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Abstract

We study the collapse of collusion in Québec's retail gasoline market following a Competition Bureau investigation, and show that it involved two empirical regularities: high margins, and asymmetric price adjustments. Using weekly, station-level prices we test whether collusion was successful, and whether asymmetric adjustments were part of the cartel's strategy. We do so in the markets targeted by the investigation, and in markets throughout the province with similar pre-collapse pricing (cyclical markets). Our results suggest that stations in both target and cyclical markets adjusted pricing following the announcement: margins fell (by 30%/15% in target/cyclical markets), and adjustments became more symmetric.

Disciplines

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THE EFFECT OF EXPLICIT COMMUNICATION ON PRICING:
EVIDENCE FROM THE COLLAPSE OF A GASOLINE CARTEL

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ABSTRACT. We study the collapse of collusion in Québec's retail gasoline market following a Competition Bureau investigation, and show that it involved two empirical regularities: high margins, and asymmetric price adjustments. Using weekly, station-level prices we test whether collusion was successful, and whether asymmetric adjustments were part of the cartel's strategy. We do so in the markets targeted by the investigation, and in markets throughout the province with similar pre-collapse pricing (cyclical markets). Our results suggest that stations in both target and cyclical markets adjusted pricing following the announcement: margins fell (by 30%/15% in target/cyclical markets), and adjustments became more symmetric.

1. INTRODUCTION

In 2004 the Canadian Competition Bureau launched an investigation in an effort to uncover evidence that collusion was taking place in the retail gasoline markets of four cities in Québec: Victoriaville, Thetford Mines, Sherbrooke, and Magog.[1] Around 130 stations and over sixty firms were thought to be involved, and fourteen companies and thirty-nine individuals were charged.[2] Our

[1]Appendix A presents a legal disclaimer and describes the Competition Bureau documents on which we base part of our economic analysis.

[2]The allegations of the Competition Bureau have not been proven in a court of justice. As of September 2012 seven companies (including some of the larger players in the target markets) and twenty-seven individuals had pleaded guilty to the charges with fines ranging from $90,000 to $1,850,000 for the companies, and from $3,000 to $50,000 for the individuals. All figures are in Canadian dollars unless otherwise noted. The competition bureau of Canada provides the details of the charges in this file (03079) on its website: **CompetitionBureau.gc.ca**. Other cases are still before the courts, and charges have been stayed against some companies, including Couche Tard (see file number 2012 QCCS 4721 at **Canlii.ca**).

objective in this paper is to quantify the impact of explicit communication on pricing by studying the collapse of these four cartels following the announcement of the Bureau's investigation.

In the first part of the paper, we document the existence of two pricing patterns in the cartels: (i) high retail margins, and (ii) asymmetric price adjustments. We show that the four cities targeted by the investigation exhibited stable margins (20% higher than the rest of the province), and asymmetric pricing during the Competition Bureau investigation and for over two years prior. Specifically, although cost changes were symmetric, price increases were large and sudden, while decreases were smaller in magnitude and occurred both more frequently, and following long periods of sticky prices. Moreover, over the same period and holding fixed the sequence of cost changes, we show that about 30% of stations located elsewhere in the province featured the same cyclical patterns, while the remainder had low margins and symmetric price adjustments.

In the second part of the paper, we quantify the effect of explicit communication on these two pricing patterns. After gathering information in the target markets for over a year through wire taps and on-site investigation, the Bureau announced its investigation by executing search warrants in May 2006. We hypothesize that the execution of the warrants increased the fear of criminal prosecution, and therefore caused the collapse of the collusive agreement in the four markets targeted by the investigation.

Our main empirical tests consist of comparing the change in pricing behavior of stations located in the target cities, with the changes in pricing behavior amongst stations throughout the province. Since there is heterogeneity across the province in the patterns of price adjustments prior to the announcement, we perform a difference-in-difference analysis comparing stations in the collusive cities to stations in two control groups: (i) competitive markets (i.e. low margins and symmetric pricing), and (ii) cyclical markets (i.e. high margins and asymmetric pricing). This strategy allows us to identify two potential effects of the announcement: a direct effect on pricing in the collusive markets, and an indirect spillover effect on pricing in the cyclical markets.

Our results show that following the announcement, margins fell by around 2.25 cents per litre (cpl) in the target market, and by around 1 cpl in the cyclical markets. As a result of these decreases, margins in the target markets became indistinguishable from those in the most competitive markets of the province (i.e. margins between 3 and 4 cpl). We also find that most of the asymmetry in price adjustments disappeared following the announcement in the target markets, and was reduced by half in the other cyclical markets. This result is mostly driven by a significant increase in the frequency and magnitude of price cuts, although price increases are also less important after the collapse. We therefore conclude that collusion was successful in the four markets targeted by the investigation, and that a primary function of explicit communication was to limit the amount of undercutting during price decreases.

These results are also consistent with the conjecture that collusion was widespread in the province, although not necessarily conclusive. To our knowledge the Competition Bureau investigation was not extended to other markets, and so there is no direct evidence of explicit communication among

players outside the target markets. The reaction of firms in the cyclical markets to the announcement may simply have been the result of not wanting to raise suspicions as a result of their pricing strategies.

Our findings on asymmetric price adjustments have implications for our understanding of price movements in commodity markets such as gasoline. Because every station in our data set faces the same sequence of wholesale price shocks, the cyclical pattern that we measure reflects both the fact that prices adjust faster to cost increases than cost decreases, and that on average price increases are larger and less frequent than price decreases. The former phenomenon has often been refereed to as *rocket-and-feathers* pass-through, first documented by Bacon (1991) in the UK and by (Borenstein, Cameron, and Gilbert 1997) in the U.S.[3] The latter has been more recently associated with *Edgeworth cycles* (Edgeworth (1925)), and arises independently of cost changes (see Castanias and Johnson (1993) for an early paper). Our results show that both patterns can be the result of collusive behavior. Market power has often been invoked as a possible explanation for asymmetric pass-through (e.g. Deltas (2008), and Borenstein et al. (1997)), but Edgeworth cycles have more commonly been explained by the non-cooperative model of Maskin and Tirole (1988) (e.g. Eckert (2002), and Noel (2007a)). This is not to say that every cycle documented in the literature is the result of explicit collusion, especially since recent papers in this literature have documented recurrent short-lived cycles that arise even with constant costs (e.g. Noel (2007b) and Lewis (2009)). Instead, we interpret our results as suggesting that pricing cycles that involve long episodes of sticky prices and that span multiple weeks are consistent with explicit collusion.

Our paper is related to a large literature focused on estimating cartel overcharges. Recent studies include Connor (2007) and Bolotova et al. (2008).[4] The idea of measuring the spillover effect of antitrust enforcement activities dates back at least to Block et al. (1981), who study collusion in the American bread industry in the 1960's. They measure the effect of cartel detection activities in one city on pricing in neighboring cities, and find that antitrust investigations reduce markups.

Our analysis also complements studies on collusion in gasoline markets. Earlier work on the topic includes Borenstein and Shepard (1996), as well as Slade's (1987, 1992) analysis of tacit collusion in Vancouver. Erutku and Hildebrand (2010) estimate the collusion overcharges in the Sherbrooke market. Their results show that following the announcement, prices decreased by nearly 2 cpl relative to Montreal, but not at all relative to Québec City. Although we use more detailed station-level data, our results are consistent with theirs, and provide an explanation for their findings: stations in Québec City are part of the cyclical markets and reacted in the same way to the announcement. More recently, Erutku (2011) builds on the conclusions found in this paper, and measures the change in the pass-through rate of wholesale prices in Sherbrooke following the announcement of the charges. Wang (2008, 2009) studies gasoline retail markets in Australia that were the subject of a price-fixing investigation. The Australian cartel shares several features with ours, including asymmetric price adjustments.[5]

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[3]Similar patterns have been noted in a wide range of retail markets by Peltzman (2000)

[4]See Connor and Lande (2006) and Bolotova and Connor (2006) for recent surveys of this literature.

[5]See also de Roos and Katayama (2010) for an analysis pricing cycles in Australia over the same period.

In a companion paper, Clark and Houde (2011), we analyze the internal organization of the Québec cartels. The objective of the paper is to explain the mechanism used by an actual cartel to solve the enforcement and coordination problems that arise in price-posting markets with heterogeneous firms. We use documents submitted by the Competition Bureau to the Superior Court of Québec containing summaries of and extracts from recorded conversations between participants to first describe the organizational form of the cartel, including the communication patterns and pricing strategy employed. We then provide evidence of the existence of a mechanism based on the ordering of moves and adjustment delays during price changes in which market share is transferred to "stronger" players. Finally, we estimate the implicit market share gains of the "stronger" players, and evaluate the importance of the transfers for cartel stability.

The focus of the current paper is quite different. Although we also rely on the Competition Bureau documents, we are interested in using micro-level price data to study the impact of the collapse of the cartels on margins and adjustment asymmetry in the target markets, and other markets throughout the province.

The rest of the present paper is organized as follows. In the next section we describe the role of explicit communication in the cartels. In Section 3 we describe the price survey and our choice of sample. In Section 4 we describe the pricing patterns in the target markets during and before the investigated period, and compare these with patterns in the rest of the province. In Section 5 we describe our main empirical results. We conclude the paper in Section 6. The appendices contain a legal disclaimer, information on the origin of the Competition Bureau investigation, as well as additional maps and figures.

2. The role of explicit communication

Our understanding of the method of functioning of the alleged cartels is based primarily on the documents submitted by the Competition Bureau to the Court. The wire taps took place from March to June 2005 in Victoriaville and Thetford Mines, and from March to June 2005 and December 2005 to April 2006 in Sherbrooke/Magog. The documents list the phone calls for each price adjustment. An extract or a summary of the conversation is given along with information about who made the call, who received it, and the time of the call. For each price change, we coded the content of reported conversations in order to measure the number, time, and direction of phone calls. In Clark and Houde (2011), we use this information to study the timing of price changes for each player.

In the four cities investigated, the cartels are structured around a leader who controls a large fraction of stations in his respective market. The main role of the leader is to coordinate the timing and magnitude of price increases. He is helped in this role by a group of stations that actively monitor the behavior of their competitors to ensure that everybody follows the instructions. As we describe in detail in Clark and Houde (2011), price increases are difficult to coordinate because of the presence of a group of more efficient stations, that have less incentives to collude, and therefore are allowed extra time to raise their prices as a form of transfer. This differential timing during adjustments creates tensions, and the ability of firms to actively communicate helps to

implement the agreement. Indeed, we document a large volume of communications during price increases: in Victoriaville, where 25 stations are active, 65 phone calls on average are recorded during a typical increase.[6]

Price decreases are coordinated very differently. Nearly every price cut documented by the Bureau is initiated by Ultramar, which is a vertically integrated firm operating the largest network of stations in the province. Importantly, this firm advertizes a "low-price guarantee" (or LPG) policy, and has built a reputation for setting the lowest price in a neighborhood around each of its stations. The company does not announce price cuts in advance, but the recorded communications suggest that firms are easily able to anticipate upcoming decreases. Most of these decreases are small, typically 1 cpl, and rarely occur more than once a week, often every two weeks. The leader's role in coordinating price decreases is to instruct firms to match the lowest price in the market. This process requires relatively few conversations: on average 25 phone calls are recorded during price decreases. Nevertheless, communication is important for the stability of the cartel since it prevents firms from systematically undercutting one another. Indeed, we document several conversations in which the leader reminds other stations to wait for his call before matching Ultramar's price, and to never undercut the new price.

These findings suggest that communication serves three distinct roles: (i) to coordinate and negotiate the timing of adjustments across players, (ii) to monitor fluctuations in market conditions and pass along information about the optimal markup (given conditions), and (iii) to convince dissidents or would-be-dissidents to participate.

Most of the conversations that we observe are associated with the first two roles. This is consistent with Whinston (2008), who points out that if explicit communication serves a purpose it must be via equilibrium selection since the set of sustainable outcomes is identified by subgame perfection whether collusion is tacit or explicit.

