Detecting Collusion: The Gasoline Retail Margin in Québec and the Price-fixing Cartel

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Abstract

The purpose of this paper is to examine whether statistical tests can successfully detect collusion, especially in the recent Québec price-fixing cartel. The underlying idea is that retail gasoline margins might exhibit some abnormality during collusion time and certain statistical tests may be able to detect it. Several autoregression models are selected with the highest adjusted R^2 for each city. However, the Chow breakpoint test, predictive failure test, and likelihood test all do not provide expected results. All three tests do not give direct evidence that retail gasoline margins behaved unusually during collusion in Sherbrooke relative to Chicoutimi. Therefore, I cannot conclude that statistical tests cannot be used to detect collusion.

1. Introduction

The gasoline industry, especially the retail gasoline industry, has always received much attention from the government and the public since the retail prices can be easily found on the gas station boards. The retail prices are frequently monitored and analyzed in order to identify any abnormality without delays. Under such circumstances, it is unlikely to have collusion among companies or retailers in Canada. Although retail prices have continuously increased for many years, the rising price of crude oil is the main reason for these increases rather than collusion.

However, in June 2004, Victoriaville newspapers reported an interview with a gas station owner who claimed that he became the target of threat since he was setting the pump price lower than most of his rivals. Four years later, the Competition Bureau had collected enough evidence for price-fixing cartel in four Québec towns: Victoriaville, Sherbrooke, Magog and Thetford Mines. The first round of charges was laid in June 2008 and many other charges were laid afterwards. Today, this case remains open as the court continues to lay charges on the individuals involved.

The research in this paper is inspired by this Québec law case. During the collusion period, the retail price patterns possibly exhibited some unusual behaviour, for instance, the mean of retail prices increased or variance of retail prices dropped. The key here is to separate the effect of collusion and the natural fluctuation of retail gasoline prices. Thus, I need to compare at least one city with collusion to another city with no collusion.

The main purpose of this paper is to examine whether certain statistical tests can detect collusion, specifically for the recent ongoing price-fixing cartel case in Québec. Time series of weekly retail gasoline margins in Sherbrooke and Chicoutimi are calculated and used in this paper. Sherbrooke is one of the cities observed with collusion while Chicoutimi does not have any detected collusive behaviour. The data can be broken down into three seperate periods: period I for before the collusion period, period II for the collusion period, and period III for the after collusion period. The methodology is to compare the retail margins of Sherbrooke and Chicoutimi before, during, and after the collusion time to see if Sherbrooke exhibited any abnormalities during the collusion period.

The econometric model for gasoline prices for each city contains autoregressive (AR) terms from order 1 to 10. Monthly time dummy variables are also added to the model to control for

seasonality. I also organized the sample into three cases to better compare each period. Case one contains all three periods. Case two consists of period I and II, while case three contains period II and period III. Once 10 estimations with different AR terms for each case in each city are done, the models with the highest adjusted R-squared are selected. Thus, there is one model selected for each city and for each subsample.

Statistical tests mainly focus on case two and case three since the point is to compare the collusion period to other periods. I expect the retail margins in Sherbrooke to behave differently to Chicoutimi during collusion. It is also reasonable to expect a structural break for period II in Sherbrooke but not in Chicoutimi. However, all three statistical tests, including the Chow breakpoint test, the predictive failure test and the likelihood test, do not provide direct evidence that the retail margins in Sherbrooke behaved abnormally during the collusion period relative to Chicoutimi. Several argument can be advanced to explain the results such as the omitted variable bias, small sample sizes, the model does not fit the data well, or Chicoutimi had unobserved collusive behaviour during that time. But further research is needed to examine these factors.

The rest of the paper is organized as follows. Section 2 roughly presents some background on the Canadian gasoline market, especially the Québec market, and the Québec price-fixing cartel case. Section 3 reviews some related literature. Section 4 discusses the data uses in the analysis and presents descriptive data. Section 5 introduces the econometric model constructed for this research. Section 6 shows the results of three statistical tests and analyzes these results. The final section is the conclusion.

2. Background

2.1 Canadian gasoline market

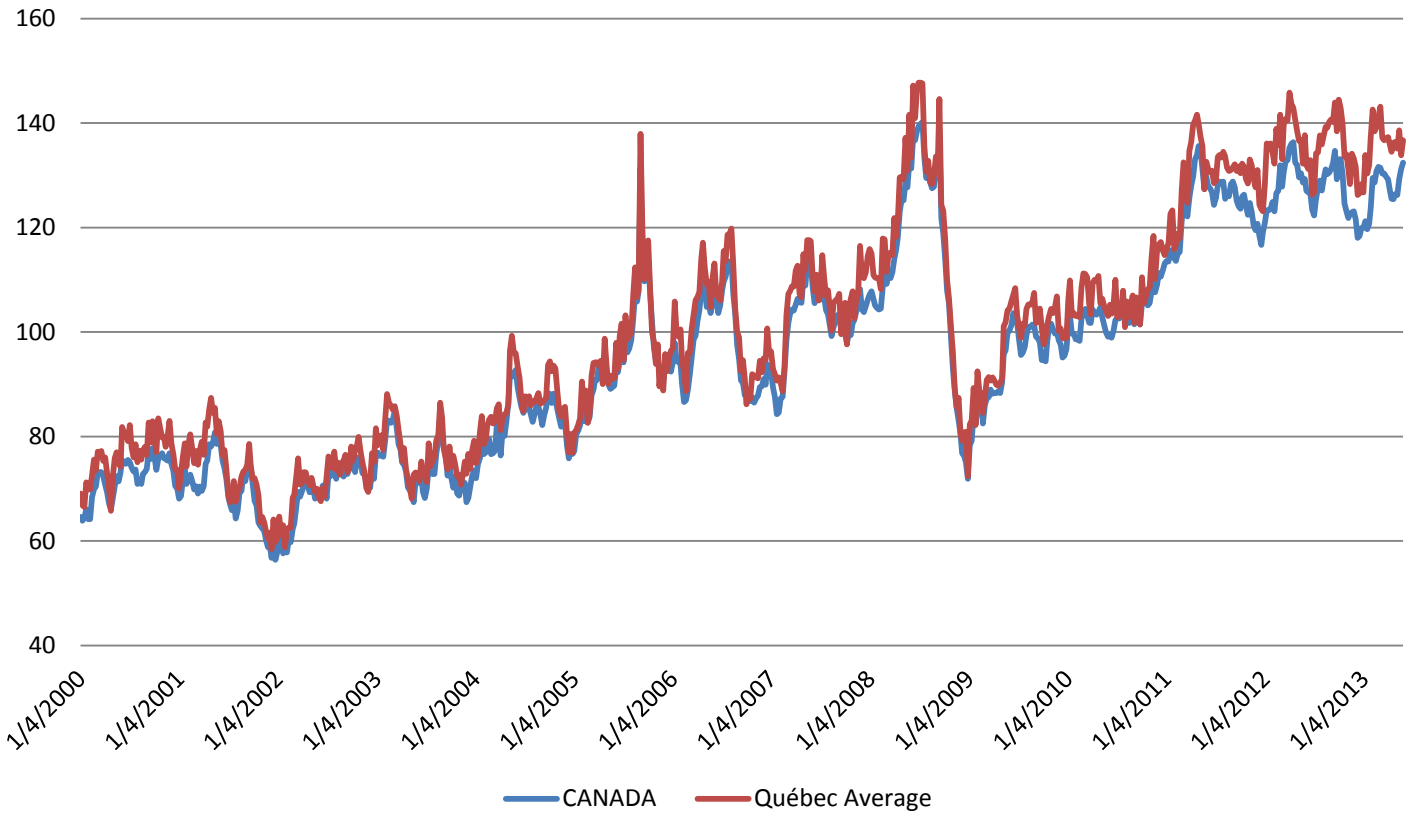
The Conference Board of Canada, a non-profit research organization in Canada that mainly focuses on economics, public policy and organizational performance, systematically studied the gasoline industry of Canada in the year 2000. With respect to the industry structure and city-based comparisons, the Conference Board of Canada (2001) concluded that the Canadian gasoline market is overall competitive and consumers are well served.

