Misallocation effects of collusion under uniform pricing in differentiated-product markets

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Abstract

This article investigates the misallocation effects of collusion under uniform pricing in differentiated markets. Unlike manufacturing cartels, allocation at retail cartels is not determined by quotas but rather by the prices firms set and consumers' choices about where to shop. Under competitive pricing, more efficient firms set lower prices and, therefore, may attract larger shares of the market. Under uniform-price collusion, consumers may instead choose to purchase from more preferred firms. The extent of misallocation will depend on the correlation between consumer preferences for firms and their relative efficiency. We examine this in the context of an alleged collusive arrangement that took place in Quebec City's retail gasoline market, for which we have access to detailed data on prices, market shares, and station characteristic. We build and estimate a structural model of demand and supply during a time of competition to recover the marginal cost. With these estimates in hand, we perform simulations that highlight patterns consistent with cost misallocation under uniform-price collusion – higher-cost firms have greater sales under uniform pricing than they would under competition. However, we also find evidence that differentiation limits the extent of misallocation. We find a persistent negative correlation between marginal costs and market shares. Low-cost stations are located near consumers and have attractive characteristics.

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1 Introduction

This article investigates the effect of collusion on the misallocation of production. This subject has been studied in wholesale/manufacturing markets, where the extent of misallocation depends on the attribution of production quotas. For example, Asker, Collard-Wexler, and De Loecker (2019) study the OPEC cartel and demonstrate that it allocated sales to less efficient members: in the 1970s the market share of the more efficient OPEC countries was roughly 50% lower than it would have been under competition. Bridgman, Qi, and Schmitz (2015) examine the sugar manufacturing cartel that operated between 1934 and 1974 under the New Deal and show that the rules on quotas/side payments underlying the cartel arrangement lowered productivity by misallocating production from more to less productive sugar manufacturers. The contribution of this paper is to provide the first investigation into the misallocation effects of cartels in retail markets.

Unlike manufacturing cartels, allocation in retail markets is usually not determined through quotas but rather by the prices firms set and consumers' choices about where to shop. In most documented retail cartel cases, collusive arrangements involve simple pricing rules characterized by important nominal rigidities and limited dispersion. Under competitive models of industry conduct, the degree of misallocation in the market depends on the cost pass-through rate and on the elasticity of substitution between stations. In contrast, under uniform prices, the extent to which sales is allocated to high cost firms depend on the preferences of consumers for locations and store characteristics. Absent of price differences, consumers select products that are most convenient, and the degree of misallocation depend on product/store differentiation and the correlation between consumer preferences for products/stores and their relative efficiency.

In addition, collusive pricing may also affect the set of firms that operate in the market, creating dynamic production inefficiency. Collusion raises industry profits, facilitating entry of new firms. However, if more efficient firms have higher entry/fixed costs, and if they do not believe they will be able to disrupt the cartel by undercutting prices and gaining market share, then relatively inefficient firms will have more incentive to enter. Collusive pricing also weakens incumbent firms' incentives to lower operational costs. Under uniform pricing, firms are unable to reduce price to increase market share following a cost reduction, so the benefit accruing to firms from cost decreases is limited relative to competitive settings, reducing the incentive to invest.

We examine this allocative inefficiency in the context of a possible collusive arrangement in Quebec City's retail gasoline market, for which we have access to detailed data on prices,

market shares, and station characteristics.[1] There exists important heterogeneity in stations' operating and fixed costs (e.g., high marginal cost/low fixed cost small full-serve stations vs low marginal cost/high fixed cost large self-serve stations). Our empirical analysis contains three parts. First, we use data on prices to document high margins and near-uniform pricing in the years after 2001, persisting for several years and coinciding with shifts in nearby markets investigated by the Competition Bureau, which we argue is consistent with the emergence of collusion. We contrast pricing in this period with patterns in the 1990s when pricing was competitive and we observe significant price dispersion and lower margins. Second, we build and estimate a structural model of demand and supply of retail gasoline using station-level price and quantity data to recover consumer preferences and the distribution of marginal costs. With the demand and cost estimates at hand, we then perform counterfactual analysis to examine two dimensions of the misallocation effects generated by collusion: (i) the correlation between sales and costs and (ii) the correlation between costs and investment decisions.

In retail gasoline markets, as in other markets for spatially differentiated products, stores (stations) and consumers are geographically dispersed. Firms and their stations are also asymmetric, with different cost and network structures. For instance, some stations may be larger, which makes them more efficient due to economies of scale. These stations require more land and significant traffic flows, and so often are located at large areas of busy road intersections. Under competitive pricing, these larger firms can leverage their scale and set lower prices. In contrast, under uniform collusive pricing, consumers could potentially elect to visit more convenient outlets close to their residences, where smaller high-cost stations are located, leading to misallocation. The magnitude of this effect, however, depends on station differentiation and how much consumers are willing to drive for lower fuel prices.

Our structural model builds on Houde (2012), which takes seriously the fact that in retail gasoline markets, like other markets for spatially differentiated products, market power arises in large part due to consumer locations and travel costs. Establishing relevant markets and quantifying market power require estimating substitution patterns between own and rival stations that capture geographical differentiation. Properly estimating these patterns, therefore, requires detailed data on stations' characteristics and consumers' locations and travel patterns. Our demand model estimates are able to capture rich substitution patterns. The results show that in Quebec City's gasoline market consumers are very price sensitive

[1] Legal disclaimer: This paper analyses any alleged cartel activity strictly from an economic point of view. To our knowledge there has been no antitrust investigation into collusive practices in this market.

(own-price elasticity of -8.8) but also put significant weight on the additional driving distance to far away stations (on average consumers are willing to forgo a price that is 3 cents per liter lower to avoid driving one more minute).

With our demand estimates and data from the competitive period in our sample, we use the system of first-order conditions implied by a Bertrand-Nash pricing game to recover stations' marginal cost. To derive the marginal cost for the collusive period, we regress our marginal cost estimates on stations' characteristics that are relevant for their opportunity cost of serving consumers. Finally, we aggregate our firm-level measure of efficiency, stations' marginal cost, into a measure of industry efficiency: the sales-weighted marginal costs.

We provide a direct link between our measure of industry efficiency and an object capturing the allocation of production between firms. We draw from Olley and Pakes (1996) and decompose sales-weighted marginal costs into two components: average marginal costs and the covariance between stations' market shares and marginal costs. The sign and size of the covariance indicate the extent of static production (mis)allocation. In a competitive environment, the covariance should be strongly negative as firms with lower marginal costs tend to have lower prices and higher market shares. In contrast, with collusive uniform prices, consumers will sort based solely on station characteristics and convenience, such that the shares of high marginal cost stations increase, and the covariance shrinks.

The comparison between observed and counterfactual market share-marginal cost covariance is the basis of our analysis. We will consider three different counterfactual scenarios. In the first, we obtain the allocation of production that minimizes the cost of producing the aggregate volume of gasoline recorded during the collusive period while accounting for spatial differentiation. To do so, we use a matching algorithm that allocates consumers to stations based on driving distance, the stations' cost, and capacity. In the second counterfactual, we will obtain sales and implied market shares by assuming that stations set prices equal to their marginal cost. In this counterfactual, relative prices fully reflect firms' efficiencies. Lastly, in the third counterfactual, we will obtain equilibrium prices and market shares, assuming stations play a Bertrand-Nash pricing game. This setting is often used as the competitive benchmark in industries with differentiated goods.

Our results suggests that there is scope for misallocation in this market. In particular, we find that the range of marginal cost across stations is equal to 1.15 cpl (or 15% of average retail margins). Our Olley-Pakes decomposition results imply that higher-cost firms have higher market shares under uniform price collusion than perfect-competition, or Nash-equilibrium pricing. The difference is small in magnitude relative to the static cost

misallocation due to the spatial differentiation and idiosyncratic preferences for stations. This is true despite the fact that cost-pass through rates are high and that consumers are highly sensitive to prices. Therefore, frictions arising from horizontal differentiation explain the bulk of the static cost misallocation in this market.

We find that this relatively small effect of collusion on static misallocation is due to the fact that low-cost stations tend to be located in areas with high consumer density and offer characteristics that are valued by consumers. This highlights the importance of analyzing the dynamic misallocation effect of collusion. We do so by measuring the incentive of stations to enter the market under collusion and competition, as well as the return to investment in cost reduction technologies. Preliminary results suggests that collusion, relative to Bertrand-Nash pricing, leads to lower investments incentives and higher costs.

Literature Review

Since at least Harberger (1954), the impact of higher prices resulting from collusion on welfare has been well understood. More recently, research has shown that cartels can harm society by misallocating sales to less efficient players (see Asker, Collard-Wexler, and De Loecker (2019) and Bridgman, Qi, and Schmitz (2015)).[2] Other papers have focused more on the impact of cartels on the entry and exit of inefficient firms. Carrera (2022) studies Chile's nitrate cartel and finds collusion may provide an umbrella under which inefficient firms can survive in a market. He finds that, under collusion, the rate of entry was higher and that entrants were of lower productivity. Model simulations suggest that had competition prevailed, a quarter of entrants would have remained on the sidelines. Finally, there is a small number of papers that estimate the overall impact of collusion on productivity. See for instance Petit, Kemp, and van Sinderen (2015) and Moreau and Panon (2023).

In addition to these papers, Asker (2010) examines bid rigging in stamp auctions. Cartel participants met before auctions to allocate the right to bid and determine side payments. His findings suggest that the bidding ring resulted in limited misallocation and therefore led to only a mild decrease in efficiency. Röller and Steen (2006) study the inner workings of the Norwegian cement cartel and find that its production-sharing rule was inefficient as it provided incentive to overinvest in capacity and to export at a loss in an effort to increase their share of domestic sales.

[2]Papers in this literature are also related to the broader discussion about misallocation and productivity (see Hsieh and Klenow (2009), Midrigan and Xu (2014), Restuccia and Rogerson (2017), and Edmond, Midrigan, and Xu (2023) for discussion).