According to the Competition Bureau documents, the cartel participants recognize these roles and understand the value of being able to explicitly communicate. In a conversation from April 19th, 2005, the Irving regional representative informs the Couche Tard representative that Irving is planning to prevent its employees from talking with their competitors about prices. The two of them discuss the implications of this new policy. In their view, without communication "it is impossible to manage gasoline prices".[7] More specifically, they claim that without the ability to discuss prices, they will be late on all of their price adjustments and they will see their volumes fall,[8] and that the agreement only works when information sharing is reciprocal.[9] Furthermore, they suggest that if communication were to be restricted, it would be necessary to "pay people

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[6]See Clark and Houde (2011) for further details on communication patterns, and price changes during the wire-tap.
[7]Translation from the original French conversation: "c'est impossible de gerer les prix d'essence."
[8]Translation from: "en retard pour tous mes changement de prix et tu peux voir la degringolade de notre volume."
[9]During this conversation, the Couche Tard representative says that she will not "freely" share price information with Irving if other competitors refuse to share information in return (translation from: "Ce n'est pas parce-que tu es bannieres Irving avec moi que je vais te donner l'information. Si les autres ne me parlent pas, moi je vais m'arranger toute seule dans l'eau benite et je vais vous donner ca [les informations sur les prix] tout gratuitement?").

to wander around the territory" to monitor prices.[10] This conversation suggests that the ability of firms to share information about upcoming adjustments prevents prices from collapsing.

The third role for communication is also important, but less frequently observed since the Competition Bureau documents cover only two deviations. However, it is interesting to note that deviations by dissidents are not immediately punished through price wars. Instead, the leader communicates directly, or indirectly through an intermediary, with the dissident, and issues threats or negotiates a change in the agreement. This role for explicit communication can also be found in Genesove and Mullin's (2001) analysis of the Sugar Institute cartel, where it is more systematic and formal than in our case. In the sugar case, the communication transcripts do not include direct discussion of prices or market shares, but the cartel sets rules in order to make detection of deviation easier.

3. DATA

The data used in this analysis come from a weekly price survey conducted by the Régie de l'énergie du Québec, the province's energy market regulatory board, in order to administer a price-floor policy. The floor is proportional to the spot price of refined gasoline (i.e. rack), and is published every Tuesday.[11] The Régie surveys a sample of stations throughout the province in order to monitor prices. We obtained the prices and address of each of the 354 stations surveyed through a confidentiality agreement with the Régie. Since most stations are surveyed every week, the panel has a small attrition rate of 0.19%. We also obtained data on the weekly price floor for all regions of the province directly from the Régie's website.

To conduct our empirical analysis we focus on the period between January 2002 and March 2007, when the Régie data set ends. We identify a group of stations that are surveyed for most of the weeks in this period. More specifically, we use 128 stations, with survey lengths varying between 263 and 270 weeks. These stations are thus observed for a large number of consecutive periods, and experienced the same sequence of aggregate demand and cost shocks. There are a total of six stations from the target markets in this restricted group (two in Sherbrooke, two in Victoriaville, and one in each of Thetford Mines and Magog); the rest are distributed across the province according to the population of gasoline stations. For most of our analysis we restrict our sample to this almost balanced panel because we construct statistics that require a large number of observations before and after the announcement of the accusations. We also drop stations that are located within 50 kms of the target markets so as not to capture any demand spillover effects of the announcement. The final panel includes 125 stations.

Figure 5 in the Appendix presents the evolution of prices and the floor prior to the announcement, along with the key dates of the Competition Bureau investigation: the publication of a newspaper article in Victoriaville that triggered the investigation (Summer 2004), and the periods

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[10]Translation from: "payer des gens qui se promenent dans le champs".

[11]The objective of the floor is to prevent below-cost pricing, and protect the average-sized station in the market. The level of the floor approximates the cost of acquiring gasoline for stations that do not benefit from a long-term agreement with a supplier, which lowers the transaction wholesale price (e.g. volume discount or guaranteed margins). As a result, it is reasonable to expect that most stations' marginal costs are below the floor. Carranza et al. (2012) analyze the content of the regulation and its impact on the market.

covered by the wire-tap recordings (the grey areas). To construct this figure we choose one station per city that was always surveyed by the Régie.

The pre-announcement window is selected based on information from the Competition Bureau documents and the newspaper article documenting collusive behavior, which suggest that collusion had been taking place for some time when the investigation started.[12] However, we also consider a shorter 74 weeks pre-announcement window in our empirical analysis. This window is chosen to correspond to the period extending to just before the beginning of the wire-taps. The post-announcement window is constrained to 41 weeks by data availability. We discuss this limitation below.

In our regressions we also make use of data from Kent Marketing, the leading gasoline market research firm in Canada. The Kent data contain information on the name and location of stations throughout Quebec. We use this information to construct measures of market structure at the municipality level. Specifically, we are interested in measuring the total number of stations, the share selling branded gasoline, the one-firm concentration ratio and the HHI, measured using the share of stations by brand. We also use data on the ownership of underground-storage tanks to measure the vertical integration of stations. This information is provided by the Québec Ministry of Natural Resources, and is available for 2003.

4. Gasoline prices prior to the announcement

In this section we first characterize the pricing behavior of stations in the target markets before the announcement, using the price survey from the Régie and the prices reported in the Competition Bureau documents. We do so both during the weeks of the wire-tap period, and during the entire collusive period from 2002 to 2006. We then characterize pricing throughout the province using the Régie price survey.

4.1. **Pricing patterns in the target markets.** Figure 1 shows the price changes that occurred in the four cities during the wire-tap periods (March to June 2005 for Victoriaville, Thetford Mines, Sherbrooke, and Magog, along with December 2005 to April 2006 for Sherbrooke and Magog). For each city, the dotted green is the Régie-imposed price floor. The solid orange line is the median price in the Régie data. The blue dots represent the prices set by all of the stations listed in Competition Bureau documents. These documents provide a complete picture of almost all price adjustments that occurred in Victoriaville and Thetford Mines during the wire-tap period, and so we are able to determine exact prices for most of the stations on almost all of the price increase attempts.[13] A smaller fraction of the stations are referred to in the documents for Sherbrooke and Magog, especially during price decreases.

The figures are meant to illustrate the accuracy of the Régie survey. Despite the fact that the survey is performed only once a week, it precisely tracks the price changes documented by the Bureau through wire-taps and visual inspections. This is in part due to the lack of price dispersion

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[12]See Appendix B for an extract from the original article.

[13]Although not all stations are mentioned, our understanding of the court documents is that stations that set a price below the agreed upon price are always mentioned since they are causing problems for coordination.

(A) Victoriaville	(B) Thetford-Mines

(C) Sherbrooke/Magog (1st wire-tap period)	(D) Sherbrooke/Magog (2nd wire-tap period)
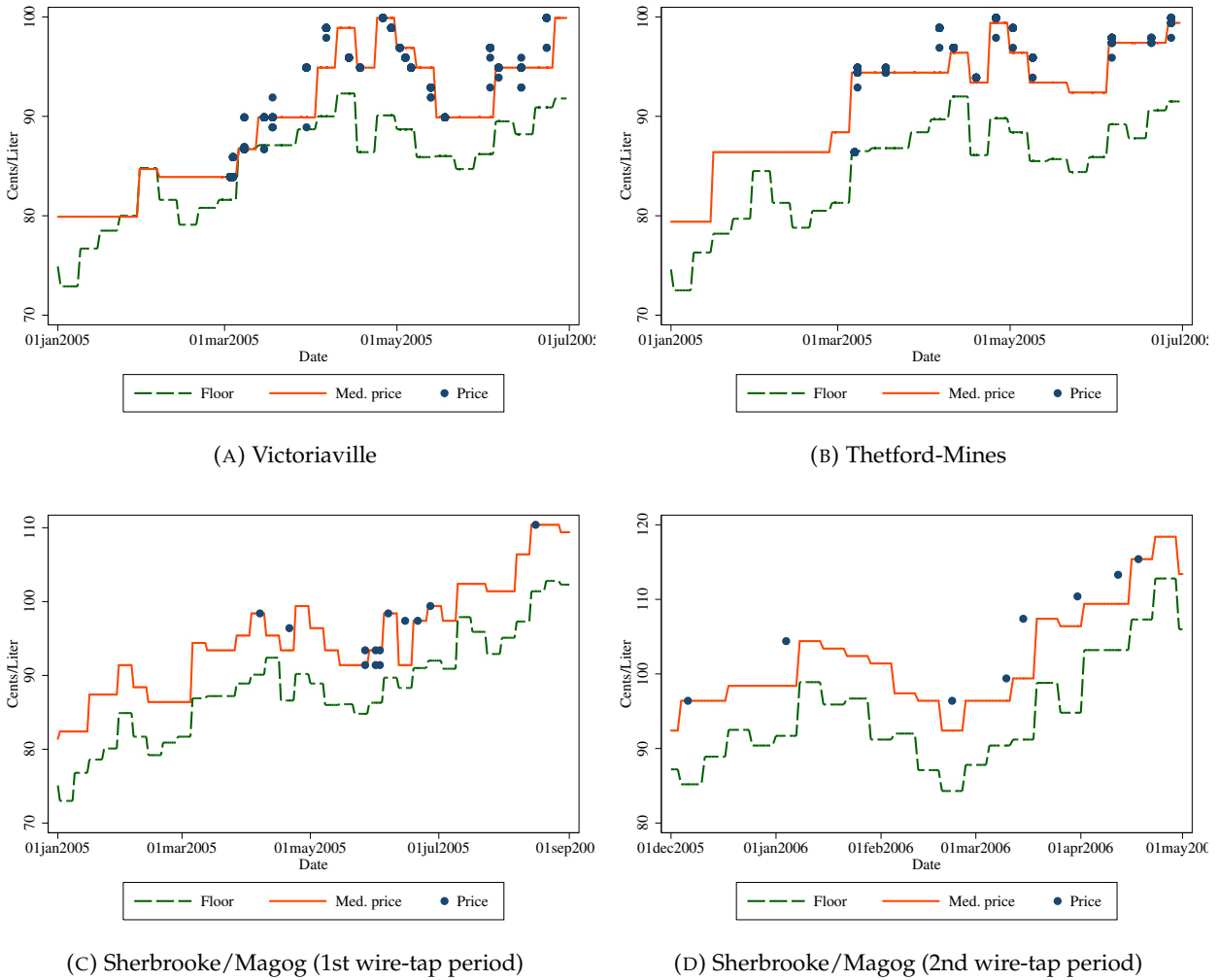
FIGURE 1. Prices in the four cities during the wire-tap period

in the four markets, and to the fact that most price changes occur once a week.[14] The figures also illustrate a recognizable pattern of price adjustments: large price increase (4-8 cents per liter), followed by a period of a week or two during which prices are stable, and then by a sequence of smaller price decreases.

In Table I we present statistics on margins and price adjustments for the four cities. Margins are measured as the difference between the posted price and the corresponding price floor.[15] We present median station-level margins over a given period t, averaged across all stations belonging to each market. In the table we report the statistic for two periods: $t =$ before the wire-tap, and $t =$ during the wire-tap. The degree of asymmetric price adjustment for a given station j is measured as the ratio of median price increases over the median price decreases, adjusted for the ratio of

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[14]See Clark and Houde (2011) for a more detailed analysis of the cross-sectional distribution of prices that the cartel leaders agree upon.

[15]Since the floor approximates the cost of acquiring gasoline for most stations, it is a good proxy for wholesale price.

TABLE I. Summary statistics on price changes during the wiretap and before the announcement

| | Wiretap period | | | 2002 / 2006 | | | |
	Sherbrooke /Magog	Thetford Mines	Victoria-ville	Sherbrooke /Magog	Thetford Mines	Victoria-ville	Floor
Variables							
Increases	4.00	5.00	5.00	4.00	4.50	4.40	1.50
Decreases	-2.00	-2.13	-1.60	-1.45	-2.00	-2.00	-2.00
Adjust. ratio	1.75	2.06	2.73	3.54	3.00	2.93	
Med. margin	6.88	7.70	5.90	6.88	7.60	6.85	

The price adjustment statistics between 2002 and June 2006 are calculated using the weekly price survey conducted by the Régie de l'énergie du Québec. The adjustment statistics in the target markets during the wire tap periods are calculated from the Competition Bureau documents (i.e. the phone calls).

median cost changes (measured by the price floor). This statistic is calculated independently for each station, and defined over a given period t. Equation 1 provides more details, and uses w to index weeks.

$$(1) \quad \text{Adjustment ratio}_{jt} = \frac{\text{Median price increases}_{jt}}{\text{Median price decreases}_{jt}} \Bigg/ \frac{\text{Median floor increases}_{jt}}{\text{Median floor decreases}_{jt}},$$

Where,

$$\text{Median price increases}_{jt} = \text{Med}\left(\{p_{jw}\}|w \in t, \Delta p_{jw} > 0\right),$$

$$\text{Median price decreases}_{jt} = \text{Med}\left(\{p_{jw}\}|w \in t, \Delta p_{jw} < 0\right).$$

Median floor increases and decreases are defined analogously. In Section 5 we define the adjustment ratio and median margins for two slightly different periods: t = before the announcement, and t = after the announcement.

