Price dispersion on the French retail gasoline market

Working paper

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Abstract: This paper studies differentiation and price dispersion in the French retail gasoline market. Using a large panel of gas station prices over three years, it finds support for the connection between consumer information and price dispersion. Indeed, changes in price rankings between pairs of competitors are found to be positively correlated with the distance that separates them, namely with a measure of consumer search costs. Furthermore, there is a strong connection between differentiation and price dispersion. Pairs of competing gas stations operated by supermarkets, which are characterized by low markups, exhibit lower price dispersion over time than pairs of independent or oil company gas stations. This suggests that the former address a significantly better informed and thus more price sensitive demand than the latter.

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1 Introduction

The seminal paper of the consumer search literature, Stigler (1961), draws attention to the relation between the "ignorance in the market", namely a lack of consumer information, and price dispersion i.e. the persistence over time of different prices for a homogeneous good. An appealing theoretical explanation was brought by Varian (1980), in which the presence of both informed and uninformed consumers creates a tension between Bertrand competition and rent extraction. Such tension prevents the existence of a pure strategy equilibrium, leading sellers to draw prices in a distribution. In equilibrium, price randomization yields a multiplicity of prices, and a dynamic interpretation allows to account for volatility in price rankings over time.

As noted by Chandra and Tappata (2011), the retail gasoline market is an interesting candidate when it comes to studying the impact of consumer search costs on competition. Consumers indeed typically purchase only one product, the homogeneity of which is high, and are imperfectly informed about prices. In France, this lack of information has led the government to create a price comparison website, on which all retailers are required to keep prices posted since 2006.

The following paper elaborates on the methodology used by Chandra and Tappata (2011) to study price dispersion in the U.S. An important difference exhibited by the French market is the presence of significant static price dispersion, with supermarket gas stations setting prices generally 8 to 10 euro cents per liter cheaper than oil company and independent gas stations. Findings yet also support a connection between consumer search and price dispersion. Among pairs of competing stations, price dispersion is indeed found to significantly increase with distance separating gas stations, namely a measure of information imperfection. Price dispersion is higher when competitors are both independent or oil company gas stations than when they are operated by supermarkets. This suggests that supermarkets generally address a well informed, thus more price sensitive demand, justifying the lower observed markups. At the market level, price dispersion is found to increase with the number of competitors and decrease with price.

2 Literature

A major contribution of the consumer search literature was made by Varian (1980) through the modeling of price dispersion as a result of mixed pricing strategies. According to the paper, price dispersion thereby obtained can be interpreted as "temporal" price dispersion, typically in the form of "sales". This provides a rationale for rank reversals i.e. a seller being either cheaper or more expensive than a competitor, both with positive probabilities.

The dynamic interpretation of the model is not unambiguous however. In the model, firms are ex-ante indifferent between all prices in the support of the equilibrium price distribution (also holds in terms of randomization over utilities). Ex-post, indifference obviously no more exists. The cheapest firm attracts shoppers but would be better off increasing its price to (almost) match the second cheapest price. Other firms would rather increase their price to consumers' reservation price, or try to undercut the cheapest firm. In the retail gasoline market, while it may not be possible for firms to change prices on too frequent a basis, periods of significant oil price variations reveal that gas stations can adjust prices on a daily basis. If one admits that gas stations play according to Varian (1980) on a given day, it is thus not clear why sellers would wish to keep prices unchanged the following day, in contradiction with observed price rigidities. A possible explanation may be that firms refrain from changing prices too often for fear of triggering more search by consumers and thus more intense competition. Whether this can be obtained in a fully competitive setting or would require some kind of collusion (possibly at the retail chain level or at the local level) remains an open question.

Chandra and Tappata (2011) study price dispersion with daily prices of gas stations within four states in the US over one year and a half. In order to test the relation between consumer information and price dispersion, they rely on the assumption that distance between sellers is likely to reflect consumer information. Indeed, when gas stations are located in the same street, a higher share of consumers is likely to perfectly observe prices than when gas stations are located further away from each other. When the share of uninformed consumers becomes negligible, sellers can be expected to compete a la Betrand (or Hotelling) and prices should essentially match cost fluctuation except for some frictions. On the other hand, if information is imperfect, persistent dispersion can be expected to arise following the intuition exposed in Varian (1980).

