THE PRICING BEHAVIOR OF ITALIAN GAS STATIONS: SOME EVIDENCE FROM THE CUNEO RETAIL FUEL MARKET

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Abstract This paper studies how gas stations adjust their gasoline and diesel prices in response to their neighboring competitors. The empirical analysis relies on daily prices of twenty gas stations located in Cuneo, Italy, collected from January to August 2011. Data show significant price uniformity especially within the same geographical section of the town. Approximately one third of gas stations has responded within a day to targeted competitors' price changes, indicating some evidence of price matching behavior in the industry. Additionally, there is some but discontinuous geographical price propagation, testifying the presence of a weak domino effect. Finally, spatial econometric analysis suggests that there is spatial dependence up to about 1.1 kilometers.

Keywords: Price transmission; Gasoline and diesel prices; Imperfect competitive markets; Spatial econometrics.

JEL classification:D4, D43, N7.

1. Introduction

Rarely does a day go by when newspapers or other mass media outlets in Italy do not discuss the presence and the reasons of excessively high retail fuel prices. Nevertheless, the academic debate on this issue, as well as contributions to the literature in the energy field, remains very limited. A notable exception is the work of Arslan (2000), who examines the fuel price fixing behavior of the main oil companies operating in Italy ('the eight majors'). His study offers support to the repeated complaints about the abuses of the majors and was in line with the decision of the Italian Competition Authority (*Autorità Garante per la Concorrenza e per il Mercato,* henceforth AGCM), that, in the same year, found oil companies guilty for restricting competition by forcing gas stations to follow the recommended retail price (AGCM, 2000; Colangelo and Martini, 2003).

In 2000, AGCM also launched a survey with the aim of investigating the spatial distribution of Italian gas stations on the territory and its impact on retail prices. The main policy recommendation emerging from this study was to reduce the number of gas stations (that was much larger when compared with other European countries) in order to better exploit the economies of scale at the retail level. However, no particular attention has been given to the price transmission mechanism (AGCM, 2001). In 2011, a new survey concerning unbranded gas stations had the goal of understanding such stations' role in stimulating price reductions. At present a clear picture of retail fuel price setting in Italy does not emerge from the Competition Authority's dossier, although the Authority recognizes that alleged high prices are a recurring source of controversy between consumer associations and oil companies.

In this paper, we aim to shed some light on the pricing behavior of Italian gas stations.[1] More precisely, we focus on how gas stations adjust their prices in response to the behavior of their

[1] The reason why we analyze the Italian case is that the functioning of the fuel sector varies considerably from one country to another and that the findings offered by the international literature may not hold for the Italian case.

neighboring competitors.[2] Indeed, it has been recently shown that retail competition and the characteristics of the price transmission mechanism have a significant impact on the market power of upstream firms (Alderighi and Piga, 2012). In a recent German antitrust case, the Decision Division emphasized the importance of analyzing the retail fuel sector and price stimuli at the local level (Bunderkartellamt, 2008).

Recently, Italian law 99/2009 (15 October) required the creation of a publicly available data bank on retail fuel prices applied by each pump within the entire Italian territory and on a daily basis. After several years, data collection is still at a preliminary stage, since only the prices of a limited set of pumps (and for a short time period) are currently available.[3] To overcome this data shortage, we collected a sample of daily gasoline and diesel prices from twenty gas stations located in the city of Cuneo (Italy), during the period January - August 2011.

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[2] We have also analyzed the potential presence of asymmetries between retail and international crude oil prices. Diverging from the results of Galeotti et al. (2002), we find a strong asymmetric effect since retail prices tend to increase rapidly when world prices rises and to decrease slowly when they fall. We do not present their results, as our series only covers seven months, and may raise concerns about the reliability of results (see, however, Baudino, 2011).

[3] Data was collected by the Italian Ministry of the Economic Development (*Ministero dello Sviluppo Economico*) from mid-2011. The gas stations involved in the data collection are those located on highways. At the moment, data can be freely retrieved from the web-site of the Ministry of the Economic Development only during the day of the query, and the coverage is partial. We will have to wait for a few years before we can obtain wider data from this source.

Our analysis follows and extends that proposed by Atkinson et al. (2008) for the town of Guelph, Canada. Our findings present some analogies but also some interesting differences. As far as price dispersion is concerned, we find that the one-price law approximately holds in the medium term, but there are some price differentials in the short term as in Atkinson et al. (2008) paper. Differences from that study, however, concern the price matching behavior of gas stations. In the Guelph case, about two-thirds of the retailers responded within a day to targeted competitors' price changes, while in our analysis, a smaller proportion of Italian retailers matched changes, i.e. less than one-third.

Moreover, a different type of behavior is observed in the spatial propagation of price changes among stations since in the Guelph case the intensity of price matching is greater than in the Italian one. More specifically, we find that price response is faster for those gas stations located along commuters' paths and slower for those gas stations located off-path. This result is in line with Houde (2012), who find that commuters modify and extend the patterns competition among gasoline retailers. In other words, the presence of local commuter paths can induce a discontinuous geographical price propagation yielding to a weak domino effect.

Finally, we rely on spatial econometric techniques to complement the analysis. We find that there is small but statistically significant spatial dependence in both markets for distances of about 1.1 kilometers.

Throughout the paper, we also compare the characteristics of gasoline and diesel markets. We find that the two markets show a similar functioning scheme although single stations may behave differently in setting gasoline and diesel prices (different target firms, different price differentials). Moreover, we find that the diesel market is more reactive than the gasoline one.

The rest of the paper is organized as follows. In Section 2 we briefly review the literature on the pricing behavior of gas stations. Section 3 provides a description of the Italian fuel sector. Section 4 presents the research questions. Descriptions of the data and data collection methods are presented in Section 5, while Section 6 presents the results of the analysis. Section 7 concludes.

2. Literature review on fuel pricing behavior

The functioning of the retail fuel markets has been widely analyzed in at least four different strains of research. Most of the literature in the field, starting with the seminal paper of Karrenbrock (1991), tests the *'double speed hypothesis'*. The key questions are whether retail prices go up and down at the same speed as crude oil prices, and whether the prices respond more quickly to increases than to decreases. Subsequently, Borenstein et al. (1997) find asymmetries in price change behaviors, using weekly data for the period 1986 to 1990 in 33 United States cities east of the Rocky Mountains, and relate the observed asymmetry in price change behavior to consumer search costs. This asymmetric behavior is also confirmed by Slade (1992, 1998) in a study on Vancouver's gasoline-price war. Furthermore, Godby et al. (2000), using weekly data for thirteen Canadian cities, also find evidence of asymmetric retail price adjustments. An exception is in the work of Bachmeier and Griffin (2003), which finds that daily regional bulk spot prices in Houston adjust almost instantaneously and symmetrically to crude oil price changes. Similar analyses have been carried out in Europe. In the UK, Bacon (1991) identifies an asymmetry in the speed of adjustment of retail gasoline prices with respect to the refineries' wholesale prices. The double speed hypothesis is corroborated by Bettendorf et al.'s (2003) analysis of the Dutch market, while opposite results were observed by Balaguer and Ripollés (2012) in a study on the Spanish gasoline retailers.

A second strand of research is *price stickiness*. An important contribution comes from Davis and Hamilton (2004), who analyze a sample of nine gasoline wholesalers in Philadelphia from 1989 to 1991 using daily data. They show that price stickiness basically derives from strategic considerations of how consumers and firms will react to price changes. Other causes of stickiness can be attributed to: the costs faced by the players in changing their prices (Rotemberg, 1982), the existence of physical barriers to the rapid adjustment of inventories (Borenstein and Shepard, 2002), and the gradual processing of information (Sims, 1998).

The third strain of research concerns *price fluctuations* (known as 'cycling'), i.e. the case where retail fuel prices go back and forth, like a wave. The first theoretical explanation of price cycling goes back to Edgeworth (1925) and has further formalized by Maskin and Tirole (1988) with a model of dynamic competition.[4] Other papers explain fluctuations through tacit collusion (Borenstein and Shepard, 1996; Noel, 2007) or through the specific contractual forms between gasoline retailers and their upstream suppliers (Gugler and Clemenz, 2006; Pennerstorfer, 2009). Eckert and West (2004) use a data set of daily observations on retail gasoline prices within the Vancouver Metropolitan Area for the period 27 July - 31 December, 1999, and find empirical evidence of price cycling with price restoration taking place mid-week. Eckert (2002) econometrically investigates price cycling using weekly retail gasoline prices in Windsor, Canada, from 1989 to 1994. He finds that new price cycles are more likely to start when retail prices are near cost, and that retail prices are relatively insensitive to cost over the decreasing phase of the cycle, suggesting that the magnitude of price decreases is primarily influenced by consumer sensitivity to price differentials across stations. Finally, Lewis (2012) finds the presence of price-leader firms (or chains) in each of those markets where prices exhibit highly cyclical fluctuations. He suggests that leadership and coordination may be another explanation of cyclical fluctuations.

[4] Maskin and Tirole (1988) prove the existence of a Markov-perfect equilibrium and characterize the solution. The retailers' behavior is as follows. When prices are above marginal costs, one retailer profitably reduces its prices to undercut its rival and capture the market. Similarly, the opponent responds by offering a lower price. Once the marginal cost threshold (i.e. zero profits) has been reached, the two producers increase their prices in the expectation that the opponent will do the same.

