 215-231.

[21] Greene, D., Patterson, P., Singh, M., Li, J. (2005). Feebates, Rebates and Gas-Guzzles Taxes: A Study of Incentives for Increased Fuel Economy. *Energy Policy*, 33(6), 757-775.

[22] Gazzetta Ufficiale n. 34 dell'11-2-2009. DECRETO-LEGGE 10 febbraio 2009, n. 5. Misure urgenti a sostegno dei settori industriali in crisi.

[23] Jacobsen, M. (2013) Evaluating U.S. Fuel Economy Standards in a Model with Producer and Household Heterogeneity. *American Economic Journal: Economic Policy*, 5(2), 148-187.

[24] Hausman, J. A. (1979). Individual discount rates and the purchase and utilization of energy-using durables. *The Bell Journal of Economics*, 33-54.

[25] Huse, C., Lucinda, C. (2014) The Market Impact and the Cost of Environmental Policy: Evidence from the Swedish Green Car Rebate. *The Economic Journal*, 124: F393–F419.

[26] Katz, M. L., Shapiro, C. (1985). Network externalities, competition, and compatibility. *American Economic Review*, 8(2):93–115.

[27] Klier,T. and Linn, J. (2010). The Price of Gasoline and New Vehicle Fuel Economy: Evidence from Monthly Sales Data. *American Economic Journal: Economic Policy*, 2(3), 134-153.

[28] Langer, A., McRae S. (2013) Fueling Alternatives: Evidence from Naturalistic Driving Data. Working paper.

[29] Mc Fadden D.(1973) Conditional Logit Analysis of Qualitative Choice Behavior. in *Frontier of Econometrics*, ed. by P. Zarembka. New York: Academic Press.

[30] Nevo, A. (2000). A practitioner's guide to estimation of random-coefficients logit models of demand. *Journal of Economics & Management Strategy*, 9(4), 513-548

[31] Shriver, S. (forthcoming) Network Effects in Alternative Fuel Adoption: Empirical Analysis of the Market for Ethanol. *Marketing Science*.

[32] Verboven, F. (1996) International price discrimination in the European car market. *The RAND Journal of Economics*, 27(2): 240-268.

Tables and Graphs

Table 1: Demand Results

VARIABLES	(1) Logit Demand	(2) IV Logit Demand	(3) IV Nested Logit
price	-0.02	-0.10	-0.10
(thousands of €)	(0.0007)	(0.02)	(0.02)
power/weight	-9.75	5.83	8.31
(kw/kg)	(0.26)	(2.83)	(2.10)
fuel cost	-0.04	0.03	0.04
(€/100km)	(0.002)	(0.01)	(0.01)
length	-0.002	0.005	0.006
(cm)	(0.0002)	(0.001)	(0.001)
tank	0.007	0.02	0.02
(dm^3)	(0.0006)	(0.002)	(0.002)
power/engine volume	-0.003	-0.004	-0.003
(kw/cc)	(0.0001)	(0.0002)	(0.0001)
(pump/kmsq)*LPG	0.25	0.26	0.34
	(0.007)	(0.01)	(0.01)
(pump/kmsq)*CNG	0.96	0.99	1.21
	(0.03)	(0.03)	(0.03)
(pump/kmsq)*diesel	-0.01	-0.005	-0.01
	(0.0003)	(0.0004)	(0.0003)
(pump/kmsq)	0.02	0.02	0.03
	(0.001)	(0.001)	(0.001)
LPG	0.14	0.92	0.18
	(0.14)	(0.14)	(0.11)
CNG	-0.18	0.27	-0.10
	(0.08)	(0.08)	(0.06)
diesel	0.05	0.52	0.61
	(0.09)	(0.09)	(0.06)
sigma			0.30
			(0.02)
R^2	0.53	0.51	0.73
Observations	267524	267524	267524
meanelasticity	-0.41	-2.41	-3.12

Note: All specifications include province, month and model fixed effects. Standard errors in brackets.
In column (2) price is instrumented while in column(3) price and within group market share are instrumented. The instrumental variables are the sum of the characteristics of cars used in the regression produced by the same firm and produced by other firms.