Chandra and Tappata (2011) measure temporal price dispersion between two stations as the probability that the gas station which is in general cheaper (in terms of day count) turns out to be more expensive. Formally, considering the prices p_{it} and p_{jt} of two stations i and j over T_{ij} days, such that $p_{it} \geq p_{ij}$ is observed most of the time, the rank reversals statistic writes:

$$r_{ij} = \frac{1}{T_{ij}} \sum_{t=1}^{T_{ij}} \mathbb{1}_{p_{jt} > p_{it}}$$

They find temporal price dispersion to be positively correlated with distance, which is all the more convincing as close gas stations tend to be less differentiated. Regressions of various measures accounting for price dispersion on marginal costs and the number of firms in the market (built by considering circles of varying radiuses) yields results consistent with the extension of Varian (1980) proposed by the paper (resp. negative and positive impacts). All the analysis is performed with raw prices.

3 The French retail gasoline market

3.1 Retail gasoline distribution

Diesel consumption currently accounts for c. 80% of retail gasoline sales in France. The share of diesel in total gasoline consumption has kept increasing over the last decades, largely as a result of a lower tax. Meanwhile, the size of the French retailer network has decreased at a steady pace, from c. 40,000 gas stations in 1980 to c. 12,000 currently. Unlike most other European countries, the French market is characterized by a strong competitive pressure generated from gas stations operated by supermarket chains. They currently represent c. 50% of sales in retail gasoline.

According to the French Union of Petroleum Industries (UFIP), there were 11,662 gas stations operating in France (of which 4,947 operated by supermarket chains) in 2012 and 11,476 in 2013 (4,979 for supermarkets). Regarding volumes, it was reported that 1,506 gas stations sold less than 500m^3 in 2012 (1,433 in 2013), with the median gas station selling between 1,000 and 3,000m^3 (same for 2013). As of May 20, 2014, the price comparison website Zagaz listed 12,832 gas stations, but no price had been recorded for long for many of them. This figure can thus be considered as an upper bound of the actual number of gas stations.

Gas stations are essentially either owned and operated by a chain or with a "location-gerance" contract according to which the manager receives a commission on gasoline sold (e.g. Total SA, the largest gas station operator, has reported that only 200 gas stations set prices independently among the c. 2,300 gas stations of its "Total" chain). Industry margins are widely acknowledged to have decreased significantly over the last decade, as a result of competition by supermarket chains and increasingly stringent environmental regulations. This has led some oil companies to exit the market (Shell and BP) or to reduce significantly the size of their network (Esso, Total).

Key cost components are the cost of wholesale gasoline, including delivery fees, gas station operating expenses, and taxes. Taxes included a fix part called TICPE, which slightly varies between regions, and the classical Value-Added Tax (19.6% over the period studied, which bear on cost and TICPE).

At an aggregate level, two kinds of consumers can be distinguished: businesses and individual customers. Businesses are typically offered card programs which allow them to monitor employees' consumptions and obtain rebates. An important implication is that the price of the gas station is irrelevant (or only partly relevant) to a significant number of transactions in the market. Individual consumers pay the posted price, and can get information from a variety of sources: at gas stations, on their gps, mobile phone applications (e.g. Zagaz, Carbeo, Essence Free) and on a computer or mobile phone browser (Prix-Carburants.gouv.fr).

The period covered by the paper is marked by two significant events of different natures. The first is the creation by the largest gas station operator in the country, Total, of a discount brand with a view to recapture market shares lost to supermarket gas stations. This creation was achieved through the rebranding of c. 600 gas stations between 2011 and 2014, accompanied for about half of them by a c. 8 euro cents per liter decrease in prices. The second event is of political nature. On August 29, 2012, following an election promise made by Francois Hollande, the government announced a decrease in price of 6 euro cents per liter, (to be) achieved by a decrease of tax of 3 Euro cents per liter and an equivalent "effort" by gas station operators.

3.2 Price comparison

Since 2007, French gasoline retailers are required by law to keep prices updated on the price comparison website prix-carburants.gouv.fr. Small gas stations[1] are exempted from this obligation hence c.10,000 gas stations are observed out of an estimated total number of 12,000 retailers[2]. Significant limitations of the governmental comparison website include the fact that users have never been provided a way to report errors such as wrong or out of date prices or wrong gas station locations, and that price comparison functionalities have always remained very poor: e.g. one cannot view prices for a given highway, nor the rivals of a given gas station on a map. As a consequence, it does not seem far-fetched to suspect that the creation of this website was actually detrimental to consumer information, as it diverted drivers from other comparison websites such as Zagaz at a time when they crucially needed to grow their user base.