The ratio is equal to 1 if pricing is symmetric: price and cost changes are of similar magnitude. We focus on station-level medians rather than means since there are some outliers in the price changes. For instance, following the announcement, stations in the target markets tried on a few occasions to restore the high margins they had been earning before. These attempts were unsuccessful, causing prices to fall back to the price floor. We also observe some negative margins in our data suggesting that there may be an imperfect match between the date of read for prices and the price floor.

In the four cities, median margins were equal to 6.69 cpl during the wire-tap period, compared to 5.56 cpl for the whole province.[16] Using the station-level panel we constructed from the Competition Bureau documents, we measure price increases to be at least twice as large as price decreases. The adjustment ratio was equal to 1.75 in Sherbrooke/Magog, 2.06 in Thetford Mines, and 2.73 in Magog.

In the right-hand side of Table I, we show that the patterns we identified during the wire-tap period were also present in the earlier period. Between 2002 and the announcement in June of 2006, average margins were equal to 6.96 cpl in the four cities, compared to 5.08 cpl for the whole

[16]This is the average over the station-level median margins during this period.

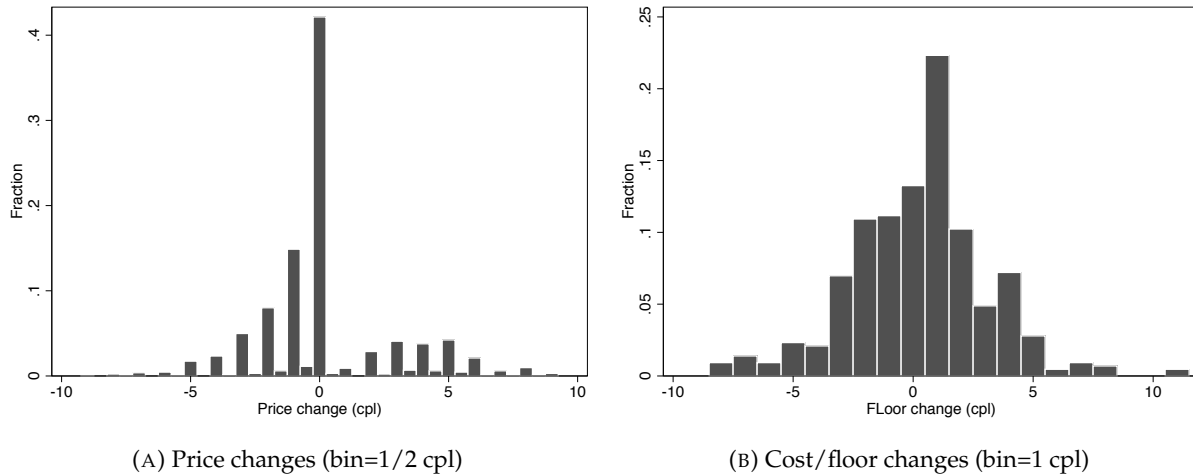(A) Price changes (bin=1/2 cpl)　　　　　　(B) Cost/floor changes (bin=1 cpl)

FIGURE 2. Distribution of weekly price and cost changes in the collusive cities from 2002 to 2006

province. Moreover, the adjustment ratios measured between 2002 and 2006 are closer to 3 over the extended period. Note that while price increases are much larger than price decreases, price floor adjustments are fairly symmetric, with decreases slightly larger than increases.

The asymmetric pricing pattern is confirmed in Figure 2. Figure 2a shows that the distribution of price increases is symmetric around four cpl (with an inter-quartile range of two cents), while the density of price cuts is quickly increasing towards zero and clustered around one or two cents (i.e. 70% are less than or equal to two in absolute value). The distribution of cost changes, shown in Figure 2b, is more symmetric, confirming that prices adjust faster upwards than downwards. Indeed, the ratio of price increases over decreases, adjusted for the ratio of cost changes, shows that price increases are more than twice the size of price decreases.

This asymmetry implies frequent periods of price stickiness. The majority of price changes are zero over the period. In Victoriaville and Thetford Mines, prices are constant two weeks in a row 48% and 57% of the time respectively. Sherbrooke tends to exhibit more volatility; the proportion of stable weeks is 36%. In comparison, the price floor remains constant only 1.2% of the time.

The differences between the wire-tap period and the 2002-2006 period reflect an episode of price instability in 2005, especially in Victoriaville and Sherbrooke/Magog. A first episode of instability occurred in the first quarter of 2005 in Victoriaville, following newspaper article documenting the occurrence of price wars in Victoriaville in the Summer of 2004 and the subsequent visit of Competition Bureau agents to various gasoline stations in the region in the Fall of 2004. Similarly, our analysis of the transcripts of wire-tap recordings illustrates that cooperation became increasingly difficult in Sherbrooke starting in the summer of 2005.

4.2. **Pricing patterns in the rest of the province.** Figure 3 plots the joint density of the two outcome variables for every station in Québec prior to the execution of the warrants. The joint density is clearly bi-modal suggesting both a strong positive correlation between margins and adjustment
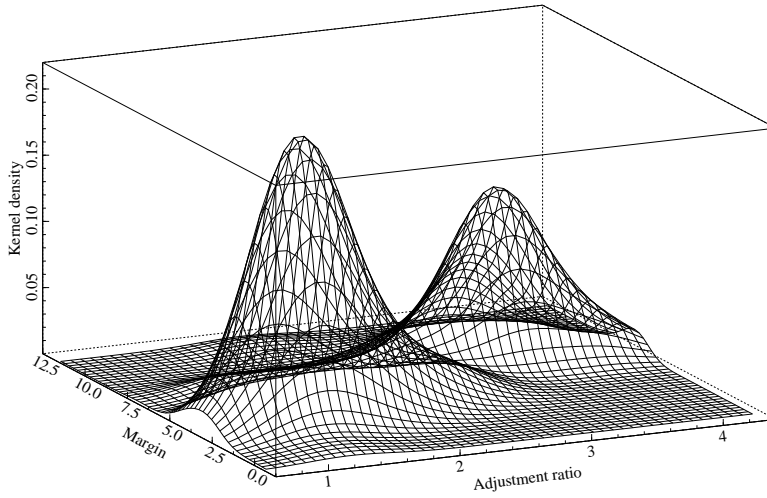
(A) 3d graph of the bivariate kernel density
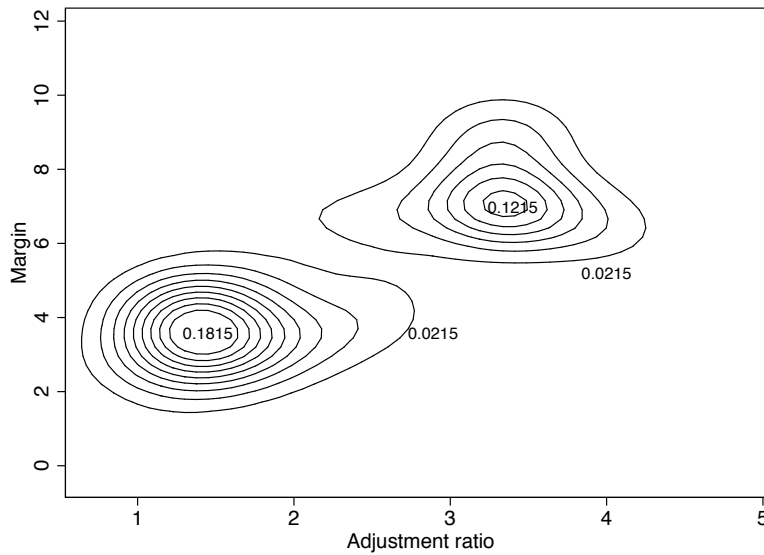
(B) Contour line plot of the bivariate kernel density

FIGURE 3. Joint density of margins and adjustment asymmetry between January 2002 and May 2006. The contour interval in (B) is 0.02.

asymmetry, and the existence of two distinct types of stations. In the lower-left quadrant is a group of stations with more competitive pricing: low margins and fairly symmetric price adjustments. Margins are between 3 and 4 cpl, while adjustment asymmetries are measured to be about 1.5. Recall that the ratio should be equal to 1 if pricing is symmetric.

In the opposite quadrant (upper-right) is a group of stations with high margins and asymmetric price adjustments. The stations from the target markets are all located in this part of the joint density, with margins between 6 and 8 cpl, and adjustment asymmetries around 3 (see Table I).

TABLE II. Market comparisons

REGIONS	Capacity X 1000 liters	Nb. tanks	% Major	HHI (stations)	Nb. Stations
Target	351	3.21	.277	0.041	16.3
	(155)	(0.402)	(0.156)	(0.054)	(12.9)
Cyclical + Target	316	3.26	0.324	0.0834	13.1
	(126)	(0.519)	(0.207)	(0.132)	(13.7)
Competitive	381	3.5	0.422	0.156	14.6
	(158)	(0.583)	(0.272)	(0.289)	(28.5)
Mean difference test p-value	0.0051	0.0056	0.0119	.0443	0.657
East	303	3.2	0.333	0.113	12.3
	(134)	(0.554)	(0.223)	(0.261)	(13.7)
West	389	3.54	0.408	0.125	15.3
	(144)	(0.522)	(0.26)	(0.191)	(27.8)
Mean difference test p-value	0.0002	0.00008	0.0547	0.746	0.403

Stations outside of the target markets but situated in the upper-right quadrant of the figure are those that we define as "cyclical". The thresholds we use for assigning stations to this group is the following: median margins greater than 6 cpl **and** adjustment asymmetries above 2 in the pre-announcement period. The average value of margins in this group is 7.42 cpl, and the adjustment asymmetry is measured to be 3.41. Stations outside the target markets and not satisfying the criteria for assignment to this group will be referred to as competitive. The average margin and adjustment asymmetry in the competitive group are 3.84 cpl and 1.57, respectively.

It is important to note that stations from the upper-right quadrant are mostly located in the Eastern part of the province around Québec City, while more competitive markets are observed around Montréal and near the Ontario border. Specifically, 9.75% of cyclical cities are located the Western part of the province, and 4% of the competitive cities are located in the East (see also Figures 6 and 7 in the Appendix). Over the whole province we find that margins are 7.51 cpl in the East versus 3.76 cpl in the West, and that adjustment asymmetry is 3.38 in the East and 1.56 in the West (this is excluding the target markets from the East).

Table II illustrates the differences in market structure between the two types of markets and regions. Overall, markets in the East are less urban, and exhibit smaller stations with less capacity (measured by the size and number of underground storage tanks). Stations in the East also tend to more often be independent. The difference in the HHI index and the number of stations also suggests smaller networks in the cyclical markets, but this difference is not statistically significant based on the East/West split.

Among the other regional differences, it is worth noting that stations in the East are predominantly supplied by Ultramar, which operates the only refinery in the region. The Québec refinery also includes an independent terminal operated by Olco. In comparison, three additional terminals were in operation in the mid-2000's in Montréal. A few markets in the West also border on

the province of Ontario, where gasoline prices are unregulated. Finally, another important difference is the presence of the discount retailer Costco in a region just North of Montréal. This station maintains very low margins, and the government has regularly imposed a higher price floor in this area.

Finally, note that the asymmetric pricing patterns that we observe in the cyclical markets differ from the short-lived price cycles documented in several gasoline markets (see for instance Noel (2007b) in Toronto, and Lewis (2009) in the U.S.). In the target and cyclical markets, price increases occur on average once a month, and the time-series involve a significant amount of price stickiness. In comparison, the cycles measured by Noel (2007b) last on average one week, are of a much larger amplitude (i.e. price increases are often 7 or 8 times larger than decreases), and are not initiated by cost changes. The literature has provided examples of both short-lived and long-lived cycles, and typically associates both types with *Edgeworth cycles*. See, in particular, Eckert (2002) and Noel (2007a) for examples of cycles measured using weekly data. Websites compiling consumer-reported gasoline prices provide clear evidence that prices in Montréal (competitive markets) do feature the same week-long cycles as in Toronto, while Québec (cyclical market) prices are typically sticky for several days (often weeks).[17]

5. MEASURING THE IMPACT OF EXPLICIT COMMUNICATION

Our objective is to quantify the impact of explicit communication on retail margins and pricing adjustments. We do so by evaluating the impact of the public announcement of the Competition Bureau investigation, as measured by the execution of the search warrants. We label this the **direct** effect of the announcement.