We are also related to the empirical literature on the organization of cartels, especially those papers that have focused on describing their inner workings such as Genesove and Mullin (2001), Asker (2010), Harrington and Skrzypacz (2011), Clark and Houde (2013), Hyytinen, Steen, and Toivanen (2019), Igami and Sugaya (2022), and Clark, Horstmann, and Houde (2024). Most relevant is Clark and Houde (2013), which makes use of documents submitted by the Competition Bureau to the Superior Court of Quebec containing summaries of and extracts from recorded conversations between participants in a cartel that allegedly operated in the early 2000s in the retail gasoline markets of four cities in the province of Quebec–Magog, Sherbrooke, Thetford Mines and Victoriaville. The paper describes the communication patterns and pricing strategy employed and explains the mechanism used by the alleged participants in order to solve the enforcement and coordination problems that arise in price-posting markets with heterogeneous firms. The mechanism is based on the ordering of moves and adjustment delays during price changes that allow market share transfers to *stronger* players. The paper estimates the implicit market share gains of the stronger players, and evaluates the importance of the transfers for cartel stability.

In a companion paper to Clark and Houde (2013), Clark and Houde (2014) use micro-level price data to study the impact on margins and adjustment asymmetry of the collapse of the alleged cartels in the same markets following the Competition Bureau investigation in 2005 and 2006. Notable is their result that not only do stations in the four target markets react to the Competition Bureau investigation by reducing their margins, but similar patterns can be detected in a number of other markets in the province, including Quebec City.[3,4] In more recent work, Clark, Duarte, and Houde (2024) study the price war that occurred in Quebec City in 2000.

In addition to the papers mentioned above, several other articles have examined collusion in retail gasoline markets, including Wang (2008, 2009) and Byrne and deRoos (2019) for Australia, and Chaves and Duarte (2023) for Brazil, and Sorgard and Steen (2024) for Sweden. Assad, Clark, Ershov, and Xu (2024) examine whether algorithmic pricing can facilitate collusion in retail gasoline markets. There have also been many papers written on

[3]See also Erutku and Hildebrand (2010) who estimate the collusion overcharges in the Sherbrooke market. Their results show that following the announcement of the Bureau investigation, prices decreased by nearly 2 cpl relative to Montreal, but not at all relative to Quebec City.

[4]These findings are suggestive, but not conclusive, of the possibility that collusion was widespread in the province. To our knowledge the Competition Bureau investigation was not extended to markets outside of Magog, Sherbrooke, Thetford Mines and Victoriaville, and as a result there exists no direct evidence of explicit coordination among players outside these four markets and other reasons can explain the similarities in pricing. However, we will present evidence of elevated margins and limited price dispersion in Quebec City, patterns that are consistent with either tacit and explicit coordination.

competition in retail gasoline markets more generally, including some that have focused on Quebec's retail gasoline market. See for instance, Houde (2012) and Carranza, Clark, and Houde (2015).

We are also related to a number of papers that quantify the impact of cartels on prices or the damages they impose. In addition to Clark and Houde (2014), see for instance Miller and Weinberg (2017), Clark, Coviello, Gauthier, and Shneyerov (2018), and Kim, Mansley, Miller, Remer, and Weinberg (2023).

Finally, we are related to the set of papers that have documented uniform pricing in retail markets and investigated the distributional impact on consumers. DellaVigna and Gentzkow (2019) and Hitsch, Hortacsu, and Lin (2021) study pricing at grocery stores and find that chain-level pricing is largely uniform. Adams and Williams (2019) examine pricing at hardware stores and documents zonal pricing. We add to this literature by establishing a connection between uniform pricing and collusion, and highlighting the production inefficiencies implied by such pricing rules.

Outline

The paper proceeds as follows. In the next section, we discuss in further detail the economic costs of retail market cartels. In Section 3 we describe the data used in this study and characterize Quebec City's retail gasoline market over time. In Section 4 we present the specification and estimation methodology of the model used to simulate counterfactual prices and sales. We then present and discuss the model estimates in Section 5, and the misallocation quantification in Section 6.

2 Uniform collusive price and misallocation

Under competition, market share is allocated as a function of firms' efficiencies, and persistent differences in production costs should drive inefficient firms from the market. In contrast, in situations of elevated market power, such as collusive arrangements, there is a potential for inefficient firms to survive and earn market shares at the expense of their more efficient rivals, creating the form of productive inefficiency discussed in Asker, Collard-Wexler, and De Loecker (2019). This productive inefficiency is the measure of misallocation that we are interested in and can be quantified from observed data and a model of production allocation.[5]

[5]Asker, Collard-Wexler, and De Loecker (2019) show that productive inefficiency is related to the most common measure of misallocation in the literature that uses the dispersion in revenue-based productivity.

In retail markets, the misallocation effect may be amplified as a result of the need for collusive arrangements to coordinate near-uniform prices. Uniform collusive pricing may yield allocations of sales that are different from those that would be observed if prices reflected the underlying cost and demand-side characteristics of firms operating in the market. In retail, there may be important cost asymmetries between firms based on features such as store characteristics, management structure, and network size. Under competition, larger low-cost players will post lower prices and sell more. In contrast, under collusive uniform prices consumers can opt to shop at more convenient outlets with more appealing characteristics, e.g. closer to their homes. Therefore, the consequential sales distribution from uniform prices can lead to greater misallocation depending on the level of product differentiation.

As noted in Asker, Collard-Wexler, and De Loecker (2019), the effect of collusive arrangements on overall welfare will have two distinct components. The misallocation component due to productive inefficiencies, as discussed above, and a dead-weight loss component due to output restriction. In spatially differentiated products, however, a third component arises from the consumers' disutility over non-ideal products in terms of non-price characteristics. Differences in prices in a competitive setting distort consumers' choices away from their ideal product toward cheaper alternatives. Therefore, uniform prices from a collusive arrangement can eliminate this distortion and have a positive impact on welfare, which goes in opposite direction to the negative effect from misallocation and output restriction.

The forces affecting the extent of misallocation on welfare in differentiated product markets can easily be seen from a textbook Hotelling model. In the linear city example with products located at the extremes of a unit length line and consumers facing linear travel cost t, if firms have asymmetric marginal costs $c_0 > c_1$, then the location of the marginal consumer in an interior equilibrium solution from price competition is $0.5 + (c_1 - c_0)/6t$. A welfare optimum allocation that minimizes the sum of travel and production costs would have the marginal consumer at $0.5 + (c_1 - c_0)/2t$, which is only achieved when firms set prices equal to their respective marginal cost. Furthermore, the allocation from a uniform collusive price would place the threshold at 0.5 and make misallocation worse relative to price competition, while an allocation that only minimizes production costs would have the threshold at zero, where the firm with the lowest cost produces for the entire market, and have zero misallocation. Which of the latter two conditions provides the highest welfare will depend on the level of differentiation between products, i.e. t.

In the context of retail gasoline, some stations may be larger, with more islands and pumps, some may be parts of chains, and some may be attached to other profit-drivers

such as grocery stores. Together, these may imply important heterogeneity in the levels of efficiency of these stations resulting from economies of scale. These larger stations are often located at important intersections. Smaller, less efficient stations may be located in residential neighborhoods and these stations could benefit from uniform collusive prices depending on how important travel costs are for consumers.

In this setting, there is also considerable heterogeneity in station operating and fixed costs (e.g., high marginal cost/low fixed cost full-serve stations vs low marginal cost/high fixed cost large self-serve stations). As a result, in addition to the contemporaneous effects just described, uniform collusive prices may also determine which firms operate in the market, generating a dynamic production inefficiency. Dynamic effects may arise caused by the increase in profits flowing to high-cost firms, which allow them to continue operating instead of exiting the market. Collusion increases industry profits, facilitating entry of new firms, but if more efficient firms have higher entry/fixed costs, and if they do not believe they will be able to disrupt the cartel by undercutting prices and gaining market share, then only relatively inefficient firms would have incentive to enter. Collusive pricing also weakens incumbent firms' incentives to lower operational costs. Under uniform pricing, firms cannot lower their price to increase market share following a cost reduction, so the benefits flowing to firms from cost decreases is limited relative to competitive settings, reducing the incentive to invest.

3 Data and Industry Backround

3.1 Data

Our main data source is Kent Marketing, the leading survey company for the Canadian gasoline market.[6] Kent surveys price and sales information for the universe of stations in many large Canadian markets (including Québec City) for one day every two months (less often in smaller cities). The survey contains accurate measures of the volumes sold for each fuel grade since the last read, along with information on station characteristics and their addresses. It also provides a snapshot of the prices for each grade collected on the date of the survey. We have this information from August 1992 to June 2001, as well as isolated periods during 2004 and 2007 (and for certain periods for a handful of other markets). The available time range allows us to capture periods of both high-dispersion and near-uniform

[6]Now known as Kalibrate Canada Inc.

prices, as we explain in further detail in the next section.

We complement the Kent data with three other data sets. First, we have access to weekly retail price information from the Régie de l'énergie du Québec (Québec's energy board), which surveys a sample of stations in a number of cities across the province in an effort to monitor retail gasoline prices. We observe station-level prices from December 1997 until February 2004 for around 13 stations in Québec City (and in some other markets in the province too). The Régie also provides information on the weekly price floor for each market, which we use as a proxy for costs (further information on the floor is provided in the next section). Second, since the Régie price survey only runs until early 2004, we complement this information with a similar survey data from MJ Ervin, a market research company.[7] MJ Ervin data cover the period from January 2001 to November 2012 for 15 stations in Québec City.[8] Finally, we 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.[9]

To estimate our model of station choice, we also make use of data on the population residency distribution and commuting patterns along with the distance / driving time for each commute route. We describe these data in more detail when we discuss the model.

3.2 Québec City's retail gas market

There are three different types of stations operating in the Québec City market: refinery-owned, and both branded and unbranded independents. Independent branded stations make up a significant share of the Québec City market (49%, 24%, 41%, and 40% of stations associated with the four majors, Esso, Petro Canada, Shell and Ultramar, respectively) and operate under two different types of contracts – commission-based and cross-lease. Both types of vertical contracts are negotiated every three to five years, reflecting local market conditions.

During our sample period, commission-based contracts were used mainly by Ultramar, the largest chain of branded retailers, which owned the nearest refinery at the time. The contracts involved Ultramar controlling the inventory and setting the price, with the station owner receiving a commission. Rather than using this arrangement, most independent branded retailers signed long-term cross-lease contracts with a refiner. The structure of these

[7] MJ Ervin performed the survey at the time, but was subsequently acquired by Kent Marketing, which in turn was acquired by Kalibrate Canada Inc.