3.3 Descriptive statistics

Prices and brand changes were collected from prix-carburants.gouv.fr on a daily basis between September 4, 2011 and December 4, 2014, hence a period of about 3 years, interrupted by some gaps related to data acquisition issues. Over this period, prices of 10,180 gas stations (after duplicate reconciliations) were recorded, of which 437 were located on highways, 124 on the island of Corsica, and 402 were found to have insufficient or suspicious price data. The analysis was thus performed with a total number of 9,217 gas stations. Due to the fact that price observations are not always available (gas station maintenance, probable mistakes, stations which are not required by law to keep prices posted), there is actually an average of 7,895 prices observed on a daily basis. On average, c. 1,500 gas stations (c. 18% of gas stations observed and retained) change prices within a day. The average gas station changes price a little less than every week.

Table 1 provides an overview of retailer chains and prices on the last day of the period studied. Except for two discount chains operated by oil companies, supermarket gas stations are found to set prices significantly lower than these of oil company and independent gas stations. Within

[1] Stations having sold over $500m^3$ gas the previous year

[2] A 2012 governmental report on the French retail gasoline market notes that "nobody knows precisely the number of gas stations operating in the markets". Two other comparison websites, carbeo.com and zagaz.com, were created in 2005 and 2006, relying on user provided information. Zagaz has stuck to its "crowdsourcing" philosophy until 2014, while Carbeo started purchasing licences from the government in 2009. In 2012, the governmental body in charge of town and country planning worked with Zagaz data to study the French retail gas station network.

supermarket groups, chain appear to provide a somewhat more detailed signal. For instance, the average gas station operated by a Carrefour (hypermarket) has a diesel price of 1.15 euros per liter vs. 1.18 for a Carrefour market (large supermarket) and 1.20 for a Carrefour contact (small supermarkets, often located in city centers). The average difference with a Total gas station thus varies from 12 to 7 euro cents per liter depending on the chain within the Carrefour group. These observations are essentially robust to the considered day. A noteworthy change is the creation by Total SA of a new chain, Total Access, with a view to expand its discount offer. As a consequence, the previous discount chain of Total, Elf, disappears over the period and is replaced by Total Access. The new discount chain also includes c. 300 former "Total" stations for a which the conversion operation is accompanied by a significant change in pricing policy. The impact of this operation is studied in a companion paper, Chamayou and Le Saout (2016).

Table 6 contains some information about the heterogeneity observed between gas stations. Supermarket gas stations change prices on a more frequent basis than others, even though the value of changes does not appear to differ significantly. Their closest rival is generally further (2.6 vs. 1.8 km), and the number of nearby competitors higher (2.5 vs. 4.1 competitors). The location of gas stations also accounts for significant heterogeneity. Gas stations within and around Paris tend to change prices for frequently, with smaller variations, and are closer to their closest rival than average.

Regardless of the specifications used to account for gas station and local market characteristics, chains (or types reported in table 1) retain a major predictive power on price. Indeed, despite differences reported between supermarket gas stations and others in table 6, more than half non supermarket gas stations are located within 1.4 km from a gas station operated by a supermarket, hence often similar market conditions.

4 Price dispersion and consumer information

A database is built in which observations are pairs of stations assumed to compete within the same market. In the following analysis, distance as the crow flies is used with an upper distance limit of 3km (figures are provided for a limit of 5km in appendix). This results in a database describing price competition between 12,264 pairs of rival gas stations (respectively 25,007 pairs with 5km).

The treatment of persistent differences in average prices is a sensitive issue in the empirical analysis of dispersion. It has been frequently addressed in the literature by working with price residuals i.e. after controlling for seller (and occasionally time) fixed effects. However, beyond the practical errors inherent to the statistical treatment, this approach is only valid to the extent that static price dispersion mirrors heterogeneity in offered utility, common to all consumers. In the case of French gasoline retailers, the relatively low predictive power of observed seller characteristics regarding prices does not offer strong support for this hypothesis. As a consequence, the analysis focuses on pairs of gas stations which are found to operate at similar price levels over the studied period. This leads to distinguish pairs of supermarket competitors, on the one hand, and pairs of oil company and independent gas stations on the other hand.

Figure 3 displays the percentage of pairs of gas stations whose price rank is reversed on each day of the period studied. Among pairs of gas stations built with a maximum distance of 3km, the percentage of reversed pairs fluctuates between 5.4% and 15.3% (mean 8.1%). The "No differentiation" series results from a focus on pairs which exhibit an average price difference below 2c/l. Among these pairs, the minimum percentage of reversed pairs fluctuates between 13.8% and 29.3% (mean 19.5%). From a consumer viewpoint, this translates in one chance in five to pay the highest price upon patronizing among two competitors of similar price level the one which is cheaper most of the time.