In addition, the execution of the search warrants may have generated an **indirect** spillover effect, causing the collapse of cartels in regions that were not targeted by the investigation. For this to be the case, it must be that firms elsewhere were colluding, that the announcement raised the probability of criminal prosecution, and that information about the investigation was diffused fast enough. Our second test evaluates these hypotheses jointly. Although there is no direct evidence of explicit price coordination in markets outside of those targeted by the Bureau, conversations described in the Competition Bureau documents suggest that collusion was not unique to the four target cities since firms sometimes discussed implementing similar price changes in other markets.[18] Moreover, some of the key players responsible for implementing price increases in the target cities were involved in setting prices at stations elsewhere in the province, which likely sped up the diffusion of the information concerning the investigation.[19]

In order to implement the tests, we construct three sub-samples of stations following the grouping suggested by the joint density of margins and price adjustment ratio presented in Figure 3. The first includes stations located in one of the four target markets. The stations in these markets all

[17]See **MontrealGasPrices.com**.

[18]See for instance the conversation from April 19th 2005 between Claude Bedard of Irving and Celine Bonin of Couche Tard that is described on pages 20-23 of Annexe B of the Competition Bureau documents.

[19]Using the data on ownership of underground-storage tanks provided by the Québec Ministry of Natural Resources we document that 19% of the firms present in the target markets are also in other markets in the East, and that 16% also have a presence in the West.

receive the direct treatment, and henceforth will be labelled by T_D. The second includes stations whose pricing patterns during the collusive period resemble those observed in the four target cities – the cyclical group. These stations receive the indirect treatment, and so we label them T_I. The third group is a set of stations that can be used as a competitive benchmark against which to compare the behavior of stations receiving the direct and indirect treatments, in the spirit of the test proposed by Porter and Zona (1999, 1993). We define the competitive control group as stations with nearly symmetric pricing and low margin, and label these stations C. In addition to the 6 stations in the target cities, our main sample includes 38 stations in the cyclical group, distributed across 29 cities and 81 stations in the competitive control group distributed across 49 cities.

Our main empirical strategy is to compare pricing in the treatment markets to pricing in the control markets during and after the collapse of the cartels. This approach hinges on a number of important assumptions. The first is that we are able to properly identify the cartel period. The second is that after the cartel ceased functioning prices returned to competitive levels, and the third is that we are able to adequately control for market-specific developments during the operation of the cartel.

We are only able to directly test the first of these assumptions in our empirical analysis, which is split into three subsections. First, we test for structural breaks in the time-series of margins, to evaluate the appropriateness of using the execution of the warrants to measure the collapse of the cartel. Second, we analyze the data using a series of mean tests, looking both at inter-temporal and cross-sectional differences in margins and price adjustments. Finally, we perform a difference-in-difference regression analysis, controlling for market-specific characteristics during the operation of the cartel. In Section 5.4 we discuss a series of caveats including the possibility that prices do not return immediately to competitive levels following the announcement.

5.1. **Tests for structural break.** In this section we test for breaks in the time series of margins. Our objective is to confirm that there was a discrete change in behavior, and that this change coincided with the announcement. Moreover, if our second hypothesis, that collusion also took place in the cyclical markets, is correct, then we should also observe a break near the date of the announcement in these markets. In contrast, in the competitive controls there should be no discernible change.

We test for breaks between the beginning of 2005 (just before the wire-taps started) and the end of our sample period by calculating the Quandt likelihood ratio (QLR) statistic for each station in our sample. The QLR statistic is a modified Chow test which tests for breaks in the regression coefficients at all possible dates in the range. That is, for any hypothesized break date τ in the range, we consider the regression:

$$(2) \qquad \qquad \text{Margin}_{jw} = \alpha_j + \gamma_j D_w(\tau) + u_{jw},$$

where $D_w(\tau)$ is a binary variable equal to zero before the break date and one after, and jw index stations and weeks. The hypothesis of a break at date τ is tested using an F-statistic that tests the hypothesis that γ_j is equal to zero. The QLR selects the largest of the resulting F-statistics to determine where is the break (see Stock and Watson (2003)).

TABLE III. Number of weeks following the announcement that structural break occurred

Markets	25%	50%	75%	Proportion of significant breaks
Magog	4	4	4	100%
Sherbrooke	9	11.5	14	100%
Thetford-Mines	0	0	0	100%
Victoriaville	4	4	4	100%
T_I	3	9	15	89%
C	-6	4	9	21%

Break date estimated using the QLR statistic. The last column calculate the fraction of stations for which the structural break is statistically significant at the 5% level, using using critical values of the QLR statistic with 15% weeks trimming.

We compute the QLR statistic for each station in our sample and present aggregate results for each of the target markets along with the cycling markets and the competitive control. More specifically, for each city or group of stations we present the median (along with the 25th and 75th percentile) number of weeks following the announcement that the break occurred (that had the largest F-statistic) and the fraction of stations in this city or group for which the test was significant.

Results are presented in Table III. We find that for all stations in our sample the date at which the largest Chow statistic occurs is within weeks of the announcement. However, these QLR statistics are not always significant. At all of the target stations and at 89% of the stations in the cyclical markets the QLR statistic exceeds the 5% critical value suggesting that for these stations we can reject the null hypothesis of no break. In contrast, only in 21% of stations in the competitive control is the QLR statistic significant.

Stations in Thetford Mines, Victoriaville, and Magog all break within the first month following the announcement. In Sherbrooke the maximal Chow test is estimated at approximately three months after the announcement, but Chow tests at dates between this date and the announcement all reject the null hypothesis of constant parameters suggesting that there is a slow evolution of the regression function starting at the announcement. The other cyclical markets all break around the same time as Sherbrooke, suggesting that the announcement triggered a price war that began around two and a half months later in the Eastern part of the province.

These breaks can also be visually detected in Figure 4, by inspecting the evolution of weekly modal prices in each of the four cities targeted by the investigation. The margins in Victoriaville and Thetford Mines quickly converged to zero early in the summer of 2006, while stations in Sherbrooke and Magog sustained higher margins in July and August. As we discuss in greater detail in Section 5.4, the slower response in Sherbrooke and Magog is explained by the fact that the cartel became increasing unstable during the wire-tap period, suggesting that the initial stages of the investigation raised suspicions among firms. We also detect instability in the two other cities (especially in the Fall if 2005), but the conversations recorded by the Competition Bureau suggest that the cartel leaders were able to maintain high margins throughout 2005. In comparison, prices in all four markets were more stable and exhibited higher margins before the beginning of the investigation, in the Fall of 2004. Figure 5 in the Appendix presents the time-series evolution of
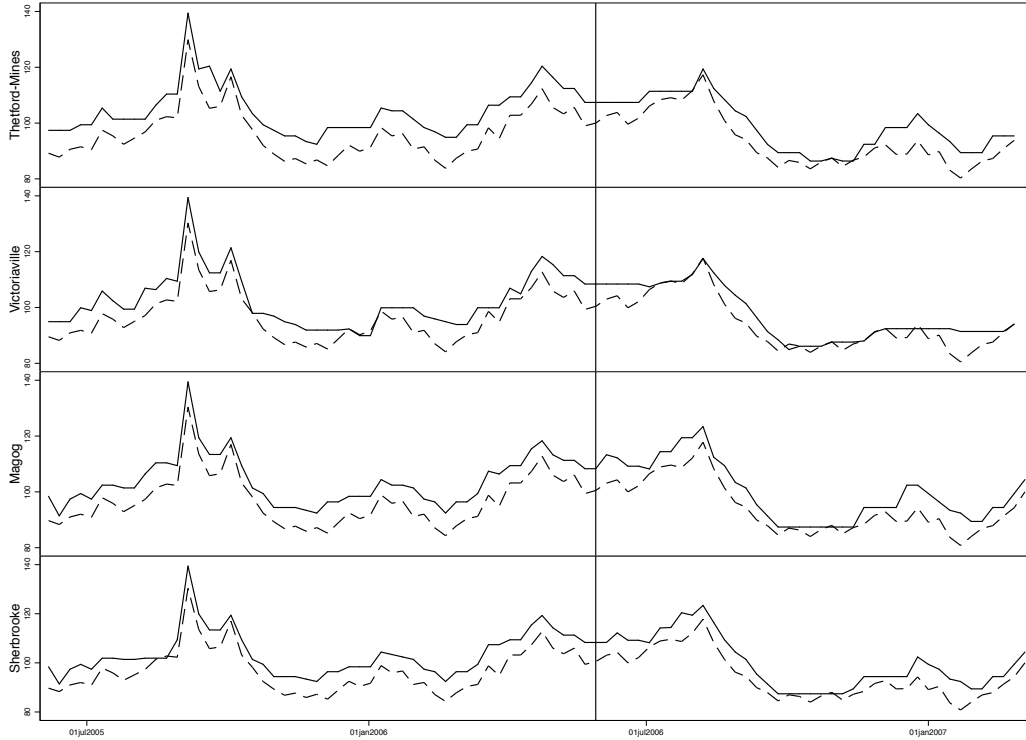
FIGURE 4. Evolution of weekly prices and floor in the four targeted cities before and after the announcement (dotted line: price floor; vertical line: announcement)

prices and margins between 2002 and May 2006. Note that if we extend our tests for structural break further back, we capture a break in Victoriaville in the Spring of 2004 that coincides with turbulence mentioned in the newspaper article that launched the investigation of the cartels.

These results confirm the appropriateness of using the announcement date to test for the effect of the collapse of collusion, and provide our first evidence that it caused a discrete change in pricing behavior. Moreover, they justify our use of difference-in-difference analysis since the target and cyclical markets all break on or around the date, while the hypothesis of no break cannot be rejected in the competitive control. This is what we turn to next.

5.2. **Difference-in-difference analysis.** In this section we evaluate the effect of the execution of the search warrants on pricing. We employ a difference-in-difference strategy in which we compare changes in margins and price adjustment asymmetries in the treatment markets to those in other markets.

Table IV presents the average outcomes across the three groups, before and after the announcement. The bottom right-hand corner presents the six difference-in-difference estimates, with either T_I or T_D as treatment group, and using either C or T_I as control. In the last three rows and last two columns we decompose these estimates to present cross-sectional (rows) and time-series (columns) differences. The superscripts indicate the statistical significance of each mean difference. Since the number of observations in the treatment group is relatively small (i.e. only four

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TABLE IV. Average outcomes before and after the announcement

MARKETS	Pre-Announcement		Post-Announcement		Differences: Post–Pre	
	Margin	Adjustment Ratio	Margin	Adjustment Ratio	Margin	Adjustment Ratio
Target cities						
Magog	6.7	2.56	5.5	2.27	-1.2	-.293
Sherbrooke	6.88	3.54	5.88	2.45	-1.00	-1.09
Thetford-Mines	7.6	3	4.8	2.17	-2.80	-.83
Victoriaville	6.85	2.93	2.75	.579	-4.10	-2.35
Avg. target (T_D)	6.96	3.08	4.59	1.75	$-2.37^{a,\alpha}$	$-1.33^{a,\alpha}$
Avg. cyclical (T_I)	7.42	3.41	6.37	2.54	$-1.05^{a,\alpha}$	$-.871^{a,\alpha}$
Competitive (C)	3.84	1.57	3.76	1.78	-.085	$.210^c$
Differences: $T_D - C$	$3.11^{a,\alpha}$	$1.52^{a,\alpha}$	.83	.03	$-2.28^{b,\alpha}$	$-1.54^{a,\alpha}$
Differences: $T_D - T_I$	$-.46^b$	$-.33^\beta$	$-1.77^{b,\beta}$	$-.79^{c,\beta}$	$-1.31^{c,\gamma}$	-.46
Differences: $T_I - C$	$3.57^{a,\alpha}$	$1.85^{a,\alpha}$	$2.61^{a,\alpha}$	$.77^{a,\alpha}$	$-.97^{a,\alpha}$	$-1.08^{a,\alpha}$

a, b, and c denote significance levels for means tests (a: p<0.01, b: p<0.05, c: p<0.1). α, β, and γ denote significance levels for Wilcoxon tests (α: p<0.01, β: p<0.05, γ: p<0.1). Margins for each entry corresponds to the median station-level margins over the corresponding period, averaged across all stations belonging to each market (rows). Adjustment ratios are similarly calculated at the station level, and then averaged across all stations belonging to each market-period pair. The sample corresponds to the balanced panel of 125 stations, between January 2002 and March 2007.

cities or eight stations in T_D), we also report the results of Wilcoxon signed-rank tests which are valid even with a small number of policy changes.

