

# Price controls and market structure: Evidence from gasoline retail markets\*

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October 5, 2009

## Abstract

In this paper we study the effect of price floor regulations on the organization and performance of markets. The textbook evaluation of these policies is concerned with short-run market distortions associated with excess supply. Since price controls prevent markets from clearing, they lead to higher prices. While this analysis is correct in the short-run, it does not consider the dynamic equilibrium consequences of price controls. The goal of this paper is to demonstrate that price floor regulations can have important unintended consequences on prices and productivity in the longer run by distorting the structure of markets. We argue in particular that these policies crowd markets and create an endogenous barrier to entry for low-cost retailers. Taken together, these factors can lower prices and productivity. We test this in the context of an actual regulation imposed in the retail gasoline market in the Canadian province of Québec and show that the policy led to more competition, lower prices for consumers, and lower productivity.

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\*This paper has previously circulated under the title “Price controls and competition in gasoline retail markets”. We have benefited from excellent discussions by Matt Lewis and Jeff Prince, and from helpful conversations with Victor Aguirregabiria, Jason Allen, Allan Collard-Wexler, Steven Durlauf, Gautam Gowrisakaran, Ig Horstmann, Robert Gagné, Amit Gandhi, John Kennan, Rasmus Lentz, Greg Lewis, Salvador Navarro, Jack Porter, Andrew Sweeting, Chris Taber, Joel Waldfogel, and seminar participants at Wisconsin, IIOC-2009, UBC-Sauder Summer Conference, the SITE-2009 conference, the NBER Summer Institute (IO), and the Institute for Computational Economics conference (Chicago). Correspondence to Juan Esteban Carranza, Email: juanes@ssc.wisc.edu; Robert Clark: HEC Montreal, Phone: (514) 340-7034, Email: robert.clark@hec.ca; Jean-François Houde: University of Wisconsin-Madison, Madison, Wisconsin and CIRANO; Phone: (608) 262-3805; Email: houdejf@ssc.wisc.edu

# 1 Introduction

Over the last twenty years, many retail markets around the world have experienced significant restructuring associated with the exit of small independent stores and the entry of large-scale chains. These changes were triggered by technological innovations that lowered the marginal cost of serving consumers, at the expense of higher fixed costs of operation.<sup>1</sup> The success of Walmart is a well documented example (see Holmes (2006) and Jia (2006)), but similar patterns exist for instance in the North-American retail hardware and gasoline markets that each experienced important shifts towards fewer large volume retail outlets.

In some cases, lobbying groups were able to convince local and state governments to impose various kinds of price-control regulations in order to protect small independent retailers.<sup>2</sup> A common example of this type of regulation is a below-cost law, also known as a “fair-trade” policy, which prevents firms from posting prices below a stated level approximating the cost of a representative firm. This effectively imposes a minimum resale-price maintenance policy common to all stores.

The impact of this type of regulation is not well understood by economists and policy makers. The traditional textbook evaluation of price floors is concerned with short-run market distortions associated with excess supply. Since price controls prevent markets from clearing, they lead to higher prices. While this analysis is correct in the short-run, it ignores the dynamic equilibrium effects of price controls on the composition of industries. The central objective of this paper is to demonstrate that price-floor regulations can have important unintended consequences on prices and productivity in the longer run by distorting the structure of markets. We argue in particular that these policies can crowd markets with smaller/less efficient retailers and create an endogenous barrier to entry for low-cost retailers. Taken together, these factors can lower prices and productivity.

We analyze this question empirically by studying a specific below-cost price regulation instituted in 1997 in the retail gasoline market in the Canadian province of Québec. The objective of the regulation is to strengthen anti-predatory pricing laws by preventing firms from pricing below their competitors’ costs, thereby protecting small independent retail outlets.

For our analysis we have constructed a rich data set at the gasoline-station level featuring close to 1100 stations observed between 1991 and 2001 in five cities in the province of Québec, and five cities in the neighboring province of Ontario, where the regulation was never implemented. The data contain detailed information on individual stations’ sales volume, posted price, and characteristics and allow us to study the effect of the floor on station behavior at the local-market level.

Figure 1 motivates our empirical analysis. It compares the evolution of prices and three local

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<sup>1</sup>See Foster, Haltiwanger, and Krizan (2006) for an empirical analysis of these trends in the context of U.S. retail markets.

<sup>2</sup>Throughout the paper we will refer interchangeably to these types of policies as: price controls, price floors, sales-below-cost laws, below-cost-sales laws, and unfair sales acts. All refer to legislation that limits the prices firms can set either in a particular industry, or broadly across all products.

market structure variables for the two provinces. Graph (a) illustrates the evolution of prices (net of taxes) in the two provinces. Looking only at the periods immediately before and after the policy, it is easy to see that the implementation of the policy in Québec in 1997 is followed by a spike in the average price, compared to the stations in Ontario. In the longer run, however, average prices in Québec are lower than in Ontario. This highlights our first result, which we support with a careful econometric analysis: in the short-run the price floor raised prices, but in the long-run prices tend to be lower.

We argue that this result is the consequence of the distorted incentives of firms induced by the policy, which significantly affected the composition of local markets as depicted in graphs (b), (c) and (d).<sup>3</sup> Graph (b) shows that the share of monopoly markets increased more in Ontario than in Quebec after the policy. Similarly, the policy appears to have affected sharply the presence of large stations as seen in graphs (c) and (d). Therefore, we claim that the policy not only affected prices directly, but also affected the composition of local markets through the entry and configuration of stations. The policy indirectly lowered the productivity of stations through endogenous changes in market structure and station characteristics. Because in the long-run more stations are present in the regulated markets, competition is more intense and prices tend to be lower.

To formalize our analysis, we first build a model of price competition and evaluate the impact of a price floor on entry, exit, prices, and sales. We show that a price-floor regulation can have two opposite effects. First, such a policy can cause excess entry into and crowding of markets by raising the expected profit of being active.<sup>4</sup> Second, by protecting small firms, the policy can block the entry of more efficient low-marginal-cost retailers who face larger fixed costs.

These two opposite forces can lead to higher or lower prices depending on the relative efficiency of firms and the importance of fixed-operating costs. We illustrate theoretically how these effects can distort firms' entry and exit decisions in two ways. In Section 2 we analyze a simple two-period model to formally define the two types of incentives, and in Appendix B we show that price floor policies can significantly affect the long-run distribution of firms using a numerical dynamic model of entry and exit similar to Ericson and Pakes (1995).

Next we perform a detailed econometric analysis of the data along two dimensions. In Section 4.1, we use a difference-in-difference specification to study the impact of the policy on three store-level outcomes: markups, sales volumes, and revenues from gasoline. Our results offer clear and robust predictions consistent with the graphs displayed in Figure 1. Comparing the period immediately after to the period immediately before the introduction of the policy, markups are higher. In the short-run, therefore, the price floor systematically increased market prices. However, in the long run, comparing the five years after to the five years before the implementation of

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<sup>3</sup>It should be noted that over this period all North-American markets underwent a major reorganization characterized by massive exit of small scale stations, and entry of large capacity self-service stations. We discuss this reorganization in Section 3 of the paper.

<sup>4</sup>A similar result can be found in the real option literature (e.g. Dixit and Pindyck (1994)).

the regulation, markups, volumes, and profits are significantly reduced. Importantly, we show that the long-run results on prices and productivity are robust to different levels of aggregation (i.e. city, local market and store), and sample frequency (i.e. weekly versus annual price information).

These results are in line with the notion that in the short run a price floor either raises the price of the firms for which the constraint binds, or has no effect. In the long run, the effect of the policy is to protect existing inefficient stations and to allow for the entry of new less productive stations, thereby indirectly lowering the productivity of stations through an endogenous change in market structure. This market crowding, together with the entry of higher quality stores in the unregulated market are responsible for most of the observed price effect.

In order to confirm the role of market structure in explaining the price results, in Section 4.2 we compare the distribution of stations' characteristics across regulated and unregulated markets. We provide evidence that in the gasoline market the policy slowed down the industry reorganization. A significant number of stations that would have exited without the protection of the price control stayed active in Québec. Perhaps more importantly, the comparison of the two types of markets reveals that the policy discouraged large stations from entering. These stations face larger fixed costs and must sell to more consumers in order to be profitable. Since regulated markets tend to be too crowded, these stations cannot survive.

The results are important for our understanding of price control regulations. Similar policies are currently in place in a large number markets. Our analysis of the Québec and Ontario gasoline markets reveals that these policies can distort significantly the structure of markets and slow down the diffusion of new technologies. However, the aggregate welfare consequences are ambiguous as consumers benefit from lower prices and travel costs (i.e. more stores per capita), but have more restricted access to large-scale stations that potentially offer greater convenience. It is also unclear whether retailers, both independents and majors, are better-off being protected by a price-control policy. We further discuss these welfare consequences in section 6.

## 1.1 Regulation background and related literature

Currently twenty-four states in the US have general sales-below-costs laws. In Europe, France recently strengthened a below-cost price regulation applied to all retail markets through the passage of the *Galland* law in 1997. A number of other states and countries have laws for specific industries or products. The most common are sales-below-costs restrictions in the retail gasoline market,<sup>5</sup> but other markets feature similar restrictions. For instance in Tennessee there are floors in the markets for cigarettes, milk, and frozen desserts. In Ireland below-invoice sales were banned in the retail grocery industry until 2005. More generally, similar policies have been enacted in other contexts: wages in most labor markets are subject to explicit floors as are prices in many agricultural markets, anti-dumping policies forbid foreign firms from setting price below average variable costs, and the

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<sup>5</sup>Currently nine states and three provinces in Canada have sales-below-cost laws in the retail gasoline market

entry of big-box retailers is often restricted. In each case, the policies are designed to protect particular groups of firms.