The forth, and last, strand of research, is the one most closely related to our paper, and investigates *price matching behavior and spatial price propagation*. In other words, a change in the fuel price of one firm triggers a price reaction (or matching) of its closest opponents, which can then stimulate sequences of price changes by subsequent neighboring competitors. The initial price change can hence induce a chain reaction known as the 'domino effect' (Chamberlin, 1933, pp. 103-104, Rothschild, 1982). Empirical works on price transmission in the fuel sector are however more limited. Atkinson et al. (2008) collected data on gasoline prices every 2 hours from 14 August to 24 November, 2005, for 27 stations in Guelph, Ontario. They observe spatial and temporal price propagation. Price transmission starts from the closest neighbors overnight, and then passes to mid-distance competitors the next day, after which the responses of the remaining stations are completed in the next two to three days. Using data on two retail gasoline markets for the Hawaiian Islands in the 1990s, Manuszak (2010) finds that price changes depend on the spatial proximity of alternatives, and mainly involve nearby products, i.e. of the same grade and/or service level. Pinkse et al. (2002), using data on US refineries, show that competition is highly localized. They find evidence of price matching behavior among clustered firms, but they do not identify a propagation effect among clusters of firms. By analyzing price correlations between Canadian refineries, Audy and Erutku (2005) find that price transmission is localized, although some city sections are connected to each other. Hogg et al. (2012), using price data on retail gas stations located in the South-Eastern Queensland, find that price responses are both affected by spatial proximity. Finally, Houde (2012) offers an interesting analysis of the pricing behavior in the Québec City. He finds that competition among gas stations is affected by their geographical location in a very complex way. Thus, the degree of competition among stations is determined not only by their relative distance but also by their belonging or not to a common local commuting path. Indeed, multiple-address users, i.e. commuters, can easily choose among all retailers on the local commuting path without incurring in significant costs, while single-address users only choose among neighboring stations close to their home.

3. The Italian fuel sector

The structure of the Italian fuel sector is similar to that of many Western countries: a few big vertically integrated oil companies control the entire production process, from the extraction of oil to the sale of the fuel at the pump.[5] According to Unione Petrolifera (2011), the overall refining capacity, approximately 107 million tons in 2010, is guaranteed by 16 plants, with a utilization rate of about 84%. Oil extraction capacity on the national territory is generally poor. In 2010, total imports were 77.9 million tons and Libya is the largest supplier (16.4 million tons). At the retail level, most of the branded stations are company-owned (i.e. the firms are vertically-integrated with the parent brand), while a few are operated by an independent dealer. Branded stations compete against a few independent unbranded retailers (also known as 'white pumps'). Such independent dealers often charge lower prices than branded stations (about 10-11 cents per liter). In Italy, white pumps cover less than 10% of the national market, while, in other European countries (UK, Germany and, in particular, France), they are more prevalent, covering over half of the retail market (Ravazzoni, 2010). This aspect provides an unusual characteristic to the Italian fuel sector when compared to other EU Countries, making it less competitive in relative terms.

Other unfavorable characteristics of the Italian fuel market include the relative abundance of gas stations, low average supply per point of sale, the limited presence of self-service, and the limited presence of non-oil activities (Table 1).[6] Recently, for environmental reasons, as well as to promote the spread of new fuel types, national and regional laws have forced entrant stations to supply of

[5] There are eight big companies holding around 95% market share of the Italian fuel retail market. These companies, ranked from largest to smallest are: Eni, Esso, Q8, Api, Tamoil, Erg, Shell and Total. Some of these (Esso, Q8, Tamoil, Shell and Total) are global players, while others (Eni, Api and Erg) are mainly based in Italy. The Herfindahl-Hirschman index at retail level is about 1,660 points.

[6] It seems that little has changed from what was reported in the Competition Commission survey in 2000 (AGCM, 2001).

LPG (propane). This measure has slightly reduced the proliferation of retail points, but has made it more difficult for small independent operators to enter the market. The impact on the market efficiency of this intervention is, therefore, ambiguous.

[INSERT TAB. 1 ABOUT HERE]

Retail prices are a function of two components: the industrial component, and the fiscal component. The industrial component is represented by the costs of crude oil extraction or purchase, refinement, storage, transportation, and retail sale. The fiscal component consists of an excise and a value-added tax applied to both the industrial component and the excise. In the last 15 years, Italian retail fuel prices have been in line with the price charged in the other European countries, although the weight of the two components has been quite different. In Italy, the industrial component is €0.722 for gasoline and €0.699 for diesel, and the fiscal components is €0.804 for gasoline and €0.613 for diesel (May 2011). Germany, France and UK have higher fiscal components and significantly lower industrial ones as shown by Table 2. The higher industrial component (especially for gasoline) is often interpreted that the Italian fuel market is less efficient relative to the comparator European countries.

[INSERT TAB. 2 ABOUT HERE]

It has been also argued that large industrial costs in Italy must be attributable to the morphology of the country, which to be adequately covered, requires a high number of gas stations. This explanation is, however, not fully convincing. Because of its geography, Italy may need a larger number of points of sale to cover less accessible areas (i.e. mountain areas). However, the observed spread of the stations over the territory does not seem to follow this logic. Indeed, the plain areas tend to have too dense coverage, while the mountain areas are poorly covered. Alternative explanations can have a different direction of the causal implication, i.e. because competition is not fierce there is room for a higher number of competitors.

As a final remark, it is worth noting that in Italy (as in most other EU Countries) the price of diesel is lower than that of gasoline.[7] According to the Ministry of Economic development, the lower cost of diesel has, therefore, induced drivers to reduce their gasoline demand from 16,070 tons in 2002 to 9,982 tons in 2010 (about -38% in eight years), whereas in the same period the demand for diesel increased from 21,511 tons to 25,272 (about +15% in the same time interval). Despite the higher prices at the pump for gasoline, the two fuels nevertheless show a very close time trend.

4. The hypotheses

A useful suggestion on how to investigate pricing practices in the retail fuel market in Italy comes from Atkinson et al.'s (2008) paper. In their empirical work on gas stations in Guelph, Canada, the authors test three relevant conjectures concerning the price setting behavior in the retail fuel market:[8]

1. The one-price law should hold in the fuel market;
2. Gas stations should respond to prices changes of opponents, or, at least, to a small number of key competitors;
3. Price changes should move rapidly through the market like a "falling sequence of dominos" possibly "radiat[ing] outward from the initial source" (p. 571).

[7] This is the opposite of the situation in the US (at any rate in 2004).

[8] Atkinson et al. s' (2008) paper presents an economic background from these conjectures which is called "the informal theory of competitive gasoline pricing". Since there is no unified formal theory of pricing behavior, we rely on these conjectures also for our analysis. The authors also analyzed a fourth hypothesis, which considers intra-price changes, that is not investigated owing to the characteristics of the Cuneo retail market. Indeed, a preliminary analysis of the gas stations has shown that the price changes no more frequently than once a day. Therefore, we choose not to collect data with a higher frequency. Finally, it is worth noting that the explanation provided in this paper partly differs from that of Atkinson et al. (2008) so as to more closely relate to the Italian case.

In addition to these three hypotheses which are referred to as "informal theory of competitive gasoline pricing", we complement the analysis with a general question about the spatial dependence among prices. More precisely, we add the following conjecture:

1. There is spatial dependence among gas stations.

This additional point relies on so called first law of geography (Tobler, 1970), which states that "Everything is related to everything, but near things are more related to each other" (p. 236). In economic terms, previous sentence can be rephrased in the claim that, at retail level, competition is localized, and that firms' pricing decisions are more affected by the behavior of those opponents which are more closely located (see: for example: Slade, 1992; Brueckner, 1998; Kalnins, 2003; Mobley, 2003; Mobley et al., 2009; Gullstrand and Jörgensen, 2011; Hogg et al., 2012; Fell and Haynie, 2013).

5. Data and methods

5.1 Data

Our analysis relies on various data sources. Data concerning our main variables of interest, the gasoline and diesel retail fuel prices in Cuneo have been privately colected at the pump.[9]

[INSERT FIG. 1 ABOUT HERE]

Fig. 1 shows the map of location of the gas stations under analysis. For the sake of convenience, gas stations are grouped into three classes depending on their geographical position. Although each geographical classification is usually discretionary, for Cuneo our choice has been quite natural. Cuneo (which literally translates *wedge* in Italian) is bounded by two rivers. The particular

[9] Cuneo is a medium-sized city located in the Northwest of Italy, whose size and characteristics are similar to those of Guelph, analyzed in Atkinson et al. (2008).

geography of Cuneo leads to the identification of three separate sections. Some bridges connect the main city with two neighboring sections: one in the North, and the other in the East. Ten gas stations of the 25 initially considered in the analysis are located in the center of Cuneo (City Area); seven on the North part of the town on road SR20 (North Area); and eight on the East part on roads SP21 and SP564 (East Area).[10] Most of major brands are present: seven Shell stations, six Agip/Eni stations, four IP/Api stations, three Erg stations, two Esso stations, one Total station, one Tamoil station, and one independent station.

[INSERT TAB. 3 ABOUT HERE]

The data covers the period from 1 January to 1 August, 2011. We have collected daily data on retail gasoline and diesel prices for 20 of the 25 gas stations.[11] Daily data on international wholesale (or rack) gasoline and diesel prices are indeed obtained by Platts, McGraw Hill Financial. All prices are deflated by Consumer Price Index (CPI, base 100 = 1 January 2011) provided by Istituto Nazionale di Statistica Italiana (ISTAT). Driving distances between gas stations have been collected from google map website (www.google.com/maps).