Table 2: Substitution pattern

fuel group	average own elasticity	average cross elasticity wrt car with fuel: LPG	CNG	diesel	gasoline
LPG	-2.44	0.06	0.002	0.001	0.001
CNG	-2.81	0.001	0.13	0.001	0.001
diesel	-3.70	0.001	0.002	0.01	0.001
gasoline	-2.38	0.001	0.001	0.002	0.01

Note: The table lists the average own and cross-price elasticities of demand for each nest. Average price elasticity is different for each fuel. The pattern of the cross-price elasticities reflects model assumptions: the average cross-price elasticities between same-fuel cars are higher than the cross-price elasticities between cars with different fuels. This pattern is much more pronounced for alternative fuel cars.

Table 3: Entry Results

Variable	coefficient	standard error
Constant	-3.22	0.41
regional law	-0.26	0.04
north east	-0.27	0.22
center	-0.15	0.22
south	-0.22	0.21
islands	-0.09	0.26
ω	0.35	0.05
Observations	110	

Note: The table reports the coefficients of the ordered probit estimated through maximum likelihood. The main coefficient of interest is the constant. The implied mean fixed cost is €40,028. I am not reporting the marginal effects, since I am only interested in coefficients' signs.

Table 4: LPG car price rebate counterfactual

	Avg Δ (%)	MinΔ (%)	MaxΔ (%)
	Direct effect		
LPG	7.9 %	0.0 %	8.8 %
CNG	-0.6 %	-8.0 %	0.0 %
diesel	-0.6 %	-8.0 %	0.0 %
gasoline	-1.0 %	-8.0 %	0.0 %
	Direct and Indirect effect		
LPG	8.9 %	0.0 %	17.5 %
CNG	-0.7 %	-8.0 %	0.0 %
diesel	-0.7 %	-8.0 %	0.0 %
gasoline	-0.7 %	-8.0 %	0.0 %
pump/kmsq	0.8%	0 %	3.6 %

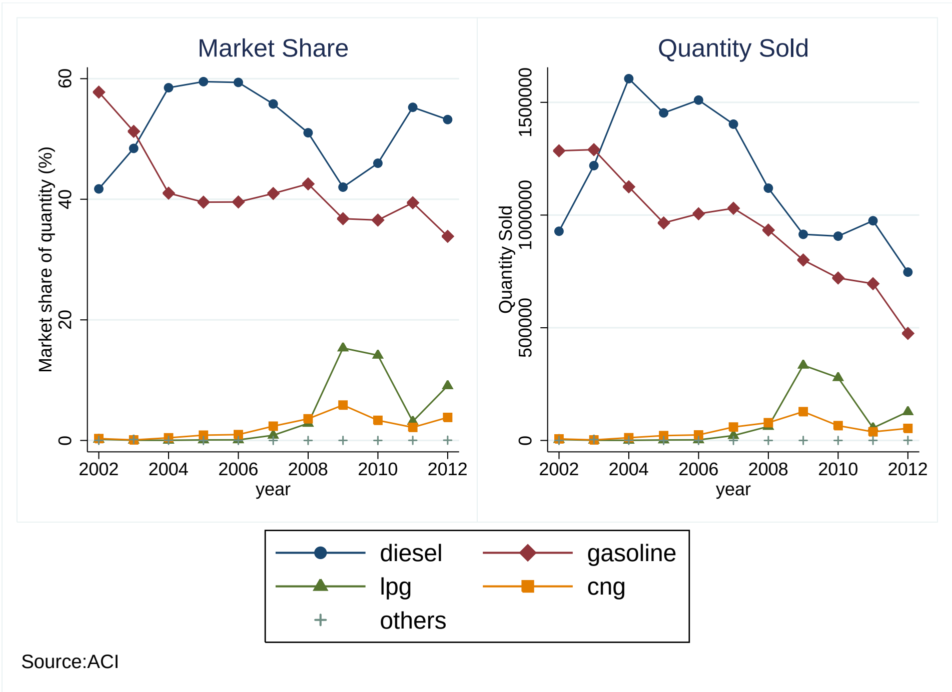
Note: The table reports the effects of 5% price reduction of LPG cars. The top panel reports the direct effect of this policy on the market shares, while the bottom panel reports the total effect of this policy on both market share and filling station density.
Results are average from 100 simulations of the model.