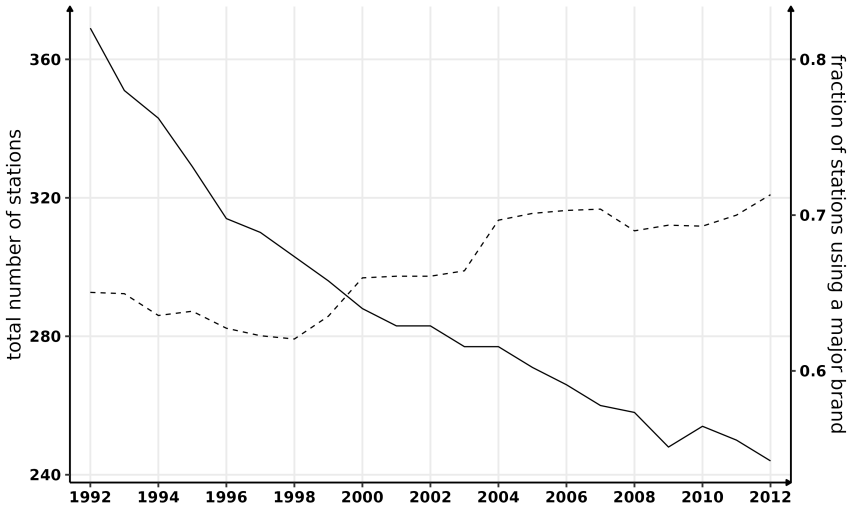
[8] Table 8 in the Appendix summarize the time coverage of each data set.

[9] Houde (2012) and Clark and Houde (2013) also use these data.

contracts differs between stations and brands, but the idea is that the independent retailer leases the facility to a refiner, and the refiner leases it back to the retailer under various terms and conditions.[10] Stations operating under cross-lease contracts are responsible for setting the retail price but face a non-linear compensation scheme.[11]

Horizontal market structure: Québec City became steadily more concentrated over the years. In Figure 1 we present the evolution of the total number of stations and the network size of the five largest brands (hereafter major brands).[12] In the first half of the 1990s, the retail market was relatively unconcentrated, with as many as 360 stations in the market and the network of stations affiliated with a major distribution brand accounting for 64% of stations and 70% of fuel sales in 1993. However, by 2004 the total number of stations had already fallen by 22%, while the networks of the major chains expanded to 68% of the market and their share of sales increased to 79%.

Figure 1: Evolution of Number of Stations & Major Brands Network



Notes: Evolution of the total number of stations(solid line) and the network size of the five largest brands(dashed line).

These changes in market structure can be linked to an important reorganization that took place throughout the 1990s in most North American retail gasoline markets. This

[10]The main reason for the existence of these contracts is that they allow the upstream supplier to maintain access to the site in the event that the station owner sells the property.

[11]These agreements specify what equipment must be installed at the facility (e.g. pumps and convenience store), and determine the structure of the retailer's compensation. The cross-lease contract specifies a "lease" paid to the station operator, which is expressed on a per-volume basis (e.g. 1.6 cpl), but not the wholesale price since it is not contractible due to fluctuations in oil prices.

[12]The largest five brands were

transformation was a response to technological innovations such as automated service and better inventory control systems, and was characterized by an increase in the size and automation of stations that resulted from the entry and reconfiguration of larger and more efficient stations, and the exit of smaller stations.

The early years of the 1990s marked the start of this reorganization in Quebec City. Table 1 presents summary statistics for size, amenities, prices, and sales volume for three different periods of our sample. As can be seen from the standard deviation for the number of pumps and islands, the size of stations can vary greatly. The difference in size is also reflected in the large variation in the daily volume sold between stations. Moreover, over time, the average station gradually became larger and invested more in convenience stores rather than repair shops.

Table 1: Summary Stats

	Fall-1993		Fall-1999		Fall-2004	
Price (cents/liter)	66.18	(0.67)	66.04	(0.81)	83.96	(0.58)
Volume (ths liters/day)	3.59	(2.21)	5.19	(3.33)	6.13	(3.58)
Number of pumps	5.87	(4.09)	7.22	(4.96)	8.10	(5.44)
Number of islands	2.20	(1.34)	2.38	(1.40)	2.51	(1.41)
Large convenience	0.25	(0.43)	0.31	(0.46)	0.41	(0.49)
Repair shop	0.31	(0.46)	0.24	(0.43)	0.21	(0.41)
Carwash	0.20	(0.40)	0.19	(0.39)	0.19	(0.39)
Major brands share	0.70	(-)	0.76	(-)	0.79	(-)

Changes in management strategy that took place in the mid-1990s in Quebec City's market have also impacted competition and influenced the pace of reorganization. Ultramar was the largest chain of branded retailers in the market, and it maintained tight control over stations under its brand through a combination of lessee retailers acting under commission and company-owned stores. In the summer of 1996, Ultramar instituted a low-price guarantee policy known as Valeur-Plus (or ValuePlus). Each Ultramar station was required to list the lowest price among stations located within *close proximity*. [13] The low-price guarantee, together with highly elastic local demand, made it difficult for other stations to raise their prices much above those of a nearby Ultramar station. In 1996, following the announcement of Ultramar's new pricing policy, we observe a price war with a significant drop in the price

[13] To operationalize the guarantee, Ultramar employed a team of regional representatives who were responsible for establishing and adjusting prices. The company has also established a centralized pricing center that monitors prices throughout the province and has provided a free phone line through which rival stations and consumers can report discrepancies.

level of gasoline, with some stations charging retail prices below the wholesale price posted on the terminal ramp.

The transition to larger and more efficient stations and Ultramar's pricing policy greatly squeezed the margins of small independent stations, and encouraged these retailers to lobby for government relief.[14]

Price floor regulation: At the start of 1997 as a response to the price war, the provincial government enacted a weekly floor price for all gasoline retailers in Quebec in an effort to protect small independent retailers. The price floor is determined according to the following approximation for the average marginal cost of selling gasoline in each local market m at time t:

$$MEP_{mt} = w_t + \tau_{mt} + T_{mt}, \tag{1}$$

where w_t is the minimum wholesale price at the terminal, τ_{mt} is an estimate of the transportation cost to deliver gasoline from the refinery to market m, and T_{mt} is the sum of federal and provincial taxes. Since most stations (especially branded stations) pay a wholesale price below w_t through negotiated discounts, the MEP is an upper bound on the marginal cost of selling gasoline.[15] After the enactment of the floor, we observe price margins rising again.[16]

The enactment of the price floor, however, was not sufficient to prevent the occurrence of a second price war beginning in January 2000. As mentioned, most independent retailers operating branded stations sign long-term *cross-leased* contracts with a refiner. Due to borrowing constraints and large fixed costs, retailers are particularly sensitive to the risk of earning negative profits during periods of low margins. To transfer part of this risk to the refiner, crossed-leased contracts include a "minimum margin" clause that effectively protects retailers against this "price war" risk. These clauses establish a lower bound on the gross margin earned by a retailer during a given delivery period. However, price-support clauses expose refiners to an important moral hazard risk – when the market price is such that the retail margin that an independent station would earn is close to, or lower than, the minimum

[14] Although the price war in 1996 was more likely the result of excess capacity in the industry and fierce price competition, according to the Régie this price war was caused by predatory pricing behavior by the major retail chains. An investigation by the Competition Bureau of Canada did not find any evidence of predatory behavior.

[15] The price floor is determined and posted on the Régie's website every Monday.

[16] In situations where firms repeatedly price below the floor, the regulation stipulates that the Régie can impose an additional minimum margin on top of the floor that allows the it to add \$0.03 per liter in a specific region following a period of sufficiently low prices. This minimum margin has two objectives. First, it establishes an implicit price floor, below which the Régie assumes stations are not covering their fixed operating costs. Second, it allows the Régie to indirectly compensate stations following a price war.

margin, the retail owner has a unilateral incentive to lower its price in order to increase its volume. In 2000 one station owner was entering the last year of its agreement with one of the major brands. This substantially weakened the ability of upstream companies to punish and, since this was a long-standing contract that may have enjoyed more favorable clauses than the contracts of its rival, the owner of this station had high incentives to substantially decrease prices.[17] This triggered a reaction from other station owners and led to price cuts across Québec City, with many stations charging no markup at all throughout the year 2000.

On December 13th 2000, the Association of Independent Gasoline Retailers (AQUIP) filed a complaint with the Régie based on its responsibility for enforcing the price floor regulation. Independent retailers asked the Régie to investigate violations of the regulation preventing stations from posting a price at or below the MEP. The goal of the investigation was twofold, first to determine if a violation of the law had occurred, and second, to evaluate whether the price war caused sufficient damages to justify raising the floor. The investigation focused on the period between September and November 2000. The Régie concluded that the severity and geographic extent of the price war justified government intervention. The final report states that "*it [the Regie] intends to send a clear message to market participants that market aberrations are not tolerated and that the rationalization of the market must continue according to the rules of free competition for the benefit of consumers.*"[18] The price floor in Québec City was raised by 3 cpl for a period of three months starting on June 27th, 2001. In a 2004 report, the Régie later examined the Québec City market and concluded that the intervention had been successful at *"preventing prolonged periods of price war."*

3.3 Conduct

The significant losses generated by the price war and the strong response from the regulatory agency (triggered by the retailers' lobby) had a significant impact on the conduct of firms during the subsequent years. Figure 2 characterizes the evolution of the median margin and price dispersion in Quebec City for the period before and after the 2000 price war. By 2001 margins had already recovered to a level above 5 cents per liter, and retailers sustained margins at least this high until 2008.[19] At the same time, price dispersion in Quebec City

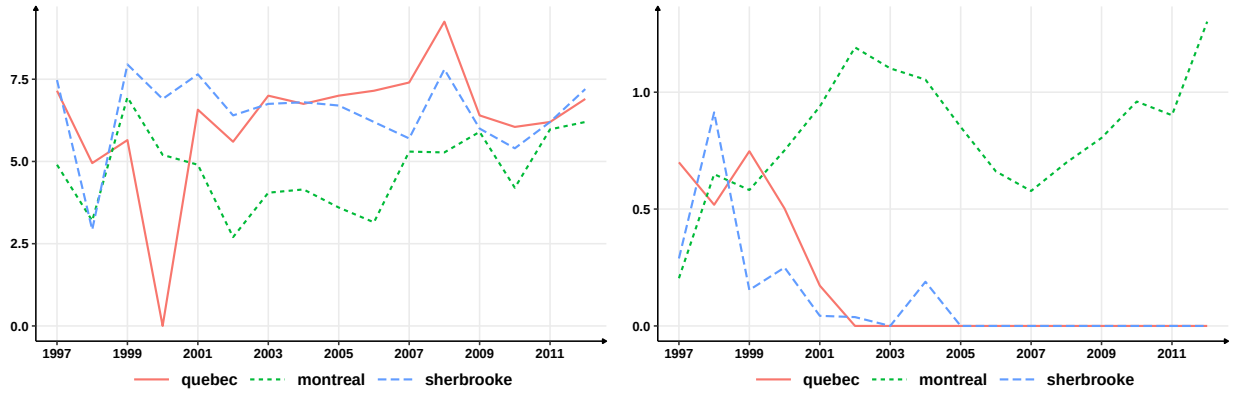
[17] Anticipating this, under complete information, no refiner should have been willing to sign such an agreement. However, since the contract was signed during an earlier period of high margins, it is likely that market participants did not anticipate the decrease in volume and margins associated with the 1998 increase in crude prices.