We also build a measure of the daily variation in the number of employees of economic activities in the surrounding of each gas station by combining different data sources. From the Chamber of Commerce of Cuneo we obtain a list of openings and closings of business activities based in Cuneo,

[10] There are two gas stations on the border of the East Area that have been assigned to the City Area because of their proximity, and because the part of the town where they stand is usually classified as 'city'.

[11] We asked to gas stations to fill up a form indicating which price they charge for the two fuels on a daily basis. The stations are randomly visited at least once a week in order to check the reported prices with the posted ones. No omissions or mistakes have been detected. Unfortunately, the five stations do not participate to our survey. Although most of them are located in such a way that they do not create significant distortions in our analysis, there is a potential risk of missing to identify some transmission effects. In particular, because of its location at the borders of the City Area, the possibility that the missing station close to C-Agip 2 is a pioneer (explanation will follow in sub-section 5.3) cannot be excluded.

the address, the VAT number, and the number of employees. For each firm, we retrieve the information on the opening and/or closing dates from *Agenzia delle Entrate* website (www.agenziaentrate.gov.it) by consulting the period in which the VAT number was valid. Finally, the map of the city was split using the method of Thiessen polygons (Pinkse and Slade, 2004) in order to assign each economic activity to the closest station.

The data also contain information on the ownership of the gas stations (company-owned vs. family-owned stations), and on the presence of supplementary services (self-service, twenty-four-hour opening, convenience store, car wash). Table 4 presents the main descriptive statistics of all variables employed in the analysis.

[INSERT TAB 4 ABOUT HERE]

Furthermore, Table 5 and 6 offer some additional information on gas station characteristics, which are more extensively commented on in Section 5.1.

[INSERT TAB. 5 AND 6 ABOUT HERE]

5.2 Methods

Our methodological approach is based on different statistical tools. A descriptive approach is applied for Conjectures 1-3, while econometric tools are employed for Conjecture 4.

The descriptive analysis strongly relies on the methodology set out in Atkinson et al. (2008). A brief description of these tools is offered in the following discussion before the presentation of the results (subsection 6.1-6.3). The econometric approach is inspired by the spatial econometric literature on localized price competition in imperfectly competitive environments (Slade, 1992; Brueckner, 1998; Pinkse et al., 2002; Kalnins, 2003; Mobley, 2003; Mobley et al., 2009; Gullstrand

and Jörgensen, 2011; Jost, 2012; Hogg et al., 2012; Fell and Haynie, 2013). The rest of this subsection is devoted to clarify the methodology developed for the econometric part.

Although the empirical analysis includes two different fuel types, we restrict the theoretical approach to a single fuel. We assume that there are T time periods indexed $t = 1,..,T$; R spatially differentiated retailers (gas stations) indexed $r = 1,..,R$; and S suppliers (national fuel suppliers) indexed $s = 1,..,S$. We let $\mathfrak{J}(r,s)$ be the indicator function which is 1 if retailer r is affiliated to one supplier s, and 0 otherwise. Moreover, we let $\mathcal{N}(s)$ represent the total number of retailers in the sample which patronize supplier s and $\mathcal{S}(r)$ be a function such that $\mathfrak{J}(r,\mathcal{S}(r)) = 1$ for every r.

Each retailer is affiliated with one supplier, from which it exclusively buys fuel at a unit cost c_{rt}. At period t, c_{rt} is proportional to a common component (i.e. the average international wholesale price) c_t plus a (time-varying) brand-specific component ζ_{rt}, where $\tilde{\gamma}$ is a parameter:

$$c_{rt} = \tilde{\gamma} c_t + \zeta_{rt} \tag{1}$$

We assume that c_t and ζ_{rt} are not affected by the retailers' behavior, i.e. in our setup c_{rt} is exogenously determined. This can be justified by the fact that supplies cannot differentiate prices among retailers for antitrust reasons.

Retailers compete in a Bertrand-Nash fashion, and at each period t, each retailer r chooses the price p_{rt} in order to maximize its profit:

$$\Pi_{rt} = (p_{rt} - c_{rt} - \psi_{rt})q_{rt} - F, \tag{2}$$

where F are the fixed costs, ψ_{st} is an idiosyncratic operating cost, and q_{rt} is the quantity sold by r which is negatively affected by the price charged by firm r and positively affected by those of opponents. We assume a linear specification of the demand function:[12]

$$q_{rt} = q_r(p_{rt}; P_{-rt}) = k\left(a_{rt} - \tfrac{1}{2}p_{rt} + \textstyle\sum_{i\neq r}\rho w(i,r)p_{it}\right), \tag{3}$$

where k is a positive parameter; $P_{-rt} = (p_{1t}, .. p_{r-1t}, .., p_{r+1t}, .., p_{Rt})$ is the vector of opponents' prices; $w(i,r)$ captures the spatial interaction between i and r; ρ is the spatial dependence parameter; and a_{rt} is a firm-specific demand variable which includes time variant βx_{rt}, and time invariant components ϕ_r:

$$a_{rt} = \beta x_{rt} + \phi_r \tag{4}$$

After substituting (1), (3) and (4) into (2) and taking first order derivatives with respect to p_{rt}, we obtain, the best response function for firm r:

$$p_{rt} = R_{rt}(P_{-rt}) = \beta x_{rt} + \phi_r + \sum_{i\neq r}\rho w(i,r)p_{it} + \gamma c_t + \tfrac{1}{2}(\zeta_{rt} + \psi_{rt}), \tag{5}$$

where $\gamma = \frac{1}{2}\tilde{\gamma}$. Equation (5) can be written in matrix form as:

$$P_t = \Phi + \gamma C_t + \beta X_t + \rho W P_t + \epsilon_t, \tag{6}$$

where, $P_t = (p_{1t}, .., p_{Rt})$; $\Phi = (\phi_1, .., \phi_R)$; $C_t = (c_t, .., c_t)$; $X_t = (x_{1t}, .., x_{Rt})$; $\epsilon_t = \frac{1}{2}\mathrm{Z}_t + \frac{1}{2}\Psi_t$ with $\mathrm{Z}_t = (\zeta_{1t}, .., \zeta_{Rt})$ and $\Psi_t = (\psi_{1t}, .., \psi_{Rt})$; and the squared matrix W is a spatial weights matrix.

Although there are some attempts to estimate the spatial weight matrix W directly, most of the literature assumes that weights $w(i,r)$ are chosen on the basis of some ad hoc assumptions on

[12] Alternatively, Pinkse et al. (2002), Pinkse and Slade (2004), Fell and Haynie (2013) derive a similar reaction function by assuming a generalized McFadden profit function (Kristofersson and Rickertsen, 2009).

spatial interactions among units. We choose $w(i,r)$ following three steps: first we identify a threshold distance $\bar{d}$ beyond which there is no direct spatial influence between spatial units. Second, we model a distance decay as the inverse of the distance among spatial units, and third, we row-normalize W in order have a simple interpretation for the parameter ρ (see, for example: Brueckner, 1998; and Jost, 2012). That is:

$$w(i,r) = \frac{\widehat{w}(i,r)}{\sum_{j\in\mathcal{D}(i)} \widehat{w}(i,j)}, \tag{7}$$

where $d(i,r)$ is the distance between i and r; $\mathcal{D}(i) \equiv \{j|0 < d(i,j) < \bar{d}\}$ the set of neighboring petrol stations of i being at a distance lower than $\bar{d}$; and

$$\widehat{w}(i,r) = \begin{cases} 0 & if\ i\ and\ r\ are\ not\ neighbors \\ 1/d(i,r) & otherwise \end{cases}. \tag{8}$$

In the analysis we apply different bandwidths in order to identify the most appropriate specification for the spatial weight matrix. In addition to this, to account for potential correlation between prices charged by firms belonging to the same brands (e.g. caused by common shocks in costs or by promotional activities of refiners), we also assume that there is spatial dependence between residuals of retailers patronizing the same supplier:

$$\epsilon_t = E_t + \lambda M U_t. \tag{9}$$

where λ is a measure of spatial dependence; E_t and U_t are random error terms; and M is a squared matrix, with entries:

$$m(i,r) = \begin{cases} 0 & if\ i \notin \mathcal{S}(r) \\ 1/(\mathcal{N}(\mathcal{S}(r)) - 1) & otherwise \end{cases}. \tag{10}$$

Equations (6) and (9) are usually known as spatial autoregressive regression model with autoregressive disturbances, which includes a spatial lag component $\rho W P_t$, and a spatial error component $\lambda \mathrm{MU_t}$ (Anselin and Arribas-Bel, 2011). We estimate this spatial model using a maximum log-likelihood estimator (LeSage and Pace, 2009).

6. Results

6.1 Price uniformity

The first conjecture to put under scrutiny using data for the Cuneo retail fuel market is price uniformity. Competitive forces and product homogeneity combined with the fact that consumers can easily compare prices should induce sellers to charge similar or identical prices. Overall price dispersion should be small, and possible price differences should not present a recognizable pattern. Table 5 offers some statistics on gasoline and diesel prices charged by the selected petrol stations in Cuneo. Overall price differences are small, especially when we exclude the white pump from the analysis.[13] Focusing the analysis on the nineteen branded stations, some price differences mainly emerge between, but not within, the three sections. Average gasoline and diesel prices are higher in the North (1.52€/l and 1.38€/l respectively), medium in the East (1.50€/l and 1.37€/l), and lower in the City (1.48€/l and 1.35€/l). Thus, price differences between stores are about 0.02-0.04€/l; while average price differentials within stores are less than 0.01€/l in the North and the East areas, and slightly more in the City area.