The first thing to note from the table is that, consistent with our discussion above, prior to the announcement margins and price adjustments were very similar between T_D and T_I, but different between each of these and C. Margins in T_D and T_I were 6.96 cpl and 7.42 cpl respectively, but only 3.84 cpl in C. Adjustment asymmetry is measured to be 3.08 in T_D and 3.41 in T_I, but just 1.57 in C. Overall, the $T_D - T_I$ differences are only marginally statistically significant (i.e. only t-test for margins, and only the Wilcoxon test for the ratio), while all the $T_D - C$ and $T_I - C$ differences are statistically different from zero at a 1% level.

In the post-announcement sample the differences between T_D and C are no longer statistically significant, and the differences between T_I and C are considerably smaller. This is especially striking for the adjustment asymmetry measure. Note that these changes are not the result of changes in the control markets after the announcement, but rather stem from changes at stations in the two treatment groups. Margins fall by 2.37 cpl in T_D and 1.05 cpl in T_I, and by only 0.085 cpl in C. Formal means and Wilcoxon tests confirm that in the cases of T_D and T_I these differences are significantly different from 0. The decrease in adjustment ratio is measured to be 1.33 in T_D and 0.88 in T_I, but not significantly different from zero in C.

Since the control markets did not experience any big change after the announcement, the difference-in-difference is very similar to the simple difference, especially when considering the direct effect. In fact all three ways of measuring the direct treatment effect yield similar results: for margins,

the pre-announcement treatment minus control difference is 3.11 cpl, the post-collapse minus pre-collapse difference is -2.37 cpl, and the difference-in-difference is -2.28 cpl, while for adjustment asymmetry the equivalent differences are 1.52, -1.33, and -1.54 respectively.

The final point from the table is that, while both T_D and T_I experienced decreases in margins, the T_D - T_I difference-in-difference suggests that the direct effect of the announcement was more pronounced than the indirect effect. This is intuitive, since the announcement of the investigation directly impacted the probability of criminal prosecutions in the target markets.

Figures 8 and 9 in the Appendix show the locations of stations experiencing bigger and smaller changes in margin and adjustment ratio across the Southern regions of the province respectively.[20] It is clear from these maps that stations in the East are more likely to experience large decreases in margins and have more symmetric pricing following the execution of the search warrants.

5.3. **Regression analysis.** The general message from Table IV is that changes in margins and adjustment ratios following the execution of the warrants in both the target markets and the other cyclical markets were more important than in the competitive control markets. However, a careful econometric analysis will be necessary to disentangle the changes that are due to the execution of the warrants from those that were driven by market structure changes. This is what we do in this subsection.

We start by performing a set of regressions in which we explain changes in the median values of outcome variables at the station level. Our main econometric specification is:

(3) $$\Delta y_j = \beta I\left(j \in T_D\right) + \alpha I\left(j \in T_I\right) + \gamma Z_j + e_j,$$

where Δy_j is the change in the outcome variable (margins or asymmetry of adjustment) after the announcement. Z_j is a vector of market structure controls including the values in both levels and changes of the total number of stations, the share selling branded gasoline, the one-firm concentration ratio and the HHI measured using the share of stations by brand. The change is measured between the first quarter of 2005 and the first quarter of 2007. The levels are the post-announcement values. Z_j also includes the change in the number of weeks surveyed before and after.

The parameter β captures the direct effect of the collapse of communication, and α the indirect effect. The number of observations is equal to the number of stations because the four outcome variables are aggregated before and after the announcement of the investigation. We estimate only a common treatment effect, due to the small number of observations. Finally, we consider two different pre-collapse windows. In the two left-hand side columns the pre-collapse window covers the full January 2002 to May of 2006 period (229 weeks). In the right-hand side columns we present results for a shorter window that starts only in January of 2005 just before the wire-taps began (74 weeks).

Results from the estimation of (1) are presented in the top panel of Table V. We measure the direct effect of the announcement on margins to be -2.27 cpl, and on adjustment asymmetry to

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[20]The maps include only a fraction of cities covered by the pricing survey. In particular it excludes stations surveyed in the far-Eastern, far-Western, and Northern regions of the province (e.g. Hull/Gatineau, Gaspé, and Chicoutimi).

TABLE V. Effect of the announcement on margins and ratios

VARIABLES	Pre-announcement windows			
	229 weeks before		74 weeks before	
	Δ Margin	Δ Adjustment Ratio	Δ Margin	Δ Adjustment Ratio
	(1)	(2)	(3)	(4)
Multiple treatments				
Target cities (T_D)	-2.269[a]	-1.630[a]	-1.736[a]	-1.782[b]
	(0.542)	(0.576)	(0.323)	(0.705)
Cyclical cities (T_I)	-1.039[a]	-0.967[a]	-1.019[a]	-0.976[a]
	(0.220)	(0.199)	(0.187)	(0.314)
Control group	C	C	C	C
Observations	110	110	110	110
R-squared	0.610	0.416	0.495	0.306
	(5)	(6)	(7)	(8)
Single treatment				
Target cities (T_D)	-1.051[b]	-0.793[c]	-0.640[b]	-1.035[c]
	(0.436)	(0.412)	(0.300)	(0.560)
Control group	T_I	T_I	T_I	T_I
Observations	37	37	37	37
R-squared	0.702	0.552	0.526	0.445

Standard errors, in parenthesis, are clustered at the municipality level. [a] p<0.01, [b] p<0.05, [c] p<0.1. Target cities (T_D) correspond to stations targeted by the Bureau investigation, and Cyclical cities (T_I) include stations with high margins and asymmetric price adjustment ratio before the announcement: $(1 - T_D) \times 1(\text{Ratio} > 2)1(\text{Margin} > 6)$

be -1.63. Our estimates suggest that there is also an indirect effect of the announcement on margins and adjustment asymmetry, that in both cases is smaller in magnitude than the direct effect. Margins fall by 1.04 cpl and adjustment asymmetry by 0.97. Shortening the pre-announcement window has little effect on results. Notice also that the treatment effects estimated controlling for market-structure variables are very similar to the difference-in-difference estimates reported in Table IV (i.e. without controls), suggesting that the treated markets did not experience important contemporaneous changes in the number and composition of stations. However, tests reveal that the market structure variables are jointly significant suggesting that these variables matter for margins and adjustment asymmetry.

Using stations from the competitive group as our control may, under certain circumstances, be problematic. Specifically, stations in this group may have been subject to a different set of trends before and/or after the announcement. Recall that many of the stations in this group are in the Western part of the province while stations in the two treatment groups are predominantly in the East. As such, results derived using the competitive control group may be confounded by the presence of region-specific unobserved trends.

To address this issue, in the bottom panel of Table V we present results from a different specification. We consider only the direct treatment, and estimate the effect of the announcement using

TABLE VI. Decomposing ratios

	Pre-announcement windows			
	229 weeks before		74 weeks before	
VARIABLES	Δ Incr	Δ Decr	Δ Incr	Δ Decr
	(1)	(2)	(3)	(4)
Target cities (T_D)	-0.818	0.400^a	-0.585	0.598^a
	(0.523)	(0.0585)	(0.513)	(0.103)
Cyclical cities (T_I)	-0.928^a	0.153^a	-0.360^c	0.374^a
	(0.174)	(0.0506)	(0.182)	(0.0691)
Control group	C	C	C	C
Observations	110	110	110	110
R-squared	0.352	0.380	0.117	0.435
VARIABLES	Δ % Incr	Δ % Decr	Δ % Incr	Δ % Decr
	(5)	(6)	(7)	(8)
Target cities (T_D)	0.0247^c	-0.0665^a	-0.00825	-0.115^a
	(0.0146)	(0.0134)	(0.0183)	(0.0247)
Cyclical cities (T_I)	0.0564^a	0.0285^b	0.0323^b	-0.0278^b
	(0.0121)	(0.0109)	(0.0122)	(0.0126)
Control group	C	C	C	C
Observations	110	110	110	110
R-squared	0.298	0.298	0.287	0.384

Robust standard errors in parentheses
[a] p<0.01, [b] p<0.05, [c] p<0.1

Standard errors, in parenthesis, are clustered at the municipality level. [a] p<0.01, [b] p<0.05, [c] p<0.1. Target cities (T_D) correspond to stations targeted by the Bureau investigation, and Cyclical cities (T_I) include stations with high margins and asymmetric price adjustment ratio before the announcement: $(1 - T_D) \times 1(\text{Ratio} > 2)1(\text{Margin} > 6)$

stations located in the cyclical markets as controls. Under this specification we measure the direct treatment relative to stations mainly located in the Eastern part of the province. Since these stations are closer both in terms of geography and pricing patterns, it is more likely that they were subject to similar trends. We find that margins and adjustment asymmetries fell to 1.05 cpl and 0.79, and remain significantly different from zero. Of course, if stations in the cyclical markets were colluding and reacted to the announcement, these measures understate the direct effect of the collapse. As a result we interpret these effects as a lower bound on the effect of collusion on margins and the adjustment ratio.

In Table VI we decompose the ratio effect. We measure the effect of the announcement on price increases and price decreases, expressed relative to the median increase/decrease of the price floor over the period surveyed. The regression coefficients therefore measure the change in the relative price increase/decrease rather than in the level. Median price cuts in the cartel cities increased significantly. Price increases also decreased in magnitude after the announcement, but the difference is not statistically significant for the cartel cities. In the bottom panel we look at the effect of the announcement on the likelihood of increasing or decreasing price (on the fraction of weeks in which there was a price increase or decrease). In the cartel cities price decreases occur

less frequently. In the cyclical markets the announcement has a positive effect on the number of increases, and an ambiguous effect on the number of decreases. Overall, these results suggest that by preventing firms in the cartel cities from communicating the announcement increased the magnitude of price cuts, and eliminated the asymmetry that existed between price increases and decreases. Following the announcement there were fewer, but larger price decreases.

Weekly analysis of margins. In this subsection we adopt another approach to address the concern raised above that our results may be confounded by region-specific unobserved trends. We disaggregate the data at the weekly level and introduce region-specific linear trends in the regression specifications. We cannot analyze the degree of price asymmetry at this level of aggregation, and thus focus only on margins. We estimate the following specification with and without linear group-level trends:

$$y_{jw} = \beta_1 I\,(w \geq A) + \beta_2 I\,(j \in T_D) \cdot I\,(w \geq A) + \beta_3 I\,(j \in T_I) \cdot I\,(w \geq A)$$

(4)
$$+\gamma Z_{jw} + \theta_{R_j}\mathrm{Trend}_{R_j,w} + \mu_j + u_{jw},$$

where y_{jw} is the margin for station j in week w, $I(\cdot)$ is an indicator function, A is the announcement week, μ_j is a station fixed effect, and Z_{jw} is a vector of time-varying controls including the current and lagged rack price and quarterly dummy variables. Parameter β_2 captures the direct effect of the announcement, while β_3 captures the indirect effect. Finally, θ_{R_j} is associated with a linear trend affecting margins for all stations in the region of station j.[21] We use three regions: T_D, T_I, and C.

In Table VII we present results for both the full pre-collapse window covering the January 2002 to May of 2006 period (columns 1-4), and also the shorter window that covers only the year prior to the announcement (columns 5-8). We also present results for both the balanced panel of 125 stations (columns 1, 3, 5, and 7), and a larger unbalanced panel (columns 2, 4, 6, and 8). Results are unchanged when using the unbalanced panel, and so we will focus our discussion on the balanced-panel specifications.

From column 1 we can see that the direct effect is measured to be -1.69 and the indirect effect -0.46. With the shorter pre-announcement window, the direct effect is measured to be smaller, at -1.10 cpl, while the indirect effect is larger, at -0.59. The direct effect may be smaller with the shorter window because there is some evidence that the cartels were already becoming unstable in the year leading up to the collapse. As we discuss in further detail in the next section, the investigation that began in 2005 may have generated changes in pricing behavior that began even before the execution of the warrants.

In column 3 we add region-specific trends. Including these trends results in a stronger indirect effect, and a weaker direct effect with the full pre-announcement window, and much stronger direct and indirect effects with the shorter window. Again, this is likely related to the instability of the cartel. The major contributor to the pre-collapse trend is the progressive collapse of the cartel throughout 2005. The T_D trend picks up this gradual collapse and explains why we find a stronger effect in the target markets once we control for group-level trends with the shorter

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[21]The trend variable is defined as: $\mathrm{Trend}_{R_j,w} = 1(j \in R) \cdot w$.

