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Automotive fuel prices at branded and unbranded service stations: differences in the impact of seller density, brand concentration and search costs

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ABSTRACT
This paper analyses the impact of local competition on gasoline and diesel pricing at branded and unbranded independent service stations. Based on our theory-driven discussion we derive a number of hypotheses, which are empirically tested on a sample of service stations in Spain. In Spain, retail prices of motor fuels have been under the spotlight since the dismantling of the state monopoly in the 1990s. The concentration of the retail market and the behavior of the main oil operators are of constant concern to the competition authorities. Our empirical analysis provides evidence for the existence of different competitive dynamics between branded and unbranded stations, and between gasoline and diesel retail pricing. Specifically, the results show that (i) fuel prices at branded (unbranded) service station are positively (negatively) associated with the number of stations operating in the same local market, (ii) prices of both motor fuels at a branded station are higher the larger the share of stations carrying the same brand in its local market, (iii) diesel price at an unbranded station is lower the larger the share of unbranded stations in its local market, and (iv) unbranded service stations undercut the price of diesel more than that of gasoline compared with prices at branded stations.

KEYWORDS
Seller density; search costs; gasoline; diesel; retail pricing; unbranded stations

1. Introduction

Motor fuels are an essential input in road transportation for both people and goods, and their prices therefore have a significant impact on the competitiveness of many firms and citizens' welfare. Thus, it is not surprising that the behavior of retail gasoline and diesel prices merit regular attention in the media, being a matter of public debate among politicians, oil industry representatives and consumer associations worldwide. Furthermore, gasoline retailing has been the subject of intense empirical research over recent decades. Such academic interest has been largely fueled by the close scrutiny that the antitrust authorities and related regulatory agencies exert on this industry in many countries.

Although *a priori* one might think that gasoline should be regarded as a relatively homogeneous product, the fact is that gasoline retailing at service stations is differentiated in a number of aspects. In addition to the brand image and reputation of the fuels sold at pump, service stations differ in their location and the provision of ancillary services. As a result, one cannot expect the prevalence of a unique equilibrium gasoline market price. Product differentiation may certainly explain part of the observed price differences. However, some of the difference in prices may be related to the presence of imperfect consumer information and the exercise of market power by the service stations. A number

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of previous papers have investigated these issues in retail gasoline price behavior from diverse approaches.[1]

This paper contributes to this strand of literature. Based on our theory-driven discussion we formulate a number of hypotheses, which are empirically tested on a sample of service stations in Spain. First, we argue that the level of local market competition (measured by the number of competing sellers and same brand concentration in the station's vicinity) has an opposite impact in the pricing behavior at branded and unbranded stations, because of the presence of consumers' search costs and service stations with different target customers. Second, we argue that differences in the intensity with which gasoline consumers and diesel consumers search would lead to differences in gasoline and diesel price setting behavior at branded and unbranded stations. Specifically, our contention is that diesel cars users have stronger incentives to search for lower fuel prices than gasoline cars users due to the more intense use of their vehicles and the higher price of diesel cars, which leads us to predict that unbranded stations will price diesel more aggressively than gasoline compared to branded stations.

Spain provides a particularly interesting context for the analysis of automotive fuel prices, which have been a matter of concern since the dismantling of the state monopoly at the beginning of the 1990s (Contín, Correljé, and Huerta 1999, 2001). Indeed, both gasoline and diesel retail pricing is at the heart of an ongoing public debate that questions the market concentration and the competitive behavior of major oil operators in the Spanish automotive fuel retail market, as reflected in a number of significant reports issued by the antitrust authorities (e.g. 2012a, 2012b; CNC 2009), while it has inspired a considerable amount of academic research.

Much of this work has focused on the analysis of price asymmetries in the Spanish fuel market (Balaguer and Ripollés 2012, 2016, 2018; Contín-Pilart, Correlje, and Palacios 2009), the study of gross margins and pretax retail average national and regional prices (Bello and Contín-Pilart 2012; Bello, Contín-Pilart, and Palacios 2018; Perdiguero 2010), the analysis of retail price dispersion and the competitive functioning of gasoline market in specific regions and cities (Bernardo 2018; Jiménez and Perdiguero 2011a, 2011b, 2012; Perdiguero and Jiménez 2021), and the effect of antitrust prosecution on retail diesel prices (González and Moral 2019).

Balaguer and Ripollés (2020) is the most recent study on retail fuel prices in Spain, and the closest to our research. They analyze the different effect of the presence of a market dominant brand or of a low-cost service station on the average diesel price set by its surrounding competitors, which is the dependent variable in their model. In contrast, our focus is on each station's gasoline and diesel prices, and whether the effect of competition on fuel pricing is different at branded and unbranded stations. To our knowledge, this is the first empirical analysis of price level differences between gasoline and diesel retail prices at branded and unbranded stations in Spain, while controlling for a comprehensive set of station characteristics.

The remainder of the paper proceeds as follows. Section 2 presents the theoretical discussion and the development of hypotheses. Section 3 describes the data and variables. Section 4 discusses the empirical model specification. Section 5 presents the empirical results. Section 6 summarizes the main findings and their policy implications.

2. Consumers' search costs, seller density and pricing behavior at branded and unbranded stations

The standard insight of economic models is that an increased number of competitors lead to lower market prices. Nevertheless, there are some theoretical approaches that move away from the basic assumptions of classical models of competition and challenge the conventional view of the inverse

[1] See Eckert (2013) and Noel (2016) for comprehensive reviews of this literature. Likewise, with gasoline and diesel derived from crude oil, the extent to which changes in crude oil prices impact retail automotive fuel prices, i.e. the rockets and feathers phenomenon, has been extensively analyzed in other strand of the literature (e.g. Gil-Alana and Payne 2017).

relationship between sellers' density and market price. Specifically, information-based (consumer search) models, beginning with Stigler (1961), depart from the assumption that all consumers have the same information. In these models, demand is divided into consumer groups that differ according to their knowledge of the price distribution. Markets consist of consumers who acquire information by actively searching for lower prices, as well as consumers who remain uninformed as they prefer to avoid search costs (e.g. Rosenthal 1980; Stahl 1989; Varian 1980). This behavior also opens the door to price dispersion as it allows some firms to set higher prices than others in equilibrium, even when all firms sell a homogenous good and have identical production costs (Chandra and Tappata 2011).

In essence, buyers are split into two groups: those who are perfectly informed about sellers' locations and prices and therefore purchase the same good from the cheapest sellers without incurring any search cost, and uninformed buyers. Rosenthal (1980) generates consumer informational asymmetries exogenously, whereas Varian (1980) does so endogenously. Put another way, Rosenthal's model is related to consumer preferences for a particular firm (loyal customers), whereas Varian's model is related to heterogeneous consumer search costs. In Varian's model, buyers only observe the price from the seller that they choose at random. If the actually charged price is below their reservation level, they purchase. In Stahl's (1989) model, uninformed buyers perform a costly search until they find a price lower than their particular reservation price. One result of these models is that, as the share of informed consumers increases, average prices should fall.