Table 5: Subsidy to LPG gas station counterfactual.

	Avg Δ (%)	MinΔ (%)	MaxΔ (%)
	Direct effect		
pump/kmsq	+9.2%	0 %	+14.5 %
	Direct and indirect effect		
LPG	9.2 %	0.0 %	40.2 %
CNG	0 %	-0.5 %	-7.5 %
diesel	0 %	-0.5 %	-7.5 %
gasoline	0 %	-0.5 %	-7.5%
pump/kmsq	10.0%	0%	16.0%

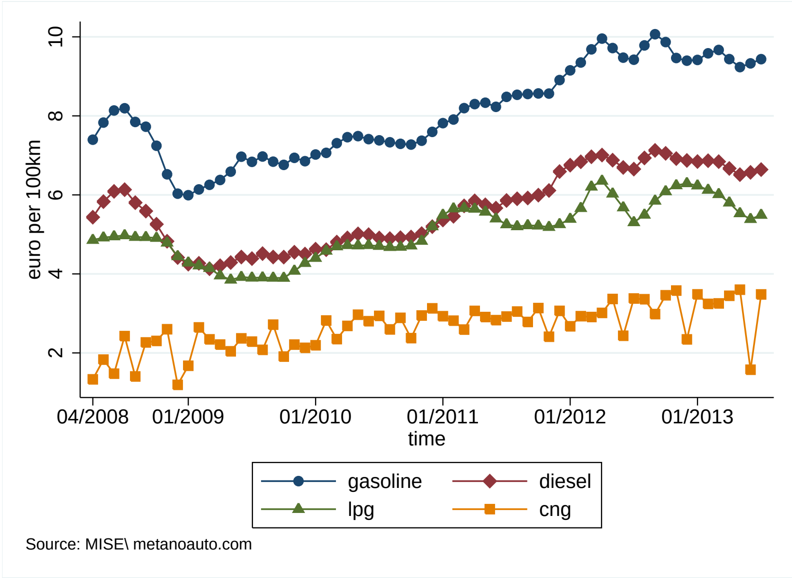
Note: The table reports the effects of a 10% reduction of the fixed costs of entry in the LPG market. The top panel reports the direct effect of this policy on the filling station density, while the bottom panel reports the total effect of this policy on both market share and filling station density.
Results are average from 100 simulations of the model.