TABLE VII. Effect of the announcement on margins

| VARIABLES | Pre-announcement time window | | | | | | | |
| | Maximum weeks before=229 | | | | Maximum weeks before=74 | | | |
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$I(w > A) \cdot I(j \in T_D)$	-1.694^a	-1.499^a	-0.956^a	-0.903^a	-1.102^a	-1.053^a	-2.159^a	-2.143^a
	(0.572)	(0.514)	(0.277)	(0.253)	(0.268)	(0.270)	(0.562)	(0.480)
$I(w > A) \cdot I(j \in T_I)$	-0.460^a	-0.511^a	-0.778^a	-0.877^a	-0.586^a	-0.659^a	-1.765^a	-1.840^a
	(0.143)	(0.121)	(0.171)	(0.151)	(0.136)	(0.127)	(0.157)	(0.139)
Regional trends	No	No	Yes	Yes	No	No	Yes	Yes
Observations	33,197	62,631	33,197	62,631	13,830	29,635	13,830	29,635
R-squared	0.052	0.063	0.056	0.066	0.060	0.070	0.068	0.078
Number of stations	125	313	125	313	125	284	125	284
Avg. T	265.6	200.1	265.6	200.1	110.6	104.3	110.6	104.3

Standard-errors, in parentheses, are clustered at the municipality level. ^{a} p<0.01, ^{b} p<0.05, ^{c} p<0.1. Columns 1, 3, 5, and 7 are for the balanced panel. Target cities (T_D) correspond to stations targeted by the Bureau investigation, and Cyclical cities (T_I) include stations with high margins an asymmetric price adjustment ratio before the announcement: $(1 - T_D) \times 1(\text{Ratio} > 2)1(\text{Margin} > 6)$.

window. In contrast, to our knowledge there is no obvious systematic pre-2005 trend that we would expect to show up in the longer window.

Overall the weekly results are consistent with the results presented in the previous subsection, but are smaller in magnitude. The difference in magnitude comes from the fact that we used changes in median margins in the previous subsection, while the weekly OLS regression estimates the change in average margins. As we discussed above, margins in the treatment group exhibit several outliers, both before and after the announcement. Before the announcement, we observe only a few price war episodes in which prices stayed close to the floor for a few weeks. Conversely, after the announcement, we observe at least two episodes during which stations appeared to have tried to (unsuccessfully) restore high margins. Because of these outliers, the average change in margins is smaller than the median change.

Erutku and Hildebrand (2010) use data from a market research firm, MJ Ervin, to study the effect of the announcement on prices. MJ Ervin surveys stations in a small number of larger Canadian cities on a weekly basis, but makes available only a city-level average price. They study the effect of the announcement on prices in Sherbrooke using Montreal or Québec City as controls. Their results show that prices in Sherbrooke decreased by 1.75 cpl when Montreal is used as a control group, but not at all relative to Québec City. Our results are consistent with theirs, and provide further details as to why the results are sensitive to the choice of control. In particular, stations located in the Québec City market tend to have pricing strategies similar to those used in the cartel cities, and, as we showed above, reacted to the announcement by decreasing their prices. Since markets in the Montreal area tend to be more competitive (i.e. symmetric pricing), the difference-in-difference estimates are nearly doubled when we use only those markets as controls.

It is worth noting that our station-level data-set predicts a smaller effect in Sherbrooke and Magog than what Erutku and Hildebrand (2010) found using the MJ Ervin city-averages. As hinted in

Table IV, the margin changes in Sherbrooke and Magog are less than half of the changes observed in Thetford-Mines and Victoriaville. When we estimate equation 4 solely using Sherbrooke and Magog stations, we obtain an estimate of the announcement effect between 0.5 and 0.75 cpl; significantly smaller than what is reported by Erutku and Hildebrand (2010) (i.e. nearly 2 cpl). We interpret this difference as most likely coming from the aggregation of station-level prices, as well as possible differences in the type and location of stations surveyed by MJ Ervin and the Régie.

5.4. **Caveats.** The objective of our empirical analysis was to test for collusive behavior in the target and cyclical markets. Our difference-in-difference approach hinged on a series of assumptions, some of which are not testable. Therefore, our conclusions are subject to the following caveats. First, the length of the period after the announcement is relatively short (around 40 weeks). In comparison we can compute margins and price adjustment statistics for more than 200 weeks beforehand. This limitation of our data-set prevents us from making general statements about the long-run impact of the collapse on prices. For instance, it is possible that the target markets experienced a period of transition following the announcement, and that firms managed to coordinate prices in a more tacit way afterwards.

A second and related point is that there may be a bias in using the post-cartel period to determine the "but-for-collusion" price. As pointed out by Harrington (2004), knowing that damages might be based on the difference between cartel prices and post-cartel prices, firms may strategically keep their price closer to the collusive price in order to minimize damages.[22] It is possible that there was also a strategic pricing response by firms in the cyclical markets to the announcement. These firms may not have been behaving collusively at all, and their reaction to the announcement may simply have been the result of not wanting to raise suspicions as a result of their pricing strategies.

Third, as mentioned above, the majority of the cyclical stations are located in the Eastern part of the province. As a result, we cannot disentangle the indirect effect of the announcement from a spatial shock common to firms in the East. For instance, since stations in the Eastern part of the province have access to only one refinery, it is possible that outcomes resulting from changes occurring at the refinery level might be confounded with outcomes stemming from the execution of the warrants. If that is the case, we can only estimate the effect of the announcement on prices in the target markets relative to stations in the Eastern regions of the province. As we saw in Table V this leads to a smaller estimate, though still significantly different from zero.

Finally, there is some evidence in the Competition Bureau documents that the collusive agreements had already become unstable several months before the announcement, especially in Magog. Towards the end of the second quarter of 2005, several station operators and chain managers grew worried about the legal consequences of talking about prices over the phone. Our hypothesis is that these concerns emerged after the publication of the 2004 article that triggered the Competition Bureau investigation. At least two vertically integrated brands, Irving and Petro-Canada, sent letters and official warnings to their lessee station operators to prevent them from discussing

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[22]There is also experimental evidence that firms can continue to collude successfully even after explicit communication has been disabled, which would bias results in the same direction (see Fonseca and Normann (2011)).

prices with competitors over the phone. For instance, on April 19th, 2005 the Irving regional representative discussed the new policy with his Couche-Tard counterpart, with whom he had a supply relationship: "It's possible that I won't be able to discuss with our little friends. The competition. [...] The only one I will be able to continue to speak with will be you. I will change my price and you'll decide on your own".[23] Later on April 18th 2006, Bourassa, co-leader of the Sherbrooke and Magog cartel, reportedly ceased all communications with competitors (other than Couche Tard) after expressing fears of going to prison for collusive activity.[24]

These concerns may explain why the margin decline in Sherbrooke and Magog was smaller than what we observe in Victoriaville and Thetford Mines. A similar pattern can be observed from the distribution of adjustment-ratio changes in Table V . While the change in ratio in Victoriaville is clearly much larger than that of stations in C or even in T_2, the ratio change in Magog is not much different than that of stations in T_2. Changes in Sherbrooke and Thetford Mines are larger, but nonetheless are less pronounced than what we observe for margins.

6. CONCLUSION

Our analysis reveals that the pricing strategies of stations featured asymmetric adjustments and high margins, and that following the execution of the warrants margins fell and adjustments became more symmetric in these markets. For the target markets, these results complement the information obtained via the Competition Bureau investigation and imply that collusion was successful and led to an increase in margins of 2.27 cpl during the collusive period. This corresponds roughly to a fifty percent increase in retail margins, relative to margins observed in the competitive regions of the province. The empirical results, in conjunction with the evidence from the Competition Bureau documents suggest that asymmetric price adjustments were part of the collusive mechanism. For the other cyclical markets the results provide suggestive, but not conclusive, evidence of collusive behavior. There is no direct evidence of explicit communication taking place outside the target markets, and so it is more difficult to attribute the observed changes in pricing entirely to collusive behavior.

Our findings have ramifications for how economists view asymmetric cycles. While high margins have long been associated with collusive behavior, conventional wisdom suggests that collusive pricing should exhibit a constant markup rule. This is clearly not the case in the cartels uncovered in Québec, since price changes are asymmetric, while cost changes are not. Moreover, not only do we observe firms explicitly coordinating their actions, some pricing patterns differ from the predictions of the Maskin-Tirole model. In particular, the identities of the firms increasing and decreasing prices are invariant and are known to all, suggesting that firms are not alternatively undercutting each other. We also do not find any evidence to support the type of menu costs or information lags that are necessary to generate the alternative move structure that is at the heart of the Maskin-Tirole model. Instead while firms do move sequentially, information

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[23]Translation from the original French conversation: "Ça ne se peut que je n'ai plus le droit de parler à nos petits amis. La competition. (...) Le seul qu'on var continuer a parler ca va être avec vous autres (Couche-Tard). (...) Je vais changer mes prix et tu t'arrangeras."

[24]From Annex C, page 118, paragraph 691.

about price changes is easily transmitted, and the time lag between price changes is an outcome of the collusive agreement rather than the result of a market friction.

Because our data are weekly and not of higher frequency, we cannot reject the hypothesis that the competitive cities exhibit this type of short-lived cycle, or that the impact of the announcement was to shorten the cycle length from close to a month to less than a week. Other sources suggest that prices in competitive cities such as Montréal feature week-long cycles, while prices in cyclical markets such as Québec City feature the longer cycles. Our empirical results combined with this external evidence suggests that shorter cycles are more likely associated with competitive behavior, while long-lived cycles may be associated with explicit collusion. Lewis and Noel (2011) reach a similar conclusion by showing that in markets with short-lived cycles, cost-change pass through is faster.

REFERENCES

Block, M. K., F. Nold, and J. G. Sidak (1981). The deterrent effect of antitrust enforcement. *The Journal of Political Economy 89*.

Bolotova, Y. and J. Connor (2006). Cartel overcharges: Survey and meta-analysis. *International Journal of Industrial Organization 24*(6), 1109–1137.

Bolotova, Y., J. M. Connor, and D. J. Miller (2008). The impact of collusion on price behavior: Empirical results from two recent cases. *International Journal of Industrial Organization 26*.

Borenstein, S., A. C. Cameron, and R. Gilbert (1997, Feb.). Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics 112*(1), 305–339.

Borenstein, S. and A. Shepard (1996, Autumn). Dynamic pricing in retail gasoline markets. *The Rand Journal of Economics 27*(3), 429–451.

Carranza, J. E., R. C. Clark, and J.-F. Houde (2012, May). Price controls and competition in gasoline retail markets. Working paper, University of Pennsylvania.

Castanias, R. and H. Johnson (1993). Gas wars: Retail gasoline price fluctuations. *Review of Economics and Statistics, 75*, 171–174.

Clark, C. R. and J.-F. Houde (2011). Collusion with asymmetric retailers: Evidence from a gasoline price fixing case. Forthcoming, *American Economic Journal: Microeconomics*.

Connor, J. (2007). *Research in Law and Economics*, Volume 22, Chapter - Price-fixing overcharges: Legal and economic evidence. Emerald Group Publishing Limited.

Connor, J. and R. Lande (2006). The size of cartel overcharges. *The Antitrust Bulletin 51*, 983–1022.

de Roos, N. and H. Katayama (2010, September). Retail petrol price cycles in western australia. working paper, Sydney University.

Deltas, G. (2008). Retail gasoline price dynamics and local market power. *The Journal of Industrial Economics 61*(613-628).

Eckert, A. (2002). Retail price cycles and response asymmetry. *Canadian Journal of Economics 35*(52-77).

Edgeworth, F. (1925). The pure theory of monopoly. *Papers Relating to Political Economy 1*, 111–142.

Erutku, C. (2011). Cost shocks at the pump: Asymmetric pass-through and price wars during booms.

Erutku, C. and V. Hildebrand (2010). Conspiracy at the pump. *Journal of Law & Economics 53*.

Fonseca, M. A. and H.-T. Normann (2011). Explicit vs. tacit collusion - the impact of communication in oligopoly experiments.

Genesove, D. and W. P. Mullin (2001, Jun.). Rules, communication, and collusion: Narrative evidence from the sugar institute case. *American Economic Review 91*(3), 379–398.

Harrington, J. (2004). Post-cartel post-cartel pricing during litigation. *Journal of Industrial Economics 52*.

Lewis, M. (2009). Temporary wholesale gasoline price spikes have long lasting retail effects: The aftermath of hurricane rita. *Journal of Law and Economics 52*, 581–606.

Lewis, M. and M. Noel (2011). The speed of gasoline price response in markets with and without edgeworth cycles. *Review of Economics and Statistics 93*(2), 672–682.