The debate over whether to adopt or overturn sales-below-cost restrictions is ongoing in many jurisdictions. The advocates of these policies typically associate aggressive pricing with predatory or loss-leading behavior. On the other hand, detractors argue that they protect inefficient firms and lead to higher prices and, more generally, to welfare loss – arguments that are consistent with the short-run distortions predicted by the textbook evaluation of price floors. Antitrust authorities typically view such legislation as unnecessary, and they point out that state governments may be too easily convinced by accusation of predation made by various interest groups. When asked to evaluate the merit of proposed below-cost sales legislation in Virginia and North Carolina in 2002 and 2003 respectively, the Federal Trade Commission argued that anticompetitive below-cost pricing rarely occurs, and that such legislation could harm consumers.<sup>6</sup> Similarly, in February 2009 following a lawsuit brought by gasoline retailer *Flying J*, the Wisconsin Supreme Court ruled as unconstitutional a local statute which guaranteed a 9.18% markup over the average posted terminal price for gasoline retailers.<sup>7</sup> In Canada, the Competition Bureau has stated that regulation of this type results in higher average prices, and that it does not provide for the highest quality products and the most efficient production, relative to competitive markets.<sup>8</sup>

In forming their views, these and other antitrust authorities make reference to the academic research on the subject of below-cost sales. They point out that, although the evidence is somewhat mixed, it is largely supportive of the notion that price floors are bad for competition and hence bad for consumers. They refer in particular to work by Fenili and Lane (1985), Anderson and Johnson (1999), and Johnson (1999). These studies evaluate the effect of sales-below-cost laws in retail gasoline markets in the U.S. and find that jurisdictions with sales-below-cost laws have higher prices and/or margins than those without. However, these studies are cross-sectional and, therefore, cannot account for the unobserved heterogeneity across jurisdictions. Their conclusion, linking sales-below-cost laws with higher prices may therefore be spurious. Not all of the prior empirical literature concluded that below-cost regulations lead to higher prices. A recent study by Skidmore, Peltier, and Alm (2005) finds that prices tend to fall after the adoption of sales-below-cost laws in US gasoline markets. Their approach involves using a monthly panel of state-level prices for thirty states over a twenty year period. Our results are consistent with their conclusions, and we provide a detailed analysis of the mechanisms that we argue are responsible for these aggregate price declines.

Our paper is related to a large literature that studies the effect of different forms of government

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<sup>6</sup>Virginia Senate Bill No. 458, “Below-Cost Sales of Motor Fuel”, <http://www.ftc.gov/be/V020011.shtm>; and North Carolina House Bill 1203 / Senate Bill 787 (proposed amendments to North Carolina’s Motor Fuel Marketing Act), <http://www.ftc.gov/os/2003/05/ncclsenatorclodfelter.pdf>

<sup>7</sup>The statute in question was s.100.30; [http://www.datcp.state.wi.us/trade/business/unfair-comp/unfair\\_sales\\_act.jsp](http://www.datcp.state.wi.us/trade/business/unfair-comp/unfair_sales_act.jsp)

<sup>8</sup><http://www.cb-bc.gc.ca/eic/site/cb-bc.nsf/eng/00892.html>

intervention on market structure and prices. Biscourp, Boutin, and Vergé (2008) look at the impact of the Galland law in France, focussing especially on the consequences of limiting intra-brand competition on prices. They find that the 1997 reform led to higher prices and softened competition from large grocery store chains. Another form of government intervention is the imposition of environmental regulations, and studies such as Brown, Hastings, Mansur, and Villas-Boas (2008), Ryan (2006) and Busse and Keohane (2009) have looked at the effect of gasoline content regulation and of the Clean Air Act on market structure. There are also studies evaluating the impact of advertising restrictions on competition and prices in various industries (Milyo and Waldfogel (1999) study the effect of a ban on price advertising, while Clark (2007) looks at the effect of a ban on advertising directed at children on competition in the cereal market and Tan (2006) considers advertising restrictions in cigarette markets). In theoretical work, Armstrong, Vickers, and Zhou (2009) point out that in markets with costly information acquisition regulations designed to protect consumers such as price caps or measures which enable consumers to refuse to receive advertising could have the unintended consequence reducing consumers' incentives to become informed resulting in softened price competition.

There is also a broader literature on competition in the gasoline market. Johnson and Romeo (2000) study the effect of bans on self-service gasoline stations in New Jersey and Oregon on prices and market structure. They find that the bans lead to higher prices, but, unlike the price floor regulation we study, do not seem to achieve their objective of protecting smaller stations. Two other papers in particular are worth mentioning: Hastings (2004) examines the relationship between competition and firm behavior in Californian gasoline markets. Her study is related to ours in the sense that it uses a difference-in-difference analysis to isolate the effects of changes in competition on firm behavior. In our case, we examine the effects of a policy that actually induces changes in the market structure, which in turn affect firm behavior in the longer run. A recent paper by Borenstein (2008) analyzes the potential impact of a specific type of minimum gasoline price regulation in California aimed at smoothing the evolution of gas prices, without addressing the potential effects of the regulation on the entry and exit of gas stations.

## 2 Model

In this section we describe a theoretical model of entry and price competition to examine the effects of a price floor regulation on market structure. More specifically we seek to understand how such a policy can distort the reorganization of an industry, by affecting the entry of larger and more efficient firms. This analysis captures the structural changes observed in the retail gasoline industry during the 1990's.

We consider a circular-city model of price competition with maximal differentiation, in which at most two firms enter the market. If both firms are active in the industry, the variable profits of

firm  $i$  are given by:

$$\pi_i(p_i, p_{-i}) = (p_i - c_i) \left( \frac{1}{2} - \frac{p_i - p_{-i}}{t} \right), \quad (1)$$

where  $t$  is the transportation cost of consumers and  $c_i$  is the marginal cost of firm  $i$ .

Initially the market is composed of a single incumbent  $I$  operating the “small” technology characterized by a cost function  $c_s(q) = c_s q + F_s$ . The potential entrant  $E$  on the other hand has the option of entering the market with the small technology or with the “large” technology. The large technology is characterized by a low constant marginal cost and high fixed cost (i.e.  $c_l < c_s$  and  $F_l > F_s$ ). The entry game is played simultaneously and the strategies of both firms are summarized by  $\{t_I, t_E\} = \{(0, s), (0, s, l)\}$ .

Before firms commit to their entry/exit decisions, a regulator imposes a price floor constraint  $p_f$ . We assume that the floor is set such that:

$$c_s < p_f < p^m,$$

which implies that the floor potentially affects the equilibrium pricing game only in oligopoly markets (i.e.  $(s, s)$  or  $(s, l)$ ). When two firms are active in the industry, the Bertrand-Nash equilibrium is characterized by the following Kuhn-Tucker first-order conditions:

$$\begin{aligned} \frac{1}{2t} (-4p_i + 2p_{-i} + t + 2c_i) + \lambda_i &= 0, \\ p_i \geq p_f, \lambda_i \geq 0, \text{ and } \lambda_i(p_f - p_i) &= 0, \end{aligned}$$

for both  $i \in I, E$ .

When the market is composed of two small firms the price floor binds if  $p_f > c_s + t/2$ . When the market is composed of one small and one large firm, since  $c_l < c_s$  there are three possible outcomes when both types are active: (i) the price-floor constraint does not bind ( $\lambda_s = \lambda_l = 0$ ), (ii) only the large type is constrained by the floor ( $\lambda_s = 0$  and  $\lambda_l > 0$ ), and (iii) both firms are constrained ( $p_s = p_l = p_f$ ). These three cases are summarized by two price-floor cutoffs ( $k_1 > k_2$ ) defined as followed:

$$(p_s^*, p_l^*) = \begin{cases} (p_f, p_f) & \text{if } p_f > k_1 = c_s + t/2 \\ (p_s^n, p_l^n) & \text{if } p_f < k_2 = \frac{1}{3}(2c_l + c_s) + t/2 \\ (B_s(p_f), p_f) & \text{otherwise.} \end{cases} \quad (2)$$

where  $(p_s^n, p_l^n) = (\frac{1}{3}(2c_s + c_l) + t/2, \frac{1}{3}(2c_l + c_s) + t/2)$  are the unconstrained Nash equilibrium prices, and  $B_s(p_f) = \frac{c_s + p_f}{2} + t/4$  is the small-type best-response to the price floor.

Obviously the price floor will distort the equilibrium entry and exit decisions only if it is sufficiently high (i.e.  $p_f > k_2$ ). We consider two types of distortions affecting the equilibrium market

structure. In the first case the floor binds in all oligopoly markets, and induces excessive crowding relative to the unconstrained situation. In the second case, the price floor distorts the market by blocking the entry of the most efficient firm.

### Case 1: Excessive crowding

Consider an example in which the price floor is high and binds even in the  $(s, s)$  market structure. Since firms are symmetric, their profits in the unconstrained and constrained cases are given by:<sup>9</sup>

$$\pi^c(s, s) = \frac{p_f - c_s}{2} - F_s \text{ and } \pi^u(s, s) = \frac{t}{4} - F_s.$$

Notice that the constrained profits are strictly increasing in  $p_f$ . Therefore if  $F_s$  is relatively high it is possible that for the incumbent staying in is profitable only in the regulated market. In particular, the regulated market will be more crowded after the policy change if  $F_s$  is in the following range:

$$\frac{t}{4} < F_s < \frac{p_f - c_s}{2}. \quad (3)$$

As a result in this example the price floor policy will have a competition enhancing effect, and lower prices relative to the unconstrained equilibrium.

### Case 2: Blockaded entry

There are two ways the policy can block the entry of the most efficient firm. As in the first example, the price floor can be set high enough such that it binds in all cases and makes the entry of a large firm less profitable. For instance, consider the case in which  $(s, l)$  is an equilibrium in the unregulated market:

$$\pi_I^u(s, l) - F_s > 0, \quad \pi_E^u(s, l) - F_l > 0, \text{ and } \pi_E^u(s, l) - F_l > \pi_E^u(s, s) - F_s.$$

When the price floor binds for both types, the incumbent is strictly better off and therefore  $s$  (i.e. staying-in) is a dominant strategy in the regulated market. However, the entrant might prefer to change its entry decision since the market is now split in half (i.e both firms charge  $p_f$ ). In particular, if the fixed-cost  $F_l$  is large relative to  $F_s$ , it is likely that the entrant's best-response to  $s$  is now to enter with the small technology:

$$\pi_E^c(s, l) - F_l < \pi_E^c(s, s) - F_s \quad \Leftrightarrow \quad F_l - F_s > \frac{c_s - c_l}{2}.$$

In this example, the equilibrium under the price-floor regulation will therefore be  $(s, s)$  instead of  $(s, l)$ . The policy thus induces efficiency losses and yields higher prices by blockading the entry of

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<sup>9</sup>We use superscripts  $c$  and  $u$  to indicate that the market is regulated and unregulated respectively.

the large firm.