According to the Conference Board of Canada (2001), the gasoline industry in Canada can be broken down into two parts: upstream and downstream. Upstream industry involves crude oil, whose price is determined outside of Canada. Downstream industry contains the wholesale and retail markets. In terms of the wholesale market, the price is more determined by the U.S. market conditions than Canada. As for the retail market, it underwent fast increases in retail prices from 1999 and public concern about these rising prices has also risen. Since there are only a few key players with vertical integration and large size in Canadian gasoline market, the public usually thinks these companies have a large amount of power to affect the gasoline retail prices. However, according to this research, they can only affect about 4.5 cents per litre (cpl) on the retail gasoline price.

The conference Board of Canada (2001) also discusses perceptions of consumers, oil companies and the independent distributors in Canada. For consumers, they believe oil companies are taking advantage of frequent price adjustments and making enormous profits. In fact, consumers in Canada are well served and enjoy the lowest prices possible. Major oil companies think they provide competitively priced products to consumers in Canada. The findings also confirm their perception. As for the independent distributors, they complain about the competition from major oil companies which makes it hard for them to make profits. The research also indicates huge disadvantages for independent distributors in the Canadian gasoline market.

However, it has been more than one decade after the report from Conference Board of Canada (2001). Dramatic changes took place during this time. The Canadian average retail gasoline prices from 2000 to May 2013 are illustrated in Figure 1. The average retail prices, although highly volatile, exhibit a growing trend. Although it decreased to the lowest price by the end of 2008 just after it had reached the highest price on July 15, 2008, it quickly recovered and even got close to the highest price again in 2013.

Figure 1: Average retail gasoline prices of Canada and Québec (tax included)



Note: data from MJ Ervin & Associates. All data are population weighted.

2.2 Québec gasoline market

Figure 1 also demonstrates the average retail gasoline price of Québec from 2000 to May 2013. Although the Québec price generally follows a similar trend as Canada on average, Québec always has a higher retail price than the Canadian average. From 2011, the difference between the Québec average and the Canadian average became even larger than previous years. This can be attributed to increasing tax rates in Québec.

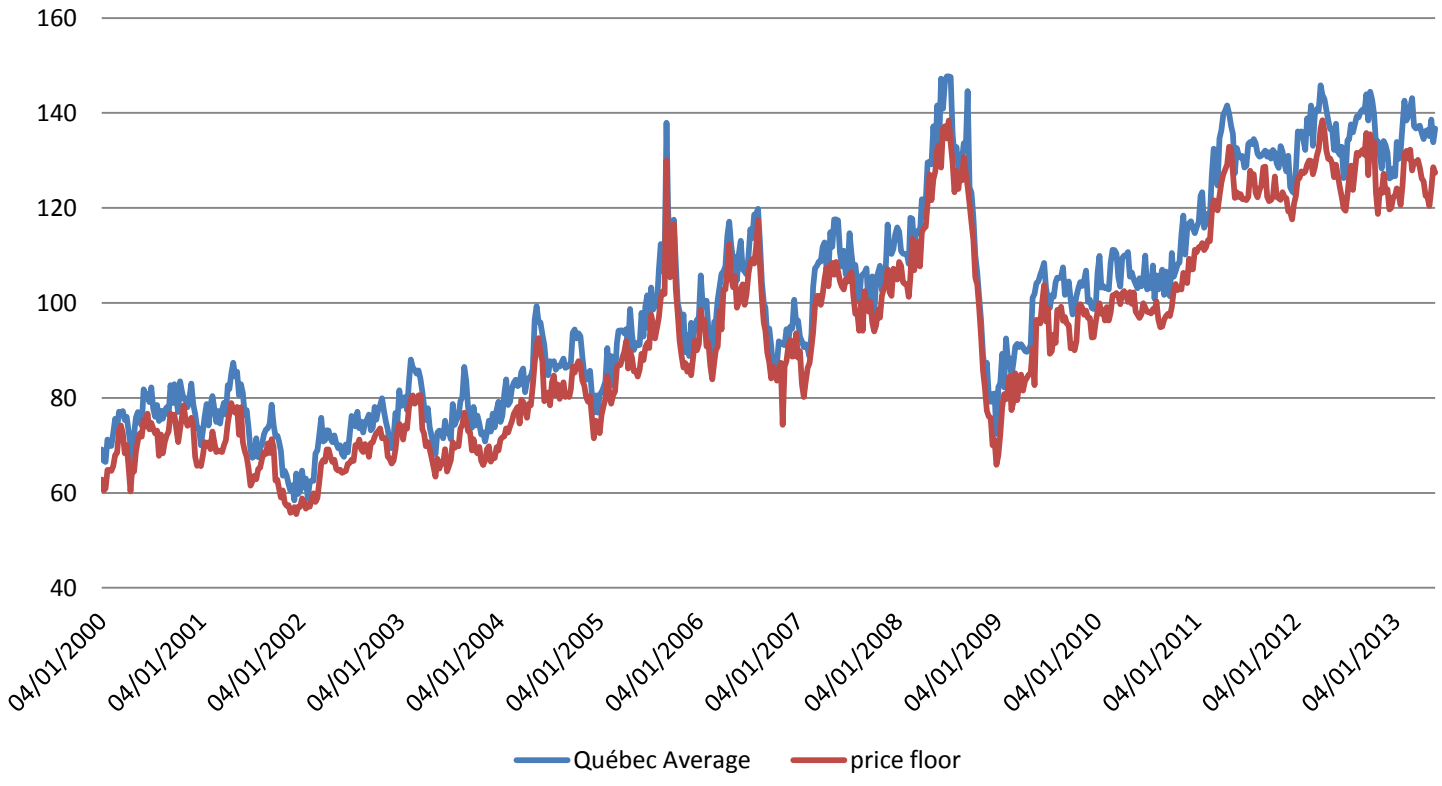
2.2.1 Regulation

One important factor which only affects Québec retail gasoline price is the regulation which was enacted in 1997 named the *Law on Petroleum Products* and is also known as the "price floor" in Québec. It is possible that latent predatory pricing behaviours in 1996 triggered this legislation. By predatory pricing, it means "a price reduction that is profitable only because of the added

market power the predator gains from eliminating, disciplining or otherwise inhibiting the competitive conduct of a rival or potential rival" (Bolton, Brodley and Riordan, 2000). Although there is no direct evidence of predatory pricing behaviour, the Québec Energy Board (Régie de l'énergie du Québec) still became responsible for setting a weekly floor price for each administrative region of Québec in 1997. This floor price is determined by the minimum wholesale price at the terminal, an estimate of the transportation cost to deliver products from refinery to the region, and the sum of taxes (Carranza, Clark and Houde, 2011). The aim of this regulation is to protect the independent distributors and reduce the frequency of price wars.

Figure 2 below shows the Québec average retail gasoline prices and the floor prices from 2000 to May 2013. The changes of the two types of prices are very similar. However, the Québec average prices often positively deviate from the price floor while sometimes Québec average prices touched the floor price.

Figure 2: Québec retail gasoline price and price floor (tax included)



Note: data from MJ Ervin & Associates and Québec Energy Board.

Houde (2008) empirically examines the impact of price floor legislation on the entry and exit decisions of firms. A panel of gasoline stations data of five cites in Québec during period 1991-2001, including the periods before and after the regulation, is applied to this paper. By measuring the changes in firms' incentive to enter and exit the market before and after the policy, Houde is able to construct a dynamic entry/exit model.