A possible explanation for these (small but existing) price differentials between stores comes from the fact that competitive pressure induces lower prices. Indeed, the concentration of gas stations in the cheapest section, the City, is larger than in the others: Fig. 1 shows that about half of the gas stations in Cuneo are based in the City and the average distance of these gas stations to their closest neighbors is smaller than that of stations placed in other sections. On the contrary, in the North Area, the most expensive one, gas stations are more insulated: they are based far away from the main residential centers and in proximity to the highway. Finally, gas stations of the East Area

[13] Although some product differences may emerge for special fuels (i.e. those including additives), the prices we have collected concern products that are physically homogeneous, since branded and unbranded stations get their fuel from the same site. However, an on average 0.05€/l spread between branded pumps and white pumps may be explained by a difference in the perceived quality of the fuels.

located on two secondary roads connecting the industrial area and the City Area on one hand, and Cuneo to the neighboring town of Mondovì on the other, are in an intermediate position both in terms of prices and spatial concentration.

Another source of heterogeneity concerns on the gas station ownership. By using information presented in Tables 6 and 7, it emerges that family-owned gas stations are more expensive than brand-owned ones. This result is in line with the theoretical findings of the literature on double marginalization (see, e.g., Cabral, 2002, Chp. 11): when an upstream and a downstream firm are not integrated, each firm only focuses on its own profits and therefore it tends to offer higher prices. Empirical evidence of double marginalization problem also emerges in many other retail markets (Thomadsen, 2005). According to the empirical literature on the North American retail fuel market (Shepard, 1993; Taylor, 2000), companies are more likely to provide longer opening hours, self-service, convenience stores, and car washes. On the contrary, the family-owned pumps would tend to have smaller and fewer facilities. Table 5, however, shows that for the Cuneo case this regularity is not confirmed since most of the family-owned gas stations have the same facilities as the brand-owned ones. Nevertheless, ownership has other implications on the pricing behavior of firms since it affects the frequency of price changes. In our data, on average, family-owned stations raised their prices 15-16 times and lowered them 8-9 times in seven months, while brand-owned pumps and the independent stations which show a similar trend have about a double number of changes.

[INSERT TABS 6 AND 7 ABOUT HERE]

Daily prices provide some additional insights on the short-term price differentials. Focusing again on the 19 branded stations, it emerges that modal daily prices for gasoline and diesel fuels are charged, on average, by only 2.7 and 3.1 stations, respectively. The remaining gas stations, which do not match the modal price, have some small but significant differences. The median absolute deviation is about 1.6 cents for gasoline and 1.3 for diesel.

To sum up, overall the one-price law approximately holds for Cuneo's stations. Although there is some structure in the data, in the medium term, price differentials, except for white pumps (are very small) especially within the same section.

6.2 Price matching

The second conjecture to be evaluated concerns 'price matching'. Frequent shocks in input prices cause gas stations to change their prices quite frequently. When a firm modifies its price, other stations should react by adjusting their prices accordingly. Therefore, firms should follow the conduct of competitors, or at least a subset of other stations (i.e. *leading* stations). It is expected that some stations, either because of their high visibility or for historical reasons are first movers in setting new prices (leaders). Some authors have noted that such reference firms play the role of a coordinating mechanism helping the synchronization of the market and its functioning. If firms are involved in strong price competition, by setting too low prices they risk reducing their profits, while with too high prices, they risk losing their customers. The characteristics of the leading firms and the nature of observed price coordination suggest that successful price jumps may be facilitated by the existence of a single retailer controlling the prices of a significant number of stations in a city. We are interested in knowing whether a price matching process among the stations of Cuneo exists, and how strong it is.

We start by analyzing the *simultaneous* changes in price for the 20 Cuneo stations. Tables 8 and 9, respectively, report information on gasoline and diesel markets, and have the same structure. The second column describes the principal match, i.e. the gas station with the highest number of simultaneous changes. The frequency of price matches with the principal match and the average difference between the price of the station and that of the principal match are listed in the third and fourth columns, respectively (for instance, station C-Agip 1 matches station C-Erg for 48% of its gasoline price decreases and increases, and in doing so keeps its overall price by 0.2 cents below).

The next two columns list the nearest station (i.e. the one that is most closely located) and the matching frequency.[14] Here we find that the average matching frequency is about 30% for both fuels.

[INSERT TAB. 7 AND TAB. 8 ABOUT HERE]

Contrary to the Guelph case, the overall degree to which a station contemporaneously matches another station's price is lower (a frequency higher than one half occurs in 20% of the total cases, for both gasoline and diesel fuels).

In the Guelph case, the percentage of gas stations with a contemporaneous match above one half is around 66%. Thus, our data indicates that the hypothesis according to which stations *simultaneously* match a target firm is only weakly validated. A relevant exception is given by the two Esso stations (N-Esso and E-Esso) whose matching rate is 65% for gasoline and 73% for diesel. The other two pairs of stations having a matching rate above one half are: N-Agip and C-Agip 2 (62% for gasoline and 52% for diesel) and C-Agip 1 and C-Erg (52% only for diesel). The former belong to the same owner, while the latter do not.

Apart from the previous examples, the rest of the data reveals that the matching process is only weakly affected by the brand. Price differentials indeed seem to vary significantly according to the location.

By analyzing the simultaneous match, we lose information about the initiator of the price change. In order to complement the analysis, we therefore consider how stations respond to past price changes within a day. Following Atkinson et al. (2008)'s approach, we study the degree to which stations match the prices charged by a small number of stations (3 in total) in the previous period. Three principal matches are identified for each gas station, using the following method. For each station,

[14] During the analysis, if it emerged that there were two stations with the same number of matches, the principal match was taken to be the gas station whose average price differential was lower.

we rank all the other stations from highest to lowest in terms of the number of lagged matches (price variations of the same sign) that this station has with the others. In the case of a tie, the station with a lower average price differential is ranked first. The first three stations of the list are identified as primary, secondary, and tertiary matches. The result is shown in Table 9 for gasoline prices and in Table 10 for diesel prices.

[INSERT TAB. 9 AND 10 ABOUT HERE]

Also in this case, the overall degree of matching is low, and even lower than simultaneous matching. None of the stations exceed one half of the (lagged) matching frequencies. The average matching frequency (switching from contemporaneous to lagged matching) decreases from 37.1 to 21.1% for gasoline, and from 39.6 to 27.5% for diesel. Note also that 18 out of the 20 stations, for both fuels, show a primary (lagged) match that differs from the contemporary match. Moreover, the role of geographical proximity is limited, since there is only one case where the nearest station is also the primary match. Finally, it is worth noting that the E-Esso and N-Erg1 stations represent the primary or secondary matches of about half the stations in the gasoline and diesel markets. Therefore, these two gas stations are the most suitable to be considered as *leading* stations in the Cuneo retail fuel market.

Differences between Canadian and Italian gas station matching behaviors are not easy to explain. There are at least three elements it is worth mentioning. First of all, in the Guelph market, over the 103 days of analysis, on average, each station has changed the price about 137 times (1.3 per day); while in Cuneo market, over the 212 days we have registered only 32 changes for each fuel type (0.15 per day). Second of all, Canadian data refer to a period where there is a negative price trend, where each station raised its price 21 times and lowered it 116 times; while in current analysis, there is a positive trend, where each station raised its price 21 times and lowered it 11 times. Finally, we have already mentioned that family-owned stations have a significantly smaller number of changes than brand-owned and independent ones. Thus, the differences in gas station matching behavior may be due to the fact that gas stations in Cuneo are less used to change their prices than Canadian counterpart and therefore they are less careful and ready to react to competitors' changes. This effect may also be exacerbated by the fact that there are divergent matching behaviors between family-owned and brand-owned stations in Cuneo and by the fact that matching behavior may differ in positive vs negative price trend periods (Noel, 2008). A weak response of Cuneo gas stations will also emerge in the next sections where we will study the domino effect and the spatial dependence of prices.

6.3 Domino Effect

The third conjecture concerns the hypothesis that price changes "radiate outward from the initial source like a falling sequence of dominos" (Atkinson et al. 2008, p. 4): that is, after a price change is set by a first main gas station, the majority of the other players follow it within a short period of time (a few days maximum), in a "chain reaction". It was previously mentioned that E-Esso and N-Erg1 represent the principal match for many of the gas stations, and therefore are the most suitable to be considered as *leading* stations in the Cuneo fuel retail market. Following Atkinson et al. (2008), we compute response time across gas stations, and we rank gas stations on the basis of the average response time to the *leader*'s price variations. More specifically, for every *leader*'s price change, we assign a time response to each station, e.g. on the same day (0), on the next day (1), or after the next day (2), etc. Then, we average the time response, and we rank the gas stations depending on their mean time response. The choice of the maximum day of response is critical, since by choosing a short period there is the risk that stations do not have time to respond, while by choosing a long period there is the risk that stations adjust their prices not as a reaction to the *leader* change but as an independent pricing strategy. Since stations generally change their prices about once a week, we choose as the maximum response lag two, three, or four days.

We have analyzed the case in which the propagation moves from North to East (i.e. assuming N-Erg1 station as the leader), and from East to North (i.e. assuming E-Esso as the leader). In the second case, we do not obtain significant results, so we only present the first case. Table 11 shows the rank of each station for two, three, and four days, the average ranking, and the Spearman's rank correlation coefficient.