When the price floor is set to a lower level, it is possible that the regulation prevents the entry of a large firm without raising prices. To see this, consider a situation in which the entry of a large firm triggers the exit of the incumbent in the unregulated market:

$$\pi_I^u(s, l) - F_s < 0.$$

In this case, if the price-floor binds only for the large firm (i.e.  $k_1 < p_f < k_2$ ), the regulation will act as a subsidy for the incumbent and will reduce the market share of the large firm. It is therefore possible for the regulator to set  $p_f$  such that the incumbent will revise its decision to exit the market:

$$\pi_I^u(s, l) - F_s < 0 \text{ and } \pi_I^c(s, l) - F_s > 0 \Leftrightarrow \frac{(3t - 2c_s + 2c_l)^2}{36t} < F_s < \frac{(t - 2c_s + 2p_f)^2}{16t}.$$

If this condition is satisfied, the policy will prevent the exit of the least efficient firm. This in turns can block the entry of a large firm, provided that  $F_l$  is large enough. The equilibrium price in the regulated market will thus be lower or equal to the price in the unregulated market. The competition enhancing effect of the policy therefore dominates the inefficiency losses present in the previous example.

Importantly, this last example shows that the policy can have a distortive impact on market structure without actually binding in equilibrium. As long as  $F_l$  is large enough,  $(s, l)$  will not be an equilibrium and the price will be higher than the floor. That is,  $(s, s)$  or  $(s, 0)$  will be the resulting equilibria depending on the parameters. This is important since the price floor in the retail gasoline market in Québec is rarely observed to bind.

To summarize, using a simple two-period entry model we have shown that a price-floor policy can distort the equilibrium structure of retail markets in two ways. First, such a policy can cause crowding by raising the expected profit of being active, which in turn tends to lower prices. Second, by protecting small firms, the policy can block the entry of more efficient firms who must incur larger operating costs. Depending on the context, this efficiency loss will increase prices relative to unregulated markets, or strengthen the competition enhancing effect by crowding the market. The net effect in the long run is therefore ambiguous.

Finally, note that these results are not specific to the simple two-period model presented here. In fact, in the Appendix B we show using numerical simulations that the two types of distortions characterized in the simple model can be generated by a dynamic equilibrium model of entry and product choice in which firms are infinitely lived. We use two parametric examples to show that a price floor policy can easily prevent the exit of smaller firms and block entry of low-cost retailers. In one example the policy clearly tends to raise prices because competition between efficient stores in the unregulated market easily compensates for the larger number of firms in the regulated one.

In the other example, the price floor is almost never binding in equilibrium, but successfully keeps the large stores out of the market and lowers prices. In all parameterizations the policy always tends to favor consumers, essentially because the policy increases the number of products available. The overall economy might be made worse-off however by the policy since firms are much less productive.

### 3 Description of the data

The gasoline station data used in this study were collected by Kent Marketing, the leading survey company for the Canadian gasoline market. The survey offers accurate measures of sales and station characteristics since each site is physically visited at the end of the survey period, and volume sold is measured by reading the pumps' meters. The panel spans eleven years between 1991 and 2001, and includes all 1088 stations in ten selected cities of Québec and Ontario. For our analysis we take the sales volume data collected during the third quarter of each year, and price and station characteristics collected at the end of the same quarter each year.

The observed station characteristics include the type of convenience store, a car-repair shop indicator, number and size of the service islands, opening hours, type of service, and an indicator for the availability of a car-wash. Brand indicator variables are also added to the set of characteristics to reflect the fact that consumers might view gasoline brands as having different qualities.

#### 3.1 Markets

Our analysis focuses on ten cities in Québec and Ontario. In Québec the cities are: Québec city (largest), Trois-Rivières, Chicoutimi, Drummondville, and Sherbrooke. In Ontario the cities are: Hamilton (largest), St. Catharines, Kingston, Cornwall, and Guelph. These cities were selected because as shown in Table 2 they are all comparable in terms of size and population growth. Table 2 also shows that the cities are similar in terms of volume of gasoline sold per capita and growth of volume per capita.

Furthermore, the major players in both provinces are the same. In both Ontario and Québec, the retailers include five chains that are integrated with the refinery sector: Shell, Esso/Imperial Oil, Ultramar, Irving, and Petro-Canada.

An important component of our empirical analysis deals with the structure of local markets, and in particular the strength of competition between neighboring stores and various measures of product differentiation. To allow for this, we need a definition of local markets which reflects the fact that stores are competing more intensely with their immediate neighbors along the same street. Moreover, to be operational this definition must allocate stores into non-overlapping markets. A common way of defining local markets is to use existing definitions of neighborhoods (e.g. census-tracts, zip codes). While these definitions typically allow researchers to get accurate measures of

population characteristics, their boundaries are arbitrary and do not necessarily reflect competition between stores.

Instead, we construct local market boundaries that define a set of spatially homogeneous locations. To do so we use a clustering algorithm that groups store locations according to two criteria related to the distance between stores and whether they share a common street. The advantage of this definition is that a local market is an intersection or a major street segment. Importantly, our definition is time invariant since the set of possible locations is defined as all locations ever active throughout our sample. We describe in greater details our procedure in Appendix C.<sup>10</sup> Table 1 summarizes the distribution of local market sizes among the ten cities. The median market size is three stations per market in the whole sample, but some cities are clearly more dense than others. For instance, in Hamilton (Ontario) the median market size is five stations, while Chicoutimi (Québec) markets have a median size of two stations. Overall the algorithm constructs local markets that are very comparable across the two provinces, since the size distributions are very similar.

### 3.2 Reorganization

A key feature of the reorganization that took place in the gasoline retail industry is the increase in the size and automatization of stations. These changes took place through the entry and reconfiguration of larger and more efficient stations, and the exit of smaller stations. Over the eleven years of our panel, we observe a total of 102 new entrants, 399 exits, and about 130 major size upgrades (out of 1,088 unique stations).<sup>11</sup> The large number of exits relative to entrants is easily explained by the fact that the new “technology” corresponds to a larger capacity and requires more expensive equipments. Table 3 illustrates this point by comparing the characteristics of new entrants, exiting and continuing stations (i.e. stations active in 2001). The first row clearly shows that entrants and continuing firms have essentially the same set of characteristics on average. Exiting firms however are significantly smaller. On average stations that exited before 2001 had 5.5 fewer pumps and nearly one fewer service-islands than entrants and continuing firms. Similarly, exiting firms were more likely to offer full-service and not to have a convenience store attached.

Table 4 presents a set of descriptive statistics for some of the key variables used in the analysis, broken down by province and pre/post policy period. Over the period studied, the entire North-American gasoline retail industry underwent a major reorganization, associated with massive exit of existing stations and entry of new categories of stations (see for instance Eckert and West (2005)). These changes were due mainly to technological innovations common to most retailing sectors which increased the efficient size of stores (e.g. automatization of the service, better inventory control

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<sup>10</sup>The size and composition of the local markets is affected by the parameters used in the clustering algorithm. It must be said that virtually all our results are robust to changes in these parameters.

<sup>11</sup>It is somewhat arbitrary to define upgrades since the number of pumps can vary from year to year due to small changes that do not require sunk investments (as would for example replacing the underground storage tank).

systems, etc.), as well as to changes in the value of certain amenities (e.g. decreased use of small repair garages), and to changes in regulations regarding the environmental safety of underground storage tanks (see Eckert and Eckert (2008) and Yin, Kunreuther, and White (2007)). These changes were evident in both regulated and unregulated markets. For example, the number of stations in the selected markets has decreased by about 30% in both provinces. Also, the proportion of stations with a convenience store, and the proportion of self-service stations have each increased by more than 20% in both regions.

Although both provinces experienced the same aggregate trends, the rate at which these changes occurred differed. As first shown in Figure 1, these differences are particularly important when looking at variables measuring the size of stations and the degree of local competition. Table 4 shows for instance that: (i) the number large stations with more than four service islands and the average number of pumps both increased by about 20% in Québec and by more than 50% in Ontario, (ii) the number of neighboring competitors decreased by 17% in Québec and by 29% in Ontario. Therefore, a careful econometric analysis will be necessary to isolate the changes that are due to the introduction of the policy from the changes that were occurring everywhere.

### 3.3 Description of the regulation

The *law on petroleum products* was enacted at the beginning of 1997 and administered by the Régie de l'énergie du Québec (hereafter the “Board”). This followed the occurrence of an important price war during the summer of 1996, which was deemed to be the result of predatory pricing behavior by the major retailing chains. The mandate of the Board is threefold:

1. Monitor the gasoline industry, and gather information on prices.
2. Determine a weekly floor price or Minimum Estimated Price (MEP).
3. Prevent the occurrence of price wars by imposing a minimum margin regulation in a designated geographic market.

The determination of the MEP is given by the following simple rule which measures the average marginal cost of selling gasoline in each local market:

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

where  $w_t$  is the minimum wholesale price at the terminal,  $\tau_{mt}$  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. The MEP is calculated and posted on the website of the Board every Monday.

The role of the MEP is to set a price floor under which a firm can sue its competitor(s) for financial compensation on the basis of “excessive and unreasonable commercial practices”. This

new feature of the law facilitates suing procedures between competitors in the market, in a fashion similar to anti-dumping laws.

In cases where companies repeatedly fail to respect the MEP, the regulation provides the Board with the ability to impose an additional minimum margin to the MEP. It allows the Board to add \$0.03 per litre to the calculation of the MEP in a specific region after the occurrence of a period of sufficiently low prices.