[18] See Régie (2000).

[19] The convergence in margins between Montreal and Québec starting in 2007 is consistent with the findings in Clark and Houde (2014) and Erutku and Hildebrand (2010) regarding the impact of the collapse of the

diverged significantly from what is observed during the 1990s. The weekly standard deviation had a sharp reduction after 2001 and by 2003 reached a point where price surveys could not capture any differences in prices throughout the market.[20]

Figure 2: Evolution of Price Margin and Dispersion in Québec City, Montreal and Sherbrooke



(a) Weekly Median Price Margin

(b) Weekly Price Standard Deviation

Source: Régie de l'Énergie du Québec (1998-2001), and MJ Ervin (2001-2012). We aggregate weekly observations using the median value in a year. The average number of stations survey in a week is 7, 10 and 5 for Montreal, Quebec City and Sherbrooke, respectively.

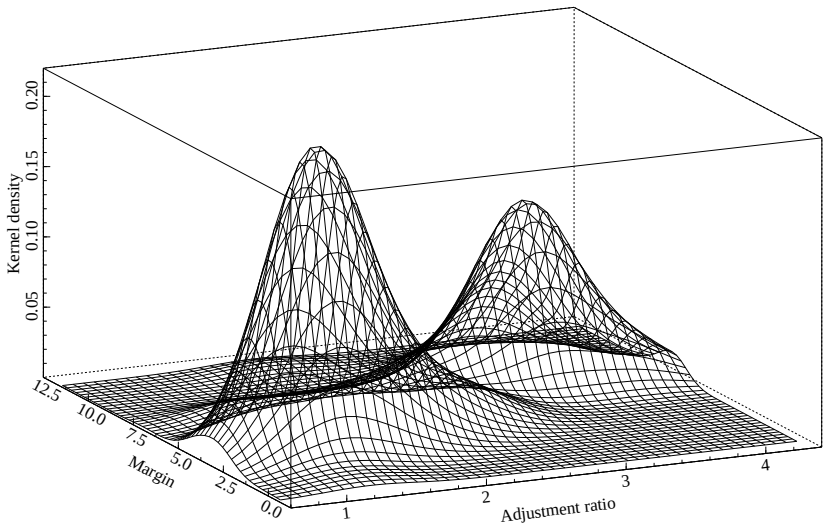
To provide evidence that the pricing pattern observed after the 2000 is due to a change in conduct, in Figure 2 we contrast the evolution of margins and price dispersion in Quebec City with two other markets in the province, Sherbrooke and Montreal. These two cities provide useful benchmarks when studying margins and price dispersion in Quebec City. First, even taking into account level differences stemming from supply chain heterogeneity, the costs in these three cities fluctuate in a similar fashion. Second, as mentioned, Sherbrooke was one of the cities targeted by the Competition Bureau of Canada in its investigation into price fixing, while there is no evidence that Montreal was ever suspected of any wrongdoing. We can see from the figure that prior to 2000 margins and price dispersion in Quebec City are similar to what is observed in Montreal. However, starting in 2001 there is an important divergence, with margins in Quebec City much higher than those in Montreal, and price dispersion significantly lower. In contrast, during this later period the pricing pattern observed in Quebec City closely resembles what is observed in Sherbrooke.

As further evidence that prices may have been coordinated in Quebec City we consider

alleged cartel in nearby cities following the Competition Bureau's investigation.

[20] One might be concerned that this is driven by the fact that the Régie and MJ Ervin only surveyed a small number of stations (around 10). But the drastic reduction in price dispersion is also observed in the single day market snapshots from the more comprehensive Kent dataset.

Figure 3: Joint density of margins and adjustment asymmetry between January 2002 and May 2006



Notes: Reproduction of Figure 3a of Clark and Houde (2014).

the findings presented in Clark and Houde (2014) regarding pricing patterns in the four markets targeted by the Competition Bureau investigation as compared to other markets in the province. In particular, they noted that several markets in the eastern part of Quebec, including Québec City, had pricing patterns similar to those in the four cities targeted by the Bureau and in stark contrast to the pattern observed in the western part of the province. Specifically, they document that the markets in the target cities had high margins and asymmetric pricing adjustments (i.e., price changes $\neq$ cost changes).[21] Figure 3 is reproduced from their paper and displays the joint density of of margins and adjustment ratios for each station in Québec before the Competition Bureau's announcement of its investigation in the four target cities in May 2006. The joint density displays a clear bi-modal pattern, indicating a strong positive correlation between margins and adjustment asymmetry, as well as the presence of two distinct types of stations. In the lower-left quadrant, we see a group of stations with more competitive pricing, characterized by low margins (3–4 cpl) and relatively symmetric price adjustments (with adjustment asymmetries close to 1.5). Most

[21] They measured the symmetry of price adjustments for station j in period t in the following manner:

$$\text{Adjustment ratio}_{jt} = \frac{\text{Median price increases}_{jt}}{\text{Median price decreases}_{jt}} \Big/ \frac{\text{Median floor increases}_{jt}}{\text{Median floor decreases}_{jt}}.$$

of those markets are located in the western part of the Quebec province, such as Montreal. In contrast, the upper-right quadrant contains a group of stations with higher margins and pronounced asymmetric price adjustments, many of which are located in the investigated cities and in Quebec City.

4 Structural model

The new equilibrium with near uniform prices and high margins that started in 2001 could imply a very different sales distribution between low- and high-cost stations and incentive to invest in cost-reducing technology than the one observed during the competitive period in the 1990s or contemporaneously in other markets. We consider these possible diversions as a misallocation of production stemming from the uniform pricing strategy. To quantify the misallocation, we need to estimate marginal costs and predict what prices, quantities, and variable profits would have been in the absence of collusion. Doing so requires a model of consumer and firm behavior, which we describe in this section.

Demand

Location plays an important role in gasoline retail markets. Although fuel is a homogeneous product, stations and consumers are geographically dispersed, so that consumers view each station differently according to how far they must travel to fill the tank of their vehicles. To incorporate such spatial differentiation into the demand model, we follow Houde (2012) and model consumers' station choices, while also taking into account the extra time that a given station imposes on consumers' commute times.

We model gas station demand as a discrete choice problem, with consumer i choosing between purchasing gasoline from one of the J stations or the alternative option of not purchasing fuel and using a different mode of transportation, such as public transport. Consumer i is characterized by an origin-destination pair (o, d). Let $r(\cdot, \cdot)$ be the function that determines the shortest driving time between two points. We define the distance from consumer i to gas station j as the additional driving time incurred by i from its commuting path when driving to j. Then our measure of distance between i and j is given by

$$D_{ij} = r(o, j) + r(j, d) - r(o, d). \tag{2}$$

The conditional indirect utility for consumer i of choosing alternative j during time period

t is:

$$u_{ijt} = \begin{cases} X_{jt}\beta + \alpha p_{jt} + \lambda D_{ij} + \xi_{jt} + \epsilon_{ijt} & j = 1, ..., J \\ \epsilon_{i0t} & j = 0, \end{cases}$$

where X_{jt} is a vector of stations characteristics, p_{jt} is the posted price, ξ_{jt} is an index of unobserved (to the econometrician) station characteristics, and ϵ_{ijt} is an i.i.d random utility shock that we assume has a Type 1 Extreme Value distribution. The set of observed station characteristics, X_{jt}, includes the number of pumps and the number of islands, a dummy variable indicating the presence of a repair shop, a dummy variable indicating the presence of carwash, a dummy variable indicating the presence of a convenience store, a dummy variable indicating if the station is self-service and brand fixed effects.

We decompose ξ_{jt} into three components: $\xi_{jt} \equiv \xi_j + \xi_t + \Delta\xi_{jt}$. The component ξ_j captures stations' unobserved characteristics fixed over time, such as the side of the street, size of the parking lot, and road congestion. ξ_t captures time-varying factors common across all stations, such as the price of public transportation, weather, and economic factors. Lastly, $\Delta\xi_{jt}$ is the structural error term that captures deviations from ξ_j and ξ_t, such as switches in the direction of traffic due to road construction.

From the assumption that ϵ_{ij} is i.i.d Type 1 Extreme Value, we obtain the probability of buying from store j for consumer i as:

$$Pr_{j,i} = \frac{\exp(\delta_{jt} + \mu_{ij})}{1 + \sum_k \exp(\delta_{kt} + \mu_{ik})},$$

where $\delta_{jt} = X_{jt}\beta + \alpha p_{jt} + \xi_j + \xi_t + \Delta\xi_{jt}$ is the mean value of store j and $\mu_{ij} = \lambda D_{ij}$ is the consumer/station heterogeneity term.

Because heterogeneity in consumer taste is fully defined by the individual commute path, we can substitute the individual index i for the origin/destination pair (o, d). Let $R_{(o,d)}$ be the measure of consumers located in a given origin/destination pair. To obtain the predicted demand at the store level, we aggregate the individual choice probabilities $Pr_{j,(o,d)}$ over every origin/destination pair:

$$s_j = \sum_d \sum_o Pr_{j,(o,d)} R_{(o,d)}.$$

The distribution of consumers across commute paths is computed using census track population data from the census and traffic flow information from the origin/destination survey by

the Quebec government for flow between 950 geographical points across Quebec City Census Metropolitan area.