[INSERT TAB. 12 ABOUT HERE]

From the table we find a (weak) correlation between location and time response. Gas stations located in the North Area and in the City Area react more quickly than those located in the East Area. The ranking is strongly affected by the choice of the maximum number of days for the time response, and varies significantly between gasoline and diesel. The data suggest that the impact of N-Erg1 on the other stations has the following characteristics. Most of the stations located farther away (i.e. in the East Area) are ranked in the bottom positions, while stations located closer (North or City) are either in the top positions or in the bottom positions. It is worth noting that the price time response of City stations is slightly lower than that of firms located closer to N-Erg1 station. This result could be partly due to the fact that, since City stations change their prices much more frequently than the other stations, the likelihood increases that the rank includes a price adjustment which is not a reply to N-Erg1.

Figure 2 offers an additional explanation for the price propagation in Cuneo. We have classified gas stations in three groups. The first group of followers includes firms ranked 1 to 5; the second group includes firms ranked 6 to 10; and the third group those ranked the remaining ones. Panel (a) refers to the gasoline market and panel (b) to the diesel one. In both cases, the map of the followers belonging to the first group is quite similar and refers to gas stations belonging to two local commuter paths from North to South-West and from North to South-East (dashed arrows)[15]. The figure thus suggests that in the Cuneo fuel market, similarly to that identified by Houde (2012) in the Québec City, there are two overlapping competition layers. The first one is due to commuters and it is characterized by a quick response of some stations located on the two paths. The second one is much more local and it presents some traits similar to that described in the Atkinson et al.'s (2008) paper for Guelph, Ontario. This finding is reinforced by the fact that primary and secondary matches rarely occur between neighboring stations (see: sub-section 6.2).

[INSERT FIG. 2 ABOUT HERE]

In summary, our analysis indicates that there is spatial propagation among the three sub-markets, although the relationship is not very strong. Moreover, we find that price changes seem to propagate along two main local commuter paths. This complicates the map of competitors among stations.

6.4 Spatial dependence

In this sub-section we rely on the methodology described in Sub-section 5.2 to verify the existence of spatial dependence among retail fuel prices in Cuneo (Conjecture 4). We estimate equations (6) and (9) by a spatial autoregressive model with auto regressive disturbances. The empirical model includes a firm specific fixed effect to account for heterogeneity among gas stations. The spatial weighting matrix of spatial lag term W is described by (7) and (8), with threshold distance $\bar{d} = 1.1$ km. The spatial weighting matrix of the spatial error component M, introduced to account for potential brand correlation of prices, is described by (10). In addition, residuals are double clustered by week and section of gas station location (City, East, West). The total number of clusters is 48

[15] These paths are identified by two-week observation of real-time traffic flows during the peak hours (8.30 a.m. and 6.30 p.m.) on the most prominent website in Italy (www.tuttocitta.it). [e' necessario inserirlo anche in bibliografia?]

and satisfies the indication provided by Angrist and Pischke (2009). We take the first difference of the logarithm prices to render these variables stationary. The variation in the number of employees is in thousands of workers. Results are reported in Tables 12.[16]

[INSERT TAB. 12 ABOUT HERE]

The estimated coefficient of the spatial lag term (ρ) is positive and significant in both estimates, indicating that neighboring firms pricing behavior is affected by that of opponents. As is largely expected from the analysis offered in subsections 6.2-6.3, the magnitude of the coefficients is small, especially in the case of the gasoline fuel. Coefficients, however, cannot be directly compared to those presented in other studies using a similar methodology but having variables in levels. For example, the spatial lag coefficient is 0.23 to 0.40 in Brueckner (1998); 0.11-0.44 in Kalnins (2003); 0.22 to 0.23 in Mobley (2003); 0.23 to 0.28 in Mobley et al. (2009); and 0.12-0.33 in Gullstrand and Jörgensen (2011). Indeed, in our analysis, moving from first differences to levels (results available upon request), our findings are in line with the above mentioned studies: the estimated coefficient of the spatial lag term raises from 0.046 to 0.328 for gasoline and from 0.093 to 0.256 for diesel. An additional explanation of the limited spatial effects is also due to the fact that W only accounts for the spatial dependence among neighboring stores, while in subsection 6.3 we have some evidence of a second competition layer among gas stations sharing the same local commuter path.

The coefficients of the spatial error term (λ), as expected, is positive in all estimates, but statistically significant only for diesel regressions, indicating that brand effects are more prominent for this type of fuel.

[16] To save space, table 12 only reports the total effect (LeSage and Pace, 2009). The other results are available upon request. Table 13 also presents main, direct, indirect and total effects.

We have also considered two additional controls: one for the demand side, and the other for the supply side. More precisely, the first control is the variation in the number of employees of economic activities in the nearby of gas stations ($\Delta Labor$). Additional workers are likely to be new clients of the gas station. Moreover, additional workers mean an increase in the economic activities in the nearby of the gas station, and, therefore, additional clients for these activities, and, in all probability, for the closer gas station. We expect a positive effect of $\Delta Labor$ variable on prices, since a positive shift on the demand, all things are equal, induces a rise of charged prices. We find that estimated coefficients of $\Delta Labor$ variable are indeed positive and significant in both models.

The second control is the change in the wholesale prices of the fuels (*Rack Prices*). An increase in the main production input induces gas stations to rise their retail prices. We model this effect over a period spanning 21 days. Estimates show that a change in wholesale prices induces an overall effect of about 0.253 for gasoline and 0.241 for diesel. The adjustment is more pronounced in the first week even if some effects last also in the second and third week.

As a robustness check, the analysis has been also carried on using different econometric specifications. In particular, we have estimated equations (6) and (9) excluding fixed effects and including various time-invariant controls, such as: *Ownership*, *24 hour service*, *Self-service*, *Car wash* and a set of dummy variables for different brands. All specifications have shown no relevant variations in the coefficients and significance of the variables of interest, and no significant coefficients were observed for these controls. The main reason relies on the fact that by taking the first difference we have removed all the time-invariant heterogeneity among gas stations.

Moreover, we have also considered different threshold distances $\bar{d}$ ranging from 0.9 km to 1.3 km (Table 13). Using the AIC and BIC criteria, we find that the preferred threshold distance is $\bar{d} = 1.1$ km. This value was then selected for the analysis reported in Table 12. Table 13 also presents different estimates of main, direct, indirect and total effects (LeSage and Pace, 2009). Estimated coefficients of the indirect effect, although significant in some estimates, are very close to zero, so that main, direct and total effects are very similar.

[INSERT TAB. 13 ABOUT HERE]

From Tables 12 and 13, we also observe that the coefficients of the gasoline equations are smaller and less significant than those of the diesel equations. Also in sub-sections 6.2-6.3, we have noticed that the diesel market is more reactive than the gasoline one. A possible explanation relies on the fact that gasoline and diesel users in Italy have different behaviors. Because diesel cars have higher fixed costs (higher purchase prices and higher car taxes) and lower operative costs (lower per liter fuel costs and higher efficiency of engines), light users usually purchase gasoline-powered cars, while heavy users usually purchase diesel-powered ones. In addition, the formers are usually less informed and price sensitive than the latter, so that we expect that gas stations are much more careful in setting prices and reacting to opponents' moves in the diesel market than in the gasoline one.

7. Concluding remarks

The retail fuel sector is often at the center of the economic debate in Italy, because of its relevance for citizens and firms. Fuel prices affect households' living standards and the efficiency of the whole economy as they impact on the costs of product delivery. Fuel prices are hence a key aspect of the functioning of this market, and the mechanism governing price transmission among gas stations appears to be at the heart of the problem.

In this paper we have first analyzed the price behavior of gas stations in Italy. Our analysis was limited to Cuneo, a medium-sized town in the North-West part of Italy. Although, we are cautious about the appropriateness of generalizing our findings to the wider Italian market, we consider that

Cuneo could be representative for the functioning of local retail markets, at least for a large number of towns of a similar size.

We find that the pricing behavior of gas stations partly differs from what scholars and practitioners usually expect. First, the 'one price law' is approximatively satisfied with the exception of white pumps, which consistently apply lower prices. A far as brand stations are concerned, small but significant price differences are detected in different sections of Cuneo. Second, price adjustments are slow and incomplete. Only one-third of retailers react within a day to competitors' price changes, and convergence in the following days remains limited. Third, we find spatial price transmission, but the propagation effect is not strong. Moreover, propagation effects follow complex patterns since they are both affected by proximity and by the presence or absence of local commuter paths.

This analysis provides some insight to suggest that competitive forces are not perfectly at work. In particular, the low frequency of price adjustments, together with a too small size of stations, could be responsible for the high level of the industrial component of the fuel price in Italy compared to other European countries. Two possible measures can help to reduce prices. One, as suggested by the Italian Antitrust Authority (AGCM) is to favor the presence of white pumps; the other is to increase the information available to drivers. The use of boards in the proximity of the gas stations requires a visit by the drivers in order for them to be acquainted with fuel prices. However, implementing the requirement for the availability of digital price databases, and, for example the development of specific applications for mobile phones which offer real-time prices to customers could help to reduce search costs, and consequently facilitate a more competitive market environment.

Acknowledgements

We are indebted to Prof. Benjamin Atkinson, who kindly provided us some useful suggestions.

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Tables and Figures

Table 1. Distribution networks in the main European Countries (2009)

Country	Italy	Germany	France	UK	Spain
Total points of sale	**22,900**	14,785	12,522	8,921	9,226
Average supplied per point of sale (m^3)	**1,516**	3,036	3,335	4,051	3,135
N.inhabitants (thousands)	**60045**	82002	64350	61595	45828
N.pumps/1000 inhabitants	**0.38**	0.18	0.19	0.14	0.20
% Points of sale with self-service	**33**	99	99	95	34

Source: Unione Petrolifera (2011).