A clear ranking of empirical distribution functions of rank reversals can be observed among pairs of gas stations depending on distances. This is consistent with the idea that nearby gas stations compete in a (virtually) complete information setting, where there is no particular reason to expect rank reversals. Conversely, distance can create an information issue for other pairs, leading to the inexistence of an equilibrium in pure strategies.

In order to evaluate the hypothesis according to which information is connected to price dispersion, two measures of price dispersion: rank reversals and standard deviation in spread, are regressed on a proxy for consumer information: distance between stations.

Overall, results seem to support the connection between price dispersion and consumer information. Pairs separated by a short distance exhibit less rank reversals, while the average price difference tends to be smaller. Though significant, the effect is weaker for differentiated gas stations. This might partly be due to errors introduced by the cleaning of prices. However, for pairs exhibiting little or no differentiation, results do not diffe significantly whether raw prices or residual prices are taken into account.

5 Market price dispersion

While the emphasis has so far been laid on examining empirical evidence about the link between price dispersion and consumer information, the following section seeks to compare predictions from a model a la Varian (1980) with French retail gasoline market data.

The methodology employed by Chandra and Tappata (2011) consists in considering each gas station successively as the center of a market delimited by a circle of a given radius (robustness of results to variations in radius size is checked). Various statistics accounting for price dispersion can then be computed for each market and period. If one observes N stations close to each other (e.g. with a limit radius of 2km: if no two stations are separated by a distance of more than 2 km) and with prices posted over T periods, this will result in $N * T$ observations as each station is successively considered and, for each station, a statistic representing price dispersion is computed at each period. An expected consequence is that it tends to over represent markets with higher gas station density (typically cities).

Regressions are then run using raw prices and cleaned prices. Also, in order to address the issue of overlapping markets, regression are performed on dispersion data generated in a way that prevents market overlap. Descriptive statistics performed on raw prices are provided.

Standard market dispersion statistics such as range and standard deviation are strongly influenced by static price dispersion. As a consequence, contrarily to the previous section where descriptives statistics performed on raw prices arguably provided a most conservative first idea of price dispersion, clean prices are now to be preferred despite their shortcomings. Results are reported with clean prices, raw prices for markets obtained with radiuses of respectively 3 and 5km. Additionnally, results are reported for non overlapping markets built in a way that is detailed in appendix.

Estimation results show that dispersion is increasing in the number of firms and decreasing in price.

6 Conclusion

This paper discusses the methodology of Chandra and Tappata (2011) to measure price dispersion in the field and see how it compares with potential theoretical explanations. The presence of differentiation in the French retail gasoline market yet requires to work both with raw and residual prices.

Rank reversals are generally found to be less frequent for pairs gas stations separated by a short distance i.e. competitors whose prices are easy to compare for consumers, hence supporting the connection between consumer information and price dispersion. When differentiation is significant, regressions performed on residual prices show a weaker effect of distance. This suggests that one should be cautious when there is differentiation despite the high number of rank reversals that one obtains with residual prices.

At the market level, price dispersion is found to increase with the number of competitors, and decrease with cost. This is consistant with predictions of a model a la Varian (1980). Importantly, in the presence of significant differentiation, working with raw prices typically leads to overestimate price dispersion reflecting randomized pricing. The average gain from search across markets and time over the period computed with residual prices varies between 1.7 and 1.0 Euro cents per litre meaning that knowing all prices in the market allows to spare on average between 50 and 85 Euro cents for a gas tank of 50L.

Further research remains to be undertaken in two directions: one is the investigation of the heterogeneity in local market price patterns and the other is the combined analysis of price dispersion together with data about consumer search (e.g. price comparison website frequentation over time if data are released).