Supply

Consider the problem of a firm f that owns a subset of the J gas stations ($\mathcal{J}_f$) operating in Quebec City in a given period t. Conditional on a vector of prices $\mathbf{p}_{-f}$ posted by the competing firms, the station chain f sets prices $\mathbf{p}_f$ to maximize profits:

$$\max_{\mathbf{p}_f} \sum_{j \in \mathcal{J}_f} \big(p_j - c_j\big) Q_j(\mathbf{p}_f, \mathbf{p}_{-f}). \tag{3}$$

The system of J first-order conditions obtained when simultaneously solving the profit maximization problem for all firms characterize the equilibrium of the pricing game. Expressing the system of first-order conditions in matrix notation, we obtain:

$$\mathbf{q}(\mathbf{p}) + (\mathbf{\Omega} * \mathbf{\Delta})(\mathbf{p} - \mathbf{c}) = 0, \tag{4}$$

where $\mathbf{\Omega}$ is a $J \times J$ matrix capturing the ownership structure in the market ($\Omega_{ij} = 1$ if $i, j \in \mathcal{J}_f$ and 0 otherwise), $*$ denotes the element-wise product, and $\mathbf{\Delta}$ is the Jacobian matrix of the demand system ($\Delta_{ij} \equiv \partial q_j(\mathbf{p})/\partial p_i$).

We recover the marginal cost for each gas station j by inverting the system of equations in (4). Cost estimates are a function of market shares, the Δ implied by the demand model, and any assumption about the ownership structure Ω. Assuming that a Bertrand-Nash pricing game reasonably approximates the competitive environment observed during the period before the 2000 price war, the observed price and sales data are sufficient to construct marginal cost measures for each station-period in our sample. In our empirical results, we recover costs only for the bi-month periods of 1999, as we are more confident about the competitive conditions.[22] For the ownership structure, we rely on our knowledge about the vertical contracts and assume an RPM model in which refineries set prices for all their entire network of stations.

To compute marginal cost estimates for periods where quantity data are unavailable, we decompose the estimated marginal cost into four components:

$$c_{jt} = W_{jt}\gamma + \theta MEP_t + \omega_b + \eta_{jt}. \tag{5}$$

[22] Our assumption relies on the fact that we observe price dispersion, and the margins measured as the price difference from the price floor are relatively small.

The first term, Wjt, contains station characteristics, such as the number of pumps and dummies for convenience store, carwash, and repair shop to capture the service costs a station incurs when selling to consumers. The second and third term, MEP and a supplier fixed effect ω_b, capture the costs stations face when purchasing fuel from refineries. Finally, η_{jt} is a mean-zero cost shock that is unobserved by the econometrician and captures events such as delivery delays and temporary wholesale price discounts.

Identification

In this section, we discuss the assumptions necessary to identify the parameters of the demand model - α and λ - that are key to determining own- and cross-price elasticities. Formally, the key identifying assumption is that, conditional on location fixed effects, the unobserved demand shocks of each station, $\Delta\xi_{jt}$, evolve independently of the attributes of nearby competitors:

$$E[\Delta\xi_{jt}|X] = 0,$$

where X is a matrix containing the characteristics of all stations for all periods t. The validity of the conditional moment restriction relies on the assumption that the transitory demand shocks do not influence stations' entry and exit decisions. This assumption is valid if stations make entry/exit and remodeling decisions based on the location's time-invariant characteristics. Given the magnitude of entry costs, we believe this is a good approximation.

In an oligopolistic setting, equilibrium prices and quantities depend on the unobserved demand shocks. This dependence leads to an endogeneity problem when estimating the demand price coefficient. To overcome this endogeneity problem, we use instruments designed to capture exogenous price variation generated by the Sunoco and Ultramar merger in 1996.[23] The merger affects the price of the stations owned by the merging firms because it allows them to internalize cannibalization effects, and it affects the price set by non-merging firms through a competitive effect. Because the merger involved every Ultramar and Sunoco station in Quebec, the change in ownership is unlikely to be correlated with the demand shocks of particular stations in Quebec City once we condition on the location fixed effects.

We follow the retrospective merger analysis to construct the price instruments based on the Ultramar/Sunoco merger and construct extra driving time rings of 90 seconds around Ultramar/Sunoco stations. The first instrument is a dummy variable equal to one if the

[23]For more details on the merger see Houde (2012).

station is within the 90-second ring and zero otherwise. The second instrument is the interaction of this dummy with a dummy equal to one for the post-merger period and zero otherwise.

The non-linear parameter λ captures the disutility for consumer i of driving one extra minute from the commuting path to a station. Heuristically, since we include location fixed effects, the covariance between changes in market shares and changes in measures of local competition should be informative about λ. For instance, if the entry of a station has a strong negative impact on the market share of nearby competitors only, then the travel cost parameter should be large. In contrast, if the entry of a station has a strong negative impact on the market share of nearby and far away competitors, then the travel cost parameter should be small.

For each station j, we construct two sets of instruments that measure the extent of local competition it faces. Following from the conditional moment restriction, the first set of instruments is constructed by counting the number of stations within a given driving distance bandwidth that have the same status as j (self-service, full-service):

$$Z_j^a = \sum_{k \neq j} \mathbf{1}(d_{jk} \in b) \times \mathbf{1}(x_j = x_k),$$

where b indexes the driving distance bandwidth ($[0, 250m]$, $(250m, 500m]$, $(500m, 750m]$), and d_{jk} is the driving distance in meters between stations k and j. The variation in this set of instruments is driven by the entry/exit of stations, which we showed in Figure XX to be meaningful during our sample period.

The second set of instruments captures the degree of local competition faced by station j during the price war. Specifically, for each station j in 2000, we count the number of stations within a driving distance bandwidth that charges a price lower than j:

$$Z_j^b = \mathbf{1}(t = 2000) \sum_{k \neq j} \mathbf{1}(d_{jk} \in b) \times \mathbf{1}(p_j - p_k > 0),$$

where b and d_{jk} are defined as in the first set of instruments. The validity of the second set of instruments relies on two assumptions: (i) that the price war observed in 2000 is independent of the transitory demand shocks stations face, and (ii) that during the war, prices were only a function of supply-side factors. These assumptions seem reasonable in our context. For instance, Clark, Duarte, and Houde (2024) argue that the war was caused by the expiration of the exclusive dealing contracts between stations and refineries, which were signed years in

advance. Furthermore, stations often set prices below the MEP during the war, suggesting that their costs and not demand were the relevant factor affecting pricing decisions.

5 Model Estimates

The left panel of Table 2 displays the demand estimates. All coefficients are precisely estimated and with the exception of repair shop and convenience store, have the expected sign. The estimate of the price coefficient implies a median own-price elasticity of -8.8, indicating that consumers are price sensitive regarding the decision of which station to purchase. The travel cost parameter is precisely estimated but not directly interpretable. To understand its economic magnitude, we consider the price difference that would justify a one-minute increase in driving time from the commuting path. This value is obtained by taking the ratio λ/α, which is equal to 2.99 cpl. Given the average price in our sample of 67 cpl, this implies that consumers are willing to forgo savings of approximately 4.5% of their purchase value to avoid a one-minute increase in their driving time.

Table 2: Model estimates

Demand		Supply	
Linear parameters - δ		*Marginal Cost*	
price (α)	-0.14 (0.027)	MEP	0.698 (0.0041)
# pumps	0.026 (0.003)	# pumps	-0.022 (0.005)
# islands	-0.003 (0.012)	no conv. store	0.383 (0.088)
repair shop	-0.277 (0.049)	repair shop	0.384 (0.102)
carwash	0.118 (0.036)	carwash	-0.117 (0.081)
conv. store	-0.146 (0.035)	self-service	0.12 (0.07)
self service	0.122 (0.028)	ultramar	-1.15 (0.084)
		constant	15.45 (0.242)
** check sd *Non-linear parameters*			
travel cost (λ)	-0.418 (0.103)		
J stat	0.853	Avg. Markup(cents)	8.11
# IVs	7	R-squared	0.922
λ/α	2.99	Obs.	1,773
Med. Own price elast.	-8.82		
Obs.	14,938		

Notes: Standard errors are robust to spatial correlation.

To develop a better understanding of the substitution patterns implied by the demand

model, Table 3 displays the average cross-price elasticities for different driving distance bandwidths around individual stations. We find that cross-price elasticities decrease substantially when the driving distance between stations increases above 1000m. This substitution pattern suggests that, for drivers in Quebec City, proximity between stations is an important source of differentiation.

Table 3: Cross-price elasticities

Cross Price E	$\leq$ 500m	$(500m, 1000m]$	$(1000m, 1500m]$	$>$ 1500m
Mean	0.327	0.30	0.21	0.02
SD	0.35	0.32	0.20	0.004
P10	0.073	0.07	0.06	0.01
P90	0.75	0.68	0.45	0.02
Avg. # Stations	0.71	1.3	1.7	252

The marginal costs are obtained under the assumption that prices are set competitively at the brand-chain level(RPM) and use only data from 1999, a year for which we are most confident that neither price wars nor collusion took place.

The right panel of Table 2 displays the summary statistics for the pricing regression. The model implies a median markup of $8.1cpl$, which is approximately $2.5cpl$ higher than the median markup we obtain when using the price floor as the only marginal cost measure. The difference between these two margins likely reflects the fact that stations are able to obtain wholesale price discounts that more than compensate for the operational cost included in the calculation of the price floor. The marginal cost estimates are precisely estimated, except for the carwash and self-service dummy variables. Considering the number of pumps as a measure of station capacity, we find that larger stations have a lower marginal cost, consistent with our intuition. The positive coefficient on the *no convenience store* dummy indicates a complementarity between gasoline sales and the presence of a convenience store, which is consistent with anecdotal evidence that stations with convenience stores often use gasoline as a loss-leader product. This complementarity is not observed in the case of repair shops, which is in line with the overall trend in the industry of newer and more productive stations focusing on size and high-margin services, such as convenience stores. Finally, the results indicate that Ultramar stations have a substantial cost advantage over the other stations operating in Quebec City, which is consistent with Ultramar having the largest network, operating as a vertically integrated firm, and owning the main gasoline refinery in Quebec at the time.

6 Misallocation effects of uniform price strategy

We use a model-based approach to evaluate the extent of misallocation caused by the collusive uniform price observed in Quebec City after 2001. To measure the extent of misallocation, the literature has mainly used revenue-based estimation of total factor productivity dispersion and investigated the extent to which inputs could be reallocated between firms within an industry to increase total output. Asker, Collard-Wexler, and De Loecker (2019) show that using dispersion in total factor productivity between firms to quantify misallocation is analogous to using dispersion in marginal costs. In what follows, we draw from Asker, Collard-Wexler, and De Loecker (2019) and rely on marginal cost estimates to measure production misallocation. Our analysis focuses on understanding two dimensions of misallocation. One is static, driven by the contemporaneous allocation of sales to high-cost stations. The other is dynamic, driven by retailers' investment decisions, such as entering and exiting the market and spending on cost-reduction technologies.