All these theoretical models predict that, in equilibrium, average prices will increase with the number of sellers in the market. The rationale behind this result is based on the profit maximization behavior of each firm, which is characterized by the decision either to follow a low pricing strategy realizing profits by attracting well-informed buyers, or to raise its price extracting surplus from uninformed customers. Thus, the probability of obtaining profits by focusing on the informed consumer (i.e. the probability of being the lowest price retailer) falls as the number of sellers increases, undermining the incentive to lower the price. Therefore, an increase in the number of sellers leads to an increase in expected prices.[2]

Similarly, 2004) show that the equilibrium can be defined in terms of how intensively uninformed consumers search. When uninformed consumers search moderately (or the economy is in a moderate search intensity equilibrium), i.e. they observe just one price and decide to acquire the product, we would expect a positive association between density and expected price. This is because the "surplus-appropriation effect" dominates the "business-stealing effect."[3] When the economy is in a low-search intensity equilibrium or the uninformed consumers search with low intensity, which means that they randomize between searching for one price quote or dropping out of the market, an increase in the number of competitors would not influence the expected price. Here the "surplus-appropriation effect" and the "business-stealing effect" are equally strengthened. Finally, when uninformed consumers search intensively, in the sense that they randomize between searching for one price and for two prices, we would expect a non-linear association between the number of sellers and the average price; entry of a new firm leads to a lower expected price when the number of competitors in the market is small to begin with, but to a higher expected price otherwise.

There is some evidence that the presence of informational differences across consumers play an important role in explaining gasoline retail price dispersion (e.g. Chandra and Tappata 2011; Johnson 2002; Lewis 2008; Marvel 1976). In general, however, the available empirical studies show mixed findings regarding the association between station density and gasoline retail prices (Eckert 2013).

[2]2006) shows empirically that an increase in seller density leads to benefits, in terms of lower prices, for informed consumers although the competitive effect causes average prices in the market to rise. Thus, the average price paid by uninformed consumers increases with increasing seller density.

[3]In any equilibrium some of the uninformed consumers search for only one price. This implies that firms always hold monopoly power over some of this type of consumer and gives firms an incentive to charge high prices. This force is referred by 2004) as "surplus-appropriation effect." On the other hand, firms have an incentive to charge low prices in an attempt to attract consumers who compare prices. This force is referred by Janssen and Moraga-Gónzalez (2004) as "business-stealing effect."

In markets of automotive fuels, branded service stations compete along with unbranded ones. Branded stations are those that sell well-recognized and often international brands of gasoline. They are typically either owned by, or franchisees of, major oil operators. By contrast, unbranded stations are independent retailers who purchase wholesale commodity gasoline from independent suppliers or from the major petroleum companies.

It is frequently alleged that independent service stations have the potential to boost competition in both wholesale and retail gasoline markets (Hastings and Gilbert 2005; Pennerstorfer 2009). The competitive role of independents in retail gasoline markets is an issue that has deserved an increasing interest in a number of recent studies (e.g. Doyle, Muehlegger, and Samphantharak 2010; Firgo, Pennerstorfer, and Weiss 2015; Hong and Lee 2020; Lewis 2012; Noel 2007; Verlinda 2008; Zimmerman 2012). Thus, several authors argue that the role played by unbranded stations is relevant because its mere presence is a key factor in determining how price competition works (Eckert and West 2004; Erutku and Hildegrand 2010). As Lewis (2008) argues, stations with different characteristics tend to sell to different types of consumer, and thereby the effect of competitor density is likely to vary across station types. Particularly, consumers at unbranded stations have less brand loyalty and a greater propensity to search than consumers at branded stations.

Thus, differences in consumers' propensity to search interact with station differences. Branded stations would attract uninformed consumers with high search costs, who probably value fuel brand as high quality and are little concerned about prices (Hastings 2004; Lewis 2008). As a result, we would expect to find a positive association between density and retail prices at branded stations, i.e. in Janssen and Moraga-González's words the surplus-appropriate effect would dominate the business-stealing-effect. On the other hand, unbranded stations would attract a larger proportion of informed consumers, with lower search costs and more concerned about prices and less about high fuel quality (Hastings 2004). If so, seller density and retail prices would be negatively correlated in the case of unbranded stations, and the business-stealing-effect would dominate the surplus-appropriate effect.

Based on the arguments above, we postulate the following hypotheses:

H1: Retail automotive fuel prices at a branded service station are positively associated with the number of stations in its local market.

H2: Retail automotive fuel prices at an unbranded service station are negatively associated with the number of stations in its local market.

2.1. The presence of multiple sellers carrying the same brand

A characteristic of service stations that carry the same brand is that they are typically owned or operated by a common oil operator. In some cases, they are either owned and managed directly by an incumbent oil refining company, or operated through exclusive selling contracts with the stations' owners.[4] In other cases, they are part of chains of service stations that are owned by oil operators other than traditional refiners and integrated multinationals. Such companies are not generally present in the exploration and refining of crude oil, but focused on the import, wholesale and retail distribution and storage of petroleum products.[5] Naturally, they use their own brands to market the automotive fuels through their respective chains of service stations. In either case, retail pricing at branded stations are largely influenced by an oil company.

In this context, the presence of stations with the same brand nearby may help to reinforce the price/brand strategy of the oil company and to coordinate prices among the stations operating in the same

[4]This is the prevalent case in the gasoline and diesel retailing markets in Spain (CNC 2009).
[5]For instance, this is the case in the Greek gasoline market (Polemis 2012).

local market. Consequently, such coordinating behavior would result in a positive correlation between price and the market concentration of stations carrying the same brand. In this sense, previous empirical studies have shown that the presence of same brand neighbors increases retail gasoline prices (e.g. Pennerstorfer and Weiss 2013, Kvasnička, Rotislav, and Ondřej 2018).

By contrast, unbranded stations are not owned or operated by a common oil operator. Consequently, their pricing decisions are not therefore shaped by any broader corporate strategy or conditioned by an overall brand performance. Hence, unbranded service stations have full control over the prices they charge to final consumers.

Due to the independent nature of unbranded stations, we would expect to find a quite different (more competitive) price-setting behavior at an unbranded station when it faces a higher proportion of unbranded stations operating in its market. It seems reasonable to expect that an unbranded station is aware that the presence of other unbranded stations nearby mainly attracts informed consumers, and thereby feel pressured to lower prices to keep/gain market share. Moreover, as Marvel (1975) argues, collusive agreements are much more difficult to enforce with informed customers. Thus, as more informed consumers generally frequent the unbranded stations, one would expect that a sustainable cooperative pricing strategy is less likely to occur among unbranded stations.

We summarize the arguments above into the following hypotheses:

H3: Retail automotive fuel prices at a branded service station are positively associated with the share of stations carrying its same brand in its local market.

H4: Retail automotive fuel prices at an unbranded service station are negatively associated with the share of unbranded stations in its local market.

2.2. Search costs differences between gasoline and diesel consumers

The benefits of searching are larger for items that account for a larger share of the consumer's budget, or that are purchased with a higher frequency, as have been noted in earlier studies on search costs

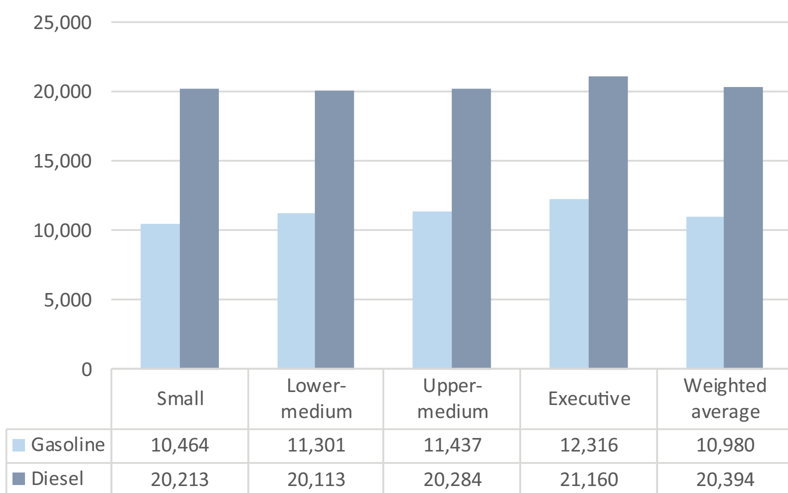


Figure 1. Annual mileage (km) of passenger cars by car segment in the EU15 (2005–2010). Note: Elaborated by the authors with data from TRACCS (Papadimitriou et al. 2013).