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A Descriptive statistics

Table 1: Overview of retailer chains (last day of the period)

		Prices (euro cents) on 2014/12/04				
Type	Chain	Count	Mean	Std	Q75/Q25	Q90/Q10
Supermarkets		**4,967**				
Large	Carrefour	201	1.15	0.03	1.02	1.05
Large	Auchan	118	1.16	0.03	1.02	1.05
Large	Cora	111	1.18	0.04	1.04	1.08
Large	Geant Casino	97	1.16	0.02	1.03	1.04
Large and medium	Intermarche	1,391	1.17	0.03	1.03	1.06
Large and medium	Systeme U	771	1.16	0.03	1.03	1.06
Large and medium	Leclerc	585	1.15	0.02	1.03	1.06
Small	Carrefour market	717	1.18	0.03	1.03	1.05
Small	Carrefour contact	233	1.20	0.03	1.03	1.05
Small	Simply (Auchan)	222	1.20	0.03	1.04	1.07
Small	Casino	200	1.21	0.03	1.03	1.06
Small	Intermarche contact	112	1.20	0.03	1.04	1.07
Other supermarkets		209				
Oil and independent		**3,770**				
Oil	Total	1,283	1.27	0.03	1.03	1.07
Oil	Elan (Total)	233	1.32	0.04	1.05	1.08
Oil	Agip	116	1.25	0.03	1.02	1.06
Oil (Independent)	BP	275	1.26	0.04	1.03	1.07
Oil (Independent)	Esso	147	1.27	0.05	1.05	1.11
Independent	Avia	376	1.27	0.05	1.03	1.07
Independent	Dyneff	55	1.26	0.04	1.05	1.07
Oil - discount	Total access	616	1.16	0.03	1.02	1.04
Oil (Independent) - discount	Esso express	318	1.16	0.02	1.02	1.04
Other independent		351				
Total		**8,737**				

Sub-classification of type for supermarkets is meant to reflect what consumers can infer from chain name (as provided on the price comparison website).

Gas stations are considered independent when they are neither operated by a supermarket nor part of a chain operated by an oil company. BP and Esso (including Esso Express) gas stations have an intermediary status: they have been sold to third-party companies with a supply agreement and the right to exploit the brand name.

Table 2: Station-level summary statistics

	All	Super-markets	Others	Paris region	Others
Nb stations					
All periods	9,217	5,055	4,162	918	8,299
Nb daily observations (avg)	7,896	4,400	3,496	776	7,119
Competition					
Distance (km) to closest rival	2.3	2.6	1.8	1.2	2.4
Nb of rivals within 3 km	3.2	2.5	4.1	6.9	2.8
Nb of rivals within 5 km	6.6	4.9	8.6	17.8	5.3
Price and Markup (euro per liter)					
Price after tax	1.37	1.33	1.4	1.38	1.36
Price excl. Tax	0.71	0.68	0.74	0.72	0.70
Markup over wholesale cost	0.10	0.08	0.13	0.11	0.10
Retail price variations (euro cents per liter)					
Daily price change probability	0.17	0.18	0.15	0.21	0.16
Average price increase	1.30	1.29	1.31	1.05	1.33
Average price decrease	1.47	1.48	1.46	1.18	1.50

Price statistics are obtained by i) computing the average for each station over time ii) taking the average over stations. Costs of transportation and distribution are to be subtracted from the markup, leading to a net margin generally estimated at c. 1 euro cent per liter.