Houde summarizes the fact that firms behave differently if stations have different features or capacity. In general, the higher the fixed operation cost is, the lower the profits are. However, the cost of entering the market is extremely high compared to profits. Thus, firms will delay entering the market since the profits must cover the average variable costs. He also found that the regulation actually helps all stations obtain more profits. Consequently, firms have lower incentives to exit the market. This is probably why the Québec gasoline retail market exhibits a slower reorganization process than other provinces of Canada.

Carranza, Clark and Houde (2011) uncover the effect of such price floor regulations on the retail gasoline market of Québec at the station level, the local-market level, and the city level. At the station level, researchers quantify the amount of changes in markup and volume, as well as the amount which can be explained by changes in market structure at the same time. With respect to the local-market level, it has been divided into two parts: "first at the neighbourhood level using the clustering algorithm……and the second as distance buffers around individual stations" (Carranza et al. 2011). As for city level analysis, Carranza et al. check the robustness of results. Their study contains a total of 14 cities: 5 cities in Québec, 7 cities in Ontario, 1 city in Nova Scotia, and 1 city in Saskatchewan.

By employing a model of entry and price competition, Carranza et al (2011) observe two substantial yet opposite impacts of price floor legislation. First, more firms enter the market than there should be. Second, more efficient retailers are discouraged from entering the market. As a result of these two effects, this legislation affects the reorganization of retail gasoline market. In all cities since the 1990s, the number of gas stations tends to decrease, while more products and services are provided. However, the number of gas stations rose after the regulation was enacted in Québec compared to Ontario. Furthermore, gas stations in Québec offered more similar products and services relative to other provinces. What's more, the price floor policy also leads to an increase in retail prices.

Carranza et al. also discuss the impact of such regulation on welfare. Through a model of supply and demand, they conclude that this policy is more harmful to consumers in smaller cities since they cannot access large gas stations with high quality products or services. However Québec City, the only large city in the sample, is neutral to this policy.

2.3 Summary of the case

On June 6th 2004, Victoriaville gas station owner Christian Goulet stated that he was under threat from other retailers since he set the gasoline price lower than most other outlets (Clark and Houde, 2012). His complaints were reported by Victoriaville newspapers and immediately triggered a four-year investigation by the Competition Bureau from June 6th 2004 to June 10th 2008, including a one-year wiretap investigation from April 1st 2005 to April 18th 2006. The investigation first started in Victoriaville but later extended to the three other Québec towns of Sherbrooke, Magog and Thetford Mines.

The Competition Bureau gradually uncovered evidence of collusion between companies as well as local gas station operators who were intentionally fixing retail gasoline prices. According to Erutku and Hildebrand (2010), evidence shows that there were 16 price increases or attempted price increases during only April 1st 2005-April 18th 2006 and 53 out of 66 gas stations became involved in this case in Sherbrooke. Among several investigation tools used in this case including wiretaps and searches, the Immunity Program, under which the parties, who cooperate with the Competition Bureau may receive immunity from charges, helped the Competition Bureau gather evidence.

The first round of charges was laid on June 12th 2008. Up to the end of March 2013, 39 individuals and 15 companies were charged being involved with a criminal price-fixing cartel with fines over $3 million and “six have been sentenced to terms of imprisonment totalling 54 months” (Individuals sentenced in Québec Gas Cartel, March 28, 2013). Here, a cartel is “an agreement between businesses not to compete with each other” (The Competition Bureau Uncovers Gasoline Cartel in Québec, June 12, 2008). Out of these charges, 9 individuals and 8 companies are from Sherbrooke (see appendix 1).

3. Literature

Soon after the Competition Bureau announced its investigation for the price-fixing case in Victoriaville, Sherbrooke, Magog and Thetford Mines, economists also started their research on this case. Four journal articles on this case are reviewed in this section. Since the point of this paper is to use statistical tests detecting collusion, some papers on detecting collusion are also reviewed here.

3.1 On this case

Erutku and Hildebrand (2010) employ a differences-in-differences approach to examine the effect of public announcement of an investigation on this collusion specifically in Sherbrooke, as well as whether the Stiglerian theory of collusion can explain this collusion case. A differences-in-differences approach is to compare a benchmark market and the target market which shares the same time trends. As for the Stiglerian theory of collusion, it states that interest groups and other political participants can use the regulatory power of government to make laws and regulations which benefit them.

According to the traditional checklist made by Stigler (1964), the retail gasoline market in Sherbrooke is not likely to evolve into a cartel. The Herfindalhl-Hirschman index which estimates the market concentration also suggests a low level of market concentration with the index below 1,800 in Sherbrooke. Furthermore, the large number of competitors involved in this cartel is unusual.

In their paper, Erutku and Hildebrand use Montreal and Québec City as two control cities and compare them with Sherbrooke from May 31, 2005 to May 22, 2007. Since the Competition Bureau publicly announced the investigation on June 2, 2006, the data set consists of data one year before and one year after the investigation. The estimated results indicate the same price patterns in Sherbrooke and Québec City both before and after the announcement. The reduction after the announcement in Sherbrooke and Québec City is 1.8 cpl. However, compared to Montreal, there was a 1.75 cpl decrease in retail gasoline prices of Sherbrooke. This suggests an at least $2 million loss due to the price-fixing cartel in Sherbrooke. The Stigler theory of collusion not only does not make a good prediction of this collusion, but also brings more difficulties in detecting it and gathering evidence.

Clark and Houde (2012a), on the basis of the research of Erutku and Hildebrand (2010), reveal the difficulties for asymmetric retailers to achieve successful collusion and mechanisms they used to sustain collusion in this conspiracy. They claim that gas station owners are "asymmetric retailers" when there are differences in storage capacities, facilities and vertical arrangements among gas stations although gasoline can be considered as a homogenous good.

Through the wire taps with recorded phone conversations among station owners provided by the Competition Bureau during 2005 and 2006, Clark and Houde (2012a) observe that low-cost firms with small networks are more willing to deviate from the collusion agreement than high-cost firms with large networks. The larger the differentials are among retailers in the market, the easier it is for the collusion to fail. In order to raise prices, the leader will determine a new price and inform big-box retailers. Hence, a price increase delay shows up between leaders and big-box retailers. Although there is also a price decrease delay between leaders and big-box retailers, it is not as significant as a price increase delay.

One way to maintain the collusion is the transfers mechanism which improves the coordination among gas station owners. The estimation suggests that price adjustment delays raise the sales of the low-cost retailers. In a dynamic pricing game, this mechanism reduces the changes of deviating agreement of low-cost firms and in turn helps sustain collusion.

Clark and Houde (2012b) also unveil the effect of explicit communication on pricing by studying the collapse of collusion for this Québec price-fixing cartel case. Explicit communication in this case refers to the phone calls that the leader made to coordinate with other gas station owners. The explicit communication mainly 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 condition), and

(iii) to convince dissidents or would-be-dissidents to participate. (Clark and Houde, 2012)

Clark and Houde (2012b) first observe higher retail gasoline margins and asymmetric price adjustments in the four cities with collusion (target markets) relative to other cities in Québec. However, the execution of the warrants made the margins decrease and made the price adjustments more symmetric. The collusion did raise margins by 2.25 cpl relative to time after

executing the warrants in target market and by 1 cpl in the cyclical markets. The asymmetry of price adjustments disappeared by a large amount in the target markets as well. The problem here is that researchers cannot determine whether the reduction in margins can be wholly attributed to collusion.

Moreover, Clark and Houde (2012b) also did several tests in attempt to uncover the collusive behaviour in both target markets and other markets in Québec. They find that target cities all exhibited structural break within the first month after the announcement of execution of the warrants. However, there is no direct evidence that there was collusion in the other cities of Québec in this paper while it is quite possible because there is some evidence collected by the Competition Bureau. Since the model does not reject the hypothesis that the competitive cities show short-lived cycles, shorter cycles might be more likely to occur in competitive markets and long-term cycles may be related to collusion.