Figure 1: Vehicles per type of fuels. Italy 2002-2012



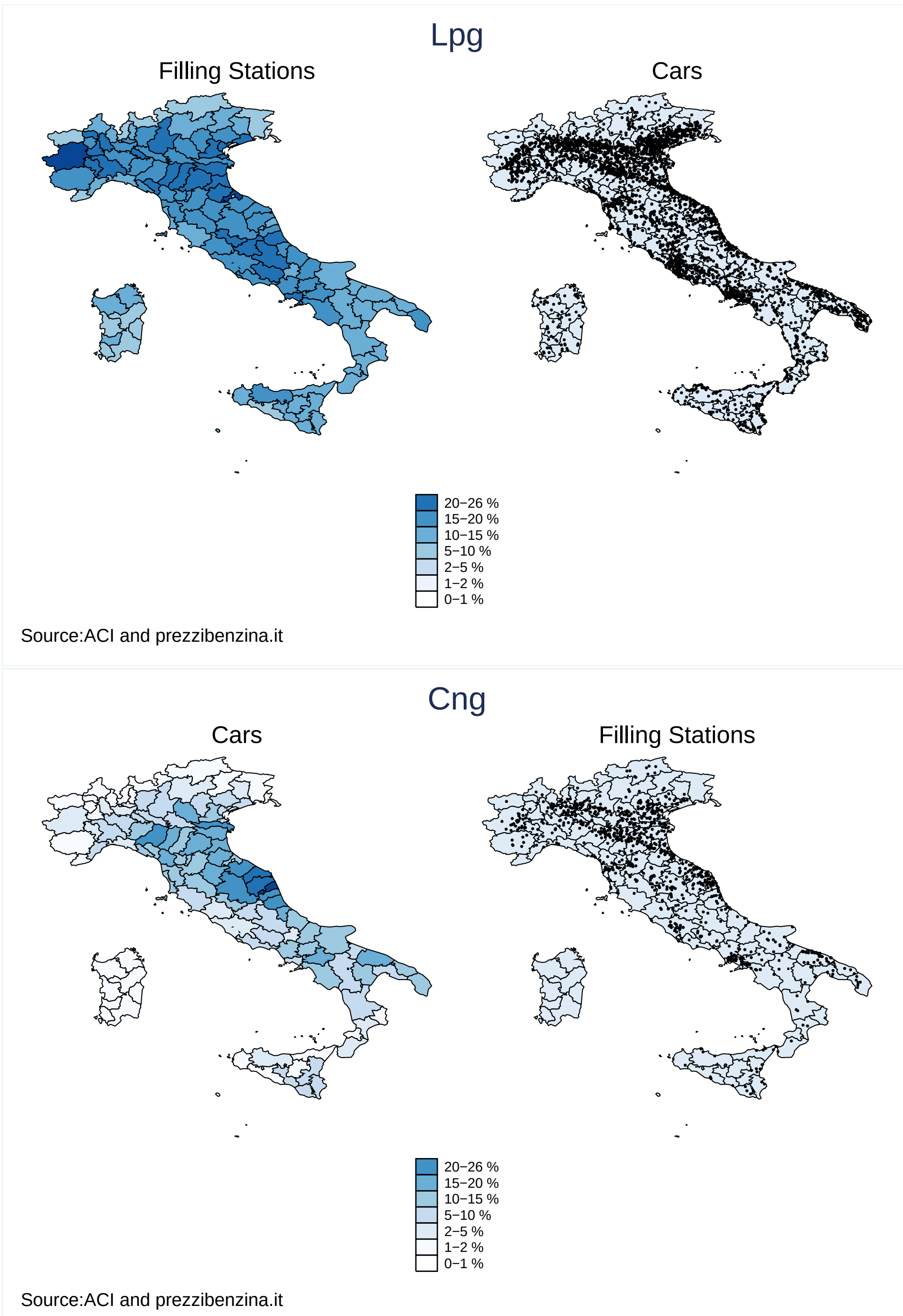
.
Note: The figure shows the market trend by fuel in Italy from 2002 to 2012.
The left panel plots the share of cars by fuel type.
The right panel plots the quantity of cars in levels.

Figure 2: Fuel price per 100 km



.
Note: The figure plots the fuel cost for running 100km. Fuel costs are computed using the average fuel efficiency for compact cars (as reported in the specialized magazine “Quattroruote” September 2012).

Figure 3: Prevalence of Alternative Fuel New Cars and filling stations by Italian Provinces.2012.