Figure 1: Daily Brent and French diesel retail prices excluding taxes

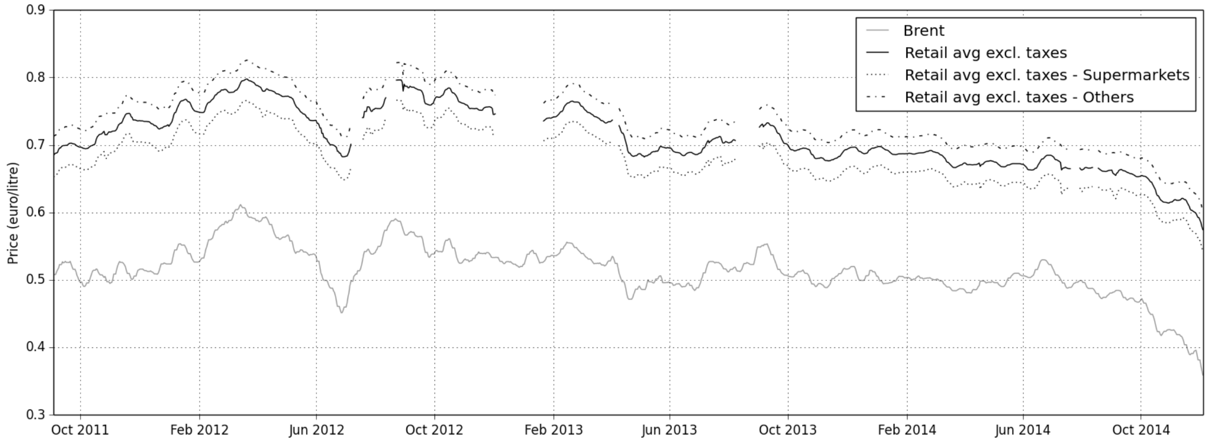
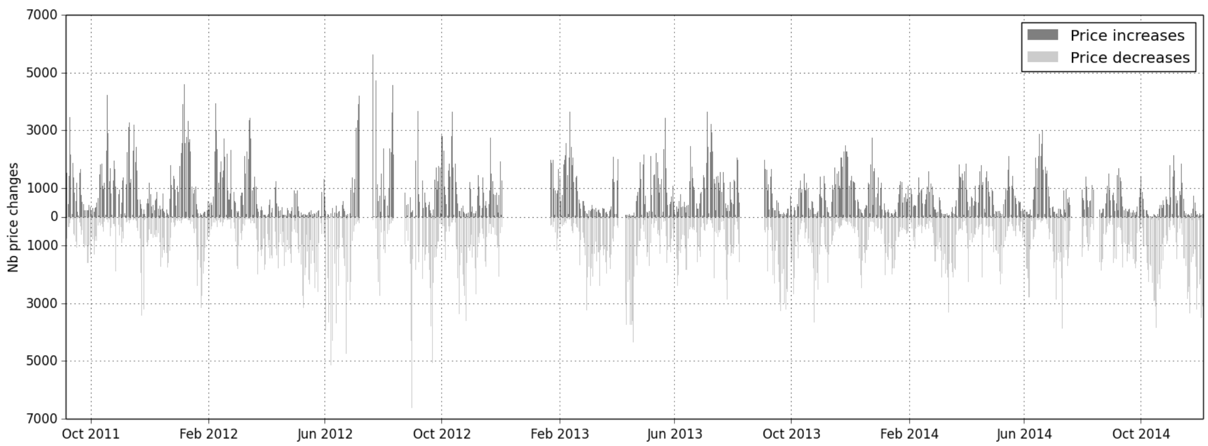
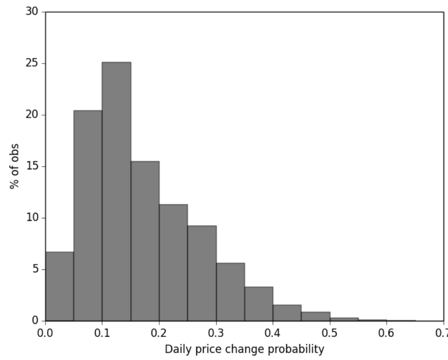


Figure 2: Daily number of retail price changes

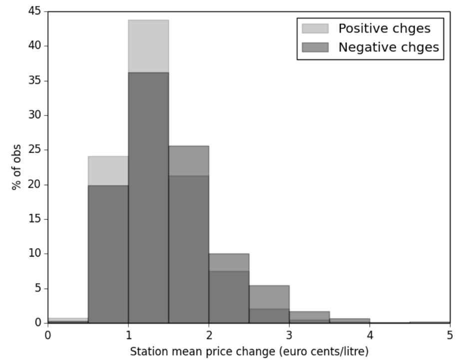


The daily collection of prices has occasionally been delayed by a few hours resulting in some imprecision regarding the exact number of price changes occurring within one day

Figure 3: Price changes by station)