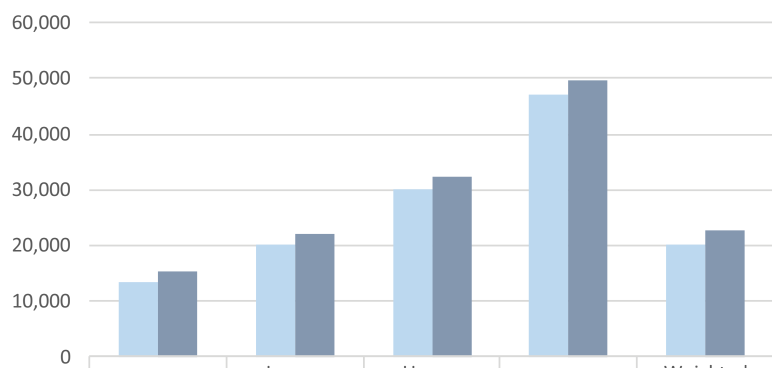
literature (e.g. Sorensen 2000; Stigler 1961). This is precisely the case for diesel cars users (Johnson 2002): they have stronger incentives to search for lower fuel prices than gasoline cars users due to (i) the more intense use of diesel cars, and (ii) the higher upfront price of a diesel car. We develop this argument below.

There is ample evidence that annual driving distances of diesel cars are significantly higher than those of gasoline cars. Schipper (2011) shows that on average annual mileage of diesel cars for eight European countries was 75% higher than gasoline cars (79% in Spain, and over 100% in Belgium and The Netherlands). Verboven (2002), from a dataset on 41 pairs of automobile models in three European countries during the period 1991–1994, reports that for gasoline consumers, the annual mileages vary between 13,501 and 15,667 kilometers, depending on the weight category of the car, while for diesel consumers, they vary between 22,217 and 25,038 kilometers.

In Figure 1 we provide additional and updated evidence by showing the average annual mileage of passenger cars in the European Union (EU15) for 2005–2010. We have computed the quantities using data from TRACCS, which was a project funded by European Commission (DG CLIMA) aimed at collecting transport data to support the quantitative analysis of measures relating to transport and climate change (Papadimitriou et al. 2013). The car models segmentation used is that of the European Automobile Manufacturers' Association-ACEA. In every country and car segment, annual mileage observed for diesel consumers is substantially higher than that for gasoline consumers. On average, the annual kilometers traveled by diesel passenger cars is 85.7% higher than that by gasoline cars.

Secondly, the price of diesel cars is typically higher than gasoline cars. Based on a dataset of new passenger car sold during 1998–2011 in seven European countries, Grigolon, Reynaert, and Verboven (2018) show that diesels were on average 29% more expensive than their gasoline counterparts. Likewise, Mayeres and Proost (2001) report price differences between diesel and gasoline cars within a comparable category in ten European countries, showing that diesel car prices (taxes included) were on average 5.4% higher than gasoline cars (6.1% in Spain, and up to 8.4% in Germany). Likewise, in India, Chugh, Cropper, and Narain (2011) find that on average, diesel hatchbacks cost 9.9% more than their gasoline twins, while diesel sedans cost 8.0% more.

We use again data from the TRACCS project (Papadimitriou et al. 2013) to produce Figure 2, which shows the average retail price (in euro) of new passenger cars registrations by car segment in the EU15 countries during the period 2005–2010. Prices include VAT and registration taxes, which also are



	Small	Lower-medium	Upper-medium	Executive	Weighted average
Gasoline	13,303	20,189	30,147	47,062	20,141
Diesel	15,234	22,032	32,346	49,577	22,654

Figure 2. Average price (euro) of new passenger cars registrations by car segment in the EU15 (2005–2010). Note: Elaborated by the authors with data from TRACCS (Papadimitriou et al. 2013). Retail prices including VAT and registration taxes

more expensive for diesel cars in all countries. Figure 2 shows that on average diesels cars were 12.5% more expensive than gasoline cars, with the difference being larger for smallest cars (14.5%). This price differential is observed in the fifteen countries analyzed.

Given that diesel fuel at pump is less expensive than gasoline,[6] consumers' choice involves a trade-off between the higher upfront price of a diesel car and the future savings derived from lower diesel retail price. Verboven (2002) and Grigolon, Reynaert, and Verboven (2018) demonstrate that European consumers trade-off the higher purchase price of a diesel car against the future fuel cost savings. They show that consumer's annual mileage is a key driving force in explaining the consumer gasoline versus diesel cars purchasing decision. Thus, the break-even mileage (i.e. the mileage threshold above which the diesel-powered car becomes more advantageous than its gasoline counterpart) rises as the diesel fuel price increases. In this regard, a quick internet search reveals the existence of hundreds of websites with simulators that allows customers to compare the costs between a diesel powered car model and its gasoline variant by entering their expected annual mileage and fuel prices.

From the above it follows that diesel cars users have stronger incentives to search for lower fuel prices due to the more intense use of their vehicles and to recover the upfront price differential. Therefore, one would expect to find a larger proportion of informed consumers, with lower search costs, among diesel consumers than among gasoline consumers. Furthermore, as argued above, given that unbranded stations attract a larger proportion of informed consumers, one would expect that unbranded stations price more aggressively in diesel than gasoline relative to branded stations, and thereby resulting in a wider differential between gasoline and diesel prices at unbranded stations than at branded stations. These considerations lead us to postulate the following hypothesis:

H5: The price differential between gasoline and diesel is wider at unbranded stations than at branded stations.

3. Data and variables

We use data from a representative sample of 485 service stations in Spain, whose distribution among brands and regions is shown in Tables 1 and 2 respectively. As shown in Table 1, at the beginning of 2007 there were 8,258 service stations in Spain (excluded the Canary Islands and the cities of Ceuta and Melilla located on the northern coast of Africa), as provided by ENPPG (2007), which is the authoritative publication on the oil and gas industry in Spain. This number includes all the stations entered into the official Business Register, even though not all were in effective operation, and some service stations only sold diesel fuel. Our study focuses on retail service stations in operation selling both fuels, gasoline and diesel, so our target population size is actually smaller than 8,258 stations. However, it is not possible to identify the number of stations that were outside our target population, so in order to avoid falling short in the determination of the sample size we keep the big total as the population size.[7]

Subsequently, a stratification protocol was applied according to the distribution of stations across regions and the oil operators' market shares. Our final representative random stratified sample accurately reflects the distribution of oil operators' market shares based on the number of stations functioning in Spain at the beginning of 2007. As shown in Table 1, the three main brands jointly account for about 70% of the total number of stations in the country, with Repsol being by far the

[6]The Eurozone weighted average price for diesel fuel at pump (inclusive of duties and taxes) has been on average 12.8% cheaper than gasoline price between 01/01/2005 and 31/12/2017, as registered by the European Commission's Oil Bulletin: https://data.europa.eu/euodp/es/data/dataset/eu-oil-bulletin.

[7]The sample size of 485 service stations (n) is representative of a total population of 8,258 (N), with a confidence level of 95% (Z=1.96), a sampling error (e) below 0.05 and population proportion $p = 0.5$ (a conservative estimate of 0.5 is assumed), resulted from the application of the formula for determining sample sizes when the population is known: $n = \frac{Z^2 \times N \times p(1-p)}{e^2 \times (N-1) + Z^2 \times p(1-p)}$.

Table 1. Number of service stations in sample and population.