Table 2. Fiscal and industrial components in Italy, Germany, France and the UK, in €/l

Country		Italy	Germany	France	UK
Industrial Component	**Gasoline**	0.722	0.714	0.682	0.626
	Diesel	0.699	0.748	0.700	0.684
Fiscal component	**Gasoline**	0.804	0.914	0.865	0.907
	Diesel	0.613	0.702	0.660	0.919

Source: Italian Ministry of Economic Development (2011).
Note: data refers to 1 May 2011.

Table 3. Gas stations in Cuneo

Denomination	Gas Stations					Tot.
North Area	N-Erg 1	N-Erg 2	N-Esso	N-Agip	N-Shell	5
City Area	C-Agip 1	C-Agip 2	C-Agip 3	C-Shell 1	C-Shell 2	10
	C-Shell 3	C-IP 1	C-IP 2	C-Erg	C-Tamoil	
East Area	E-Shell	E-Esso	E-Agip 1	E-Agip 2	E-indep.	5

Table 4. Main descriptive statistics

Variable	Description	Mean	Std. Dev.	Min	Max
p^g	Gasoline prices, constant prices	1.490	0.042	1.385	1.600
p^d	Diesel prices, constant prices	1.364	0.043	1.250	1.445
P^g	Gasoline rack prices, constant prices	0.631	0.0329	0.567	0.696
P^d	Diesel rack prices, constant prices	0.609	0.027	0.544	0.658
d	Distance between gas stations in km.	3.341	1.517	0.200	6.630
$\Delta Labor$	Change in the daily number of employees of economic activities in the nearby of the gas station, absolute values	0.020	0.695	-28.000	20.000
$Family$	Dummy variable equal 1 if the station is family owned	0.400	0.490	0.000	1.000
$24\ hour$	Dummy variable equal 1 if there is a 24 hour service	0.850	0.357	0.000	1.000
$Self\ serv$	Dummy variable equal 1 if there is a self-service	0.950	0.218	0.000	1.000
$Store$	Dummy variable equal 1 if there is a store	0.450	0.497	0.000	1.000
$Carwash$	Dummy variable equal 1 if there is a carwash	0.500	0.500	0.000	1.000

Table 5. Gasoline and diesel prices by gas station

	Gasoline					Diesel				
	Gas station	**Average Price (€/l)**	**Std. Dev.**	**Min**	**Max**	**Gas station**	**Average Price (€/l)**	**Std. Dev.**	**Min**	**Max**
North	N-Erg 2	1.524	0.041	1.443	1.590	N-Erg 1	1.386	0.039	1.313	1.445
	N-Erg 1	1.522	0.040	1.447	1.600	N-Agip	1.385	0.039	1.286	1.436
	N-Agip	1.521	0.036	1.444	1.583	N-Shell	1.381	0.039	1.309	1.439
	N-Shell	1.516	0.040	1.440	1.580	N-Erg 2	1.376	0.042	1.299	1.433
	N-Esso	1.515	0.042	1.439	1.587	N-Esso	1.372	0.038	1.304	1.434
	North Area	**1.520**	**0.040**	**1.439**	**1.600**		**1.380**	**0.040**	**1.286**	**1.445**
East	E-Agip 2	1.500	0.039	1.415	1.572	E-Agip 1	1.379	0.038	1.317	1.437
	E-Shell	1.499	0.039	1.417	1.560	E-Agip 2	1.379	0.039	1.312	1.437
	E-Esso	1.498	0.036	1.431	1.564	E-Esso	1.369	0.038	1.299	1.434
	E-Agip 1	1.497	0.040	1.424	1.572	E-Shell	1.366	0.039	1.298	1.419
	E-Indep.	1.444	0.033	1.385	1.513	E-Indep.	1.318	0.040	1.250	1.379
	East Area	**1.487**	**0.043**	**1.385**	**1.572**		**1.362**	**0.045**	**1.250**	**1.437**
East w/o E-indep.		**1.498**	**0.038**	**1.415**	**1.572**		**1.373**	**0.039**	**1.298**	**1.437**
City	C-Agip 2	1.484	0.034	1.415	1.555	C-Agip 2	1.371	0.038	1.285	1.438
	C-Agip 3	1.479	0.034	1.410	1.555	C-Agip 1	1.366	0.038	1.288	1.430
	C-Tamoil	1.479	0.035	1.414	1.545	C-Agip 3	1.362	0.038	1.300	1.420
	C-IP 1	1.477	0.033	1.404	1.536	C-Shell 1	1.357	0.039	1.280	1.429
	C-Erg	1.477	0.035	1.408	1.538	C-Tamoil	1.355	0.048	1.285	1.430
	C-Agip 1	1.475	0.035	1.408	1.539	C-IP 2	1.352	0.045	1.270	1.433
	C-Shell 1	1.474	0.035	1.405	1.535	C-Erg	1.351	0.045	1.279	1.418
	C-IP 2	1.472	0.031	1.410	1.530	C-Shell 2	1.350	0.039	1.290	1.410
	C-Shell 3	1.470	0.030	1.414	1.530	C-IP 1	1.350	0.046	1.264	1.425
	C-Shell 2	1.468	0.031	1.410	1.535	C-Shell 3	1.349	0.040	1.280	1.404
	City Area	**1.475**	**0.033**	**1.404**	**1.555**		**1.356**	**0.042**	**1.264**	**1.438**
	All	**1.490**	**0.042**	**1.385**	**1.600**	**Tot.**	**1.364**	**0.043**	**1.250**	**1.445**

Table 6. Gas station Characteristics

	Gas station	Brand	24 h	Self-Serve	Store	Car Wash
company-owned	C-Shell 1	Shell	√	√		
	C-Shell 2	Shell	√			
	C-Shell 3	Shell	√	√		√
	N-Shell	Shell	√	√		√
	E-Shell	Shell	√	√	√	√
	C-Agip 1	Agip	√	√	√	
	E-Agip 1	Agip	√	√	√	√
	C-Erg	Erg	√	√		√
	N-Erg 2	Erg	√	√	√	√
	N-Esso	Esso	√	√	√	√
	E-Esso	Esso	√	√	√	√
	C-IP 2	IP	√	√	√	√
Family-operated	C-Agip 2	Agip	√	√		
	C-Agip 3	Agip		√		
	N-Agip	Agip	√	√	√	√
	E-Agip 2	Agip	√	√	√	
	N-Erg 1	Erg		√		
	C-IP 1	IP	√	√		
	C-Tamoil	Tamoil	√	√		
	E-Indep.	Independent		√		

Table 7. Principal match identified through contemporaneous matching (Gasoline)

Gas station	Principal match	Frequency (%)	Δ (€)	Nearest station	Frequency with nearest station
N-Erg 1	C-Erg	33	0.045	N-Agip	2
N-Erg 2	C-IP 2	26	0.052	N-Shell	9
N-Esso	E-Esso	65	0.017	N-Agip	15
N-Agip	C-Agip 2	62	0.037	N-Erg 1	4
N-Shell	C-Shell 1	23	0.042	N-Erg 2	9
C-Agip 1	C-Erg	48	-0.002	C-IP 1	19
C-Agip 2	N-Agip	59	-0.037	C-Shell 3	11
C-Agip 3	C-IP 2	19	0.007	E-Agip 1	7
C-Shell 1	N-Shell	22	-0.042	C-Tamoil	17
C-Shell 2	C-Shell 3	37	-0.002	C-IP 1	5
C-Shell 3	C-Shell 2	33	0.002	C-IP 2	10
C-IP 1	C-Agip 2	29	-0.007	C-Agip 1	14
C-IP 2	N-Erg 1	29	-0.050	C-Shell 3	6
C-Erg	C-IP 2	50	0.005	E-Shell	19
C-Tamoil	C-IP 2	28	0.007	C-Shell 1	13
E-Shell	C-Agip 2	33	0.015	C-Erg	29
E-Esso	N-Esso	64	-0.017	E-Shell	11
E-Agip 1	N-Erg 1	18	-0.025	E-Agip 2	14
E-Agip 2	C-Agip 2	39	0.016	E-Agip 1	7
E-Indep.	C-Erg	25	-0.033	E-Agip 2	11

Table 8. Principal match identified through contemporaneous matching (Diesel)

Gas station	Principal match	Frequency (%)	Δ (€)	Nearest station	Frequency with nearest station
N-Erg 1	C-Erg	36	0.035	N-Agip	26
N-Erg 2	N-Esso	36	0.004	N-Shell	27
N-Esso	E-Esso	73	0.003	N-Agip	22
N-Agip	C-Agip 2	52	0.014	N-Erg 1	41
N-Shell	E-Shell	36	0.015	N-Erg 2	27
C-Agip 1	C-Erg	52	0.015	C-IP 1	41
C-Agip 2	N-Agip	47	-0.014	C-Shell 3	3
C-Agip 3	C-Agip 2	17	-0.009	E-Agip 1	13
C-Shell 1	E-Esso	26	-0.012	C-Tamoil	13
C-Shell 2	C-Shell 3	30	0.001	C-IP 1	15
C-Shell 3	C-Shell 2	26	-0.001	C-IP 2	4
C-IP 1	N-Esso	42	-0.022	C-Agip 1	31
C-IP 2	E-Esso	29	-0.017	C-Shell 3	3
C-Erg	N-Erg 1	47	-0.035	E-Shell	6
C-Tamoil	E-Esso	38	-0.014	C-Shell 1	14
E-Shell	N-Shell	40	-0.015	C-Erg	10
E-Esso	N-Esso	72	-0.003	E-Shell	4
E-Agip 1	E-Agip 2	22	0.000	E-Agip 2	22
E-Agip 2	C-Agip 2	46	0.008	E-Agip 1	18
E-Indep.	N-Esso	25	-0.054	E-Agip 2	7