Maskin, E. and J. Tirole (1988). A theory of dynamic oligopoly, ii: Price competition, kinked demand curves, and edgeworth cycles. *Econometrica: Journal of the Econometric Society 56*(3), 571–599.

Noel, M. (2007a). Edgeworth price cycles, cost-based pricing and sticky pricing in retail gasoline retail markets. *Review of Economics and Statistics 89*(2), 324–334.

Noel, M. (2007b). Edgeworth price cycles: Evidence from the toronto retail gasoline market. *Journal of Industrial Economics LV*(1), 69–92.

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy 108*(3), 466–502.

Porter, R. H. and J. D. Zona (1993, Jun.). Detection of bid rigging in procurement auctions. *Journal of Political Economy 101*(3), 518–538.

Porter, R. H. and J. D. Zona (1999, Summer). Ohio school milk markets: An analysis of bidding. *The Rand Journal of Economics 30*(2), 263–288.

Slade, M. (1987). Interfirm rivalry in a repeated game: An empirical test of tacit collusion. *Journal of Industrial Economics 35*, 499–516.

Slade, M. E. (1992). Vancouver's gasoline-price wars: An empirical exercise in uncovering supergame strategies. *The Review of Economic Studies 59*(2), 257–276.

Stock, J. and M. Watson (2003). *Introduction to Econometrics*. Addison Wesley.

Wang, Z. (2008). Collusive communication and pricing coordination in a retail gasoline market. *Review of Industrial Organization 32*(1), 35–52.

Wang, Z. (2009). (mixed) strategy in oligopoly pricing: Evidence from gasoline price cycles before and under a timing regulation. *Journal of Political Economy 117*(6).

Whinston, M. D. (2008). *Lectures on Antitrust Economics*. MIT Press.

APPENDIX A. LEGAL DISCLAIMER AND COMPETITION BUREAU DOCUMENTS

The Canadian Competition Bureau's investigation into, and prosecution of, the alleged price fixing in retail gasoline markets in Quebec is ongoing. The allegations of the Competition Bureau have not been proven in a court of justice. This paper analyses the alleged Quebec retail-gasoline cartel case strictly from an economic point of view.

For the purpose of this paper, we base our understanding of the facts with respect to the alleged Quebec retail-gasoline cartel case mostly on documents prepared by the Competition Bureau. We were given a copy of the 52-page affidavit of Mr. Pierre-Yves Guay of the Competition Bureau dated May 16, 2006 in file no 500-26-039962-067 of the Superior Court of Quebec, district of Montreal. From the Court, we received copies of the three annexes attached to the affidavit of Mr. Guay. Annex A is a 143-page document which contains mostly reported wiretap telephone conversations with respect to the region of Victoriaville; Annex B is a 45-page document which contains mostly reported wiretap telephone conversations with respect to the region of Thetford Mines; Annex C is a 121-page document which contains mostly reported wiretap telephone conversation with respect to the regions of Sherbrooke and Magog. We will refer to the affidavit of Mr. Guay and its three annexes as the "Competition Bureau documents." We also found information on the actions taken by the Competition Bureau on its website : **CompetitionBureau.gc.ca**.

The wire taps took place from March to June 2005 in Victoriaville and Thetford-Mines, and from March to June 2005 and December 2005 to April 2006 in Sherbrooke/Magog. For each price adjustment attempt that is documented, the phone calls are listed along with an extract or a summary of the individual conversations (including information about who made the call, who received the call, and the time of the call). For example, pages 27 and 41 of Annex A represent a typical entry for a price adjustment attempt. The annex makes reference to a 4 cent per liter price increase attempt on April 6th 2005 in Victoriaville. The Competition Bureau explains that the increase was initiated by two players and that twenty-three gas stations were involved. The annex lists these stations, and then summarizes eighty-eight telephone conversations which took place between 6:44 am and 3:42 pm. The summaries explain that the price increase was to take place at 9:15 am. Finally, in the annex the Bureau concludes that according to observations in the field, the agreement had been executed.

The cartels were discovered following the publication on June 6th 2004 of an article in a Victoriaville newspaper describing an interview with gas station owner Christian Goulet who claimed to be the victim of harassment by other station owners for not participating in their attempts to fix prices. This initiated a Canadian Competition Bureau investigation into suspected collusive behavior in violation of Section 45 of the Competition Act.

Below is an extract from the newspaper article:

Ce n'est pas la premiére fois que M. Goulet veut provoquer une guerre de prix. Il l'avait aussi fait en 1993... et avait fait la manchette, ses pompes ayant été brisées a coups de hache.

Lui et même ses employés auraient reçu une dizaine de coups de file au cours des derniers jours, l'enjoignant de remonter le prix de son essence. Certains ont joué de l'humour et de l'ironie. Mais d'autres se faisaient carrément menaçants, du genre: "On va s'arranger pour te faire fermer."

Christian Goulet dit qu'il en a assez de cette "clique" qui fait en sorte qu'a Victoriaville, un prix unique soit offert... et toujours plus haut qu'ailleurs au Quebec. "C'est pas normal! Les gens qui dénocent cette situation dans les rubriques de lettres d'opinions on bien raison. Moi je veux avoir le droit de vendre l'essence au prix que je veux, sans me faire menacer."

English translation:

It is not the first time that Mr. Goulet wanted to initiate a price war. He also did it in 1993... and, as the newspaper reported, his pumps were broken with an axe.

He and even his employes received several phone calls over the last few days, pressuring him to raise the price of his gas. Some were humorous and ironic. But others were more threatening of the sort: "We will make sure that you close down."

Christian Goulet says that he tired of this "clique" who makes sure that in Victoriaville, only one price is offered... and is always higher than elsewhere in Québec. "It is not normal! People who complain about this situation in letters to the newspaper are right. I would like to have the right to sell gas at whatever price I want without being threatened."
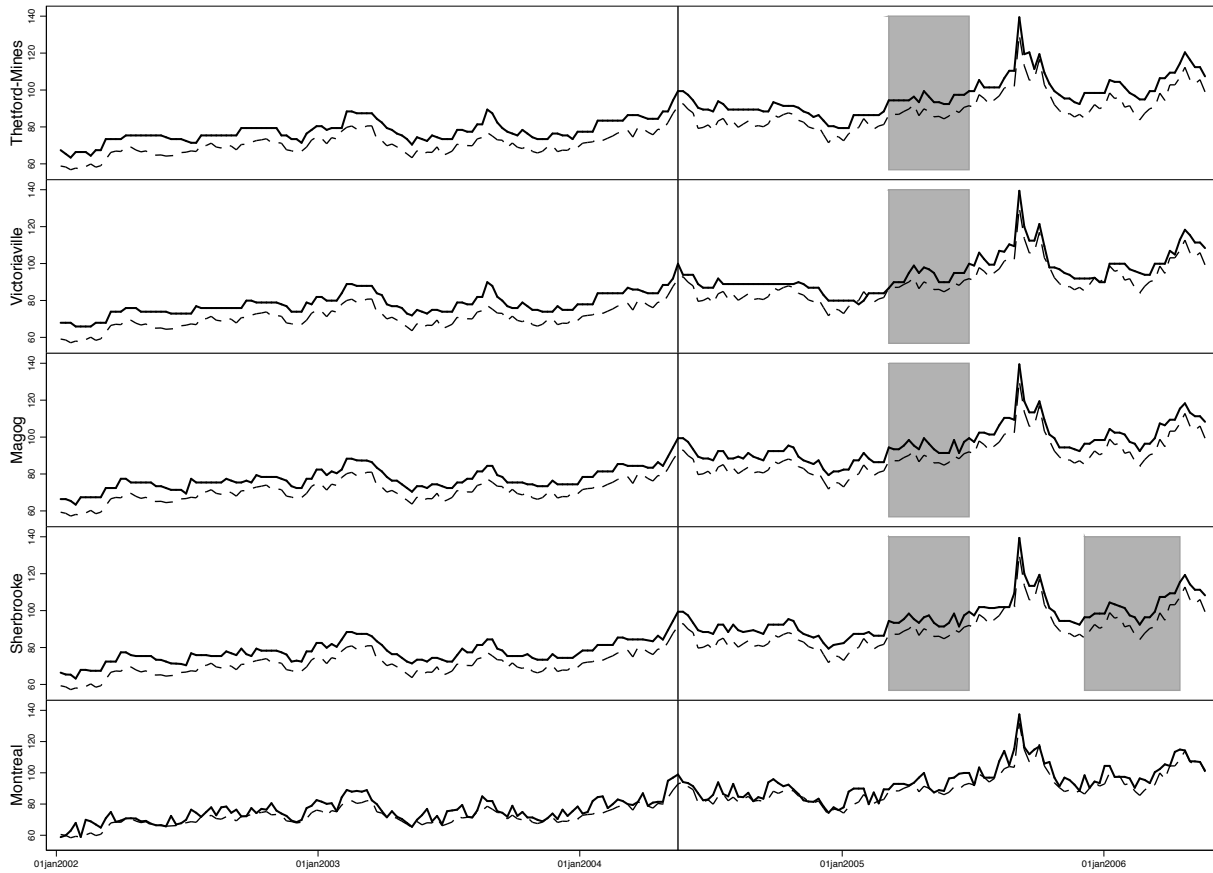
Dotted line: Price floor; Solid line: Representative station's price; Vertical line: Publication of the newspaper article, Grey areas: Wire-tap periods.