	Population[a]	Sample	Population share %	Sample share%
REPSOL	3,556	213	43.1	43.9
CEPSA	1,513	92	18.3	19.0
BP	584	35	7.1	7.2
AGIP	321	19	3.9	3.9
SHELL	266	17	3.2	3.5
GALP	209	10	2.5	2.1
MEROIL	200	11	2.4	2.3
ERG	126	7	1.5	1.4
AVIA	100	6	1.2	1.2
ESSO	89	5	1.1	1.0
PETROCAT	65	4	0.8	0.8
TAMOIL	43	4	0.5	0.8
Q8	40	2	0.5	0.4
Unbranded	1,146*	60	13.9	12.4
Total	8,258	485	100	100

[a]Source: ENPPG (2007).
*The number includes the service stations located in the North African cities of Ceuta and Melilla.

Table 2. Distribution of service stations among Spanish regions.

	Population[1]	Sample	Population share (%)	Sample share (%)
Andalucía	1,656	84	20.1	17.3
Aragón	370	20	4.5	4.1
Asturias	239	13	2.9	2.7
Baleares	189	12	2.3	2.5
Cantabria	147	9	1.8	1.9
Castilla-La Mancha	730	42	8.8	8.7
Castilla y León	742	44	9.0	9.1
Cataluña	1,026	68	12.4	14.0
C.Valenciana	723	55	8.8	11.3
Extremadura	330	17	4.0	3.5
Galicia	605	35	7.3	7.2
Madrid	569	38	6.9	7.8
Murcia	362	21	4.4	4.3
Navarra	198	7	2.4	1.4
País Vasco	303	15	3.7	3.1
La Rioja	69	5	0.8	1.0
Total	8,258	485	100	100

[a]Source: ENPPG (2007).

largest player. As can be observed, the share of every brand in sample virtually mirrors their actual share in the population. The actual population share of unbranded stations is somewhat lower than the percentage shown in Table 1, and thereby closer to sample share.

For each station we collect retail prices for automotive diesel and 95 octane unleaded gasoline come from weekly prices collected by the Spanish Ministry of Industry every Monday from 5th February to 29th October 2007,[8] resulting in a period of analysis of 39 weeks.

[8]Extracted at that time from the website of the Ministry: http://geoportal.mityc.es/hidrocarburos/eess/.

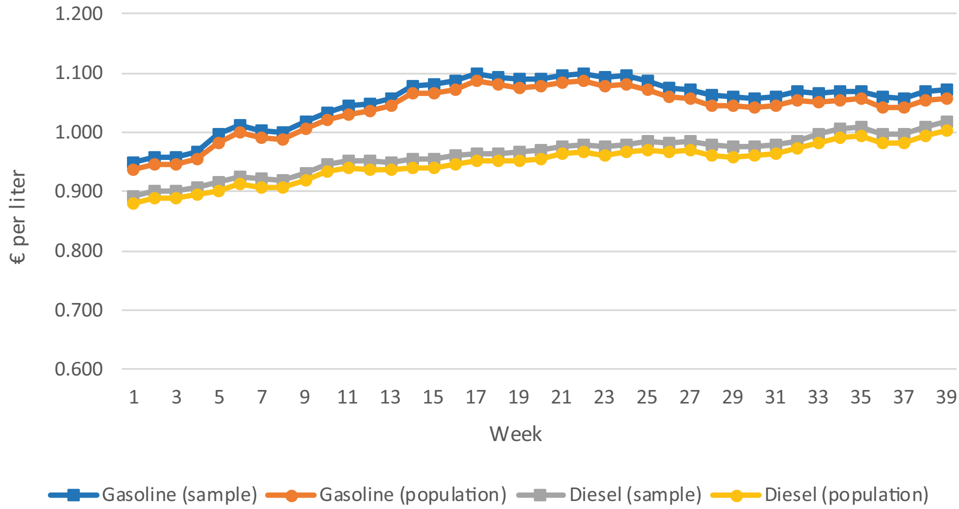


Figure 3. Average weekly prices (€ per liter). Note: Population average prices come from National Commission on Markets and Competition (CNMC 2019)

Figure 3 depicts the weekly average retail prices in our sample for gasoline and diesel at national level over the period of analysis. Additionally, Figure 3 shows the nationwide weekly average gasoline and diesel prices reported by the National Commission on Markets and Competition (CNMC 2019), which are average prices calculated from the whole population of service stations in the country. Figure 3 reveals that (i) both fuel prices increased throughout the period under consideration, and (ii) average sample prices and population prices are virtually identical throughout the period, which confirms the representativeness of the sample.

As stated above, the dependent variables are retail prices after taxes for gasoline (p_g) and for diesel (p_d) in euro cents per liter. For each service station in sample we obtained detailed information from Catalist[9] about their brands, location, the services they offered and the local market characteristics. The covariates are clustered into five categories: (i) wholesale prices; (ii) regional taxes; (iii) station characteristics; (iv) station location and local demographic characteristics; and (v) market competition proxies. Descriptive statistics for all variables are reported in Table 3.

3.1. Wholesale prices

The most relevant cost for the automotive fuel retailer is the spot wholesale price of gasoline and diesel, considered the closest available measure of its marginal cost (Bacon 1991). Indeed, spot prices are employed as the transfer price between the refining and the selling divisions of those refiners who operate their own service stations. Thus, we include variables $SPOT_g$ and $SPOT_d$, which are, respectively, the spot prices of gasoline and diesel in Rotterdam in euro cents per liter for every Monday from 5th February to 29th October 2007.

3.2. Regional taxes

In Spain retail prices after taxes for automotive fuels are calculated as

[9]Experian Catalist (http://www.catalist.com) is a well-known consultancy company, specialized in collecting information from service stations in various European countries. See http://www.catalist.com.

Table 3. Descriptive statistics.

Variable	Description	*Mean*	*SD*	*Min*	*Max*
Pg	Gasoline price (euro cents per liter)[a]	105.21	4.56	89.9	117.2
Pd	Diesel price (euro cents per liter) [a]	96.24	3.60	83.5	106.5
Spotg	Spot price of gasoline in Rotterdam[b]	38.68	3.43	30.27	44.03
Spotd	Spot price of diesel in Rotterdam[b]	38.00	2.83	32.77	45.00
Taxg	Regional taxes on gasoline after VAT[a]	1.38	1.34	0	2.78
Taxd	Regional taxes on diesel after VAT[a]	1.04	1.15	0	2.78
Density	No. of stations within a 2 km radius[c]	2.97	2.37	1	10
Stbshare	Share of stations with the same brand as station *i*[c]	.716	.305	0	1
Distance	Distance to closest station[c]	2.93	4.00	.01	32.70
Tollway	Station is located on a tollway[c]	.022		0	1
Service bay	Station provides repair service[c]	.086		0	1
Car wash	Station has a car wash[c]	.602		0	1
C-Store+	Station has a convenience store[c]	.187		0	1
Traffic flow	Station traffic level[c]	3.20	.84	1	4
Rural	Station is located in a rural area[c]	.336		0	1
Urban	Station is located in an urban area[c]	.325		0	1
Commercial	Station is located in a commercial area[c]	.338		0	1
Unemployment	Unemployment rate[d]	4.19	1.68	1.30	12.30
Repsol	Station brand: Repsol[c]	.439		0	1
Cepsa	Station brand: Cepsa[c]	.189		0	1
BP	Station brand: BP[c]	.072		0	1
Agip	Station brand: Agip[c]	.039		0	1
Shell	Station brand: Shell[c]	.035		0	1
Galp	Station brand: Galp[c]	.022		0	1
Meroil	Station brand: Meroil[c]	.023		0	1
Erg	Station brand: Erg[c]	.014		0	1
Avia	Station brand: Avia[c]	.012		0	1
Esso	Station brand: Esso[c]	.010		0	1
Petrocat	Station brand: Petrocat[c]	.008		0	1
Tamoil	Station brand: Tamoil[c]	.008		0	1
Q8	Station brand: Q8[c]	.004		0	1
Unbranded	Station is unbranded[c]	.124		0	1