6.1 Counterfactuals

Our starting point is to obtain counterfactual station-level marginal costs for a period in which the collusive uniform price was in place. To this end, we use the cost function estimates from Equation 5 based on 1999 data to predict what stations' marginal costs would have been during 2004 Sep-Oct. Our estimate of marginal cost for 2004 updates the rack price accordingly and considers the characteristics of any newly active station. With the predicted marginal costs for each station in 2004 Sep-Oct, we simulate the market equilibrium in five counterfactual scenarios:

1. *Marginal cost pricing*: Each station sets price equal to its marginal cost. Even though this is not a realistic conduct, as stations would not be able to cover fixed costs, it provides a benchmark in which prices fully reflect stations' efficiencies.

2. *Store-level pricing*: Each station j sets price independently without internalizing the diversion to stores carrying the same brand as j. This counterfactual provides the competitive benchmark in a differentiated goods setting.

3. *RPM*: Brand suppliers set prices of stations carrying their brand jointly. This is the same assumption we made to recover marginal costs for 1999. This counterfactual provides an intermediary baseline in which brands set prices independently from each other but are still able to internalize the diversion within their network of stations.

4. *Joint-pricing*: Stations set prices in order to maximize joint profits. This counterfactual captures the ideal collusive pricing.

5. *Cost-minimizing benchmark*: Allocation mechanism designed to minimize the cost of producing the aggregate volume of gasoline recorded in 2004 Sep-Oct while accounting for spatial differentiation. The algorithm is as follows:

    a. Let C consumers arrive at the market needing to buy gasoline. Each station k can serve up to $200 \times S_k$, where S_k is the number of pumps in station k.[24] As before, we define each consumer's choice set by its commuting path, e.g. stations within x minutes of extra driving time).

    b. We draw a consumer out of the C consumers who arrived at the market. The consumer goes to the lowest-cost station in its choice set and purchases its desired quantity. The number of available pumps in that station is updated to $200 \times S_k - 1$. If no station is within the extra driving time bandwidth, that consumer does not purchase gasoline. If the lowest-cost station is already at capacity, the consumer goes to the next lowest-cost station.

    c. We keep drawing consumers until the total quantity sold equals the total quantity we observe in the data under the collusive uniform price.

We repeat the process described in a) to c) 100 times for different sequences of consumer arrival and report the averages across simulations. We consider two different thresholds to define the consumer choice set: all possible stations in the market; and 3.25 minutes extra driving time from the commute path. The first threshold gives us the minimum possible production cost and corresponds to the maximal efficiency. The other is closer to the average extra driving time observed in the data.

To facilitate the comparison across time periods, the first panel of Table 4 summarizes the distribution of the component of marginal cost that depends only on station characteristics ($W_j\gamma$). This component is the main source of cost heterogeneity across stations and reflect differences in stations' opportunity cost of serving customers. With an average of 15 cpl, standard deviation of 0.6 cpl and difference between 10th and 90th percentile at 1.5 cpl, the results indicate meaningful marginal cost dispersion between stations. Therefore, the misallocation of production across stations is a potential market feature.

[24] We obtain the factor of 200 by assuming that a station is open 14 hours per day and that each customer takes approximately 4 minutes to get in, fill the tank and exit.

Table 4: Counterfactual summary statistics

	Mean	SD	P10	P90	Total
Marginal Cost (cpl)					
	15.02	0.57	14.24	15.75	
Markups (cpl)					
Uniform Price	13.31	0.84	12.54	14.15	
Store	7.53	0.43	7.24	7.96	
RPM	8.32	0.78	7.44	9.28	
Joint Profit	17.99	3.21	14.82	23.82	
Quantity (L)					
Uniform Price	6,675	3,923	2,833	11,540	1.8mn
P = MC	9,814	6,076	3,649	17,657	2.7mn
Store	8,286	4,953	3,207	14,776	2.3mn
RPM	8,095	4,897	3,332	14,570	2.2mn
Joint Profit	5,554	3,409	1,983	10,057	1.5 mn
$\frac{\Delta P_j}{\Delta c_j}$					
Uniform Price	-	-	-	-	
P = MC	1	0			
Store	0.957	0.037	0.911	0.989	
RPM	0.958	0.036	0.911	0.989	
$\frac{\Delta Q_j}{\Delta c_j}$					
Uniform Price	-	-	-	-	-
P = MC	1,367	829	504	2,495	
Store	1,110	644	426	1,927	
RPM	1,087	636	445	1,888	

The second and third panel of Table 4 display summary statistics on markups and sales. The statistics are obtained for the collusive uniform price observed in the data and the five counterfactual scenarios previously described. The markup summary statistics highlight two relevant patterns. First, because markups implied by RPM (8.32 cpl) are substantially closer to markups implied by single store pricing (7.53 cpl) than markups implied by joint profit maximization (17.99 cpl), we have that even when brands internalize consumer diversion within their network, the market is still closer to the competitive benchmark. Second, markups implied by the collusive uniform price (13.3 cpl) are 60% higher than markups under RPM but substantially below markups under joint profit maximization. This result

illustrates that despite the considerable profitability of the collusive equilibrium reached in Quebec City, stations were still leaving profits on the table. The third panel indicates that the markup increase is followed by a reduction in the total volume sold. This reduction in aggregate volume indicates that a not negligible fraction of consumers reacted to the increase in price levels from the collusive uniform price equilibrium by reducing consumption, which creates another source of inefficiency besides misallocation.

The last two panels of Table 4 display the price and quantity changes that follow a one cpl marginal cost decrease. Cost pass-through is similar under single store pricing and RPM. Specifically, the average cost pass-through to prices is 96%, ranging from 91% to 99.9%. As such, the change in sales following the cost reduction is also heterogeneous across stations, with an average of approximately 1,100 L. Furthermore, under marginal cost pricing, pass-through is complete by construction for all stations. In contrast, with the collusive uniform price, a station does not reduce price following a marginal cost reduction and thus it does not increase sales. As such, the only benefit accrued by a station when reducing costs comes from higher markups. The fact that the collusive uniform price does not allow stations to benefit from a cost reduction by increasing sales is at the heart of the potential dynamic misallocation. First, it indicates that this collusive strategy may distort stations' incentives to invest in cost-reducing technologies. Second, by disproportionally benefiting high-cost stations, the collusive uniform price may distort the type of stations that enter or exit the market during the cartel.

6.2 Misallocation of sales distribution

To evaluate the extent of misallocation in the market we use our measure of firm-specific marginal cost ($W_j\gamma$) and the market-shares obtained in each counterfactual conduct scenario to construct a measure of production efficiency, the sales-weighted marginal costs. As before we focus on cross-sectional differences in cost across stations. Following Olley and Pakes (1996), we decompose the sales-weighted marginal costs into two components:

$$c_t = \bar{c}_t + \sum_{j=1}^{Jt}(c_{jt} - \bar{c}_t)(s_{jt} - 1/J_t), \tag{6}$$

where $\bar{c}_t$ is the unweighted average of firm-specific marginal cost ($W_j\gamma$). The covariance between market shares and marginal costs in equation 6 is informative about the sales share obtained by high-cost firms. This correlation is positive if high-cost stations have relatively large market shares (strong misallocation), and negative if low-cost stations have higher-

than-average market shares. Since there is limited vertical differentiation between stations in our market we expect this covariance to be negative under competitive pricing as firms with lower marginal costs tend to have lower prices and, all else equal, higher sales. However, if prices are uniform, consumers will sort to stations based solely on station characteristics and convenience. Therefore, the share of sales that goes to high marginal cost stations increases, and the covariance term reflects the correlation between consumer preferences for stations and cost.

Table 5 displays the Olley and Pakes marginal cost decomposition for the uniform collusive price and the counterfactual scenarios. Interestingly, the covariance between market shares and marginal cost is negative for all counterfactuals, which indicates that more efficient stations tend to have higher market shares regardless of the competitive conduct. However, with the covariance closest to zero, the uniform price weakens this relation and therefore it creates production misallocation. To quantify the extent of this misallocation, we contrast the covariance between market share and marginal cost implied by the uniform price with the covariance implied in the two cost minimizing benchmarks.

Table 5: Marginal cost decomposition

	c_t	$\bar{c}_t$	$\sum_j \Delta c_{jt} \Delta s_{jt}$	Extra time (min.)
Uniform Price	14.89	15.02	-0.129	1.75
P = MC	14.86	15.02	-0.158	2.77
Store	14.86	15.02	-0.159	2.23
RPM	14.88	15.02	-0.138	2.17
Joint Profit	14.86	15.02	-0.161	1.37
Cost Minimizing				
all stations	13.87	15.02	-1.150	25.72
3.25 min.	14.18	15.02	-0.84	1.77

Notes: See Equation 6 for definitions of c_t, $\bar{c}_t$ and $\sum_{j=1}^{J_t} \Delta c_{jt} \Delta s_{jt}$.

To have a sense of the potential cost reduction in this market, we consider the extreme case in which consumers are allocated to the low-cost stations regardless of the extra time incurred to visit the station. In this setting, the daily industry marginal cost is 1 cpl lower than the daily industry marginal cost under uniform price, indicating significant room for reducing the aggregate cost of production. At the same time, the average extra driving time incurred by consumers is more than ten times the average extra driving time incurred by consumers in the uniform price scenario. From the demand estimates, consumers are willing to forgo savings of 3 cpl to avoid driving one extra minute. Because of these travel costs, it

is unlikely for the cost-minimizing allocation to be Pareto improving.

A less extreme and more plausible benchmark is the cost-minimizing allocation that keeps the average extra driving time incurred by consumers similar to what we observe with the collusive uniform prices. According to this benchmark, the covariance term is -0.84. Relative to this cost-minimizing benchmark, we have that the misallocation implied by the uniform price increases daily industry marginal costs by 0.71 cpl (-.084 to -0.129). Since the interquartile range of the station specific cost component is 0.78 cpl, the effect of the production misallocation on daily industry marginal cost is non-negligible.

To understand what part of the production misallocation is generated by consumer preferences for station characteristics and what part is generated by the fact that colluding firms rely on uniform prices, we use the covariance between market shares and marginal costs implied by the marginal cost pricing counterfactual. Similar to the cost-minimizing benchmark, in this counterfactual, relative prices fully reflect firms' efficiencies. However, consumer preferences are also a determinant of stations' production. Therefore, the difference in covariances between the marginal cost pricing setting and the cost-minimizing setting captures the allocative inefficiency implied by the spatial and service differentiation. Lastly, in the uniform price setting, prices carry no information regarding stations' efficiencies and production is determined solely by consumer preferences. Therefore, the difference in covariances between the marginal cost pricing counterfactual and the observed uniform price allocation captures the allocative inefficiency implied only by the uniform price strategy.