Erutku (2012) tries to measure the economic damage due to the price-fixing cartel in Sherbrooke before the announcement of investigation in June 2006. Unlike the differences-in-differences approach in Erutku and Hilderbrand (2010), he employs measures of overcharge which are "the sum of the total over charge and the deadweight loss associated with the supra-competitive pricing because of the conspiracy" (Erutku, 2012). Since there is a deadweight loss associated with the estimated total damages, there could be an underestimation of total damages if the court determines the charges only relying on the total overcharge. The monthly data of Sherbrooke is indirectly computed from quarterly or annual data.

Erutku defines the total damages at the pump equals to the monthly population times the sum of the monthly quantity of gasoline sold per capita times the overcharge and the deadweight loss. The total damages he estimates during January 2000-May 2006 are at least $8.7 million and at most $16.2 million if measured in 2002 Canadian dollar. The related deadweight loss in Sherbrooke is between 3.0% and 8.3% of total damages. Since this case is still going on, it is possible to have fines from $10 to $25 million according to this research. So far the punishment is very small relative to the total charges.

3.2 Detecting collusion

Feuerstein (2005) mentions that a successful collusion requires two conditions: (i) firms have to reach either an explicit or implicit agreement and, (ii) firms resist deviating from the agreement.

Hence, factors which affect the collusion usually have an impact on the incentives of firms to reach an agreement or to exit the cartel. The factors could be capacity constraints, demand fluctuations, tariffs and quotas, transportation costs and so on, but sometimes these factors have ambiguous results which depend on the exact circumstances. One thing to note is that firms do update their rules of the collusion if new policies are enacted.

Porter (2005) attempts to describe how to determine if there is a collusive agreement among firms based on the work of Stilger (1964). He reveals some factors that facilitate or prevent collusion and some situations where detection is possible. There are two types of collusion according to him: explicit cooperation and tacit cooperation. Explicit cooperation refers to the condition where firms communicate directly whereas tacit cooperation refers to the condition in which firms communicate indirectly.

Porter covers five cartel cases in his paper and shows how to detect them. The first method is "finking". The finks, people who tell the conspiracy to antitrust agencies, can be any individual or company. However, if they are rivals who are not part of the conspiracy, they remain suspicious since their purpose can be harming other companies by making up non-existing collusion. If there is no evidence from a dissident, it can be hard to detect collusion. Sometimes collusion can also be prevented if one of the rivals cheats on the agreement. However, new entries are encouraged to enter the market if firms successfully collude and achieve high profits. This may lead to illegal sanctions, predatory pricing or non-inclusive cartel which then makes the collusion easily detected. Another way to prevent collusion is based on the fact that firms have different interests and the agreement needs to reconcile disparate interests. If the cartel cannot provide an effective way to allocate market shares and determine prices, the collusion may fail. Once costs or market demand changes, the cartel needs to adjust the agreement and this may lead to cycles which can be detected by antitrust agencies.

4. Data

The gasoline price data are obtained from the Québec Energy Board and MJ Ervin & Associates. The Québec Energy Board is an economic regulation agency in the energy sector. As part of the Québec government, it mainly approves and modifies the distribution rates of electricity, natural

gas and petroleum products. The Québec Energy Board regularly releases daily weekday retail gasoline data for major cities and weekly retail gasoline data for 17 Québec administrative regions. The Board receives daily data by email from gasoline companies every day before 9 a.m. and receives weekly data by email from gasoline companies every Wednesday morning. They also do phone calls to collect price data. MJ Ervin & Associates, one of the leading petroleum data collecting organizations, collects the prices of several petroleum products in about 60 Canadian cities by making phone calls to and receiving emails from many sites individually.

4.1 Obtaining the data

The Conference Board of Canada (2001) defines the retail margin as "the difference between the cost to acquire product at wholesale and the selling price of the product at retail, exclusive of taxes". The retail margin is the only component of retail gasoline prices that gas station owners can directly affect. What counts is that the profit of outlets also comes from retail margin. The purpose of collusion at the retailer level is generally to keep the retail margin at a higher level. Therefore, retail margin is the key data for this research. However, the retail margin is not directly available in any database and needs to be calculated through other data. One way to calculate the retail gasoline margin is the following formula:

retail gasoline margin= retail gasoline price –IQCA

where IQCA is the acquisition cost indicator defined by the Québec Energy Board. Furthermore, IQCA is made up of rack gasoline price, transportation cost and several taxes on gasoline as the following equation shows:

IQCA= Rack gasoline price + GST + QST + TAF + TCP + transportation cost

where GST refers to the goods and services tax and QST refers to the Québec sales tax. TAF is the federal excise tax and TCP is the provincial fuel tax.

Since this is a city-based research, I chose the daily weekday price data of cities from the Québec Energy Board which consists of both retail gasoline prices and IQCA. However, the problem of this set of data is that it starts on June 4th 2007 and ends on May 27, 2013. Due to the unavailability of data before June 4th 2007, I retrieved weekly retail gasoline price data from MJ Ervin & Associates. However, MJ Ervin & Associates only releases data of five Québec cities from 2000, including Montreal, Québec City, Sherbrooke, Chicoutimi and Gaspé. The Québec

Energy Board has data for all cities except Gaspé. Due to the very different demographic and geographic features of Montreal and Québec City with respect to Sherbrooke, Chicoutimi is the only choice left as a smaller control city with no detected collusion.

Retail gasoline prices are available from 2000 to 2013 and the weekly rack prices from Montreal are available since 1997. What's more, rates of GST and QST, as well as the amount of TAF and TCP, are clearly defined by Canada Revenue Agency. The four tax rates over time are shown in Appendix 2. As for transportation cost, due to the available data from the Québec Energy Board, transportation cost only changed once in the period 2007-2013. The transportation costs of 2007 and early 2008 stayed the same and are based on the 2005 survey. Therefore, it is not farfetched to assume that transportation costs remained the same from 2000 to early 2008.

The weekly retail gasoline margin is now available from 2000 to 2013. In order to check whether statistical tests can detect the price-fixing cartel in Sherbrooke, the collusion period needs to be determined. Although there are no exact starting or ending dates of the price-fixing cartel in Sherbrooke, the information provided by The Competition Bureau does help to make plausible assumptions. Since the case started on June 4, 2004 due to the complaints by the gas station owner, it is reasonable to consider it started earlier than June 4, 2004. Thus, I assume that the collusion started at the beginning of year 2004. The investigation ended on June 10, 2008, which can imply that there is no more collusion afterwards according to Clark and Houde (2012). Therefore, the collusion period of Sherbrooke is assumed to be Jan 1, 2004- June 10, 2008. For the convenience of later research, the period from January 3, 2000 to December 29, 2003 is labeled period I. The period from Jan 5, 2004 to June 9, 2008 is period II and the period from June 16, 2008 to May 27, 2013 is referred to as period III.

4.2 Descriptive data

Sherbrooke and Chicoutimi have different demographic and geographic characteristics. Sherbrooke is located in Southern Québec as part of the Estrie administrative region with 154,106 residents as presented by 2011 Census. Chicoutimi, merged with Tremblay and Laterrière as Saguenay in 2002, situated about 400 km north of Sherbrooke with a population of 67,565 according to the 2011 Census.