Table 9. Principal matches identified through lagged matching (Gasoline)

	Primary match			Secondary match			Third match		
Gas station	**Gas station**	**Freq (%)**	**Δ (€)**	**Gas station**	**Freq (%)**	**Δ (€)**	**Gas station**	**Freq (%)**	**Δ (€)**
N-Erg 1	E-Esso	24	0.023	C-Agip 2	24	0.037	N-Agip	22	0.001
N-Erg 2	N-Erg 1	26	0.002	E-Indep.	22	0.080	N-Agip	17	0.003
N-Esso	E-Esso	33	0.017	N-Erg 1	25	-0.006	C-IP 1	22	0.038
N-Agip	C-IP 1	27	0.044	N-Erg 1	23	-0.001	E-Esso	23	0.023
N-Shell	N-Esso	23	0.001	E-Esso	23	0.018	C-IP 2	23	0.045
C-Agip 1	E-Agip 2	37	-0.025	C-Agip 2	30	-0.009	N-Agip	22	- 0.046
C-Agip 2	N-Erg 1	30	-0.037	C-IP 1	26	0.007	C-IP 2	26	0.013
C-Agip 3	C-Agip 2	27	-0.005	E-Esso	23	-0.019	N-Erg 1	23	-0.043
C-Shell 1	C-IP 1	17	-0.003	C-Shell 3	17	0.004	E-Esso	17	-0.024
C-Shell 2	N-Shell	26	-0.048	C-Shell 3	21	-0.001	E-Indep.	21	0.025
C-Shell 3	C-Erg	29	-0.007	E-Shell	29	-0.029	E-Esso	29	-0.029
C-IP 1	E-Agip 2	31	-0.023	N-Erg 1	29	-0.045	C-Erg	20	0.001
C-IP 2	N-Erg 1	29	-0.050	C-IP 1	17	-0.006	E-Agip 2	17	-0.028
C-Erg	E-Esso	25	-0.022	C-IP 1	22	-0.001	E-Agip 2	22	-0.023
C-Tamoil	E-Agip 2	25	-0.021	C-Agip 2	19	-0.006	N-Esso	19	-0.037
E-Shell	E-Esso	33	0	N-Esso	29	-0.017	N-Erg 1	24	-0.023
E-Esso	N-Erg 1	12	-0.023	N-Esso	18	-0.017	C-IP 1	15	0.021
E-Agip 1	E-Esso	27	-0.002	C-Tamoil	23	0.018	C-Shell 3	23	0.027
E-Agip 2	N-Erg 1	29	-0.022	C-IP 1	20	0.023	N-Esso	15	-0.016
E-Indep.	N-Esso	32	-0.072	E-Esso	29	-0.055	C-Erg	25	-0.033

Table 10. Principal matches identified through lagged matching (Diesel)

Gas station	Primary match			Secondary match			Third match		
	Gas station	Freq (%)	Δ (€)	Gas station	Freq (%)	Δ (€)	Gas station	Freq (%)	Δ (€)
N-Erg 1	E-Esso	24	0.017	N-Agip	21	0.002	N-Esso	21	0.015
N-Erg 2	E-Esso	36	0.007	N-Esso	32	0.004	E-Agip 1	23	-0.003
N-Esso	E-Esso	27	0.003	N-Erg 1	24	-0.015	C-IP 1	15	0.010
N-Agip	N-Erg 1	26	-0.002	C-IP 1	22	0.035	E-Agip 2	15	0.005
N-Shell	E-Esso	40	0.012	N-Esso	32	0.009	C-IP 2	27	0.029
C-Agip 1	E-Agip 2	22	-0.013	N-Erg 1	22	-0.020	E-Esso	19	-0.002
C-Agip 2	E-Esso	23	0.002	N-Erg 1	23	-0.015	C-Shell 1	17	0.009
C-Agip 3	N-Esso	23	-0.010	C-IP 1	20	0.012	C-Agip 1	17	-0.004
C-Shell 1	N-Esso	20	-0.014	C-Shell 3	17	0.009	N-Shell	17	-0.023
C-Shell 2	E-Shell	30	-0.016	E-Esso	20	-0.019	C-Erg	15	-0.001
C-Shell 3	C-Erg	35	-0.002	N-Erg 1	26	-0.038	C-Tamoil	17	-0.006
C-IP 1	E-Esso	22	-0.019	E-Agip 2	22	-0.029	N-Agip	22	-0.035
C-IP 2	N-Esso	29	-0.020	C-IP 1	23	0.002	N-Esso	23	-0.017
C-Erg	E-Esso	25	-0.018	C-IP 1	19	0.001	N-Esso	19	-0.021
C-Tamoil	E-Esso	31	-0.014	N-Esso	28	-0.017	C-Erg	21	0.004
E-Shell	E-Esso	35	-0.003	N-Esso	30	-0.006	C-Agip 1	25	-0.001
E-Esso	N-Erg 1	27	0.017	C-IP 1	22	0.019	N-Esso	18	-0.003
E-Agip 1	N-Erg 1	26	-0.007	E-Esso	26	0.010	N-Shell	17	-0.002
E-Agip 2	N-Erg 1	28	-0.007	N-Esso	25	0.008	E-Esso	25	0.011
E-Indep.	C-Tamoil	21	-0.036	C-IP 1	18	-0.032	C-Agip 3	18	-0.044

Table 11. Price response of gas stations to a price change of N-Erg1 station

Gasoline				**Diesel**			
Gas station	**2-day**	**3-day**	**4-day**	**Gas station**	**2-day**	**3-day**	**4-day**
N-Agip	4	4	8	N-Agip	5	3	1
N-Esso	7	5	2	N-Esso	12	6	5
N-Erg 2	15	9	12	N-Erg 2	11	14	11
N-Shell	8	17	16	N-Shell	11	17	15
C-Erg	1	1	1	C-Shell 2	8	1	18
C-IP 1	3	2	5	C-Agip 2	3	2	3
C-Agip 2	5	3	3	C-Erg	2	4	2
C-IP 2	14	7	7	C-Agip 1	7	5	4
C-Agip 1	3	8	4	C-Agip 3	1	8	10
C-Agip 3	11	10	10	C-Shell 1	7	10	7
C-Tamoil	9	15	11	C-Tamoil	11	11	14
C-Shell 2	17	15	18	C-IP 1	4	13	9
C-Shell 3	18	18	17	C-IP 2	16	16	12
C-Shell 1	14	19	19	C-Shell 3	19	19	13
E-Esso	6	6	6	E-Esso	13	7	8
E-Indep.	11	15	15	E-Agip 2	14	9	6
E-Agip 1	14	15	14	E-Agip 1	18	12	19
E-Agip 2	16	16	9	E-Shell	15	16	17
E-Shell	19	15	13	E-Indep.	18	19	16
North Area	8.5	8.75	9.5	**North Area**	9.75	10	8
City Area	9.5	9.8	9.5	**City Area**	7.8	8.9	9.2
East Area	13.2	13.4	11.4	**East Area**	15.6	12.6	13.2
Spearman rank	0.16	0.23	0.21	Spearman rank	0.23	0.20	0.01

Table 12. Estimates of the Spatial autoregressive model

	(1) *ΔLog(Gasoline Prices)*		(2) *ΔLog(Diesel Prices)*	
Total effect	Coeff.	Std. errors	Coeff.	Std. errors
ΔLabor	0.0539**	(0.0247)	0.139***	(0.0477)
ΔLog(Rack Prices)	0.00618	(0.00840)	-0.00525	(0.00834)
ΔLog(Rack Prices)t-1	0.00488	(0.00681)	-0.00894	(0.0107)
ΔLog(Rack Prices)t-2	0.0118**	(0.00467)	0.0246***	(0.00815)
ΔLog(Rack Prices)t-3	0.0219***	(0.00531)	0.0360***	(0.00855)
ΔLog(Rack Prices)t-4	0.0228***	(0.00719)	0.0334***	(0.00855)
ΔLog(Rack Prices)t-5	0.0177***	(0.00597)	0.0165**	(0.00725)
ΔLog(Rack Prices)t-6	0.0111	(0.00713)	0.0397***	(0.0143)
ΔLog(Rack Prices)t-7	0.0200***	(0.00535)	0.0145	(0.0137)
ΔLog(Rack Prices)t-8	0.00824	(0.00597)	0.00901	(0.00783)
ΔLog(Rack Prices)t-9	0.00290	(0.0141)	0.0289***	(0.00653)
ΔLog(Rack Prices)t-20	0.0277***	(0.00886)	0.0116*	(0.00687)
ΔLog(Rack Prices)t-11	0.00366	(0.00511)	0.00157	(0.00636)
ΔLog(Rack Prices)t-12	0.00151	(0.00588)	0.00710	(0.00697)
ΔLog(Rack Prices)t-13	0.000735	(0.00809)	-0.00691	(0.00967)
ΔLog(Rack Prices)t-14	0.0141**	(0.00719)	0.0188**	(0.00797)
ΔLog(Rack Prices)t-15	0.0153***	(0.00430)	-0.00912	(0.00692)
ΔLog(Rack Prices)t-16	0.0160**	(0.00724)	-0.00868	(0.0102)
ΔLog(Rack Prices)t-17	0.0177***	(0.00442)	0.0291***	(0.00718)
ΔLog(Rack Prices)t-18	0.0107**	(0.00467)	-0.00861	(0.00597)
ΔLog(Rack Prices)t-19	0.0112**	(0.00493)	0.0116	(0.00829)
ΔLog(Rack Prices)t-20	0.00345	(0.00491)	0.00353	(0.00665)
ΔLog(Rack Prices)t-21	0.00341	(0.00697)	0.00272	(0.00721)
Controls				
Gas station fixed effect	YES		YES	
Spatial coefficients				
rho	0.0460***	(0.0148)	0.0934***	(0.0168)
lambda	0.0211	(0.0179)	0.0463***	(0.0124)
Variance				
Sigma-squared res.	0.0000145***	(0.0000024)	0.0000228***	(0.0000031)
N. of observations	4240		4240	
Degree of freedom	43		43	
Number of clusters	48		48	
Log Likelihood	17606.3		16642.0	
AIC	-35160.69		-33232.00	
BIC	-34995.53		-33066.84	