(a) Histogram of station daily price change probabilities



(b) Histogram of station average price variations

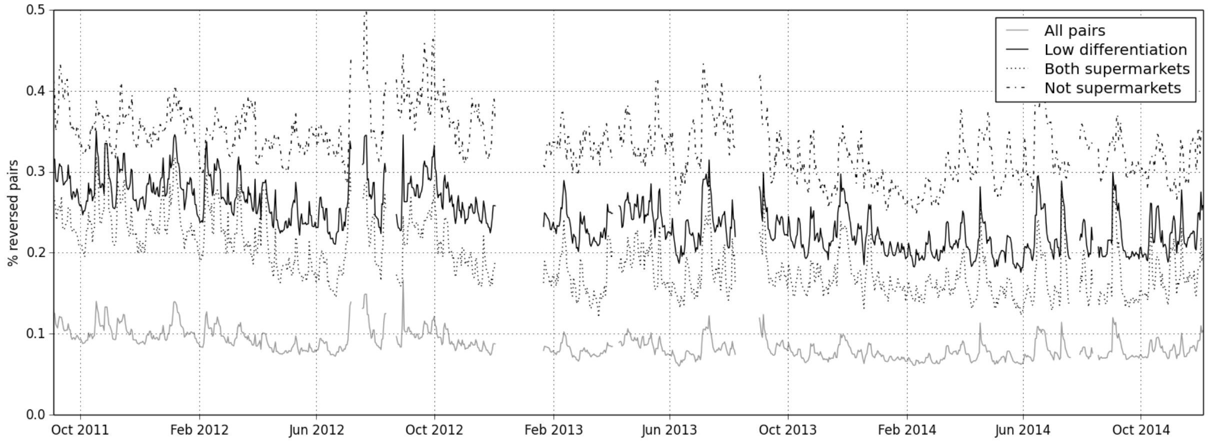
B Rank reversals

Table 3: Pair rank reversals

	Nb pairs	Avg price spread avg	Avg price spread std	Avg rank reversals (%)	Avg same price (%)
$d_{ij} \leq 3km$					
No price spread restriction					
All types	12,298	5.1	1.6	8.3	7.7
Supermarket pairs	2,331	1.0	1.3	13.7	26.6
Oil/independent pairs	1,126	2.7	1.9	14.9	2.9
Discounter pairs	200	0.4	1.1	28.3	13.0
Discounter vs. supermarket pairs	1,484	0.9	1.3	18.9	12.5
Price spread $\leq$ 1 cent per liter					
All types	3,429	0.4	1.2	22.4	24.5
Supermarket pairs	1,524	0.4	1.1	16.9	37.9
Oil and independent pairs	286	0.5	1.8	35.3	5.8
Discounter pairs	176	0.3	1.0	30.0	13.9
Discounter vs. supermarket pairs	1,034	0.5	1.2	22.9	16.0
$d_{ij} \leq 5km$					
No price spread restriction					
All types	25,076	5.2	1.7	8.5	6.0
Supermarket pairs	4,515	1.1	1.4	14.6	21.3
Oil/independent pairs	2,680	3.0	2.0	13.3	2.3
Discounter pairs	401	0.5	1.2	28.4	10.4
Discounter vs. supermarket pairs	3,067	1.0	1.4	19.9	10.3
Price spread $\leq$ 1 cent per liter					
All types	6,413	0.4	1.3	24.2	20.4
Supermarket pairs	2,758	0.4	1.2	18.9	32.1
Oil and independent pairs	575	0.5	1.9	35.5	5.1
Discounter pairs	330	0.3	1.1	31.5	11.5
Discounter vs. supermarket pairs	2,003	0.5	1.2	25.0	13.6

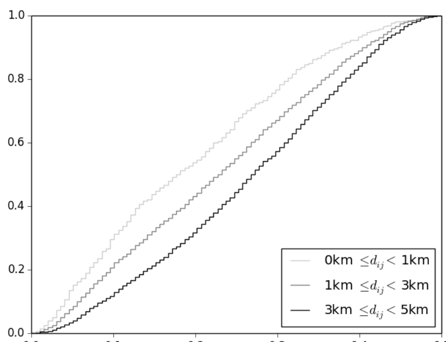
Except for the first column, all figures are category averages of statistics which were first computed at the pair level. The average and standard deviation in price spread respectively account for the existence of a persistent price difference, and dynamic price dispersion around this difference.

Figure 4: Percentage of rank reversals among pairs

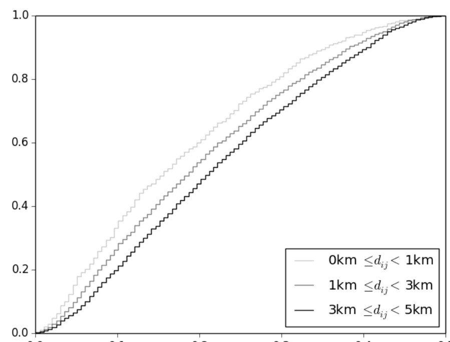


Series represent for each day the percentage of pairs observed where the usual price order is not respected (reversed rank). No differentiation implies that pairs exhibit an average price difference below 1c/l.