Sources of data: [a]Spanish Ministry of Industry; [b]Platts; [c]Catalist; [d]National Statistics Institute of Spain.

$$p_j = \left(p_{bj} + T_{nj} + T_{rj}\right) \times VAT$$

where p_{bj} is the price of fuel j before taxes, T_{nj} denotes national excise taxes for fuel j and T_{rj} denotes regional excise taxes for fuel j. The National Excise Taxes are uniform nationwide, and are therefore not included in our regression models. In contrast, regional taxes vary across regions, with T_r ranging from 0 to 2.4 euro cents per liter over the period analyzed. Accordingly, we include variables TAX_g and TAX_d to account for differences in regional taxes after VAT, which was 16% in 2007. Thus, the tax variables are defined as $TAX_g = T_{rg} \times VAT$ and $TAX_d = T_{rd} \times VAT$. Table 3 shows that on average, regional governments charge higher taxes on gasoline (1.38 euro cents per liter) than on diesel (1.04 euro cents per liter).

3.3. Station characteristics

Although in theory gasoline (and diesel) can be considered a homogeneous good with respect to its physical and chemical properties, in practice the product specifications may vary across brands due to the use of diverse additives Van Meerbeeck (2003). Fuel additives are used to improve motor fuel performance in vehicles and to reduce specific emissions. They include octane enhancers, antiknock compounds, and oxygenates, as well as corrosion inhibitors, detergents, and dyes (Demirbas and Sahin-Demirbas 2010). For instance, a good diesel fuel is characterized by low sulfur and aromatic content, good ignition quality, the right cold weather properties, low content of pollutants, and the right density, viscosity, and boiling point (Demirbas 2007). Some consumers may be willing to pay a premium for a fuel brand that they perceive to be of higher quality. The branding of a product implies product consistency – that the product will have the same quality every time the consumer purchases it. That expectation is reinforced by a significant amount of advertising, which serves to signal that the high-quality product will continue to be supplied (Kleit 2005). In Spain, as in many other European countries, the refiners and large oil operators' brands are the results of decades of operations, backed by large national advertising campaigns. Major brands own and operate refineries in Spain (e.g. Repsol, Cepsa and BP), while others (e.g. Agip, Shell, Galp) have refining capacity abroad and/or storage facilities for oil products in the main Spanish ports.

The impact of brands on retail prices is controlled by means of dummy variables. The variable *UNBRANDED* identifies the stations that are independently owned and managed and do not carry any known brand.

In addition to brand names, service stations differ in the amenities provided at the station premises, which may also explain price differences across stations (e.g. Shepard 1991). Three dummy variables are included to account for the provision of three facilities at each station: *SERVICEBAY, CARWASH* and *C-STORE*, denoting whether the station offers repair and maintenance service, car wash and convenience store, respectively. Table 3 shows that 60% of service stations in the sample have carwash service, while the presence of convenience stores and service bays is less widespread (18.7% and 8.6% respectively).

The effect of complementary services on fuel prices can be positive or negative, depending on the overall business strategy. Thus, the manager of the station may profit from the value that consumers obtain from the utilization of a service (e.g. carwash) by charging higher prices for fuel; that is, using the complementary services to attract consumers and increase the margin of fuel sales. Conversely, it might be more profitable to charge lower fuel prices to increase the sales of high-margin services (e.g. convenience store). Empirical evidence tends to reflect such mixed effects.

3.4. Station location and local demographic characteristics

Location may have a substantial impact in determining the demand faced by a particular service station. Thus, stations located in commercial areas may benefit from the power of attraction and the advertisement of commercial centers. Similarly, stations located on tollways (i.e. controlled-access highways for which a fee or toll is charged for passage) can take advantage of the fact that drivers become to a large extent captives of the road. In other words, the alternative for a driver looking to fill the tank requires leaving the tollway to find a station outside, which may be particularly costly.

We therefore include four variables *Rural, Urban, Commercial and Tollway* to control for stations' location. *Rural* takes the value 1 when the station is located in the countryside. *Urban* equals 1 when the station is located in an urban area, that is, routes with major commuter traffic, bypasses and ring roads or in residential areas. *Commercial* equals 1 when the station is in a low residential district with relatively high incidence of industry and office units, applicable to business infrastructures, such as manufacturing, distribution centers, and port areas. Finally, the variable *Tollway* takes the value 1 if the station is sited on a tollway and zero otherwise.

The variable *TRAFFIC* measures the traffic flow at each station. It is an estimate, provided by Catalyst, for a two-way, 24-hour traffic flow for the service station's primary street. This variable ranges from 1 to 4. It takes the value 1 when the level of traffic on the station's primary road is less than 5,000 vehicles per day; the value 2 when it is between 5,000 and 15,000 vehicles per day; the value 3 when it is between 15,000 and 20,000 vehicles per day, and the value 4 when the traffic flow is higher than 25,000 vehicles per day.

The variable *DISTANCE* measures the distance in km to the nearest service station. This variable is particularly relevant to control for stations without competitors nearby, specifically for cases where the nearest competing seller of the station under consideration is located more than two km away (see the measure for local competition below).

Finally, certain demographic characteristics may have an impact on the demand for and prices of automotive fuels. Particularly relevant is the income of the population, e.g. the average level of income per person or per family at a municipal level, which has been considered in some earlier studies (e.g. Hosken, MacMillan, and Taylor 2008). To control for this effect, we use the variable *UNEMPLOY*, defined as the unemployment rate of the municipality in which the station is located, i.e. the number of unemployed people at the municipality divided by its inhabitants.[10] Given that the unemployment rate is inversely correlated with population income, we would expect that the increase in unemployment would be associated with falling demand for automotive fuels and subsequently with lower average retail prices.

3.5. Market competition

In most previous studies, the local competition for a service station is defined as the area within a certain radius, typically 1.5 miles or 2 kilometers, around the station (e.g. Barron, Taylor, and Umbeck 2004; Chandra and Tappata 2011; Eckert and West 2005; Hong and Lee 2020; Hosken, MacMillan, and Taylor 2008; Lewis 2008).[11] We also follow this circular approach and take the area within a 2 km radius to delimit the local market around each sampled service station.

We then use two proxies to measure the level of competition in the station's market. The first variable is $DENSITY_i$, which measures the number of competing sellers in the market of station *i*, that is, the number of service stations that are less than two km away from station *i* (all the existing stations in the market, not only those in our sample).

The second variable is $STBSHARE_i$, which is the proportion of service stations that carry the same brand of station *i* within the market of station *i*. If the station is unbranded, the variable indicates the proportion of unbranded stations operating in its market.

[10] A more income-related variable was not available. Nevertheless, we do believe that it is reasonable to expect that the unemployment rate is highly correlated with other income-related variables.

[11] Alternatively, some studies consider local markets based on the municipality or the administrative district in which a station operates. e.g. Van Meerbeeck (2003) and Clemenz and Gugler (2006). Other studies define local markets on the basis of driving distance (e.g. Balaguer and Ripollés 2020; Perdiguero and Borrell 2019).