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. In column 1 (2), Rack prices refer to the gasoline (diesel) wholesale prices. Spatial weighting matrix of the autoregressive term is obtained using a threshold distance $\bar{d} = 1.1$ km. Spatial weighting matrix of the spatial error component accounts for brand identity. Residuals are double clustered by week and area of gas station location (City, East, West).

Table 13. Estimates of the Spatial autoregressive model: Direct, Indirect and Total effect.

	ΔLog(Gasoline Prices)					*ΔLog(Diesel Prices)*				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Threshold distance $\bar{d}$ (in km)	0.9	1.0	1.1	1.2	1.3	0.9	1.0	1.1	1.2	1.3
Main effect										
ΔLabor	0.049*	0.052*	0.052*	0.050*	0.049*	0.122**	0.133**	0.130**	0.122**	0.121**
	(0.0281)	(0.0283)	(0.0280)	(0.0283)	(0.0282)	(0.0525)	(0.0530)	(0.0519)	(0.0512)	(0.0512)
Controls										
Gas station fixed effect	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Rack prices (lags 0-21)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Spatial coefficients										
rho	0.0076	0.0313*	0.0460***	0.0346***	0.0164	0.0407***	0.0668***	0.0934***	0.0660***	0.0591***
	(0.0300)	(0.0168)	(0.0148)	(0.0123)	(0.0141)	(0.0123)	(0.0136)	(0.0168)	(0.0147)	(0.0181)
lambda	0.0286*	0.0240	0.0211	0.0221	0.0259	0.0565***	0.0510***	0.0463***	0.0484***	0.0504***
	(0.0171)	(0.0176)	(0.0179)	(0.0177)	(0.0172)	(0.0120)	(0.0121)	(0.0124)	(0.0127)	(0.0129)
Direct effect										
ΔLabor	0.0483**	0.0521**	0.0519**	0.0498**	0.0484**	0.121***	0.132***	0.129***	0.122***	0.120***
	(0.0239)	(0.0240)	(0.0238)	(0.0240)	(0.0240)	(0.0446)	(0.0450)	(0.0442)	(0.0435)	(0.0435)
Indirect effect										
ΔLabor	0.000296	0.00138	0.00199*	0.00157*	0.00075	0.00331**	0.00721**	0.00996**	0.00719**	0.00640*
	(0.00092)	(0.00099)	(0.00113)	(0.00094)	(0.00077)	(0.00164)	(0.00298)	(0.00404)	(0.00314)	(0.00335)
Total effect										
ΔLabor	0.0486**	0.0535**	0.0539**	0.0514**	0.0491**	0.125***	0.139***	0.139***	0.129***	0.126***
	(0.0240)	(0.0247)	(0.0247)	(0.0248)	(0.0244)	(0.0458)	(0.0475)	(0.0477)	(0.0460)	(0.0459)
N. of observations	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240
Degree of freedom	43	43	43	43	43	43	43	43	43	43
Number of clusters	48	48	48	48	48	48	48	48	48	48
Log Likelihood	17603.0	17604.9	17606.3	17605.2	17603.4	16630.6	16636.8	16642.0	16636.7	16635.0
AIC	-35153.9	-35157.7	-35160.7	-35158.5	-35154.8	-33209.2	-33221.6	-33232.0	-33221.4	-33217.9
BIC	-34988.7	-34992.6	-34995.5	-34993.3	-34989.6	-33044.1	-33056.5	-33066.8	-33056.2	-33052.8

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parenthesis. In column 1-5 (6-10), Rack prices refer to the gasoline (diesel) wholesale prices. Spatial weighting matrix of the autoregressive term is obtained using a threshold distance $\bar{d} = 1.1$ km. Spatial weighting matrix of the spatial error component accounts for brand identity. Data are double clustered by week and area of gas station location (City, East, North).

Figure 1. Map of the gas stations in Cuneo. Data considered in the analysis cover 20 of the 25 gas stations. Stations selected in the analysis are in grey and labelled, the excluded stations are in white. Source: google maps.

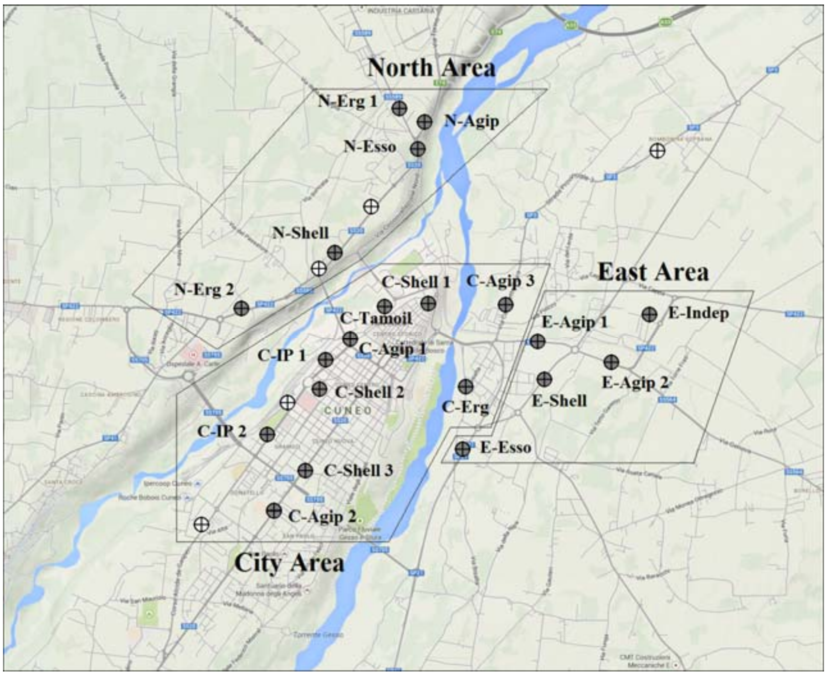
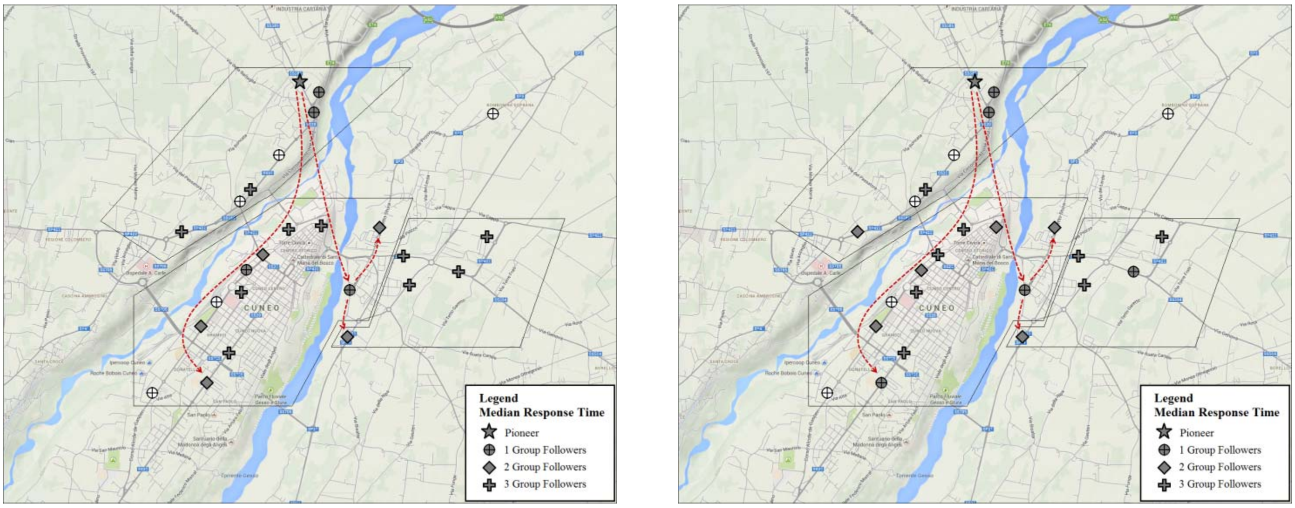


Figure 2. Average response time of gas stations (ranking, 3 days). Panel (a) gasoline prices and Panel (b) diesel prices.



(a) Gasoline

(b) Diesel