Figure 3 illustrates the movement of the gasoline rack price, as well as the retail prices of Sherbrooke and Chicoutimi from 2000 to May 2013. Obviously, the retail prices in both cities

moved at the same pace as the rack price but the retail price in Sherbrooke was higher than Chicoutimi for most of the time. There was an upward trend for both rack price and retail prices from 2000 to the mid-2008. In June 2008, the rack price and retail prices reached the peak for rack price at 97 cpl, retail price of Chicoutimi at 142.02 cpl and of Sherbrooke at 145.4 cpl. Afterwards, there was a dramatic drop for about 60 cpl, at the end of 2008 due to the financial crisis, it recovered rapidly especially in 2011.

Figure 3: gasoline rack prices and retail prices (tax included)

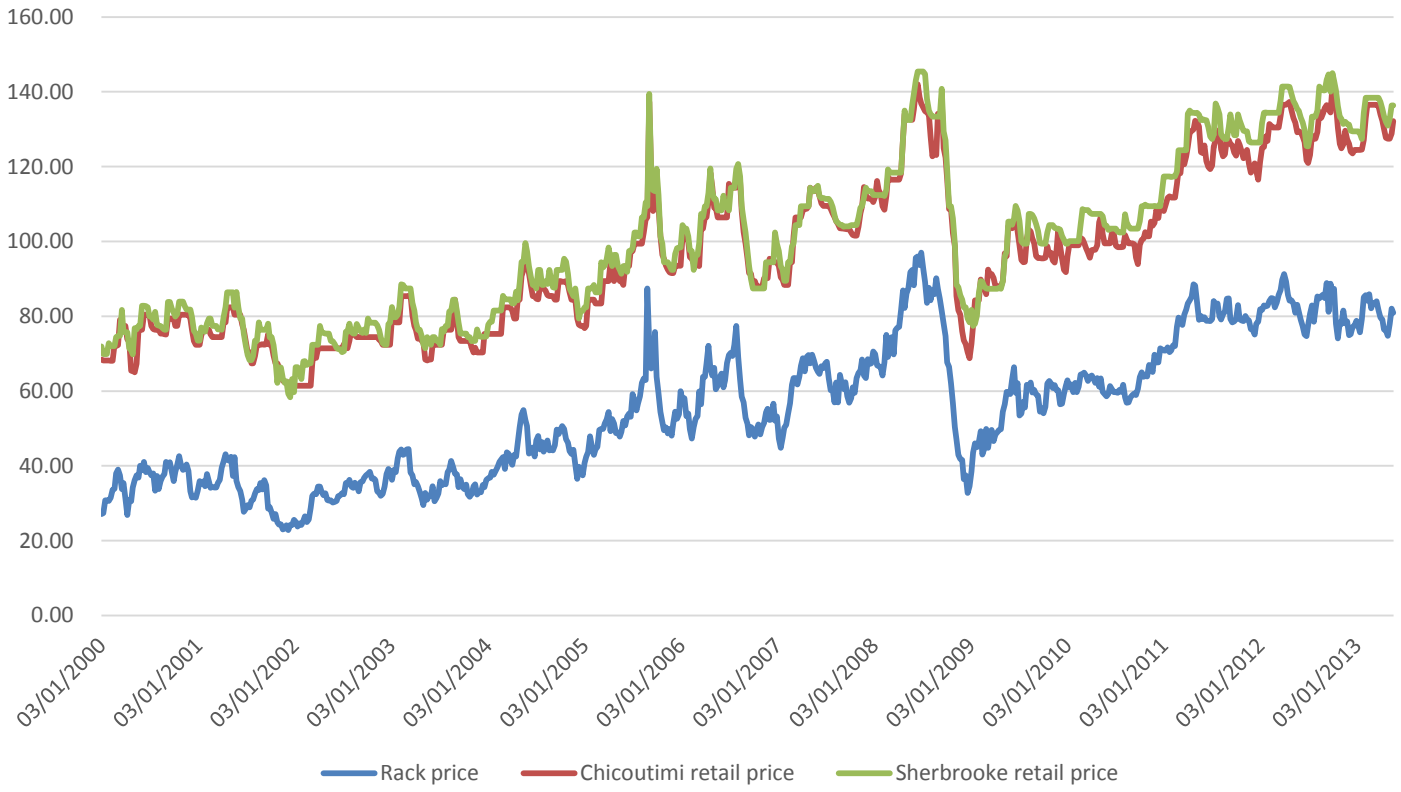


Figure 4 shows how the estimated weekly retail gasoline margin fluctuated from 2000 to the end of May 2013. The retail margin of Chicoutimi was higher than Sherbrooke for the majority of the time. The retail margin did not have as high a volatility as the rack price and retail prices. However, there was a huge jump in the week of September 5, 2005. The retail margin of the week of August 29, 2005 was about -20 cpl for both cities but was above 25 cpl in the week of September 5, 2005. The considerable decrease in rack price and enormous increase in retail prices caused this unusual jump.

Figure 4: Weekly retail margin

Table 1 presents the summary statistics. I expect the mean retail gasoline margin in period II to be higher than period I and period III since the retailers tried to keep the margin at a high level during collusion. Furthermore, the standard deviation is expected to be smaller in period II than period I and period III due to the complicated and costly process of changing prices during collusion. As can be seen from the table, the mean retail gasoline margin in Chicoutimi was always higher than Sherbrooke in all three periods. Although Sherbrooke and Chicoutimi shared the same trend in the mean of retail gasoline margin, the amount of change was quite different from period II to period III. There was a 0.7 cpl decrease from period I to period II for both cities but only a 0.3 cpl decrease in Sherbrooke from period II to III. On the other hand, 2.7 cpl decreased in Chicoutimi from period II to period III. The changes of standard deviation in Sherbrooke was very similar to the changes in Chicoutimi, in terms of trend and amount. At a glance of the means and variances, there has to be no abnormality in period II in Sherbrooke relative to Chicoutimi.

Table 1: summary statistics

period	Mean gasoline retail margin	
	Sherbrooke	Chicoutimi
Period I, II and III	6.279 (3.326)	8.062 (3.841)
Period I	6.896 (3.085)	9.544 (3.354)
Period II	6.188 (4.181)	8.835 (4.353)
Period III	5.860 (2.476)	6.168 (2.831)

Note: standard deviations are in brackets. All numbers are in cpl.

5. Econometric Model

We use an autoregressive form to model gasoline retail margins. An autoregressive (AR) model is a special case of the more commonly known autoregressive moving-average (ARMA) model. It represents a type of random process which depicts a specific time-varying processes in economics. The basic idea of the AR model is that the independent variable depends on its past values linearly. This model deals with some usual problems exhibited by time series data like persistence and autocorrelation. The AR(*p*) refers to an autoregressive model with order *p*. In this paper, the AR order takes values from 1 to 10 for both Sherbrooke and Chicoutimi.

Another problem often exhibited by time series data is seasonality, that is, "a dependent variable contains a seasonal or cyclical pattern, where certain features periodically occur" (Brooks, 2008, p.156). Retail gasoline prices also exhibit strong seasonality such as the "summer effect" where retail gasoline prices are higher in summer than in winter. One way to resolve this problem is to create time dummy variables. Since the retail gasoline margin fluctuates very often, I create 12 monthly time dummies for each month of the year and take the time dummy for January as the reference case.

The econometric model therefore takes the form of AR model with time binary variables as the following:

$$\text{margin}_{i,t} = \beta_0 + \beta_1 \text{margin}_{i,t-1} + \ldots\ldots + \beta_p \text{margin}_{i,t-p} + \gamma_1 \text{February} + \ldots\ldots + \gamma_{11} \text{December} + \mu_{i,t} \quad (*)$$

where the dependent variable margin $_{i,t}$ is the retail gasoline margin of city *i* at time *t*. Margin$_{i,t-1}$ to margin$_{i,t-p}$ are the AR terms where the number of AR terms depends on the order *p*. As stated above, February to December are time binary variables which equals to 1 if the *t* is from a certain month and equals to zero otherwise. For instance, for a retail margin in Sherbrooke in the week of March 6, 2002, the time dummy March would be 1 and other time dummy variables are equal to zero.