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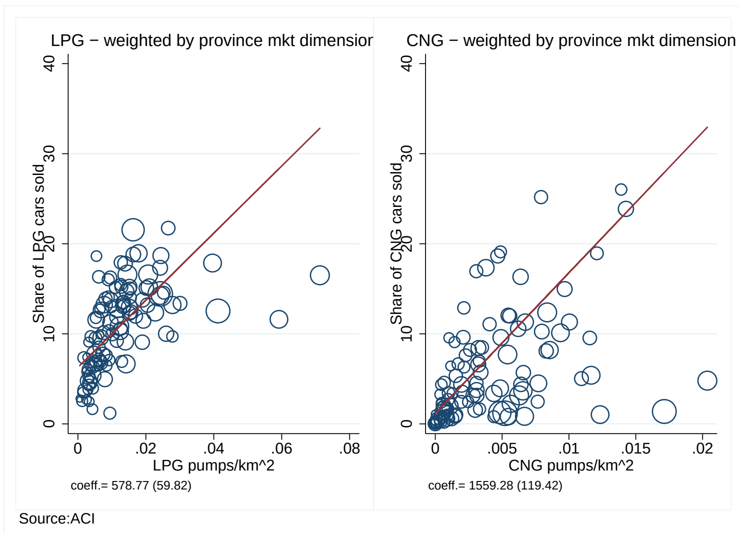
Note: The figure shows maps of Italy to give an overview of spatial variation in share of AF cars and filling stations. The maps above refer to LPG (autogas) cars and filling stations, the below maps refer to CNG (natural gas) cars and filling stations.
The maps on the left refer to the market share at province level, the dots in the maps on the right are the locations of the filling stations offering the specified fuel.

Figure 4: Share of new cars 2012 vs pumps per km^2



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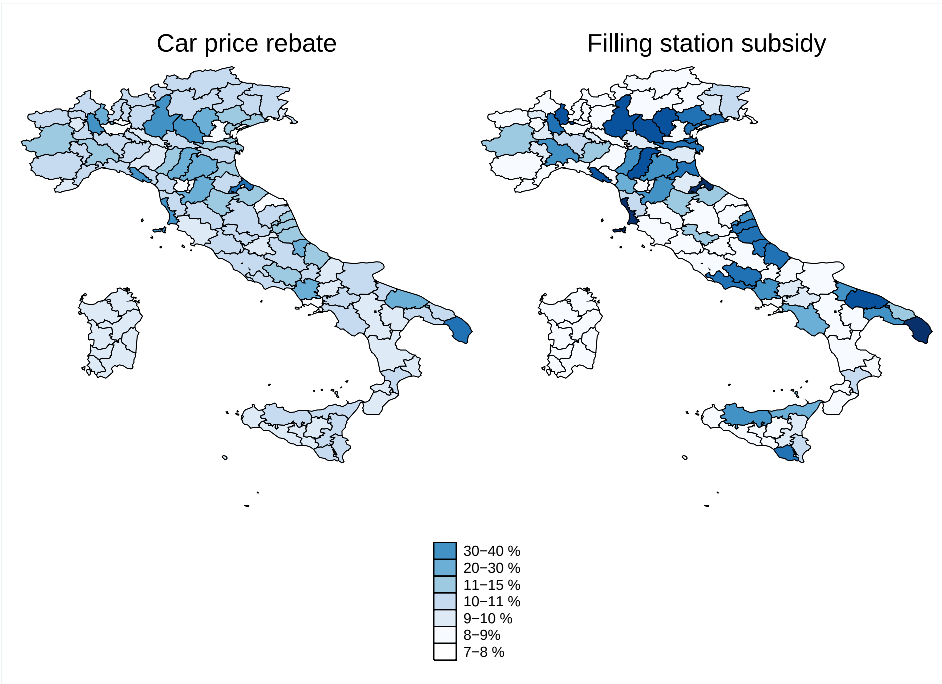
Note: The panels report scatterplots between the share of AF cars sold in 2012 and the AF filling stations' density. Each dot refers to a province and its dimension is proportional to province market dimension. The line refers to the slope of a weighted regression of the share of AF cars on the AF filling stations' density.

The left panel refers to LPG (autogas) cars, the left panel refers to CNG (natural gas) cars.

Figure 5: Policies effects at province level.



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Note: The figure shows the intensity of the total average effects of the two counterfactuals LPG market share in each Province.
The left panel plots the effect of the price rebate on the share of LPG cars.
The right panel plots the effect of the subsidies to LPG filling stations on the share of LPG cars.