The minimum margin serves two purposes. First, it establishes an implicit (or long run) price floor, under which the Board considers that stations are not covering their fixed operating costs. Second, it enables the Board to indirectly compensate stations after a price war.

The mechanics of the policy are roughly as follows. First, after the occurrence of a long enough low-price period, a gasoline retailer can ask the Board to investigate evidence of price anomalies. The Board then conducts a formal consultation of different groups (retailers, consumer protection groups), in order to evaluate the credibility of the predatory accusation. If the Board is convinced of the accusation, it can add \$0.03 per litre to the calculation of the MEP for a certain period of time in a specific geographic zone where the price war occurred. In practice the Board considers that a price is predatory if the margin (price minus the MEP) is below \$0.03 per litre for a month or more.

This minimum margin approximates the average operating cost of a representative station in the province.<sup>12</sup> The geographic zone typically includes all local markets which suffered from the price war. Similarly the length of time for which the minimum margin is applicable is proportional to the length of time of the price war.

The minimum margin has been put in effect three times in two different markets, St-Jérôme and Québec city. In St-Jérôme (north of Montréal), it was added to the MEP from April of 2002 to February of 2003, and again from December of 2003 to June of 2005. The imposition of this price floor followed the entry of Costco in St-Jérôme in 2000, which drove the market price to the MEP level for more than a year. In Québec city, it was added to the MEP from July to October of 2001. Its imposition followed a severe price war in the Québec City metropolitan area, during the fall of 2000.

As discussed in the model section, it is important to recognize that a price floor regulation can generate important distortions without binding in equilibrium. Our experience from studying the Québec gasoline regulation is that, although the minimum margin has been put into effect on a few occasions, the price floor is rarely observed to be binding. Figure 2 presents the evolution of weekly average price in Québec city, along with the price floor and the average retail margin. The red dots identify weeks when the average market price was equal to or smaller than the price floor, and the two vertical gray lines indicate the imposition of the additional minimum margin. Over the period studied, the floor is thus binding less than 10% of the time.

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<sup>12</sup>After public consultations, the Board decided that the representative station is a self-service station operating a convenience store, and having an annual sales volume of 350 million liters.

Finally, notice that the overall policy has both a short run and long run dimension. On the one hand, firms are constrained to set a price higher than the MEP, which is relatively low and unlikely to bind unless a low-cost retailer enters the market or firms engage into a price war. The other two aspects of the policy directly affect the option value of being in the market as they provide an insurance against the losses incurred during a price war. Indeed the regulation includes two dynamic compensation mechanisms: the legal channel (i.e. firms can sue their competitors), and extra government intervention (i.e. the additional \$0.03 per litre margin).

## 4 Econometric analysis

The model presented in Section 2 illustrates that the price floor policy can distort market structure and therefore influence pricing. We showed in Figure 1 that the overall trends of the markets are consistent with this prediction. In this section we perform a rigorous statistical analysis, controlling for observed and unobserved factors that might be correlated with the introduction of the policy.

To do so, we examine in detail the effects of the price regulation on the behavior of firms and the structure of local markets. First, we perform a station-level difference-in-difference analysis, in which we compare the behavior of gas stations in Québec and Ontario before and after the introduction of the policy in 1997. We are particularly interested in the effect of the policy on store-level markups, sales-volume, and revenues. We further distinguish between the short and long run effect of the policy by looking at the periods immediately before and after the regulation change, versus the full panel.

Next, we perform a second set of difference-in-difference regressions, this time at the neighborhood level, to measure the effect of the policy on the structure of local markets. The richness of the data-set allows us to analyze the impact of the policy on the number of competitors, the presence of store amenities, and the degree of differentiation between stores. This analysis allows us to test the hypothesis that the long-run price and volume effects that we observe in the first part of the analysis are the result of changes in degree of competition in local markets.

### 4.1 Station-level analysis

We want to evaluate the effect of the policy on the prices and profits of stations. Let  $y_{it}$  denote one of the four variables of interest: Markup $_{it}$ , ln Volume $_{it}$ , ln Revenue $_{it}$ , where  $t$  is the time period and  $i$  is the station.<sup>13</sup> For each dependent variable we estimate the following equation using station-level data:

$$y_{it} = \alpha_i + \theta_t + \gamma D_{it} + \beta X_{it} + \epsilon_{it}, \quad (4)$$

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<sup>13</sup>We have also used prices and margins as dependent variables, but do not include results from these regressions in the paper since they are very similar to those obtained using the Markup specifications. However, these results are available upon request. Markups are calculated as follows:  $(p_{jt} - c_t)/p_{jt}$ .

where  $D_{it}$  is a dummy variable equal to one in Québec after 1996,  $\alpha_i$  and  $\theta_t$  are stations and time fixed-effects. The parameter  $\gamma$  captures the effect of the policy, provided that there are no additional unobserved confounding factors that are correlated with the introduction of the policy. We consider different specifications for  $X_{it}$ . In the simple difference-in-difference specification  $X_{it}$  includes only an indicator variable equal to one after 1996 and a Québec dummy. In most specifications we control for store-level fixed effects, time fixed effects, and a full set of observed characteristics of the stores and measures of competition. Adding controls is important in our context since we expect the policy to affect the composition of local markets, which is in turn correlated with the outcomes of interest. If this is the case,  $D_{it}$  will be correlated with the residuals in the simple specification. By comparing the results of various specifications with and without market structure controls we can thus indirectly test that the policy had an impact on the composition of the market.

#### 4.1.1 The effect of the policy on markups

Table 5 displays the results of the markup regressions. We estimate two types of regressions. First, we estimate a short-run specification using only observations in 1996 and 1997, immediately before and after the introduction of the policy. Second, we estimate the regression using the whole sample so that the results capture the long-run effects of the policy. Columns (1)-(3) correspond to the short run regressions, whereas columns (4)-(6) correspond to the long run regressions. Columns (1) and (4) are simple difference-in-difference regressions in which we only control for the province where the station is located and add a control for all periods after 1997 to control for all the common shocks that might have affected both provinces at the time the policy was introduced. The regressions in columns (2) and (5) include controls for the number of competitors in the same market and on nearby streets that capture the intensity of very local competition, and for the number of stations and pumps per capita at the city level (both are measured in logs) that capture the level of competition at the city level. Controlling for city-level influences on competition is important in the retail gasoline market since markups are mainly driven by city-level factors in this market (see Houde (2009) for instance). In contrast, sales volume is much more affected by local market structure. These specifications also include controls for the wholesale price of gasoline (the rack price), as well as location-fixed effects and time-fixed effects to account for any unobservable shock that is either common across stations or constant for each station over time. Columns (3) and (6) include all the variables above plus additional station characteristics such as number of pumps, brand, size of convenience-store, carwash facilities, etc.

The striking result from these regressions is how the policy coefficients vary between the two samples. In particular, the effect of the policy is positive in the short run and negative over the longer span of the sample. According to the estimates, right after the introduction of the policy gasoline markups in Québec **increased** by 13 percentage point over what they would have been otherwise. Notice that this estimate is stable across all three specifications, consistent with our

hypothesis that the policy did not affect the market structure immediately.

Over the whole time-span of the sample though, gasoline prices/markups in Québec **decreased**. From Column (4) we see that the policy results in a markup decrease of 7.5%. This effect is both economically and statistically significant. Most importantly the addition of controls decreases the magnitude of the effect by 4.5 percentage points (or 60%), which is consistent with the notion that the regulation affected market conditions in a way that favored lower prices. The interpretation of the market structure variables reveals that changes in local market conditions have little impact on markups, while a decrease in the number of competitors along a common street increases prices significantly. This is consistent with the fact that gasoline markets exhibit very little price dispersion between neighboring stores.

### **Robustness: Weekly markup data**

Since our price data represent a once-a-year snapshot of station pricing, we test the robustness of our results to the use of higher frequency price data. Since weekly station-level price data are not available in the Kent data set, we turn to weekly city-level price data available from MJ Ervin, a gasoline market consulting firm. For the time period in question these data are only available for two cities in Québec (Montréal and Québec) and two cities in Ontario (Toronto and Ottawa). In our analysis we use both of the available cities in Québec, but we drop Ottawa from our analysis since it is situated right at the border with Québec and so its retail gasoline market is integrated with the neighboring markets in Québec (namely Hull and Gatineau). Using the weekly city-level price data we perform similar difference-in-difference regressions to those done using the station-level data. Our results are presented in Table 6. The results are very similar to those found using the annual station-level data, with the long-run policy coefficient being nearly identical.

We also test the robustness of our results to the variation of the start date of the 'before' period in our analysis. More precisely, using the weekly MJ Ervin data we re-estimate the markup regressions successively dropping the earliest years of data (first dropping 1991 and estimating using 1992-2001, then dropping 1992 and estimating with 1993-2001, and so on). Our results are presented in Table 6 and show that the long-run result is robust to this variation: the long-run effect of the policy on prices is negative even when we exclude the first four years. We also performed a similar analysis using the Kent data-set (i.e. annual frequency) and found that the long-run negative effect of the policy on markups is robust to exclusion of the first three years ( $t \geq 1994$ ). In other words, the long-run decrease in markups that we attribute to the policy is not (entirely) due to the observed decline in prices and markups in Québec between 1991 – 1995 (see Figure 1).<sup>14</sup>

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<sup>14</sup>We thank Matt Lewis and Erin Mansur for suggesting these two robustness checks.

### 4.1.2 The effect of the policy on productivity and profitability

Next we explore the effect of the policy on stations' productivity and profitability, measured by their sales' volume and revenues. Table 7 combines the results of the short-run and long-run specifications. With respect to sales volume, the policy did not have any statistically significant effect in the short-run, which is consistent with the fact that gasoline demand is fairly inelastic. That is, the 14% increase in average markup was not accompanied by any significant drop in aggregate demand. In the revenue specifications, we see that once we add control variables (and fixed-effects) the policy appears to have increased revenues by about 13% on average, which is consistent with the short-run results on markups.