The comparison between the cost-minimizing benchmark, the marginal cost pricing counterfactual and uniform price setting show that spatial and product differentiation explain most of the misallocation. Specifically, going from the cost-minimizing benchmark to marginal cost pricing increases the covariance between market share and marginal cost from -0.84 to -0.158. Going from the marginal cost pricing benchmark to the uniform price setting increases the covariance between market share and marginal cost from -0.158 to -0.129. Therefore, frictions arising from horizontal differentiation, due to distance and random-utility shocks, explain the bulk of the static cost misallocation in this market.

The persistent negative covariance across the three scenarios and the fact that uniform prices imply a market share and marginal cost covariance similar to marginal cost pricing indicates that low-cost stations tend to be located in areas with high consumer density, which limits the extent of misallocation caused by the uniform price.

6.3 Misallocation of investment decisions

Next, we investigate whether the uniform collusive price may have had lasting effects on the (mis)allocation of production by affecting stations' incentives to enter/exit the market and invest in cost-reducing technologies. We start our analysis by comparing the evolution of the covariance between market share and marginal cost in Quebec City with other markets, such as Sherbrooke, Hamilton, Guelph, and Windsor. Motivated by our discussion in section 3, Sherbrooke provides a comparison market that seems to have been collusive since the mid 1990s, and for which the Competition Bureau has documented collusive practices in the early 2000s. Hamilton, Guelph and Windsor are markets in Ontario for which there has never been any suspicion of collusion and, as pointed out in Carranza, Clark, and Houde (2015), experienced major restructuring.

We use our estimates of the marginal cost function for Quebec City and stations' characteristic data for each comparison market to predict stations' marginal cost. Together with the data on stations' market share, we have all the elements required to perform the Olley and Pakes decomposition in each market. Because of current data limitations, we do so for Ontario cities in 1995 and 2001 and for Quebec City and Sherbrooke for 1995, 2001, 2006 (Sherbrooke) and 2007 (Quebec City).

Table 6 displays the covariance between market share and marginal cost for Quebec City and the comparison markets over time. Consider 1995 to 2001, before the uniform price equilibrium took place in Quebec City. Consistent with the industry restructuring observed in the North American fuel industry in the 1990s, the results show an improvement in the allocation of production in Ontario markets and Quebec City. In contrast, Sherbrooke, which by the mid-1990s already experienced high margins and low-price dispersion, had no improvement in the allocation of production. Next, consider 2001 to 2007, when the uniform collusive price was in place in Quebec City and the Competition Bureau investigated a cartel in Sherbrooke. The covariance between market share and marginal cost stays virtually unchanged in Quebec City and Sherbrooke. This change in the trend observed in Quebec City and the fact that it started to mirror Sherbrooke provide evidence that the uniform collusive prices might have had a lasting impact on the misallocation of production. In what follows, we investigate the channels through which the collusive uniform prices could reshape production inefficiencies.

The cartel raised industry profits. While extra profits create incentives for incumbent gas stations to continue operating, they also incentivize the entry of new stations and the adoption of different technologies. We use our model estimates to understand the differences

Table 6: Olley and Pakes decomposition - Evolution cov(share,mc)

	Quebec		Ontario		
	QC	Sherbrooke	Guelph	Hamilton	Windsor
1995	-0.118	-0.099	-0.042	-0.062	-0.083
2001	-0.171	-0.094	-0.20	-0.163	-0.181
2006/2007	-0.168	-0.076			

in the effect of uniform price collusion on operational profits between low and high-cost stations. Our analysis builds on the assumption that stations can freely choose among available technology to determine their marginal cost and consider whether to operate while assuming it will not be able to disrupt the cartel. By classifying stations according to their marginal cost level, we try to answer three questions. First, which type of incumbent station benefits the most from the collusive agreement? Second, what type of station would be willing to enter? Lastly, how much do incumbent stations benefit from the adoption of cost-reducing technologies?

With our demand estimates and the empirical distribution of demand and marginal cost shocks, we can address those questions by measuring the expected equilibrium variable profit obtained by incumbent stations and the different types of potential entrants. We do so assuming two different competitive conducts in the pricing stage of the game: collusive uniform price and rpm (multi-product Bertrand-Nash). The expected profit for each station gives our measure of the entry value.

As in the previous section, we address both questions using the market structure observed during 2004 Aug-Sep as a reference. We measure the value of operating a station in the context of a simplified two-stage entry game where incumbent stations are the observed list of active stations during 2004 Aug-Sep, and potential entrants are defined based on location/marginal cost pair observed at future periods. Specifically, we define the set of potential entrants' locations as every location we observed a gas station from 2005 to 2013 but not in 2004. Based on this definition, an entrant station can operate in sixteen locations. As for the marginal cost of the potential entrant, we consider ten values ranging from 67 cpl to 71.5 cpl in .5 cpl increments.[25] All simulations assume that potential entrant are unbranded self-service station with a carwash, convenience store, twenty-four pumps, and six islands.

[25]The 67 to 69 cpl values were artificially constructed and are out of the marginal cost sample range. However, Ultramar stations with at least 24 pumps can rationalize the marginal costs greater than 68.5 cpl. The other values are within the sample range.

Table 7 Panel A displays the expected profit estimates for incumbents and entrants under the two conduct scenarios. On average, collusion increases the value of operating for incumbent and potential entrants. This is mostly driven by the increase in margins in the collusive equilibrium. However, we show next that this increase is not for all stations and that in some locations, potential entrants are worst off under the collusive uniform price.

Table 7: Variable profits comparison - Uniform Price vs RPM

Panel A: Yearly expected profits ($)

	Incumbents			Potential Entrants		
	UP	RPM	Ratio	UP	RPM	Ratio
Avg.	343,941	260,201	1.32	223,578	191,418	1.18
P10	120,650	91,770	1.22	34,085	32,195	1.01
P90	630,280	475,035	1.42	564,025	499,939	1.36

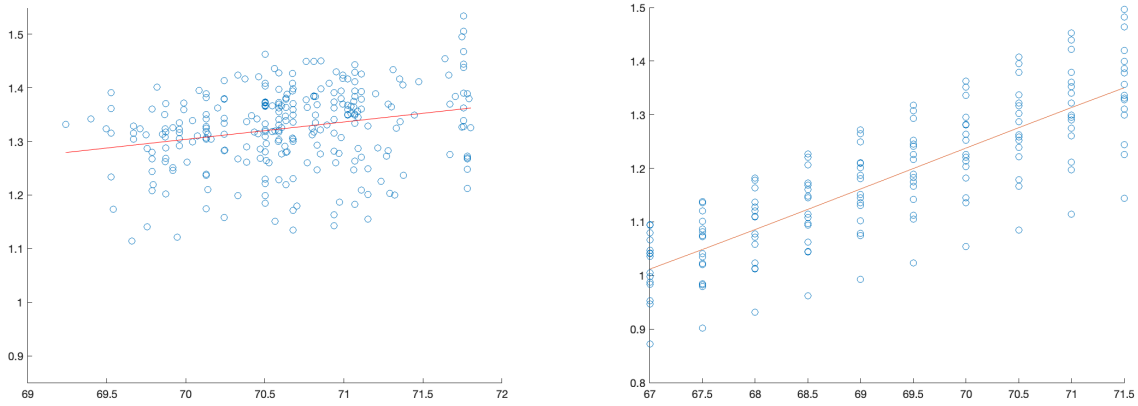
Panel B: Profit difference after 1sd reduction in cost ($)

	Incumbents		
	UP	RPM	Ratio
Mean	13,986	19,372	0.74
P10	5,935	7,631	0.64
P90	24,177	34,403	0.84

Let the ratio $\frac{E[\pi_j^{up}]}{E[\pi_j^{rpm}]}$ measure the value of operating under collusion relative to competition. Figure 4 displays the scatter plots of this ratio versus marginal cost. The figure on the left considers incumbent firms and the figure on the right consider potential entrants. Each point in the graphs correspond to a particular location. First, consider the case of incumbent stations. Because the expected profit ratio is greater than one for all incumbent stations, they benefit from the cartel with uniform prices. Furthermore, the positive correlation between the expected profit ratio and marginal costs indicates that high-cost, inefficient incumbents benefit more from the cartel than the low-cost, efficient incumbent. This result indicates that inefficient incumbent stations are more likely to keep operating under a uniform price strategy than under competition. Figure 4 b displays the scatter plot of the expected profit ratio versus marginal cost for potential entrant stations. In contrast with the incumbent stations, not all potential entrants benefit from the uniform collusive price. In particular, low-cost stations in a few locations would have a higher expected variable profit if the market was competitive.

In addition to affecting entry/exit decisions, the collusive uniform price can also increase

Figure 4: Expected profit ratio vs marginal cost



(a) Incumbent Stations

(b) Potential Entrants

Source:

inefficiencies by distorting incumbents' incentives to invest in cost-reducing technologies. With the collusive uniform price, the only effect of a cost reduction is to increase profits in proportion to the quantity sold. Under competition, this effect should be greater because the quantity sold is larger for most stations. In addition, with competition, prices adjust to the cost reduction. This indirect price effect, absent under collusion, should increase profits and depend on the pass-through rate.

We use our demand model and marginal cost estimates to quantify how collusive uniform prices reduce incumbent stations' gains from investing in cost-reducing technologies. To this end, we estimate each station's profit change when it decreases its marginal cost by one standard deviation (0.95 cpl) while holding all other stations' marginal cost fixed. We compute this change for two cases: the RPM, our competitive benchmark, and the collusive uniform prices observed in the data.[26] With the change in profits for both cases, we compute,

$$\frac{\pi_j^{up}(mc_j - 0.95) - \pi_j^{up}(mc_j)}{\pi_j^{rpm}(mc_j - 0.95) - \pi_j^{rpm}(mc_j)},$$

The ratio indicates how much less profitable the cost reduction is when firms collude with the uniform price than when they compete. Table 7 Panel B displays summary statistics on the change in profits for each competitive conduct and the respective. The results show that the benefit of reducing costs is, on average, 25% smaller when firms set collusive uniform

[26]For the RPM case, we re-compute the equilibrium for each perturbation in the vector of marginal costs.

prices. Assuming that the cost of investing is not affected by the stations' competitive conduct, these results indicate that while the arrangement with uniform collusive prices is in place, stations' costs in QC would probably decrease at a slower pace than stations' costs in competitive markets.