Appendix

A Summary statistics

In Table A.1 I report summary statistics on car sales. The level of observation is a variant, defined as the combination of make, model, body type (including doors) and engine displacement. An example of variant is Volkswagen Golf: I can distinguish among different frames (sedan, station wagon, cabrio and multispace), the engine size and the fuel (1.2 TSI, 1.4 TSI, 1.6 TSI, 1.6 bifuel, 1.6 TDI, 2.0 TDI, 2.0 TDI 4 motion and 2.0 GTD). I observe $2,135$ "variants" in 110 provinces each month in 2012. Such a disaggregation leads to many variant/province/month combination with no sales. In the market are sold 36 different brands belonging to 19 manufacturing groups.

Table A.1: Summary statistics - Demand

Variable	**Mean**	**(Std. Dev.)**
price (thousands of €)	21.276	(9.525)
power/weight (kw/kg)	0.061	(0.0131)
€/100 km	8.718	(2.121)
length (cm)	416.726	(37.176)
tank (dm^3)	51.460	(11.146)
power/engine size (kw/cc)	50.99	(13.39)
(pump/km^2)*100	8.18	(8.27)
(LPG pump/km^2)*100	0.16	(0.62)
(CNG pump/km^2)*100	0.01	(0.11)
(diese pump/km^2)*100 l	4.89	(7.49)
(gasoline pump/km^2)*100	3.14	(6.70)
N. of "variants"	2135	
N. of obs.	267524	

Note: The table reports summary statistics of car characteristics sold in 2012. Price includes local taxes.

Table $A.2$ reports summary statistics of the variable used to compute variable

profit, the expected variable profit and a binary variable indicating whether in that province the regional law regulates the opening of a new filling station imposing the supply of three fuels.

Table A.2: Summary statistics - Entry

Variable	**Mean**	**Std. Dev.**
fuel per car (liters)	1259.494	1100.096
LPG pumps	27.90909	22.27622
stock LPG cars (2012)	17610.16	22363.77
variable profit (thousands of €)	108.9	
LPG mandate	0.53	0.50
Observations	110	

Note: The table reports summary statistics on filling stations' variable profits at province level. Fuel per car refers to the average number of liters of LPG consumed in one year in a province. Variable profit is computed using the expected quantity of LPG cars sold in a province. Law is a binary variable indicating whether in that province the regional law regulates the opening of a new filling station imposing the supply of three fuels.

In table A.3 I report the time series of AF filling stations in Italy.

Table A.3: AF filling stations in Italy. 2000-2013.

year	LPG	CNG
2000	1949	336
2002	2126	402
2006	2311	529
2008	2351	665
2009	.	693
2010	2364	718
2011	2350	718
2012	3201	896
2013	3275	974

Note: The table reports the time series of the number of AF filling stations in Italy. Sources: ecomotori.net, prezzibenzina.it, Euromobility Report(2007) Quagliano et al. (2009)"Libro Bianco sul metano per autotrazione", "Report on Fuel Distribution Network in Piedmont" (2012).

Table A.4: Summary statistics - Market share by manufacturer and fuel type.

Car builder group	**Gasoline**	**Diesel**	**LPG**	**Natural gas**
Fiat	9.0 %	7.1%	5.5%	4.7%
Volkswagen	3.8%	8.4%	0.3%	0.2%
BMW	1.19%	2.5%		
GM(Chevrolet, Opel)	3.2%	3.4%	2.7%	0.4%
PSA (Citroen Peugeot)	4.2%	5.1%	0.7 %	
Renault	2.5 %	5.9%	2.1%	
Daihatsu Motor Co., Ltd (Toyota)	3.9%	1.6%		
Ford	2.5%	4.6%	1.1%	
Hyundai	2.9%	3.7%	0.2%	
Mercedes	0.4%	1.5 %		0%
Suzuki	1.2%	0.3%	0%	

Note: The table reports summary statistics on market share for the elven largest manufacturer I compute the market share over the total number of units sold in 2012 to private owners (863,818).