Columns 3 – 4 and 7 – 8 contains the results for the long-run sales and revenue regressions. In this sample it is clear that both outcomes were negatively affected by the policy. Without controlling for any market structure or location characteristics the estimates reveal that volume and revenues decreased significantly, by 15% and 22% respectively. Importantly, these numbers are drastically reduced when we control for characteristics of the stations and local markets. The effect of the policy on volume is no longer significantly different from zero, and the effect on revenue is now just an 8% decrease consistent with the price/markup decreases. In other words, almost all of the decrease in volume and about two thirds of the decrease in revenue associated with the policy can be attributed to a change in the structure of local markets and the type of amenities offered by stations after the introduction of the price floor. The policy therefore indirectly reduced the productivity of stores in this market through an endogenous change in the structure of local markets and the characteristics of stations.

We argue that one main reason for the decrease in volume per station in Quebec relative to Ontario is that Ontario markets became relatively less crowded after the policy change. We can see this at the level of individual stations by estimating equation 5 below, which relates the distance between each station  $i$  and its closest competitor to the policy dummy  $D_{i,t}$  and a full set of fixed station- and time-effects:

$$d_{it} = \underset{(0.011)}{-0.038} \times D_{it} + \underset{(.0099)}{0.0741} \times \mathcal{I}(t \geq 1997) + \mu_i + \epsilon_{it} \quad (5)$$

The results indicate that the distance from each station to its closest competitor decreased significantly in Québec relative to Ontario after the introduction of the policy after 1996, so that markets became less crowded.

These results on firms' productivity and profitability are consistent with the results on the effect of the policy on prices/markups. Holding fixed the structure of markets, the short-run effect of the policy was to raise prices and firms' revenues. However, by comparing the evolution of markets in Ontario and Québec over the full sample we conclude that the price floor lowered prices and profits. Note that we are not claiming that prices fell in Québec as a direct consequence of the

policy. Rather, we are claiming that the price controls modified the equilibrium entry and exit decisions of firms in the regulated markets compared to the control group, which in turn affected prices and profitability of stations. In the next section we further investigate this hypothesis by looking specifically at the impact of the policy change on the structure of local markets.

## 4.2 Market-level analysis

To study the effects of the price floor policy on the organization of the industry we adopt a similar difference-in-difference approach as above, focussing only on the long-run dimension of the data (i.e. full panel). We estimate the following equation:

$$y_{mt} = \alpha_m + \theta_t + \gamma D_{mt} + \beta X_{mt} + \epsilon_{mt}, \quad (6)$$

where the coefficient of interest is the expected change  $\gamma$  in local market conditions after the policy implementation in Québec relative to the control markets in Ontario. Similarly to the previous section, we include in all specifications a full set of time and local-market fixed-effects.

The unit of observation here is a local market  $m$  observed at time  $t$ , as described in the data section.<sup>15</sup> The size of these markets varies between 0 and 11 stations, with a median of 3. For each local market, we construct three types of variables measuring (i) the degree of competition, (ii) the station characteristics, and (iii) the degree of differentiation (the within local market variance of station characteristics). We present the results from these regressions in Table 8.<sup>16</sup> For each regression we report the estimated coefficient of the policy indicator with HAC standard-errors. Each row corresponds to one regression.

We have already shown that the distance from each station to its closest competitor decreased after the introduction of the policy relative to the control group. In the first two rows of Table 8 we examine the effect of the policy on competition. Row (1) presents the effect on the number of competitors in each local market, which is our measure of competition. The result implies that on average the policy increased the number of stations in each market by 0.13 after controlling for all observed station characteristics and all unobserved market and time-specific unobservables. Row (2) shows that the impact of the policy on the likelihood of a local market being a monopoly is negative and highly significant. These results strengthen our argument in favor of the hypothesis that the policy had a positive impact on competition in the market, compared with the counterfactual alternative.

Having established the positive effect of the policy on market competition, we turn to the specifics of the difference in market structure induced by the experiment. We have already pointed

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<sup>15</sup>Most of the results are also robust to a larger definition of local markets constructed using groups of postal-codes (i.e. FSA). Those results are available upon request.

<sup>16</sup>The number of observations can vary slightly between specifications due to the inclusion or exclusion of the “empty” markets.

out that gasoline markets went through a substantial reorganization during the 1990's that affected simultaneously all stations in all markets. The regression analysis allows us to test whether the regulation affected this process. Rows (3)-(11) report the results for several average characteristics of stations across markets.

Rows (3) and (4) show that the estimated coefficients of  $\gamma$  associated with the average number of pumps and islands per station in each market respectively are negative and very significant. In other words, the average size of stations in Québec markets became significantly smaller due to the policy. The other measure of size is the proportion of stations which offer more than 2 service islands, or more than 20 pumps. The coefficient estimates reported in Rows (5) and (6) clearly show that on average Ontario stations have the capacity to serve more consumers than Québec stations after the policy.

Rows (7)-(11) describe the effects of the policy on the average number of stations per market that offer certain types of services. The results imply that the policy had a significant effect on all these average characteristics. Relative to Ontario, stations in Québec after the policy are less likely to offer complementary services, like service at the pump, a convenience-store, a car wash, and a repair shop. Importantly, row (11) shows that the policy had a negative impact on the likelihood of a station offering electronic payment at the pump, which is one of the main features of the new bigger stations. The adoption of this service is possible thanks to the development across the economy of electronic payment technologies, which we think was one of the major driving forces of the overall transformation of the retail gasoline industry during the 1990's.

Finally, Row (12) measures the effect of the policy on the ratio of the total number of pumps to the number of regular gas pumps. In other words, we measure the effect of the policy on the average variety of gasoline types offered by gas stations. The negative and significant estimate implies that Québec stations offer a smaller variety of gasoline grades as a consequence of the policy change. This reflects in part the fact that the newer types of gasoline pumps are designed to offer more than two grades of gasoline, and therefore that a larger proportion of stations have upgraded their equipment in Ontario after the policy.

We showed above that the policy was associated with a decrease in markups. Now we have shown that it is associated with a decrease in the scale and the variety of amenities offered by stations. To the extent that some people value these station characteristics, the net effect of the policy on the welfare of consumers is not clear. Moreover, from the firms' point of view, if these characteristics increase the value of a station, our results suggest that firms in the regulated markets are less likely to invest in vertical characteristics that would have softened price competition.

We analyze directly the idea that the regulation might have affected firms' incentive to differentiate themselves from their neighbors in Rows (13)-(20) of Table 8. The dependent variable is the standard deviation in the amenities offered by competing stations within a local market. Recall that the local markets are constructed such that the locations of stores are relatively homogeneous.

An increase in the standard-deviation of a particular characteristic therefore corresponds to a net increase in the differentiation between stores.<sup>17</sup>

The results indicate that for all characteristics, the policy had a negative effect on differentiation. Stations within markets in Québec are becoming more similar relative to stations in Ontario along all dimensions. In particular, the results indicate that firms in the regulated markets tend to be less differentiated in terms complementary services (e.g. convenience store, car-wash) and size (i.e. number of pumps and service islands).

It must be remembered that the entire industry underwent a dramatic reorganization during this period, and that the policy was implemented in the middle of this process. The estimated effects are measured with respect to what was happening in Ontario, and the evidence suggests that markets in Ontario experienced more profound changes than Québec markets.

## 5 Sensitivity analysis

We have exploited a very rich data set to control as much as possible both for observed and unobserved variables. A potential problem with the structure of our data-set is that time-varying regional shocks might be driving the empirical results. If these shocks are important factors determining exit and reconfiguration decisions they could (i) invalidate our method of inference, and (ii) bias our parameter estimates. We discuss these two related issues in the following paragraphs.

The literature on difference-in-difference methods has long recognized the fact that regional serially-correlated unobserved shocks can severely bias downwards traditional estimates of standard-errors (see for instance Moulton (1990)). A common solution is to cluster standard-errors at the province or market level as suggested by Bertrand, Duflo, and Mullainathan (2004).<sup>18</sup> Obviously, this is not asymptotically correct in our context since we use data covering ten metropolitan areas in two provinces. A complementary approach is to aggregate the information at the city level and perform a series of exact rank tests comparing changes in the variables of interest before and after the government intervention.<sup>19</sup> In Table 9 we formally compare these changes using a Wilcoxon rank-sum test for several variables.<sup>20</sup> For each we report two results: (i) a rank-test statistic, and (ii) an estimate of the probability that a random draw from the Ontario population is larger than a random draw from the Québec population. The results are consistent with the regression results

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<sup>17</sup>Except for the size, all variables are qualitative and take value zero or one. The variation in size is measured as the standard deviation of the number of pumps across stations within each market, which is affected by the scale with which the size is measured. The results shown do not vary when we use the coefficient of variation, which is invariable to changes in scale, instead of the standard deviation.

<sup>18</sup>Recall that in order to deal with serial-correlation and heteroskedasticity we clustered standard-errors at the station-level in store-level regressions (section 4.1), and use HAC standard-errors with a six period window in market-level regressions (section 4.2).

<sup>19</sup>Conley and Taber (2009) proposed a similar “exact” test when the number of treatment and control groups is small.

<sup>20</sup>Formally we are testing the null hypothesis that the city-level changes are random draws from the same population, which violates our hypothesis that the policy had an impact on these variables.

presented above, but the rank tests are not as powerful as the regression results since they do not use the same within-city variation in the structure of local markets. The average size and the productivity of stations increased significantly more in Ontario than Québec. However, the changes in the number of stations (i.e. local competition) are not statistically different at traditional levels (i.e. the p-value is equal to 0.17), despite the fact that the probability of observing a larger increase in the competitiveness of local markets in Ontario is only 24%. The discrepancy between some of these results and the regression results is likely due to the fact that the rank tests ignore the information contained in the size of cities: larger markets contain more information than smaller ones in regression analysis. Overall these results are reassuring and complementary to the results presented above. They indicate that our key results are not driven by an outlying market, and that our method of inference is not biased by the presence of strong serial-correlation.