7 Conclusion

This article examined the misallocation effects of collusion under uniform pricing in differentiated markets. We investigated this phenomenon in the context of a collusive arrangement in Quebec City's retail gasoline market, using detailed data on prices, market shares, and station characteristics. With these data, we built and estimated a structural model of demand and supply during a competitive period to recover marginal costs. Using these estimates, we performed simulations that revealed patterns of cost misallocation under uniform-price collusion. Specifically, we found evidence that higher-cost firms achieved greater sales under collusion than they would have in a competitive market.

References

Adams, B. and K. R. Williams (2019, February). Zone pricing in retail oligopoly. *American Economic Journal: Microeconomics 11*(1), 124–56.

Asker, J. (2010). A study of the internal organization of a bidding cartel. *American Economic Review 100*(3), 724–762.

Asker, J., A. Collard-Wexler, and J. De Loecker (2019, April). (mis)allocation, market power, and global oil extraction. *American Economic Review 109*(4), 1568–1615.

Assad, S., R. Clark, D. Ershov, and L. Xu (2024). Algorithmic pricing and competition: Empirical evidence from the german retail gasoline market. *Journal of Political Economy 132*(3), 723–771.

Bridgman, B., S. Qi, and J. Schmitz (2015). Cartels destroy productivity: Evidence from the new deal sugar manufacturing cartel, 1934–74. *Staff Report, Federal Reserve Bank of Minneapolis* (519).

Byrne, D. and N. deRoos (2019). Learning to coordinate: A study in retail gasoline. *American Economic Review 109*, 591–619.

Carranza, J. E., R. Clark, and J.-F. Houde (2015). Price controls and market structure: Evidence from gasoline retail markets. *The Journal of Industrial Economics 63*(1), 152–198.

Carrera, F. (2022). Cartels, entry, and productivity: Evidence from the chilean nitrate cartels. Working paper.

Chaves, D. and M. Duarte (2023). The inner workings of a hub-and-spoke cartel in the automotive fuel industry. Forthcoming, *American Economic Journal: Microeconomics*.

Clark, R., D. Coviello, J.-F. Gauthier, and A. Shneyerov (2018). Bid Rigging and Entry Deterrence in Public Procurement: Evidence from an Investigation into Collusion and Corruption in Quebec. *The Journal of Law, Economics, and Organization 34*(3), 301–363.

Clark, R., M. Duarte, and J. Houde (2024). Cartel instability and price wars: retail gasoline in canada. In *Cartels Diagnosed: New Insight on Collusion*.

Clark, R., I. Horstmann, and J. Houde (2024). Hub-and-spoke cartels: Theory and evidence from the grocery industry. *American Economic Review 114*, 783–814.

Clark, R. and J.-F. Houde (2013). Collusion with asymmetric retailers: Evidence from a gasoline price fixing case. *American Economic Journal: Microeconomics 5*(3), 97–123.

Clark, R. and J.-F. Houde (2014). The effect of explicit communication on pricing: Evidence from the collapse of a gasoline cartel. *Journal of Industrial Economics 62*, 191–228.

DellaVigna, S. and M. Gentzkow (2019). Uniform pricing in us retail chains. *The Quarterly Journal of Economics 134*(4), 2011–2084.

Edmond, C., V. Midrigan, and D. Y. Xu (2023). How costly are markups? *Journal of Political Economy 131*(7), 1619–1675.

Erutku, C. and V. Hildebrand (2010). Conspiracy at the pump. *Journal of Law & Economics 53*, 223–237.

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.

Harberger, A. C. (1954). Monopoly and resource allocation. In *American Economic Review, Papers and Proceedings*, pp. 77.

Harrington, J. and A. Skrzypacz (2011). Private monitoring and communication in cartels: Explaining recent collusive practices. *American Economic Review 101*, 2155–2191.

Hitsch, G. J., A. Hortacsu, and X. Lin (2021). Prices and promotions in us retail markets: Evidence from big data.

Houde, J.-F. (2012). Spatial differentiation and vertical mergers in retail markets for gasoline. *American Economic Review 102*, 2147–2182.

Hsieh, C.-T. and P. J. Klenow (2009). Misallocation and manufacturing tfp in china and india. *The Quarterly Journal of Economics 124*(4), 1403–1448.

Hyytinen, A., F. Steen, and O. Toivanen (2019). An anatomy of cartel contracts. *The Economic Journal 129*, 2155–2191.

Igami, M. and T. Sugaya (2022). Measuring the incentive to collude: The vitamin cartels, 1990-1999. *Review of Economic Studies 89*(3), 1460–1494.

Kim, M., R. Mansley, N. Miller, M. Remer, and M. Weinberg (2023). Price-fixing allegations in the canned tuna industry: A look at the data. *Anitrust Bulletin 68*, 154–163.

Midrigan, V. and D. Y. Xu (2014, February). Finance and misallocation: Evidence from plant-level data. *American Economic Review 104*(2), 422–58.

Miller, N. and M. Weinberg (2017). Understanding the price effects of the Miller/Coors joint venture. *Econometrica 85*, 1763–1791.

Moreau, F. and L. Panon (2023). How costly are cartels? Working paper.

Olley, G. S. and A. Pakes (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica 64*(6), 1263–1297.

Petit, L. T., R. G. Kemp, and J. van Sinderen (2015). Cartels and productivity growth: An empirical investigation of the impact of cartels on productivity in the netherlands. *Journal of Competition Law & Economics 11*(2), 501–525.

Régie (2000). *Requête demandant l'inclusion du montant fixé au titre des coûts d'exploitation dans le prix minimum prévu au paragraphe 59 (2) de la Loi sur la Régie de l'énergie (R-3457-2000).*

Restuccia, D. and R. Rogerson (2017, August). The causes and costs of misallocation. *Journal of Economic Perspectives 31*(3), 151–74.

Röller, L.-H. and F. Steen (2006, March). On the workings of a cartel: Evidence from the norwegian cement industry. *American Economic Review 96*(1), 321–338.

Sorgard, L. and F. Steen (2024). Coordinated rebate reductions and semi-collusion: Retail gasoline in sweden. Forthcoming in, *Cartels Diagnosed: New Insight on Collusion*.

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).

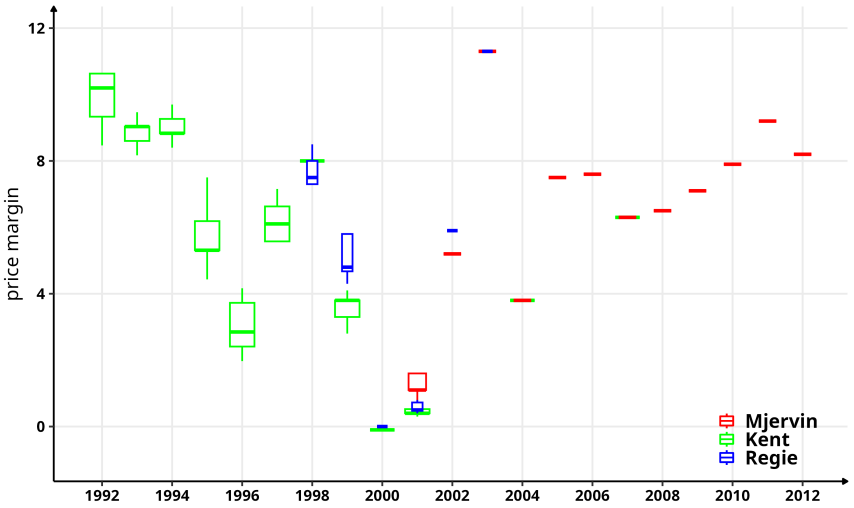
A Appendix - Data

Table 8: Data set coverage

Dataset	Frequency	Time window	Time periods	Station coverage
Kent	Bi-monthly	1995-1 to 2001-6	42	306
Regie	Weekly	1997-12-08 to 2004-02-23	325	13
MJervin	Weekly	2001-01-16 to 2012-11-06	617	15
Eko	Daily	2000-08-29 to 2000-11-27	91	29

Notes: Station coverage is the average number of stations surveyed during each period.

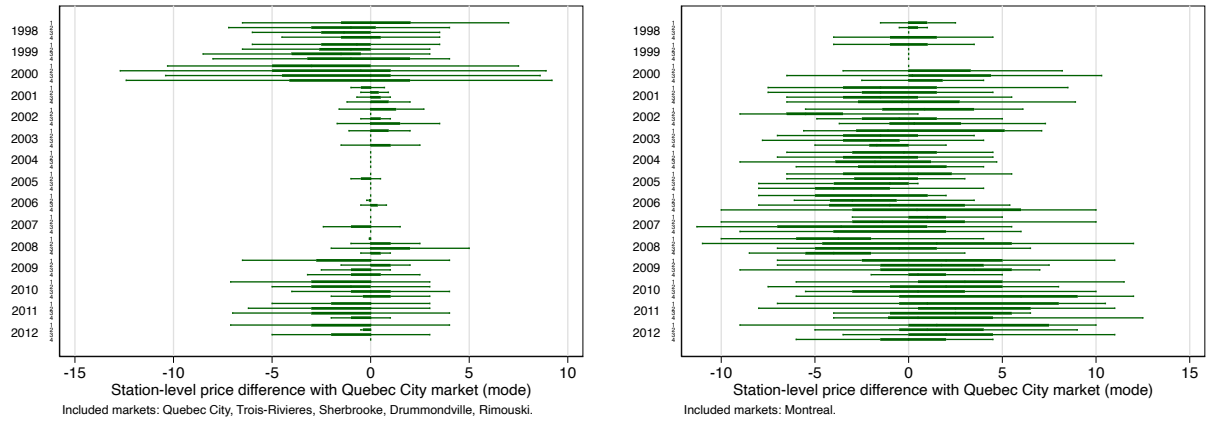
Figure 5: Evolution of Margin Distribution across data sources



Notes: For comparison, we select Kent observations only from stations that are closest to the stations surveyed by Régie. Margins are surveyed around the last week of August of each year except for Kent in 2004 and 2007 that is surveyed at the last week of October.

B Appendix - Market comparison

Figure 6: Distribution of gasoline prices in the South and East regions of Québec relative to the modal price in Québec City



(a) Central and eastern regions (b) Montreal

Source: Régie de l'Énergie du Québec (1998-2001), and MJ Ervin (2001-2012). Each observation corresponds to the difference between the station-level posted price and the modal price in Québec City on the same survey date.