Table A.5: Summary statistics - Filling stations by brand and fuel

Brand	**Gasoline**	**Diesel**	**LPG**	**Natural gas**
Api-IP	3444	3425	391	67
Eni	4029	4025	677	165
Esso	2331	2329	273	34
Q8	2186	2184	254	30
Shell	688	686	114	22
Tamoil	1476	1469	197	37
TotalErg	2818	2811	308	56
Others and unbranded	2742	2739	856	425
Total	19,714	19,668	3,070	836

Note: The table reports summary statistics on filling station brands.

In Table$A$.4 and Table$A$.5 I report some summary statistics about car builders' market share per fuel and filling stations by brand and fuel, to give further insights about the market.

B Derivation of likelihood function.

Given the primitives of the model, the profitability condition bounds naturally lead to an ordered probit. I can write the log-likelihood according to the distribution of ν_m.

$$\mathcal{L}(\theta) = \sum ln \left(\Phi \left(\frac{ln(vp_m(n_m)) - \gamma W_m}{\omega} \right) - \Phi \left(\frac{ln(vp_m(n+1)) - \gamma W_m}{\omega} \right) \right). \tag{9}$$

Substituting vp with $\hat{vp}$ I get

$$\begin{aligned} \mathcal{L}(\theta) = \sum_m ln & \left(\Phi \left(\frac{ln((p_m - mc_i) k_{\frac{1}{n_m}} (\hat{q}_m(n_m) + Q_m)) - \gamma W_m}{\omega} \right) \right. \\ & \left. - \Phi \left(\frac{ln((p_m - mc_i) k_{\frac{1}{n_m+1}} (\hat{q}_m(n_m+1) + Q_m))) - \gamma W_m}{\omega} \right) \right). \end{aligned} \tag{10}$$

Consider the number of sold cars q_{mf} in a market m with a given fuel f. Since I consider a nested logit, following Berry (1994), I can compute the market share as:

$$\begin{aligned} s_{jm} &= s_{j|mf} s_{mf} = \\ &= \frac{\exp(\delta_{jm}/(1-\sigma))}{D_{mf}} \frac{D_{mf}^{1-\sigma}}{\sum_{mf} D_{mf}^{1-\sigma}}, \\ D_{mf} &= \sum_{j \in f} \exp(\delta_{jm}/(1-\sigma)), \end{aligned} \tag{11}$$

where the mean utility is $\delta_{jm} = \alpha p_{jm} + x_j \beta + n_{jm} \lambda + \xi_{jm}$.
The quantity of cars using a given fuel is:

$$q_{mf} = \sum_{j \in \mathcal{C}_f} s_{jm} L_m. \tag{12}$$

Using equation (10) and (12) I get the likelihood I maximize to estimate γ.

$$\mathcal{L}(\theta) = \sum_m ln\left(\Phi\left(\frac{ln\left((p_m - mc_i)k\frac{1}{n_m}(\sum_{j\in\mathcal{C}_f}\hat{s}_j(n_m) + Q_m)\right) - \gamma W_m}{\omega}\right)\right.$$
$$\left. - \Phi\left(\frac{ln\left((p_m - mc_i)k\frac{1}{n_m+1}(\sum_{j\in\mathcal{C}_f}\hat{s}_j(n_m+1) + Q_m)\right) - \gamma W_m}{\omega}\right)\right).$$

C Robustness check

In this section I explore the robustness of my results in demand estimation, considering filling station density endogenous. The idea is that stations and cars' market shares are co-determined. A valid instrument for filling station density is the number of filling stations at the beginning of 2009 since during 2008 the sector was liberalized. I could assume that before 2009 entry choice could happen/not happen even if it was not/was profitable. Therefore, the pre-reform number of filling stations is exogenous. The relevance of the instrument is suggested by the persistence of the number of filling station during time. I checked the relevance of the instruments computing the F-statistic for each endogenous regressor.

D Policy effects at local level

In this section I give further details to compare the effect of the policies examined in the paper. Table $D.1$ shows that price subsidies have a more homogeneous effect all over the country, while the subsidies to filling stations have very strong effect in some provinces and almost no effects in other provinces.