Another obvious limitation of our difference-in-difference approach is that the policy introduction may have been correlated with other confounding factors (i.e. province level time-varying shocks). As a result our parameter estimates may be biased. One potentially confounding event that occurred close to the implementation of the price floor policy was that Ultramar, one of the leading retail chains, instituted a low-price guarantee (ValeurPlus or ValuePlus) in the summer of 1996. Since Ultramar has a greater presence in Québec than in Ontario, we might worry that the effects on prices and market structure that we have attributed to the price floor policy were actually the result of the Ultramar program. For example, if the price matching guarantee served to facilitate collusion this could explain the short run increase in prices. However, it is unlikely that such a pricing strategy could explain the long-run distortion in market structure. In fact, theoretical work suggests that price matching guarantees cannot deter entry, since they do not represent a credible commitment from incumbent firms (see for instance Arbatskaya (2001)).

Nevertheless, we can confirm empirically that the Ultramar program is not driving the changes that we observe. Although Ultramar was more dominant in Québec, it still owned roughly 5% of stations in Ontario. This fact, combined with the assumption that the low-price guarantee strategy has only a direct impact on local markets where Ultramar is present, allows us to simultaneously estimate both policy changes using a similar difference-in-difference approach. We have redone all of the regressions described in the results section, but in addition to our policy indicator via which we compare the behavior of gas stations in Québec and Ontario before and after the introduction of the price floor policy in 1997, we also include an indicator for the low-price guarantee program that compares the behavior of gas stations in local markets with and without Ultramar stations before and after the introduction of the guarantee. The inclusion of this indicator variable has no impact on the price-floor policy indicator variable. The only notable effect of the Ultramar program is that local markets directly affected became relative less competitive after 1996 (i.e. firms are less likely to enter into local markets where Ultramar is already present). Since our results suggest that the price floor policy led to the opposite consequence, the inclusion of the Ultramar pricing

policy actually strengthens our results concerning the number of competitors and the proportion of monopoly local markets.<sup>21</sup>

Another concern is changes in the regulations regarding underground storage tanks.<sup>22</sup> As mentioned above, one of the factors influencing the reorganization in the retail gasoline industry in the 1980's and 1990's was the advent of regulations on the environmental safety of underground storage tanks – more specifically, regulation on the removal of older tanks. Legislation requiring new tanks to meet certain standards had already been enacted in both provinces before 1991. In 1988 an Environmental Code of Practice for Underground Storage Tank Systems Containing Petroleum Products was published in Canada providing guidance on appropriate upgrading and removal behavior for storage tanks. It was up to individual provinces as to whether they adopted these guidelines or established their own regulation. In both Québec and Ontario regulation came into effect around 1991 regarding approval of unprotected tanks. In terms of timing these restrictions seem to be very similar. In Québec all tanks not meeting the protection standards were to be removed within two to seven years depending on the age of the tank as of July 1991, while in Ontario no approval was to be given for unprotected tanks that had not been upgraded and they would have to be removed by 1997. Given the similarity in terms of timing, the only remaining concern would be with regard to the extent to which these regulations were enforced in the two provinces. If Québec was more lenient in its enforcement of the upgrading and removal policy, this could explain some of the pattern that we observe. We have found no evidence that this is the case.

More generally, the purpose of our empirical work is to provide evidence supporting the argument that the reason bigger and more efficient stations do not enter in Québec is because the crowding in the market that results from the price floor implies that they will not earn sufficient profits to cover their bigger fixed costs. It should be pointed out that there are other possible means by which the price floor could negatively affect the profits that stations expect to earn upon entry. For instance it may also be that the presence of a price floor makes it difficult for firms engaged in tacit collusion (as in Porter (1983)) to revert to a “punishing” stage and therefore makes it increasingly difficult to sustain this type of equilibrium. The expected reduction in profit may deter the entry of new firms.

Similarly, the price floor may also reduce expected profits by making it more difficult to engage in intertemporal price discrimination. Stations may vary prices over time to take advantage of the fact that some consumers are patient and able to postpone the purchase of gasoline in anticipation of better prices in the future, while others are not. Those who are patient can wait for prices to fall, while those who cannot have more inelastic demand. A price floor limits the ability of stations to vary their prices in order to discriminate between these two groups and so may lower their overall profits.

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<sup>21</sup>We do not include these results in the paper. They are available from the authors upon request.

<sup>22</sup>We thank Heather Eckert for providing us with the following information.

## 6 Conclusion

We have shown that the impact of the price regulation on the Québec retail gasoline market was substantial. We identified the effect using a differences-in-differences approach with before and after observations in both Québec and Ontario, where the policy was never used.

First, we find that the policy significantly affected the reorganization of the markets. In Québec, there were more stations after the policy was introduced compared to Ontario, after controlling for unobserved market- and time-specific effects. Moreover, stations in Ontario became bigger and offered a wider variety of products. After the policy was introduced, Québec stations became relatively more homogeneous in terms of the type of services that they offered, mostly because new stations entering in Ontario were very different from the stations that stayed in the market.

Second, we find that these changes in market structure had an effect on the pricing behavior of firms. In the short run, before the policy had any effect on the structure of the markets, the policy seems to have increased prices, which is the standard expected effect of such price regulation. In the longer run, though, prices in Québec decreased sharply relative to Ontario, after accounting for the changes in all observed market and station characteristics and all types of location-specific and time-specific unobserved shocks.

So do these results provide support for the advocates of sales-below-cost regulation? Was pricing in Ontario where there was no floor predatory? Our results suggest that although pricing may not have been predatory in the sense that the entrants were pricing below cost, the effects on market structure experienced in Ontario were consistent with a predation story. That is, in Ontario, following the entry of new stations in retail markets, incumbents were driven out, markets became more concentrated, and prices increased. Incumbents were driven out not because entrants priced below cost, but because they were more efficient. In this sense, although the floor resulted in lower prices for markets in Québec, it may have done so at the expense of the entry of more efficient stations.

### 6.1 Welfare

What can be said about welfare? It seems clear that the policy decreased prices at the pump for consumers. On the other hand, there is evidence that after the policy, stations in Québec and in Ontario became increasingly dissimilar. Moreover, stations in local markets in Québec became more homogeneous than stations in local markets in Ontario. Therefore, after the policy consumers in Ontario were paying for different services than consumers in Québec, in the sense that new stations in Ontario were generally bigger and offered a wider variety of products.

On the firms' side, we find that after the policy stations in Québec were charging lower prices than stations in Ontario and had lower markups. This increase in net revenues for stations in Ontario may reflect an increase in rents due to decreased competition. On the other hand, the

higher prices may just reflect higher fixed or entry costs which reflect the expanded services they provide. Evaluating all these welfare effects requires the structural estimation of a precise market model, which is something we leave for future research.

## 6.2 Generalizability of the results

Notice that our results are specific to the Québec gasoline markets during a particular interval of years. Even though extrapolation of our results to other markets is not possible, our findings do provide evidence that such effects might be present in *any* market. As discussed in the Introduction, similar price regulation is not uncommon. For example, agricultural price controls that provide insurance to local producers against excessively low prices are a form of price floor. In Europe, regulation aimed at protecting small retailers from the aggressive pricing of big retailers is common. And throughout the world, anti-dumping regulation aimed at protecting local producers by forbidding foreign firms to set price below average variable costs are a subtle form of a price floor. All these policies have longer run effects on market structure and performance that are not always fully recognized.

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## A Tables and figures

Table 1: Number and size distribution of local markets

MARKETS	Count	Q <sub>5</sub>	Q <sub>25</sub>	Q <sub>50</sub>	Q <sub>75</sub>	Q <sub>95</sub>	Max
Chicoutimi, Qc	39	1	1	2	4	7	9
Cornwall, On	15	1	2	2	3	5	5
Drummondville, Qc	17	1	2	3	3	8	8
Guelph, On	14	1	2	2	5	9	9
Hamilton, On	39	1	3	5	7	10	15
Kingston, On	15	1	3	4	5	8	8
Québec, Qc	94	1	3	4	6	11	12
Sherbrooke, Qc	28	1	2	4	5	8	8
St. Catharines, On	25	1	2	3	4	7	8
Trois-Rivières, Qc	24	1	2	3	5	8	9
Total	310	1	2	3	5	9	15

Table 2: Market characteristics

Market names	Population	$\Delta$ Population (%)	Volume per cap. (litres)	$\Delta$ Volume per cap. (%)
Cornwall (On)	45726	0.29	3.16	1.98
Guelph (On)	109822	0.88	2.49	-1.34
Hamilton (On)	483981	0.91	2.42	0.54
Kingston (On)	145090	1.10	2.59	1.55
St Catharines (On)	129588	0.41	2.84	0.314
Chicoutimi (Qc)	112857	-0.42	2.82	1.69
Drummondville (Qc)	64241	0.99	2.72	0.30
Quebec (Qc)	512746	0.33	3.15	1.58
Sherbrooke (Qc)	138957	0.70	2.64	1.67
Trois-Rivieres (Qc)	140847	0.05	2.22	0.94

*Population* and *Volume per capita* are market (i.e. city) averages taken over the period 1991 – 2001. The change variables are averages of year-to-year log-changes taken over the same period and expressed in percentage ( $\times 100$ ).

Table 3: Entrant, exiting, and continuing stations

	Nb. Pumps	Nb. Islands	Conv. Store	Full service
$E(X \text{Entrant}) - E(X \text{Continuing})$	0.473 (0.996)	0.080 (0.145)	0.062 (0.049)	-0.020 (0.052)
$E(X \text{Entrant}) - E(X \text{Exiting})$	5.5252*** (0.989)	0.6945*** (0.144)	0.4768*** (0.051)	-0.3705*** (0.053)
$E(X \text{Exiting}) - E(X \text{Continuing})$	-5.4066*** (0.378)	-0.6402*** (0.070)	-0.4141*** (0.028)	0.3432*** (0.028)

Robust asymptotic standard-errors are in parenthesis. Each entry corresponds to the regression coefficient  $\beta = E(X|\text{Group}^1) - E(X|\text{Group}^2)$  from:

$$X_j = \alpha + \beta I(j \in \text{Group}) + e_j.$$

For each row the sample corresponds to stations that part of Group<sup>1</sup> and Group<sup>2</sup>, where Group corresponds to either *Entrant*, *Continuing* or *Exiting*.