FIGURE 5. Evolution of weekly prices and floor in the four targeted cities and Montreal between January of 2002 and May of 2006
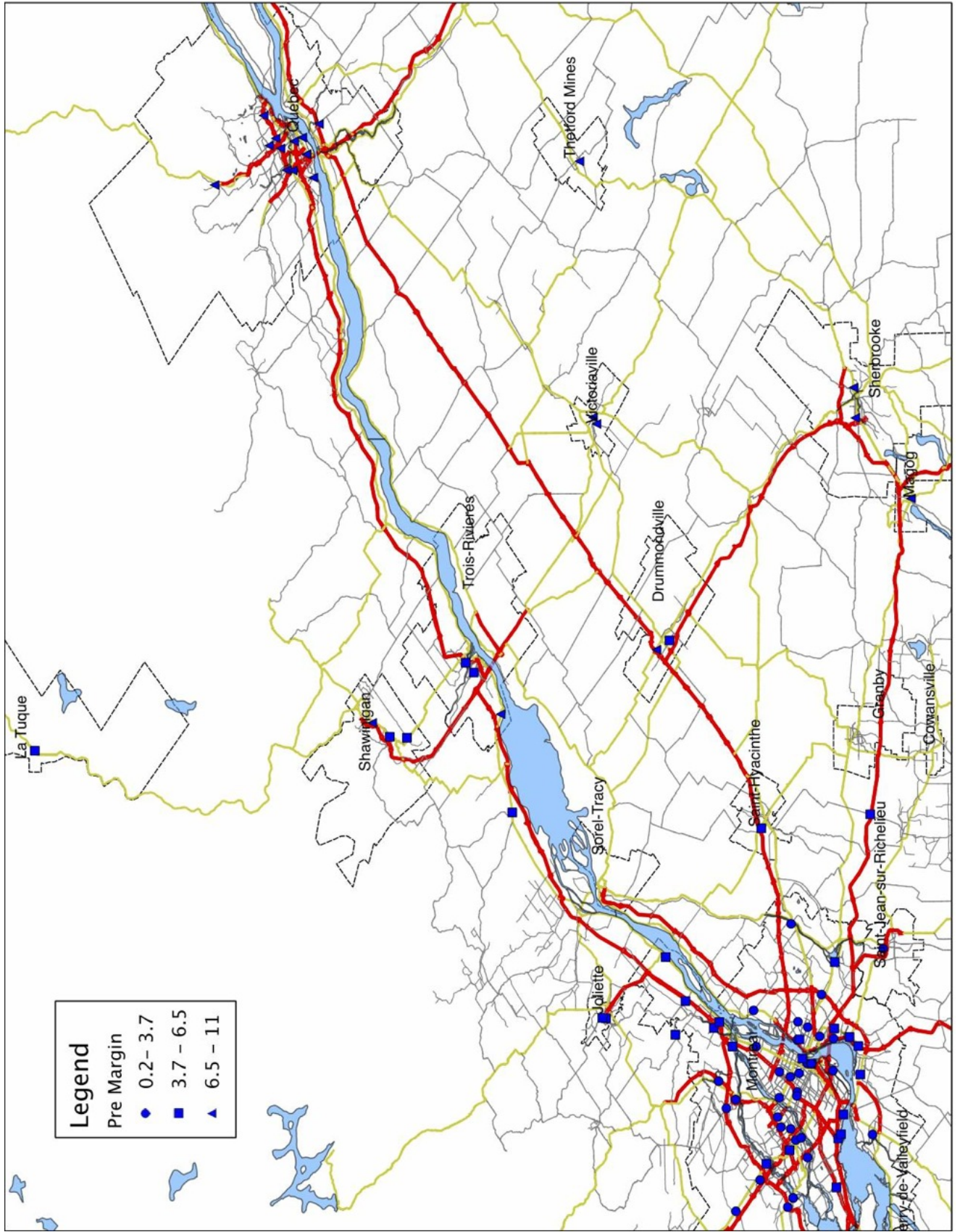
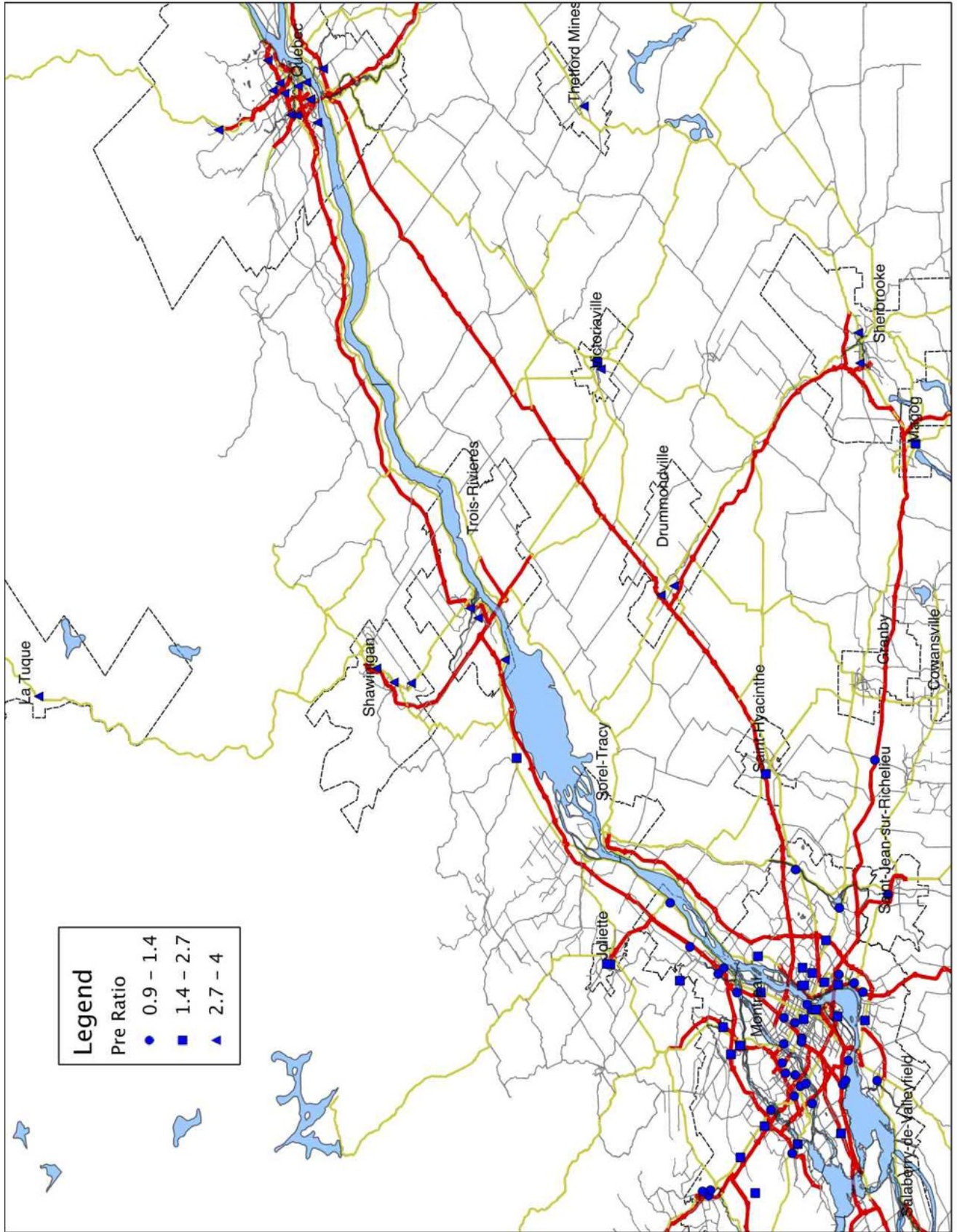FIGURE 6. Geographic distribution of margins before the announcement

FIGURE 7. Geographic distribution of price adjustment ratio before the announcement

Legend

Pre Ratio
- ● 0.9 – 1.4
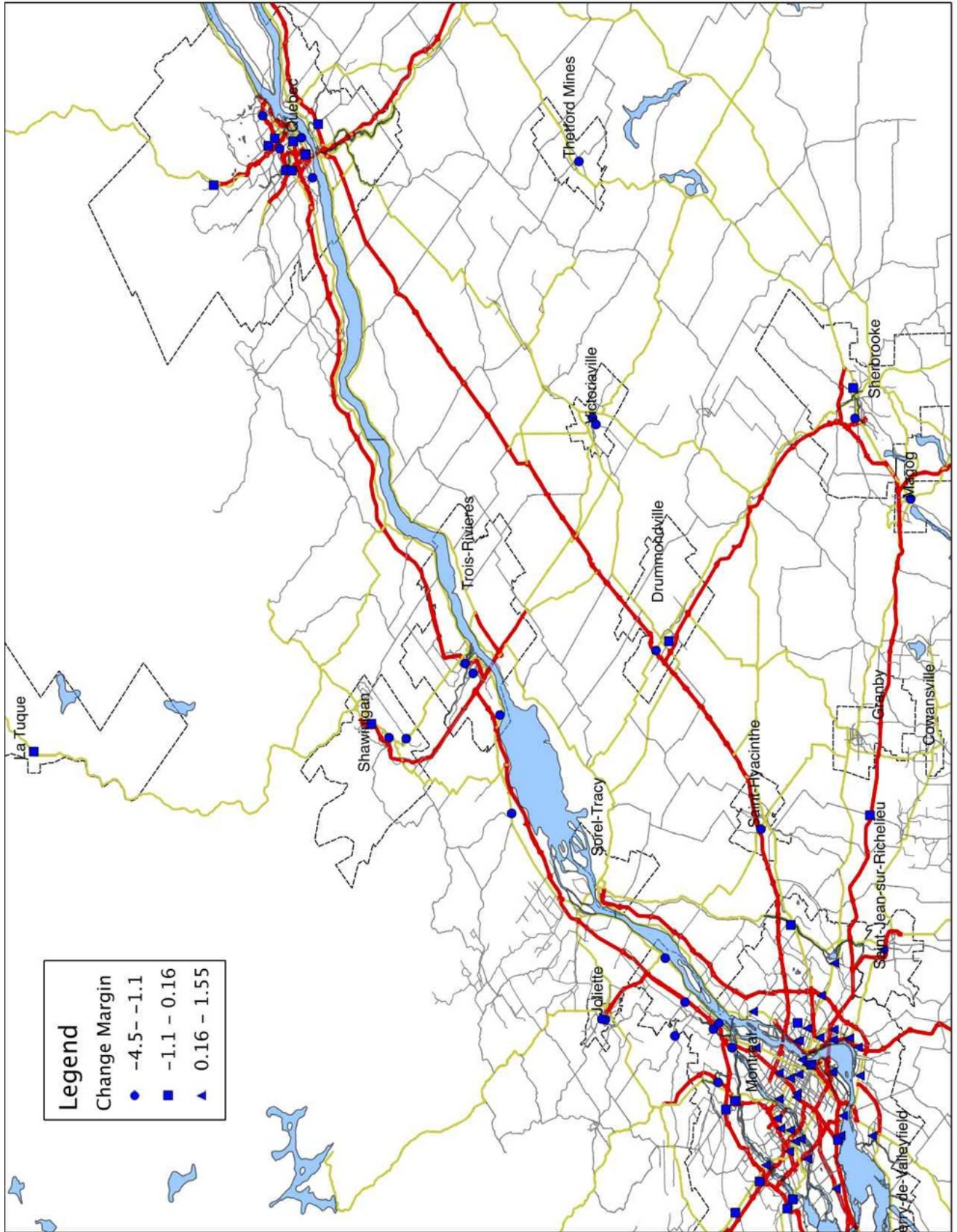- ■ 1.4 – 2.7
- ▲ 2.7 – 4

FIGURE 8. Geographic distribution of margin changes before and after the announcement
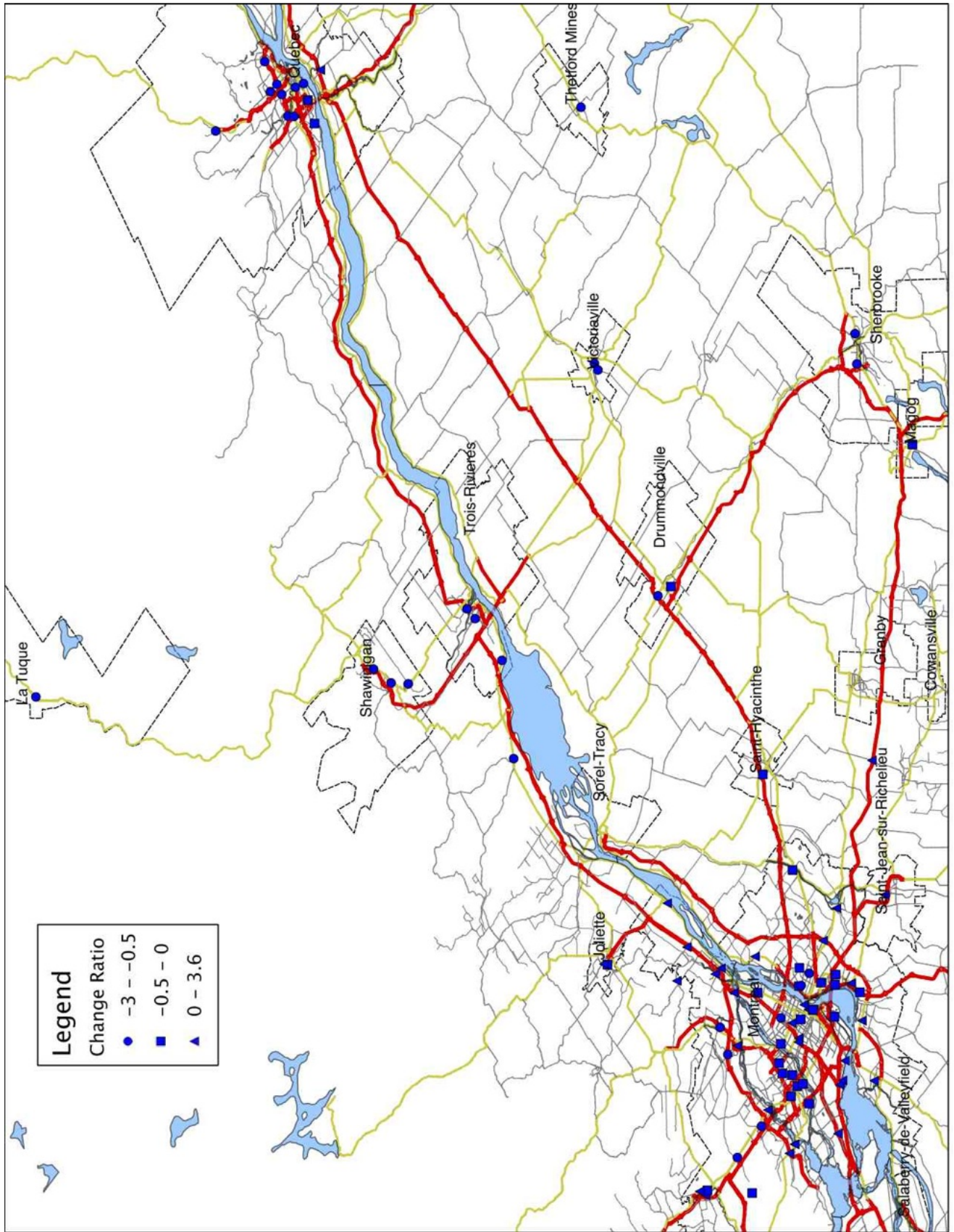
FIGURE 9. Geographic distribution of changes in the price adjustment ratios before and after the announcement