4. Empirical model specification

To test the hypotheses H1 to H4 formulated above, we estimate the following equation separately for gasoline and diesel:

$$p_{it} = \beta_0 + \beta_1 Spot_t + \beta_2 Tax_i + \beta_3 Density_i + \beta_4 Density_i * Unbranded_i + \beta_5 Stbshare_i + \beta_6 Stbshare_i * Unbranded_i + \theta X_i + \varepsilon_{it} \quad (1)$$

where p_{it} is the retail price of gasoline or diesel in station *i* at week *t*; $Spot_t$ is the spot price of gasoline or diesel at week *t*, and ε_{it} is a random error term. Note that *Tax*, market variables (*Density* and *Stbshare*) and the matrix of the control variables for station and environmental characteristics (*Xi*) are denoted without the subscript *t* because they are time-invariant in our sample. The opposite is true in the case of the variable *Spot*, since spot prices change from one week to another but do not vary across service stations. According to our hypotheses H1 to H4, we would expect a positive sign for coefficients β_3 and β_5 in (1), but negative signs for β_4 and β_6.

To test hypothesis H5, we estimate the following model:

$$D_{it} = \delta_0 + \delta_1 SPOTdif_t + \delta_2 TAXdif_i + \delta_3 Density_i + \delta_4 Unbranded_i + \delta_5 Density_i * Unbranded_i + \delta_6 Stbshare_i + \delta_7 Stbshare_i * Unbranded_i + \varphi X_i + \varepsilon_{it} \quad (2)$$

The dependent variable D_{it} in equation (2) is defined as the difference between the gasoline prices and diesel prices in station *i* at week *t*, i.e.: $D_{it} = p_{g_{it}} - p_{d_{it}}$. Likewise, *SPOTdif* denotes the difference between the gasoline spot price and the diesel spot price at week *t* ($SPOTdif_t = SPOT_{gt} - SPOT_{dt}$), while $TAXdif_i$ is the difference in taxes between gasoline and diesel ($TAXdif_i = TAX_{ig} - TAX_{id}$) in the region where station *i* is located. According to our hypothesis H5, we would expect a positive sign for coefficient δ_4 in equation (2).

We estimate a pooled OLS model correcting for spatial correlation and heteroscedasticity. Our analysis involves a number of estimation issues. First, the model could suffer from potential endogeneity issues. A first source of endogeneity may come from the omission of local demand variables. We have included a number of indicators to control for differences in local demands, and thereby correct the potential bias around this issue. Specifically, local demand may vary considerable across locations. In rural areas, residential density is lower than in urban areas, whereas commercial areas have relatively high incidence of industry and office units. For these reasons, the variables that control for stations' location (*Rural, Urban and Commercial*) would contribute to alleviate the presence of heterogeneity in local demand. The same applies to the variables TRAFFIC and UNEMPLOYMENT. The former measures the traffic flow at each station, which would capture variations in potential demand for service stations. The latter are used to capture demand shifts among municipalities in which the stations are located. As such, an increase in unemployment could lead to lower prices as demand falls.

There is however a second potential source of endogeneity coming from the simultaneity of density and prices, which the use of demand indicators cannot solve. Specifically, higher retail prices due to increased demand could attract more sellers, whereas lower prices could lead to the exit of some sellers. However, we believe that this potential effect should not be significant in our setting. As Sen and Townley (2010) point out, from a practical viewpoint the possibility of simultaneity bias occurring with respect to monthly automotive fuels data (weekly data in our case) is highly unlikely. Retail automotive fuels industry is capital intensive and entering this industry requires a significant amount of time, thus reducing the likelihood of immediate firm entry (or exit) because of contemporary price shocks.

In addition, ignoring possible correlation of regression disturbances between subjects (service stations) and over time can lead to biased statistical inference. Both the Pesaran (2004) test and the Friedman (1937) test leads us to reject the null hypothesis of cross-sectional independence at any standard level of significance in all our regression models.

Second, since the OLS estimation procedure yields consistent and unbiased estimates only when the data are stationary, we test for the presence of unit root in the variables that change over time (i.e. retail and spot prices for gasoline and diesel). Specifically, we have performed the Harris and Tzavalis (1999) test, which is designed for cases where N is relatively large and the time dimension, T, is small, and allows us to remove cross-sectional means to help control for contemporaneous correlation. The null hypothesis of a unit root is strongly rejected for the four variables of interest. This indicates that these variables are stationary (I(0)). The Im, Pesaran, and Shin (2003) test also confirms that the variables are stationary. In summary, the results of the tests employed leads us to conclude that the variable included in our modes are stationary. Additionally, to address the problem of contemporaneous correlated errors, all regressions are estimated with Driscoll and Kraay standard errors. The Driscoll and Kraay (1998) method produce heteroscedasticity- and autocorrelation- consistent standard errors that are robust to general forms of cross-sectional and temporal dependence.

Third, the inclusion in our model of a wholesale price that is the same for all service stations is equivalent to the inclusion of time effects (Cooper and Jones 2007; Hoechle 2007). In any case, as in Cooper and Jones (2007), we have formulated an alternative model specification by dropping the variable $Spot_t$ and re-estimating instead the models with weekly time variables to capture time effects. The results do not change at all. Additionally, the inclusion of the spot price allows us to analyze the pass-through of main input cost variations onto retail prices, as discussed below.

Fourth, the only regulatory disparity across regions in Spain is the existence of different regional excise taxes. As stated above, this has led us to include the variable Tax_i. Initially, we estimated the models by including regional dummy variables to capture further regional fixed effects. However, due to the high multicollinearity between the variable *Tax* and the regional dummy variables, we dropped the latter from our models.[12] Keeping the variable Tax_i has the advantage of allowing us to estimate the extent to which regional taxes are passed on to retail prices, an issue that led to an intense policy debate in Spain.

Finally, the empirical analysis greatly relies on cross-sectional variation. The data consist of a fixed number of stations in which prices greatly vary over time, but there are no variations in the independent variables over time, with the exception of $Spot_t$. Thus, as an alternative specification we regress prices averaged at the station level on variables that vary across stations and skip the variable on spot prices, while clustering the residuals at the station level. However, in this cross-sectional specification we are unable to address the issue of spatial correlation, i.e. the HAC estimator by Kelejian and Prucha (2007). This requires having a spatial-weighting matrix, for which it is necessary to know the distance between all service stations. Unfortunately, we do not have that information. Further, by omitting the spot price in this model the analysis of the pass-through of main input cost variations onto retail prices is missed out, which provides an interesting insight as discussed below.

5. Results

Table 4 reports the parameter estimates of our price equation (1) for both gasoline and diesel. We note that the estimates of the model specification without the interaction terms are also reported in Table 4. The coefficients of the interaction terms are in all cases statistically significant, and the nested-F test comparing the full interaction model with the no interaction model indicates that the former as a whole performs significantly better for both fuels (F = 13.49, p = 0.000 for gasoline, and F = 34.04 p = 0.000 for diesel).

Let us focus first on the key variables of the analysis. As hypothesized, our results show that the relationship between the number of sellers and prices varies across different types of service station. Thus, the positive and highly significant coefficients for the variable *DENSITY* provide consistent evidence for the positive relationship between the number of competitors and retail prices in branded

[12]Estimates of the model without the *Tax* variable and with regional dummy variables instead, show similar results (not shown here).

Table 4. Estimates for the price specification by type of automotive fuels.