Figure 1: Evolution of prices and local market structure characteristics in Québec and Ontario between 1991 and 2001

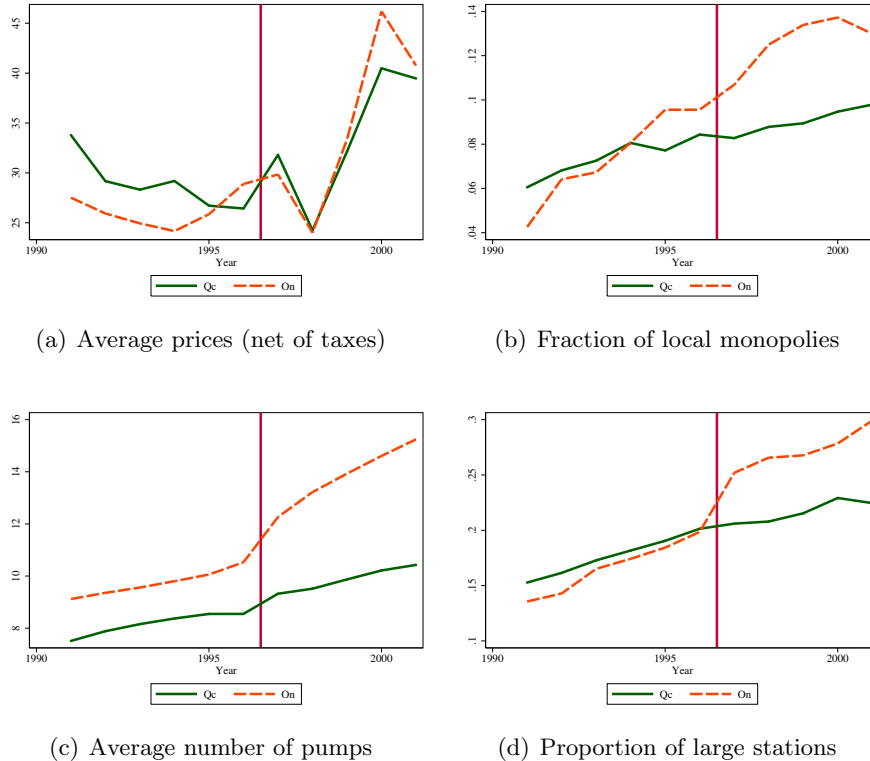


Table 4: Summary statistics of the key variables for the two Provinces before and after the policy change

VARIABLES	Before 1997				After 1997			
	Quebec		Ontario		Quebec		Ontario	
	N	Average (sd)	N	Average (sd)	N	Average (sd)	N	Average (sd)
Price (log)	3715	4.100 (0.044)	1747	3.969 (0.056)	2704	4.204 (0.110)	1260	4.143 (0.136)
Revenue (log)	3381	12.229 (0.741)	1383	12.622 (0.759)	2431	12.615 (0.747)	905	13.217 (0.864)
Sales volume (log)	3495	8.124 (0.751)	1533	8.638 (0.774)	2447	8.410 (0.742)	917	9.071 (0.844)
Nb. of pumps	3840	8.148 (5.731)	1921	9.690 (5.535)	2723	9.856 (7.314)	1281	13.842 (9.941)
Nb. Islands	3840	2.118 (1.271)	1921	2.339 (1.227)	2723	2.263 (1.342)	1281	2.665 (1.403)
Islands > 4	3840	0.176 (0.381)	1921	0.164 (0.371)	2723	0.216 (0.412)	1281	0.272 (0.445)
No Conv. store	3840	0.580 (0.494)	1921	0.674 (0.469)	2723	0.399 (0.490)	1281	0.435 (0.496)
Carwash	3840	0.190 (0.392)	1921	0.168 (0.374)	2723	0.187 (0.390)	1281	0.219 (0.413)
Pay at the pump	3840	0.001 (0.036)	1921	0.022 (0.148)	2723	0.039 (0.193)	1281	0.141 (0.348)
Repair shop	3840	0.191 (0.393)	1921	0.069 (0.253)	2723	0.155 (0.362)	1281	0.061 (0.239)
Self service	3840	0.369 (0.483)	1921	0.366 (0.482)	2723	0.502 (0.500)	1281	0.463 (0.499)
Local comp.	3840	3.663 (2.295)	1921	3.558 (2.718)	2723	3.010 (1.953)	1281	2.539 (1.997)
Street comp.	3840	10.099 (9.466)	1921	9.353 (7.276)	2723	7.701 (6.961)	1281	7.624 (5.868)

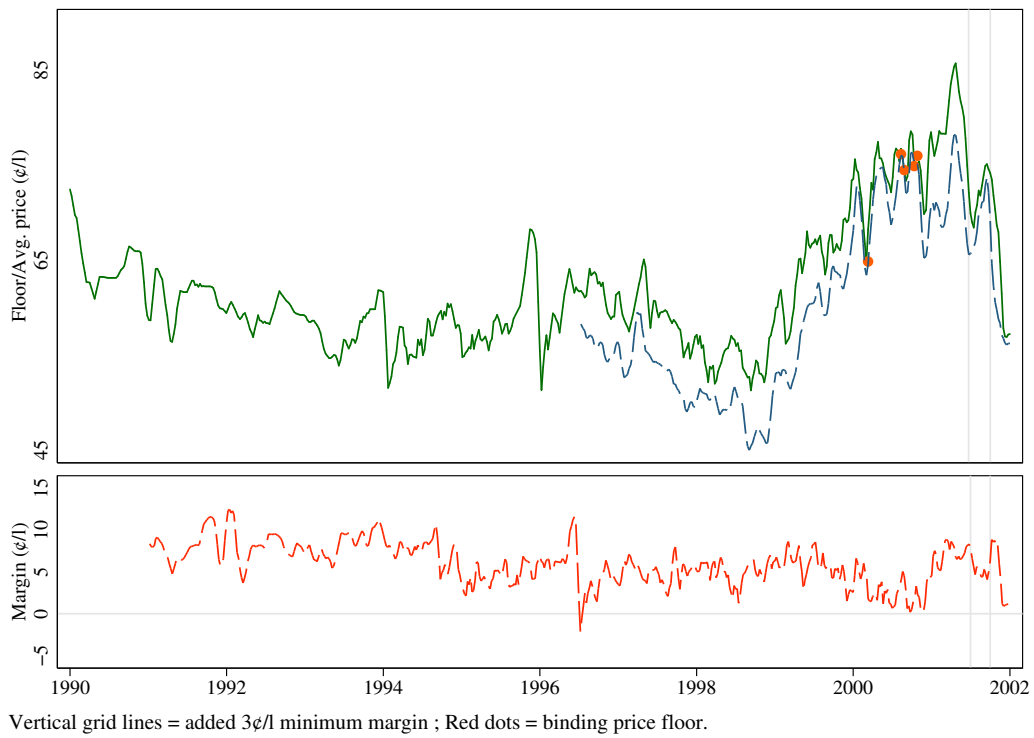


Figure 2: Evolution of average prices, margins and floor in Québec City between 1991 and 2001

Table 5: Long-run and short-run effects of the policy on markups

VARIABLES	(1) Short-run	(2) Short-run	(3) Short-run	(4) Long-run	(5) Long-run	(6) Long-run
Policy	0.132*** (0.00453)	0.144*** (0.00462)	0.141*** (0.00473)	-0.0751*** (0.00308)	-0.0350*** (0.00565)	-0.0292*** (0.00573)
Local competitors (log)		-0.0120 (0.0159)	-0.00885 (0.0162)		-0.000270 (0.00694)	0.00171 (0.00688)
Size of local competitors (log)		-0.00215 (0.0101)	-0.000879 (0.0104)		-0.00639 (0.00431)	-0.00723* (0.00426)
Street competitors (log)		0.0253 (0.0208)	0.0191 (0.0212)		-0.00465 (0.00829)	-0.00599 (0.00815)
Size of street competitors (log)		-0.00685 (0.0163)	-0.00938 (0.0174)		-0.0135* (0.00793)	-0.0109 (0.00792)
Stations per capita		-0.954*** (0.0570)	-0.942*** (0.0548)		-0.274*** (0.0467)	-0.286*** (0.0462)
Pumps per capita		-0.212*** (0.0281)	-0.204*** (0.0288)		0.170*** (0.0244)	0.177*** (0.0251)
Quebec	-0.0562*** (0.00312)			0.0956*** (0.00224)		
After 1996	-0.0109*** (0.00286)			-0.0244*** (0.00237)		
Constant	0.157*** (0.00154)	-0.302*** (0.0765)	-0.351*** (0.0776)	0.167*** (0.00200)	-0.115* (0.0605)	-0.110* (0.0602)
Observations	1683	1683	1683	9765	9765	9765
Number of stations		880	880		1174	1174
$R^2$	0.527	0.808	0.825	0.261	0.559	0.573

Dependent variable: markup.

All specifications except 1 and 4 include period fixed-effects.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Robust standard errors in parentheses (clustered at the station level).

Col. 3 and 6 also include a full set of station characteristics and location fixed-effects.