In order to better compare the different periods, I conduct three smaples out of the whole sample. In the first case, the estimations are for the regressions of the whole sample, that is, period I, II and III. The second case, estimates the regressions of the period before collusion and period of collusion together, that is, period I and II. The third case estimates the regressions for period of collusion and period after collusion together, that is, period II and III. For each case, a best fitted model needs to be selected for each city. The selection is based on the adjusted R-squared (R^2). The higher the adjusted R^2, the better the model explains the data. The following table presents the adjusted R^2 for all models in all cases. For case one, an AR(6) is selected for Sherbrooke and an AR(10) for Chicoutimi. For case two, AR(6) better fits Sherbrooke and AR(10) better fits Chicoutimi. For case three, the table shows same adjusted R^2 of AR(6) and AR(9). Since it is preferred to use the same AR orders for all the cases, AR(6) is selected for Sherbrooke and AR(10) for Chicoutimi. Overall AR(6) is selected for Sherbrooke and AR(10) is selected for Chicoutimi in all three cases.

The OLS results of selected models can be found in Appendix 3. Appendix 3 also addresses the Durbin-Watson statistic of each selected model. Durbin-Watson statistic is used to test the autocorrelation in the residuals. A Durbin-Watson statistic equals to 2 implies no autocorrelation in the residuals. Since the Durbin-Watson statistics are very close to 2 in selected models, it is plausible to conclude that there is no remaining autocorrelation in the estimated models.

Table 2: Adjusted R^2 of autoregressive models for retail gasoline margin

case	city	AR Terms									
		1	2	3	4	5	6	7	8	9	10
Period I, II and III	Sherbrooke	0.112	0.120	0.119	0.120	0.120	0.126	0.125	0.123	0.125	0.121
	Chicoutimi	0.232	0.240	0.243	0.243	0.241	0.239	0.239	0.242	0.242	0.248
Period I and II	Sherbrooke	0.053	0.061	0.060	0.059	0.062	0.080	0.077	0.074	0.080	0.075
	Chicoutimi	0.107	0.105	0.104	0.102	0.105	0.111	0.109	0.108	0.112	0.113
Period II and III	Sherbrooke	0.093	0.098	0.097	0.103	0.102	0.111	0.108	0.106	0.111	0.110
	Chicoutimi	0.157	0.168	0.176	0.179	0.177	0.174	0.173	0.184	0.184	0.188

6. Statistical tests

The statistical tests applied here are used to identify whether the retail margins behaved differently during collusion relative to two other periods in Sherbrooke compared to Chicoutimi. The three statistical tests are: the Chow breakpoint test, the predictive failure test and the likelihood ratio test.

6.1 Chow breakpoint test

The Chow breakpoint test, constructed by economist Gregory Chow in 1960, is one of the statistical tests to examine the stability of parameters, that is, whether the parameters are constant through the whole sample (Brooks, 2008, p.180). For time series data, the Chow breakpoint test is an often-used test in detecting structural changes. Since the Chow breakpoint test is an extended application of the F-test, all assumptions for a regression model apply to all the observations in the sample.

The null hypothesis of the Chow breakpoint test is that parameters are stable over time, that is, the parameters are the same for two sub-samples. A Chow breakpoint test requires splitting the data into two sub-samples where each of the sub-sample consists of enough data. The next step is obtaining the residual sum of squares (RSS) for each regression after estimating the regressions of the whole period and the two sub-samples. With all the RSS, the statistic is:

$$test\ statistic = \frac{RSS - (RSS_1 + RSS_2)}{RSS_1 + RSS_2} \times \frac{T - 2k}{k}$$

Where *RSS* is the RSS for the whole sample, RSS_1 is the RSS for sub-sample 1 and RSS_2 is the RSS for sub-sample 2. T is the number of observations in the whole sample and *k* is the number of independent variables in each regression for sub-samples. If the test statistic is greater than the critical value of the F-distribution for (*k, T-2k*), the null hypothesis is rejected (Brooks, 2008, p.180-181).

I apply the Chow breakpoint test for case two and case three. Note that in order to eliminate the effect of period I on period II due to the lags, in period II of case two, the first 6 weeks for Sherbrooke and the first 10 weeks for Chicoutimi are removed from the sample. The same process is also done in period III of case three. I expect Sherbrooke to reject the null hypothesis and Chicoutimi not to reject the null hypothesis for both cases. This implies that the price-fixing cartel did affect the margin patterns during that period comparing to other time. In contrast, the control city with no collusion should have consistent margin patterns. However, the test yields very different results as Table 3 illustrates. Unlike the expectation, Sherbrooke does not reject the null hypothesis in both cases. That is to say, there is no structural change in period II compared to period I as well as period III compared to period II. On the other hand, Chicoutimi rejects H_0 in case three rather than case two which suggests that there are structural breaks in period III compared to period II but not in period II compared to period I. Consequently, the Chow breakpoint test fails to prove that retail margin patterns change during the collusion period.

Table 3: chow breakpoint test results

Chow breakpoint test				
case	Sherbrooke		Chicoutimi	
	Test statistic	Whether reject H_0	Test statistic	Whether reject H_0
Period I and II	1.177	not reject	1.701	not reject
Period II and III	1.858	not reject	2.470	reject at 1% level

6.2 Predictive failure test

One significant drawback of the Chow breakpoint test is only valid when the two subsamples have enough numbers of observations. If the subsample that I try to predict is small, another type of Chow test named the predictive failure test needs to be used here.

The process of the predictive failure test is very similar to the Chow breakpoint test. The key difference here is that the predictive failure test uses a large sub-sample to check whether it successfully predicts the data of the following or preceding short period. The "large" here refers to most of the data. The predictive failure test also has a different null hypothesis which is that "the prediction errors for all of the forecasted observations are zero" (Brooks, 2008, p.183). This test still needs RSS of the whole sample and of the large sub-sample (RSS_1) as following:

$$test\ statistic = \frac{\quad}{\quad} \times \frac{\quad}{\quad}$$

where T_1 is the number of observations in the large sub-sample and T_2 is the number of observation that the model is trying to predict. If the test statistic is greater than the critical value of the F-distribution for (T_2, T_1-k), the null hypothesis is rejected.

Like the Chow breakpoint test, I also employ the predictive failure test in cases two and case three while removing the overlapped lag effects from the previous period. The period that the model is trying to predict is always the next six-month of the estimated period. For example, I attempted to predict the first half-year of year 2005, that is, Jan 3, 2005 to June 27, 2005. Thus, the regression of the period I is used as the larger sub-sample and the whole sample is period I plus the first half-year observation in 2005. Then the latter half-year of 2005, July 4, 2005 to December 26, 2005 is predicted by estimating period I plus the second half-year of 2005. However, the models are always the same as before, that is, AR(6) for Sherbrooke and AR(10) for Chicoutimi in all cases.

I expect Sherbrooke rejects the null hypothesis during most time in collusion period. It can then suggest that the data of before collusion period is not able to predict the retail gasoline margin in collusion time. As for the control city of Chicoutimi, it should not reject the null hypothesis during the collusion period. The two tables below present the results of the predictive failure test. Table 4 is for case two. Only three half-year during the collusion period reject the null hypothesis. With respect to Chicoutimi, it rejects the null hypothesis in the same three half-year as Sherbrooke, These results imply the model only suffers from predictive failure during these three

half-year. As for the results of case three in Table 5, none of the half-year in both cities get rejected. In other words, the data of the collusion period can successfully predict the retail gasoline margin patterns in after collusion time for both Sherbrooke and Chicoutimi. In conclusion, results from the predictive failure test are not as expected and cannot suggest the fact that the price-fixing cartel took place in period II in Sherbrooke.