	Pooled OLS[b]				Cross-sectional specification[b]	
	Gasoline		Diesel		Gasoline	Diesel
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Spot	1.048*** (.133)	1.048***(.133)	1.076***(.086)	1.076*** (.086)	-	-
Tax	1.008*** (.007)	1.007***(.007)	1.024***(.008)	1.023***(.008)	.983***(.029)	1.021***(.032)
Density	.077*** (.006)	.096***(.006)	.075*** (.004)	.096*** (.004)	.110** (036)	.106** (.034)
Density*Unbranded	-	−.172***(.010)	-	−.177*** (.017)	−.183**(.067)	−.338** (.171)
Stbshare	.407*** (.047)	.477*** (.032)	.378***(.035)	.518*** (.034)	.488** (.235)	.648** (.251)
Stbshare*Unbrande	-	−.628** (.185)	-	1.117***(.112)	−.700 (.553)	−2.42* (1.40)
Distance	.001 (.002)	.0007 (.002)	.0003 (.001)	.0007 (.0009)	.0017 (.010)	−.0021 (.009)
Service bay	.112** (.041)	.122** (.041)	−.049** (.021)	−.050** (.020)	.115 (.146)	−.060 (.198)
Car wash	.127***(.011)	.119** (.011)	.212*** (.011)	.206*** (.011)	.133 (0.09)	.100 (.136)
C-Store	.003 (.030)	−.006 (.030)	−.079***(.010)	−.088*** (.010)	.012 (.1015)	−.071 (.108)
Urban	.193*** (.019)	.165*** (.020)	.351*** (.007)	.333*** (.008)	.146 (.105)	.301** (.132)
Rural	.172*** (.025)	.152*** (.025)	.260*** (.015)	.248*** (.014)	.176 (.107)	.209 (.142)
Tollway	.473*** (.041)	.483*** (.039)	.617*** (.030)	.616*** (.029)	.517 *(.276)	.635** (.239)
Traffic	.118*** (.008)	.115*** (.008)	.042** (.011)	.036** (.011)	.097*(.051)	.010 (.066)
Unemployment	−.050** (.013)	−.051** (.013)	−.029** (0.08)	−.028** (.008)	−.052* (.029)	−.027 (.023)
Repsol	−.046 (.077)	.158* (.081)	.416*** (.038)	.621*** (.048)	.184 (.176)	.615*** (.163)
Cepsa	.353** (.126)	.568*** (.130)	.559*** (.052)	.774*** (.065)	.557** (.184)	.798*** (.165)
BP	.509*** (.102)	.716*** (.109)	.443*** (.054)	.663*** (.065)	.751*** (.194)	.702*** (.185)
Agip	.031 (.063)	.239*** (.060)	.210*** (.042)	.434*** (.053)	354 (.240)	.480* (.278)
Shell	−.161*** (.037)	.038 (.051)	.278*** (.030)	.503 *** (.050	.052 (.235)	.568*** (.239)
Galp	.034 (.061)	.234** (.070)	.230*** (.058)	.452** (.076)	.543 (.338)	.516** (.222)
Meroil	−.554*** (.081)	−.327***(.077)	−.277***(.068)	−.031 (.083)	.-.321 (.419)	.038 (.322)
Erg	.094* (.051)	.304*** (.062)	−.013 (.049)	.214** (.062)	.335 (.325)	.214 (.316)
Avia	−.106* (.058)	.097 (.059)	.433*** (.034)	.627*** (.042)	.088 (.298)	.625*** (.256)

(Continued)

Table 4. (Continued).

	Pooled OLS[b]				Cross-sectional specification[b]	
	Gasoline		Diesel		Gasoline	Diesel
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Esso	−.200 (.149)	.020 (.147)	−.298***(.061)	−.052 (.057)	.032 (.703)	0.025 (.937)
Petrocat	−.187 (.113)	.040 (.103)	−.121 (.085)	.122 (.086)	0.077 (.276)	.163 (.246)
Tamoil	−.188 (.173)	.007 (.167)	−.004 (.163)	.200 (.175)	.029 (.620)	.190 (.652)
Q8	.870*** (.180)	1.098***(.176)	.612*** (.086)	.852*** (.101)	1.13** (.553)	.885*** (.230)
constant	62.28*** (5.31)	62.73***(5.31)	53.09***(3.32)	53.51***(3.32)	103.3***(.31)	94.6***(.384)
R^2	.7196	.7200	.8330	.8336	.7436	.6267
No.observations	18,915	18,915	18,915	18,915	485	485†‡

The excluded brand category is unbranded independent stations. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.
†Standard errors clustered by stations are in parentheses.
‡Driscoll-Kraay standard errors are in parentheses.

stations, i.e. branded stations with a greater number of competitors within a 2 km radius show higher prices in both automotive fuels. We therefore accept hypothesis H1.

Further, the estimated coefficients of interaction terms *Density*Unbranded* are negative and statistically significant. The sum of the coefficients of *Density* and *Density*Unbranded* is significantly negative both for gasoline and diesel, Therefore, hypothesis H2 is confirmed, indicating that an increase in the number of competitors significantly decreases retail prices at unbranded stations.

The positive and highly significant coefficient for the variable *Stbshare* across all model specifications indicates that an increase in the share of stations that carry the same brand within a 2 km radius significantly increases gasoline and diesel retail prices. This result confirms our hypothesis H3, suggesting that competition among branded stations is mitigated, as the brand concentration increases.

Furthermore, the sum of the coefficients of *Stbshare* and the interaction term *Stbshare *Unbranded* is significant for diesel, but not in the gasoline regression. Therefore, hypothesis H4 is only supported in the case of diesel pricing. On the other hand, we believe that this result reflects differences in fuel competition at unbranded stations. As argued above, unbranded stations would compete more intensively for informed diesel consumers, while the demand for diesel is substantially greater than gasoline demand in Spain. Competition at unbranded stations is on diesel. Therefore, the greater concentration of unbranded stations in a given market would increase the competitive pressure on diesel pricing at unbranded stations, but not in gasoline pricing.

In the case of gasoline pricing, Perdiguero and Jiménez (2021) provide evidence that Spanish major oil operators (Repsol, Cepsa and BP) could have maintained coordinated cuts in gasoline prices precisely on Mondays, a matter of concern for the Spanish energy regulator (CNE 2013). Specifically, the strategy consisted of significantly reduce the price on Mondays, and later increase it for the remainder of the week, with the ultimate goal of lowering official gasoline prices, since prices were collected by the government on Mondays (as stated above) to be subsequently sent to the European Commission for publication in the European Union Oil Bulletin statistics. Thus, with this behavior these leading companies could make gasoline prices in Spain appear lower in the European price ranking than they really were, and reduce public and media attention on the high gasoline prices in Spain. If the "Monday effect" was present in the period analyzed in this paper, the sign and magnitude of the effect of our key variables could be underestimated. Specifically, it could be behind the lack of statistical significance of the different effect of *Stbshare* on gasoline pricing at branded versus unbranded stations, which might have occurred if gasoline prices had been collected on another day of the week.

Regarding the Tax_i variable, the coefficient values are positive and statistically significant. Note that a coefficient value equal to one would indicate full pass-through rate. Thus, our results suggest that stations fully passed-through regional gasoline taxes to retail prices, and potentially more than full pass-through of regional diesel taxes.[13] This result is not surprising, given that demands for both products are highly inelastic, and is consistent with most previous studies (e.g. Bello and Contín-Pilart 2012; Marion and Muehlegger 2011).

Likewise, the sign of the coefficient for *Spot* is also positive and highly significant across all model specifications. We recall however that retail prices (p_{it}) are VAT inclusive, which was 16% in Spain. Therefore, in this case a coefficient value of 1.16 would indicate full cost pass-through rate to consumers. Table 4 reveals that coefficient values of *Spot* are significantly smaller than 1.16 indicating that cost pass-through to consumers was incomplete in both fuels. Specifically, one Eurocent increase in the spot price is estimated to increase the retail price of gasoline and diesel respectively by 1.048 and 1.076 cents, suggesting that competition is less than perfect (Haucap, Heimeshoff, and Siekmann 2017).

[13]Theoretical work on tax incidence shows that pass-through rate exceeding unity is possible under imperfect competition (see Besley 1989; Hamilton 1999, among others).