Table C.1: Demand Robustness check. Endogenous pump density

VARIABLES	(1) IV Logit	(2) IV Logit with density instr.	(3) IV Nested Logit	(4) IV Nested Logit with density instr.
price	-0.10	-0.11	-0.10	-0.10
	(0.02)	(0.02)	(0.02)	(0.01)
power/weight	5.83	5.44	8.31	7.85
	(2.83)	(2.83)	(2.10)	(2.10)
euro/100km	0.03	0.03	0.04	0.03
	(0.01)	(0.01)	(0.01)	(0.01)
length	0.01	0.01	0.01	0.01
	(0.001)	(0.001)	(0.001)	(0.001)
tank	0.02	0.02	0.02	0.02
	(0.002)	(0.002)	(0.002)	(0.002)
power/engine vol.	-0.004	-0.004	-0.003	-0.003
	(0.0002)	(0.0002)	(0.0001)	(0.0001)
(pump/kmsq)*LPG	0.26	0.26	0.34	0.35
	(0.01)	(0.01)	(0.01)	(0.01)
(pump/kmsq)*CNG	0.99	1.08	1.21	1.31
	(0.03)	(0.03)	(0.03)	(0.02)
(pump/kmsq)*diesel	-0.005	-0.005	-0.01	-0.01
	(0.0004)	(0.0004)	(0.0003)	(0.0003)
(pump/kmsq)	0.023	0.025	0.03	0.04
	(0.001)	(0.001)	(0.001)	(0.001)
LPG	0.92	0.87	0.18	0.13
	(0.14)	(0.14)	(0.11)	(0.11)
CNG	0.27	0.27	-0.10	-0.10
	(0.08)	(0.08)	(0.06)	(0.06)
diesel	0.52	0.52	0.61	0.61
	(0.09)	(0.09)	(0.06)	(0.06)
sigma			0.30	0.30
			(0.02)	(0.02)
R^2	0.51	0.51	0.73	0.73
Observations	267524	267524	267524	267524
meanelasticity	-2.41	-2.36	-3.12	-3.04

Note: All the specifications include province, month and model fixed effects.. Standard errors in brackets.
Column (1) and column(2) report coefficients of logit estimation. Colum(1), endogenous variable, price; column (2), endogenous variables, price and pump density.
Column (3) and column(4) report coefficients of nested logit estimation (nests=fuels). Colum(3), endogenous varibles, price and within nest share; Column(4), endogenous varibles, price, within nest share and pump density.
In column (1) and (3) instruments: “classical BLP”. In column (2) and (4) instruments: “classical BLP”, the number of filling stations in 2009 as instruments.

Table D.1: Counterfactuals. Heterogeneity of the effect by region.

Region	Car price rebate Δ% LPG market share	Filling station subsidy Δ% LPG market share
ABRUZZO	9.8 %	14.44 %
BASILICATA	8.3 %	2.8 %
CALABRIA	8.3 %	4.5 %
CAMPANIA	7.4 %	8.0 %
EMILIA-ROMAGNA	10.6 %	14.9 %
FRIULI-VENEZIA GIULIA	8.9 %	7.7 %
LAZIO	9.0 %	8.5 %
LIGURIA	9.4 %	9.0 %
LOMBARDIA	7.9 %	7.3 %
MARCHE	9.0 %	9.9 %
MOLISE	8.4 %	4.0 %
PIEMONTE	9.3 %	8.1 %
PUGLIA	10.7 %	17.3 %
SARDEGNA	8.0 %	3.3 %
SICILIA	8.7 %	7.8 %
TOSCANA	8.7 %	9.3 %
TRENTINO-ALTO ADIGE	8.9 %	5.7 %
UMBRIA	9.4 %	8.6 %
VALLE D'AOSTA	8.7 %	1.7 %
VENETO	9.7 %	15.3 %

Note: The table compare the total average effects of the two counterfactuals LPG market share by region.