Table 4: predictive failure test – semi-annual results of period I and period II (case two)

	Predictive failure test			
Week of	Sherbrooke		Chicoutimi	
	Test statistic	Whether reject H_0	Test statistic	Whether reject H_0
01/05/2004-06/28/2004	0.944	not reject	1.243	not reject
07/05/2004-12/27/2004	0.515	not reject	0.983	not reject
01/03/2005-06/27/2005	0.888	not reject	2.043	not reject
07/04/2005-12/26/2005	7.525	reject at 1% level	10.129	reject at 1% level
01/02/2006-06/26/2006	2.384	reject at 1% level	3.274	reject at 1% level
07/03/2006-12/25/2006	1.778	reject at 5% level	1.758	reject at 5% level
01/01/2007-06/25/2007	1.184	not reject	1.420	not reject
07/02/2007-12/31/2007	0.481	not reject	0.488	not reject
01/07/2008-06/09/2008	0.978	not reject	0.830	not reject

Table 5: predictive failure test – semi-annual results of period II and period III (case three)

	Predictive failure test			
Week of	Sherbrooke		Chicoutimi	
	Test statistic	Whether reject H_0	Test statistic	Whether reject H_0
07/07/2008-12/29/2008	0.271	not reject	0.571	not reject
01/05/2009-06/29/2009	0.567	not reject	0.387	not reject
07/06/2009-12/28/2009	0.322	not reject	0.802	not reject
01/04/2010-06/28/2010	0.294	not reject	0.537	not reject
07/05/2010-12/20/2010	0.348	not reject	0.745	not reject
01/03/2011-06/27/2011	0.327	not reject	0.672	not reject
07/04/2011-12/26/2011	0.288	not reject	0.628	not reject
01/02/2012-06/25/2012	0.136	not reject	0.365	not reject
07/02/2012-12/31/2012	0.294	not reject	0.478	not reject
01/02/2013-05/27/2013	0.160	not reject	0.257	not reject

6.3 Likelihood ratio test

A likelihood ratio test is based on the maximum likelihood function which is to "find the most likely values of the parameters given the actual data" (Brooks, 2008, p.395). By estimating an unrestricted model and a restricted model, the likelihood ratio suggests the number of times the data are more likely to be in one model than the other. The likelihood ratio also suggests the differences between two models. The larger the ratio, the larger the differences. Here, the unrestricted model is also called the alternative model and the restricted model is called the null model. If the null hypothesis is rejected, the alternative model is preferred. The likelihood ratio is

$$LR = -2(L_r - L_u) \sim \chi^2 (m)$$

where L_r is a maximized value of the log-likelihood function of the unconstrained model and L_u is a maximized value of the log-likelihood function of the restricted model (Brooks, 2008, p.419). Here m is the number of constraints and the likelihood ratio follows a Chi-squared distribution. If LR value is greater than $\chi^2 (m)$, the null hypothesis is rejected.

To apply the likelihood ratio test, I need an unrestricted model and a restricted model for cases two and three. The unrestricted models in case two are still AR(6) for Sherbrooke and AR(10) for Chicoutimi estimating period I and II. The restricted models for each city are the sum of two separate estimations for period I and for period II with the same model. Consequently, the log-likelihood of the restricted model is the sum of the log-likelihood values of the two estimations for each period. Case three follows a similar process with the restricted model which is built by adding up two separate estimations for period II and period III.

I expect to see that Sherbrooke rejects the null hypothesis in case two and case three while Chicoutimi does not reject the null hypothesis in any case. The removal of overlapped lag influence from previous period is also applied here. The likelihood ratio test results are illustrated in Table 6. Sherbrooke rejects the null hypothesis at 1% level in both cases as does Chicoutimi. The results not only imply that data are more likely belong to the alternative model, but also demonstrate the large difference between the unconstrained models and constrained models. Since the alternative model is the sum of two estimations in each period, it also suggests that the two estimations are different from the null model in both Sherbrooke and Chicoutimi. Note that the differences here refer to both mean and variance. In summary, the likelihood ratio test is not able to provide any evidence of changing price patterns during the collusion period compared to the period before and after collusion.

Table 6: likelihood ratio test results

		Sherbrooke	Chicoutimi
period I and II	period I:log-likelihood	-490.004	-468.689
	periodII: log-likelihood	-632.567	-628.872
	L_r	-1122.571	-1097.561
	L_u	-1149.112	-1140.185
	LR	53.082	85.248
	whether reject H_0	reject at 1% level	reject at 1% level
Period II and III	period II:log-likelihood	-632.567	-628.872
	Period III: log-likelihood	-505.342	-513.002
	L_r	-1137.909	-1141.874
	L_u	-1216.555	-1228.420
	LR	157.292	173.092
	whether reject H_0	reject at 1% level	reject at 1% level

6.4 Possible cause

The three statistical tests all fail to show that the price patterns in period II is different to period I and III in Sherbrooke while Chicoutimi should not have such large differences in peirod II compared to period I and III. Several factors can possibly explain why the statistical tests results are not as expected. The following factors are all likely to cause the failure of statistical tests but further research is needed to check whether each of these factor actually exists.

First, there is the possibility that the model does not well fit the data. Although I selected the model with the highest adjusted R^2, the values of adjusted R^2 are small. 5 selected models only have an adjusted R^2 around 10% and only one model has an adjusted R^2 at 24.8%. If only 10% of the variation of the dependent variable can be explained by the model, the model probably does not catch the key features of data. Also in the OLS results in appendix 3, most estimates are not statistically significant. Although R^2 and estimates cannot indicate whether the model is correct or not, there is still a possibility that the model does not well explain the sample.

Second, omitted variable bias probably plays a role here. These omitted variables have effects on the current retail gasoline margin and are correlated with the independent variables whereas not accounted for in the equation. In the econometric model I constructed, only lagged terms of retail gasoline margins and monthly binary variables have impacts on the current value of margin. It is possible that there exists some unobserved variables which greatly affect the current value of retail gasoline margin in both Sherbrooke and Chicoutimi as well. Potential omitted variables could be weather, macroeconomic conditions, strikes in major industries and specials events.

Third, Chicoutimi probably also has collusive behaviours. Since the Competition Bureau has collected some evidence that the price-fixing cartel was widespread to other Québec cities (Clark and Houde, 2012), Chicoutimi could be one of the cities which has undetected collusion. If this is true, Chicoutimi is not a proper control city and is useless in comparison with Sherbrooke. This could also explain why the retail gasoline price patterns of Chicoutimi behave in a similar fashion to Sherbrooke.

7. Conclusion

Inspired by the Québec price-fixing cartel, I attempt to examine whether statistical tests can detect collusion. The weekly data of retail gasoline margins from January 2000 to May 2013 in Sherbrooke and Chicoutimi are divided into three periods: period I for before collusion time, period II for during collusion and period III for after collusion. To better compare each period, there are also three cases here. Case one contains all three periods, case two includes period I and II while case three includes period II and III. An AR model of the highest adjusted R^2 is selected for each city in each case.

I apply three statistical tests in this research: the Chow breakpoint test, the predictive failure test and the likelihood test. However, I do not obtain any expected results. There are structural breaks in both Sherbrooke and Chicoutimi in period II relative to other time. Furthermore, both Chicoutimi and Sherbrooke have three six-month data that cannot be predicted by the previous period. Moreover, the alternative model and null model are very different according to the likelihood ratio test. Therefore, all three tests do not provide any evidence that the retail margins behaved unusually during the collusion period in Sherbrooke relative to Chicoutimi.

Thus, I cannot conclude that the retail margins exhibit any abnormality during the collusion period in Sherbrooke. It is likely that the model I constructed cannot well explain the data. Another possible reason is an omitted variable bias. It is plausible to doubt that Chicoutimi also had undetected collusive behaviours during period II. Further research must address these factors. Other methods to detect collusions can also be developed in further research.