Figure 5: Empirical distribution functions of rank reversals (raw prices)



(a) Pair average price spread $\leq$ 1 cent/litre



(b) Pair average price spread $\leq$ 1 cent/litre

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Table 4: Regression of rank reversals

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	Dependent Variable	OLS	Quantile regressions 25%	50%	75%	90%
All pairs	r_ij	-0.035	-0.030	-0.047	-0.043	-0.033
(N = 3,345)		[6.57]**	[4.01]**	[5.12]**	[5.34]**	[4.45]**
	std_ij	-0.001	-0.001	-0.001	-0.001	-0.002
		[4.73]**	[3.09]**	[3.53]**	[3.52]**	[2.75]**
Supermarket pairs	r_ij	-0.026	-0.016	-0.027	-0.043	-0.036
(N = 1,488)		[3.73]**	[2.56]*	[2.77]**	[2.78]**	[2.34]*
	std_ij	-0.000	-0.000	-0.000	0.000	-0.000
		[1.01]	[0.71]	[1.04]	[0.25]	[0.54]
Oil/ind pairs	r_ij	-0.033	-0.057	-0.039	-0.02	0.017
(N = 277)		[2.60]*	[2.73]**	[2.17]*	[1.29]	[1.16]
	std_ij	-0.003	-0.003	-0.003	-0.001	-0.002
		[3.48]**	[3.85]**	[3.76]**	[1.04]	[1.02]

The "same corner" variable is a dummy variable that takes value one for pairs of gas stations separated by a distance of less than 500 meters, namely those for which consumers are expected to be relatively well informed about prices at each retailer.

C Market price dispersion

Figure 6: Market-level summary statistics

	3 km radius		5 km radius		Nonoverlapping	
Nb obs	5,834,850		7,159,153		641,314	
Nb markets	5,484		6,722		604	
Nb sellers	5.98	3.35	9.68	8.07	4.36	2.06
Nb sellers observed	5.74	3.18	9.28	7.65	4.18	2.02
Raw prices (euro cent / litre)						
Range	9.70	3.88	10.78	4.18	8.61	3.88
Standard deviation	3.80	1.43	3.96	1.35	3.65	1.66
Gain from search	3.93	2.00	4.13	1.98	3.40	1.75
Residual prices (euro cent / litre)						
Range	2.50	1.04	3.01	1.38	2.01	0.74
Standard deviation	0.88	0.26	0.93	0.25	0.79	0.24
Gain from search	1.25	0.51	1.50	0.67	1.01	0.38

Table 5: Regressions of market dispersion

	All Raw prices	All Residual prices	No overlap Residual prices	Stable markets Residual prices
Gains from search				
Nb competitors	0.003***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Cost	0.007*	-0.006*	-0.005	-0.005
	(0.003)	(0.003)	(0.003)	(0.003)
Intercept	0.015***	0.015***	0.013***	0.012**
	(0.004)	(0.004)	(0.004)	(0.004)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D In progress

D.1 Spurious rank reversals

French data raise the issue of the nature of rank reversals measured by the statistic previously described. Indeed, the transformation by the firm "Total" of a significant number of its gas stations to low cost gas stations generates rank reversals which are clearly unrelated to the use of randomized pricing (cf. appendix). In order to avoid including "spurious rank reversals" in the analysis, the frequency of changes in price ranking was also considered in the analysis. Conservatively, pairs of gas stations involving such a brand and price policy change have been excluded from the analysis. It has also been checked that price policies implemented by competitors of rebranded gas stations were not significantly affected.

The following figure displays prices posted at a gas station which is rebranded "Total Access" (low cost brand of Total) in the middle of the period studied and at two nearby gas stations. It is easily seen how naively considering the percentage of rank reversals of the rebranded gas station vs. each of its competitors over the whole period would lead to record spurious price dispersion. The price level indeed changes abruptly in a way that cannot go unnoticed by consumers. It thus clearly does not reflect any used of randomized pricing and such rank reversals are thus excluded from the analysis. More generally, this suggests the need to control the frequency of changes in price ranking so as to limit the risk of capturing dispersion reflecting such deterministic changes in pricing policies.

D.2 Number of digits after decimal point

There is heterogeneity between the number of digits displayed after decimal point among stations. Some stations indeed appear to restrict themselves to two digits after decimal point, hence giving up the possibility to undercut or match a competitor's price. Though accounting for this phenomenon is out of the scope of this paper, its connection with price dispersion is (to be) investigated.

D.3 Leadership

Maskin and Tirole (1988) [TODO: add ref] offer an alternative explanation for rank reversals. They indeed show that in a context where sellers have to commit on prices for at least one period, cycles can occur which are characterized by periods of undercutting punctuated by one firm accepting to set a high price when margin becomes too small. XXX [TODO: add ref] find evidence of such cycles with XXX data. Though standard test rule out the presence such cycles in French data, evidence of other specific patterns of prices has been found.

D.4 Monopoly, information, inventory and rule of thumb

Finally, a natural explanation for rank reversals could be that gas stations actually do not really compete and that their prices simply reflect their flow of information and/or inventory through more or less complex pricing rules. Such explanations are (to be) examined.