The other explanatory variables behave very much as expected. The estimated coefficients for the location variables broadly confirm the predicted impact of location on prices. Thus, average gasoline and diesel prices are significantly higher at stations located on tollways, as well as on roads with intense traffic level. Likewise, both fuel prices at stations located in urban and rural areas are significantly higher than at stations located in commercial areas, which is the reference category. Regarding the customer services provided by stations, the presence of *service bay* and *carwash* show a statistically significant influence, while the presence of *c-store* is only significant on the diesel equation. As expected, the unemployment rate shows a significant negative sign.

It is interesting to note that most branded stations set significantly higher prices than unbranded stations, especially diesel prices. This is particularly true for those brands with a longer tradition in the automotive fuel market that have refineries in Spain, e.g. Repsol, Cepsa and BP, which jointly account around 70% of service stations in the country.

The last two columns in Table 4 show the cross-sectional specification discussed above. As can be observed, even though the model does not account for the presence of spatial correlation, the sign and statistical significance of the main coefficients are broadly maintained.

Table 5 shows the parameter estimates for equation (2). Note that in this case the excluded brand category is all branded stations, with the aim of testing the potential difference in the price-setting behavior of both fuels between unbranded and branded stations. The positive and statistically significant sign of the coefficient for the variable *Unbranded* in Table 5 indicates that the differential between gasoline and diesel prices is larger at unbranded stations than at branded stations, and thus provides strong support for hypothesis H5. This result confirms that unbranded stations price more aggressively in diesel than gasoline as compared to branded stations.

6. Conclusions and policy implications

In this paper we have formulated and empirically tested a number of hypotheses that postulate that seller density and brand concentration of local competition may have a different impact on gasoline

Table 5. Estimates for the price differential specification.

	Pooled OLS [1]	Cross-sectional specification [2]
SPOTdiff	0.672*** (.009)	-
TAXdiff	0.653*** (.002)	0.569*** (.087)
Unbranded	0.362*** (.078)	0.360** (.108)
Density	−0.016*** (.005)	−0.012 (.026)
Density*Unbranded	−0.012 (.018)	0.160 (.150)
Stbshare	−0.258*** (.040)	−0.330* (.180)
Stbshare*Unbranded	0.353* (.186)	1.508 (1.17)
Distance	−0.001 (.005)	0.003 (.007)
Tollway	−0.072*** (.024)	−0.083 (.112)
Traffic flow	0.069*** (.013)	0.084* (.044)
Service bay	0.028 (.026)	0.031 (.103)
Car wash	−0.036*** (.012)	0.093 (.115)
C-Store	−0.003 (.020)	−0.029 (.070)
Urban	−0.145*** (.020)	−0.115 (.108)
Rural	−0.074*** (.018)	−0.005 (.123)
Unemployment	−0.029*** (.007)	−0.028* (.016)
constant	8.220*** (.347)	8.550** (.213)
R^2	0.655	0.222
Number of observations	18,915	485

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.
[a]Driscoll-Kraay standard errors are in parentheses.
[b]Standard errors clustered by stations are in parentheses.

and diesel pricing at branded and unbranded service stations, due to consumers' search costs differentials.

The results provide empirical evidence for the existence of different competitive dynamics between branded and unbranded stations, and between gasoline and diesel retail pricing. Thus, the results show that the relationship between the number of sellers and prices varies across types of service stations. After controlling for station-level characteristics, we find that the number of competitors is positively associated with retail automotive fuel prices at branded stations, a result consistent with the predictions of theoretical search models that typically divide the market into informed and uninformed buyers. In contrast, we find that seller density is negatively associated with retail prices at unbranded independent stations. These findings are consistent with the view that consumers at unbranded stations have a greater propensity to search than those at branded stations. In other words, unbranded stations would attract a larger share of informed consumers, with lower search costs and sensitive to retail prices, whereas branded station would attract relatively more uninformed consumers with higher search costs and less sensitive to prices.

The results also suggest that the concentration of stations carrying the same brand in a local market mitigates gasoline and diesel price competition among nearby branded stations. That is, gasoline and diesel prices at a given branded station are positively associated with the share of stations carrying its same brand in the same market. In contrast, the concentration of unbranded competitors in a local market is negatively associated with diesel pricing at unbranded stations. However, we do not find such effect on gasoline pricing. Likewise, our results indicate that at unbranded stations the competitive pressure is stronger on diesel pricing than on gasoline pricing, as it is shown that unbranded stations price more aggressively in diesel than gasoline relative to branded stations.

Our theoretical discussion and the empirical findings provide relevant insights for policy makers. Thus, results indicate that the mere increase in the number of sellers does not *per se* entail a price-lowering effect. Rather, they suggest that promoting the entry of independent stations would be much more effective in enhancing price competition, especially in the diesel market, than a substantial increase in the number of branded stations. In this sense, our findings are consistent with those of Balaguer and Ripollés (2020) on diesel prices in Spain and the role of "low cost" stations. Thus, they find that the entry of stations of any of the two dominant operators (Repsol and Cepsa) is less favorable to decrease the diesel prices of local competitors (actually, they find that the presence of such brands increases the prices charged by surrounding competitors), while the entry of "low cost" stations produces relative downward effects on diesel prices. In the same way, the findings are also in line with the concern of Spain's antitrust authorities about the consequences of high level of geographical concentration of stations operated under the same brand (2012a; CNC 2009). In this respect, our results inform policy makers about the need of lessening the incentives for coordination among firms, avoiding the confluence of commercial interests between operators, and weakening the possibilities of aligning their business strategies.

Notwithstanding the limitations of the data and the time span of the dataset, the research questions and their policy implications raised in this paper are however still relevant today. Thus, despite the entry and the increase in the number of service stations, pretax automotive fuel prices continue to be a matter of concern for competition authorities in Spain, as they continue to be higher than those in neighboring European countries (e.g. CNMC 2020). Likewise, the brand concentration of service stations, as well as the level of vertical integration and coordination among service stations by the major oil operators, continue to be characteristic of the structure of the retail automotive fuel market in Spain (CNMC 2015).

In this regard, we note that the local market has been defined as the area within a 2 km radius around each service station. We recognize that, although this threshold has been used in several previous studies, this choice is rather arbitrary. We would have liked to test the scope and intensity of our results in markets of increasing size. Unfortunately, we do not have the necessary information from all service stations to perform such an analysis. For example, Kvasnička, Rotislav, and Ondřej (2018) found that local competition affects gasoline prices in the Czech Republic up to a radius of 6 km, showing a decreasing trend in the magnitude of its impact as driving distance increases beyond 2 km. Moreover, the relevant definition of the local diesel market may be arguably larger than that for gasoline.

Likewise, beyond the "Monday effect" discussed above, which arguably ceased in May 2013 when the government stopped submitting gasoline prices to the European Oil Bulletin only on Mondays, our analysis suggest that it would be advisable to use prices observed on different days of the week, or even at different times of the day. Not only as a robustness check of the results presented in this paper, but also to analyze the existence and effect of different temporal patterns in the pricing of automotive fuels. In summary, the findings reported here suggest that future research along these lines might prove useful.

Finally, a feature of our dataset is that in 2007 there were virtually no established chains of unbranded independent service stations. This is an advantage in the sense that ensures the independent behavior of the unbranded stations included in the sample. However, during the last decade in Spain have emerged chains of unbranded stations. The presence of such chains may have an impact on automotive fuel pricing at unbranded stations. Thus, pricing at stations that are part of the same chain might be determined by a coordinated corporate strategy, as in the case of stations that are owned or controlled by a refiner. Specifically, a related extension of our research is to analyze whether being member of a chain modifies the effect that the density of sellers and the concentration of unbranded stations of the same chain have on the gasoline and diesel pricing of unbranded stations. This is an issue with potentially significant policy implications that justifies further research.

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Disclosure statement

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