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Appendices

Appendix 1: List of charges and sentences in Sherbrooke

Individuals

Charges and sentences

Individuals	Banners	Charges	Sentences
Serge Parent	Irving	September 28, 2012	Before the courts
Pierre Bourassa	Olco/Pétroles Global Inc.	June 12, 2008	12 months imprisonment to be served in the community
Christian Payette	Olco/Pétroles Global Inc.	June 12, 2008	12 months imprisonment to be served in the community and $5,000 donation
Gisèle Durand	Esso/9045-0586 Québec Inc.	June 12, 2008	4 months imprisonment to be served in the community and $20,000 donation
Michel Dubreuil	Esso	June 12, 2008	6 months imprisonment to be served in the community and $25,000 donation
Claude Bédard	Irving	July 15, 2010	Stay of proceedings (see Thetford Mines)
Stéphane Grant	Irving	July 15, 2010	Stay of proceedings (see Thetford Mines)
Richard Bédard	Multiple/Couche-Tard Inc.	June 12, 2008	Before the courts
Céline Bonin	Multiple/Couche-Tard Inc.	June 12, 2008	Before the courts
Donald Darby	Shell	July 15, 2010	$10,000 fine
Valérie Houde	Petro-Canada	July 15, 2010	$3,000 fine
Sylvie Fréchette	Petro-Canada	July 15, 2010	$5,000 fine
Martin Proulx	Petro-Canada	July 15, 2010	$5,000 fine
Jean-Pierre Durand	Petro-Canada	July 15, 2010	$5,000 fine
Yves Gosselin	Irving	July 15, 2010	Before the courts

Companies

Charges and sentences

Companies	Banners	Charges	Sentences
Irving Oil	Irving	September 28, 2012	Before the courts
Les Pétroles Therrien Inc.; and Distributions Pétrolières Therrien Inc.	Pétro-T	June 12, 2008	Fine (see Victoriaville)
Les Pétroles Global Inc.	Olco	June 12, 2008	Before the courts
9045-0586 Québec Inc.	Esso	June 12, 2008	Stay of proceedings and prohibition order
9046-0601 Québec Inc.	Esso	June 12, 2008	Stay of proceedings
9064-4360 Québec Inc.	Esso	June 12, 2008	Stay of proceedings
Couche-Tard Inc.	Multiple	March 25, 2010	Before the courts
134553 Canada Inc.	Esso/Shell	July 15, 2010	Stay of proceedings

Note: Adapted from the List of charges and sentences in the Quebec gasoline price-fixing cartel. Retrieved July 5, 2013 from Competition Bureau: http://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/03079.html

Appendix 2: Rates of four types of taxes on gasoline in Québec

Start	End	TPS	TVQ	TAF		TCP	
				Sherbrooke (cent)	Chicoutimi (cent)	Sherbrooke (cent)	Chicoutimi (cent)
01/01/1998	30/06/2006	7%	7.50%	10.00	10.00	15.20	10.55
01/07/2006	31/12/2007	6%	7.50%	10.00	10.00	15.20	10.55
01/01/2008	31/03/2010	5%	7.50%	10.00	10.00	15.20	10.55
01/04/2010	31/12/2010	5%	7.50%	10.00	10.00	16.20	11.55
01/01/2011	31/03/2011	5%	8.50%	10.00	10.00	16.20	11.55
01/04/2011	31/12/2011	5%	8.50%	10.00	10.00	17.20	12.55
01/01/2012	31/03/2012	5%	9.50%	10.00	10.00	17.20	12.55
01/04/2012	31/12/2012	5%	9.50%	10.00	10.00	18.20	13.55
01/01/2013	31/03/2013	5%	9.98%	10.00	10.00	18.20	13.55
01/04/2013	now	5%	9.98%	10.00	10.00	19.20	14.55

Note: data from Canada Revenue Agency.

Appendix 3: OLS results of selected models

Variable	Period I, II and III		Period I and II		Period II and III	
	Sherbrooke	Chicoutimi	Sherbrooke	Chicoutimi	Sherbrooke	Chicoutimi
AR(1)	0.278*** (0.039)	0.403*** (0.039)	0.206*** (0.049)	0.299** (0.050)	0.236*** (0.047)	0.314*** (0.047)
AR(2)	0.109*** (0.040)	0.076* (0.042)	0.113** (0.050)	0.017 (0.051)	0.081* (0.048)	0.076 (0.049)
AR(3)	0.006 (0.040)	0.058 (0.042)	0.032 (0.050)	0.039 (0.051)	0.032 (0.048)	0.084* (0.049)
AR(4)	0.058 (0.040)	0.036 (0.042)	0.063 (0.050)	0.012 (0.051)	0.100** (0.048)	0.072 (0.049)
AR(5)	-0.009 (0.040)	-0.006 (0.042)	-0.046 (0.050)	-0.042 (0.051)	-0.019 (0.048)	-0.024 (0.049)
AR(6)	-0.097** (0.039)	-0.028 (0.042)	-0.150** (0.049)	-0.079 (0.051)	-0.110** (0.048)	-0.026 (0.049)
AR(7)	-	0.008 (0.042)	-	-0.061 (0.051)	-	0.009 (0.049)
AR(8)	-	0.086** (0.042)	-	0.049 (0.051)	-	0.134*** (0.049)
AR(9)	-	-0.071* (0.042)	-	-0.011** (0.052)	-	-0.072 (0.049)
AR(10)	-	0.110*** (0.039)	-	0.080 (0.050)	-	0.093* (0.049)
February	0.274 (0.730)	-0.290 (0.822)	-0.198 (1.000)	-1.514 (1.120)	0.044 (0.881)	0.135 (1.003)
March	0.355 (0.806)	0.359 (0.889)	-0.132 (1.096)	-0.334 (1.120)	0.364 (0.970)	0.058 (1.044)
April	0.230 (0.798)	-0.628 (0.924)	-0.690 (1.057)	-0.973 (1.108)	0.129 (0.960)	-0.990 (1.094)
May	0.885 (0.790)	0.104 (0.964)	0.110 (1.038)	-0.269 (1.097)	1.057 (0.947)	0.532 (1.141)
June	1.851** (0.806)	1.194 (0.998)	1.555 (1.057)	1.468 (1.129)	1.798 (0.974)	-0.522 (1.189)
July	0.278 (0.800)	-0.477 (1.001)	-0.726 (1.064)	-0.176 (1.132)	0.756* (0.971)	-0.522 (1.192
August	0.618 (0.804)	-0.581 (1.003)	-0.360 (1.075)	-0.630 (1.146)	1.225 (0.967)	-0.343 (1.196)
September	1.884** (0.808)	1.159 (0.986)	0.854 (1.074)	0.964 (1.136)	2.644*** (0.978)	1.477 (1.177)
October	1.837** (0.808)	1.202 (0.945)	1.057 (1.079)	1.016 (1.129)	2.256** (0.980)	1.221 (1.126)
November	0.444 (0.815)	0.031 (0.904)	-0.425 (1.115)	-0.132 (1.207)	0.401 (0.986)	-0.321 (1.064)
December	0.753 (0.732)	0.031 (0.803)	-0.311 (1.017)	0.006 (1.101)	1.524* (0.887)	-0.043 (0.971)
c	5.494*** (0.479)	7.983*** (0.760)	6.465*** (0.755)	9.254*** (0.802)	5.001*** (0.704)	7.359*** (0.916)
R^2	0.148	0.271	0.116	0.157	0.142	0.225
Durbin-Watson statistic	1.995	1.997	2.003	1.983	1.999	2.004
observations	700	700	441	441	491	491

Note: standard deviations are in brackets. * is significant at 10%; ** is significant at 5%; *** is significant at 1%.