Table 6: Long-run and short-run effects of the policy on markups using weekly data

VARIABLES	(1) Short run	(2) Long run (t≥1991)	(3) Long run (t≥1992)	(4) Long run (t≥1993)	(5) Long run (t≥1994)	(6) Long run (t≥1995)
Policy	0.0251* (0.0144)	-0.0787*** (0.00701)	-0.0697*** (0.00731)	-0.0633*** (0.00769)	-0.0493*** (0.00853)	-0.0375*** (0.00972)
Rack price	-0.00547** (0.00216)	-0.00826*** (0.000599)	-0.00861*** (0.000626)	-0.00851*** (0.000628)	-0.00821*** (0.000639)	-0.00790*** (0.000643)
Constant	0.294*** (0.0704)	0.541*** (0.0286)	0.499*** (0.0324)	0.412*** (0.0304)	0.408*** (0.0334)	0.412*** (0.0399)
Observations	303	1650	1491	1350	1197	1068
$R^2$	0.158	0.529	0.470	0.428	0.308	0.255

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 7: Short-run and long-run effects of the policy on sales and revenues

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log Vol. Short-run	Log Vol. Short-run	Log Vol. Long-run	Log Vol. Long-run	Log Rev. Short-run	Log Rev. Short-run	Log Rev. Long-run	Log Rev. Long-run
Policy	-0.0165 (0.0349)	0.0371 (0.0260)	-0.147* (0.0402)	-0.0477 (0.0320)	0.0717* (0.0350)	0.126* (0.0266)	-0.221* (0.0406)	-0.0835* (0.0315)
Local comp.		-0.105 (0.106)		-0.137* (0.0323)		-0.126 (0.109)		-0.132* (0.0315)
Size of local comp.		-0.0753 (0.0647)		0.0264 (0.0234)		-0.0637 (0.0639)		0.0219 (0.0231)
Street comp.		-0.156 (0.112)		-0.0855 (0.0487)		-0.163 (0.113)		-0.0859 (0.0480)
Size of street comp.		0.0824 (0.0769)		-0.0675 (0.0466)		0.105 (0.0787)		-0.0844 (0.0470)
Stations per capita		-0.241 (0.353)		-0.310 (0.161)		-0.543 (0.365)		-0.494* (0.158)
Pumps per capita		0.435* (0.182)		-0.0634 (0.133)		0.323 (0.186)		0.0231 (0.131)
Quebec	-0.617* (0.0676)		-0.514* (0.0509)		-0.598* (0.0675)		-0.382* (0.0509)	
After 1996	0.0816* (0.0285)		0.433* (0.0339)		0.0984* (0.0286)		0.611* (0.0344)	
Observations	1451	1451	8392	8392	1451	1451	8392	8392
R <sup>2</sup>	0.115	0.112	0.136	0.255	0.102	0.223	0.137	0.412
Nb. of stations		784		1129		784		1129

Col. 2-4-6-8 include station characteristics and location/time fixed-effects.

Robust standard errors in parentheses (clustered at the station level). \* p<0.05

Dep. variables: log sales volume (col. 1-4) and log revenue (col. 5-8). The market structure variables are measured in log.

Table 8: Long-run effect on local competition, station characteristics, and differentiation

		VARIABLES	Policy coefficients	$n$	Number of markets	$R^2$
Competition	(1)	Competitors	0.126** (0.062)	3399	309	0.225
	(2)	Local monopoly	-0.0754*** (0.025)	3399	309	0.017
Store characteristics	(3)	Total Pumps	-2.000*** (0.372)	3220	307	0.232
	(4)	Nb. Islands	-0.118*** (0.038)	3220	307	0.316
	(5)	Large pumps	-0.0821*** (0.019)	3220	307	0.189
	(6)	Large islands	-0.0772*** (0.016)	3220	307	0.116
	(7)	Full service	-0.0341** (0.016)	3220	307	0.138
	(8)	Conv. store	-0.0454*** (0.016)	3220	307	0.185
	(9)	Car wash	-0.0458*** (0.012)	3220	307	0.031
	(10)	Repair shop	-0.0163** (0.008)	3220	307	0.033
	(11)	Electronic Payment	-0.0596*** (0.0121)	3220	307	0.125
	(12)	Grade variety	-0.233*** (0.036)	3220	307	0.058
Product differentiation	(13)	Size variation	-0.0598*** (0.020)	2384	246	0.050
	(14)	Islands variation	-0.0564** (0.025)	2384	246	0.266
	(15)	Large island variation	-0.0335* (0.020)	2384	246	0.028
	(16)	Large pumps variation	-0.0204 (0.021)	2384	246	0.073
	(17)	Conv. store variation	-0.0428** (0.018)	2384	246	0.051
	(18)	Car wash variation	-0.0491*** (0.015)	2384	246	0.017
	(19)	Full service variation	-0.0164 (0.021)	2384	246	0.011
	(20)	Repair shop variation	-0.0364*** (0.013)	2384	246	0.053

HAC asymptotic standard-errors are in parenthesis. All specifications also include time and location fixed-effects.

Table 9: Wilcoxon rank-tests comparing changes in Québec and Ontario cities before and after 1997

VARIABLES	Wilcoxon test (Mann-Whitney)	$\Pr(E(\Delta Y On) > E(\Delta Y Qc))$
Nb. pumps	1.984**	0.88
Large stations (4+ islands)	2.193**	0.92
Pump variety	2.402**	0.96
Carwash	2.611***	1
No conv. Store	-1.57	0.2
Pay at the pump	1.57	0.8
Productivity	2.611***	1
Local competitors	-1.36	0.24

Each variable measures the change before and after 1997 in the market-level average taken over all stations active in a given year. The Wilcoxon rank-sum statistics are calculated separately for each variable using Stata *ranksum* command. The test is valid asymptotically if the number of individuals (i.e. stations) within group (i.s market) is large. The test compares the changes in Ontario and Quebec markets (cities), before and after 1997. The second column calculates the probability that changes in Ontario markets are greater than changes in Quebec markets. Productivity is measured as the residual a regression of sales volume on store characteristics.

## B A dynamic industry model with price controls

We describe a dynamic model of entry, exit and product choice in an industry that is subject to a price floor regulation. The model illustrates the role of price controls in distorting the structure of retail markets. We are particularly interested in characterizing the potential effects of regulation on the number of and type of competitors and the resulting prices.

The model has two components: (i) a static pricing game, and (ii) a dynamic entry and product choice game. We first describe the pricing game and then the industry dynamic equilibrium. Finally, we compare the equilibria with and without price regulation using numerical examples.

### B.1 Demand and prices

In the short-run the structure of the market is constant and firms post prices simultaneously. There are two types of firms, large and small (i.e.  $l$  and  $s$ ). These two types differ with respect to their quality ( $\delta_l \geq \delta_s$ ) and their constant marginal cost ( $c_l \leq c_s$ ). Firms face a passive outside competitor that provides a good with net value  $\nu$ . The market structure is therefore described by the number of active firms of each type and the value of the outside option. The state of the industry is further characterized by the number  $n_s, n_l$  of active firms and an exogenous price floor  $p_f \geq 0$  set by the government. We group these state variables in a vector  $\omega = \{n_s, n_l, \nu, p_f\}$ . For simplicity we assume that the state space is finite.

To characterize demand at each store, we use a logit model with congestion similar to the model proposed by Akerberg and Rysman (2005), who suggest the addition of congestion to the logit model of product differentiation to mimic the localized nature of competition in retail markets. Since in the logit model differentiation is measured by the variance of consumers' idiosyncratic tastes for products, we let it depend on the number of competitors as follows:

$$\sigma(n) = \frac{1}{\mu} n^{-\mu}, \quad (7)$$

where  $0 < \mu < 1$ .

Demand for product  $j \in \{s, l\}$  is therefore given by:

$$D_j(p|\omega) = M \frac{e^{(\delta_j - p_j)/\sigma(n)}}{e^{\nu/\sigma(n)} + \sum_k e^{(\delta_k - p_k)/\sigma(n)}}. \quad (8)$$

Without a price floor constraint, a symmetric price equilibrium is described by two prices  $p(\omega) = \{p_s(\omega), p_l(\omega)\}$  solving the following FOCs:

$$D_j(p(\omega)) - M \frac{1}{\sigma(n)} (p_j(\omega) - c_j) s_j (1 - s_j) = 0, \quad j \in \{s, l\} \quad (9)$$

where  $s_j = \frac{e^{(\delta_j - p_j)/\sigma(n)}}{e^{\nu/\sigma(n)} + \sum_k e^{(\delta_k - p_k)/\sigma(n)}}$ .

When firms are constrained by a price floor  $p_f > 0$  the equilibrium is characterized by four

Kuhn-Tucker conditions:

$$D_j(p(\omega)) - M \frac{1}{\sigma(n)} (p_j(\omega) - c_j) s_j (1 - s_j) + \lambda_j = 0 \quad (10)$$

$$\lambda_j (p_j(\omega) - p_f) = 0 \quad (11)$$

for each  $j \in \{s, l\}$  and  $\lambda_j \geq 0$ . Throughout the paper we focus on cases that satisfy the following two properties:<sup>23</sup>

If  $n_j > 0$  for all  $j$ :  $p_l(\omega) \leq p_s(\omega)$ ,

If  $n = 1$ :  $p_l(\omega) \leq p_s(\omega)$ .

These conditions simply mean that the large firm always charges a weakly lower price in equilibrium, both in oligopoly and monopoly setups. As a result the price floor will generate three possible outcomes: (i) no prices are constrained ( $\lambda_l = \lambda_s = 0$ ), (ii) both prices are constrained ( $p_s = p_l = p_f$ ), or (iii) only the large firm is constrained ( $\lambda_s = 0$  and  $p_l = p_f$ ). We assume that a symmetric Nash equilibrium satisfying these conditions exists and is unique. Let  $\pi_j(\omega)$  denote the static equilibrium profit of type  $j$  firm.

## B.2 Entry and exit

In the long-run incumbents are able to adjust their configurations and new firms can enter the market. Conditional on their current type, the state of the industry and a vector of privately observed profitability shocks  $\epsilon = \{\epsilon_o, \epsilon_s, \epsilon_l\}$ , firms simultaneously choose between three options: (i) small configuration, (ii) large configuration, (iii) exit/stay-out. As in Rust (1987) we assume that the private information component of the state is *iid* across players and time, and distributed according to a double-exponential distribution (i.e. multinomial logit).

The timing of actions is as follows. At the beginning of the period firms observe the state of the industry  $\omega$  and their private information shock  $\epsilon$ . Firms then simultaneously commit to a price and a configuration choice, and profits are realized. Entry/exit and reconfiguration actions are taken at the end of the period.

Potential entrants face the same problem but live for only one period as in Pakes and McGuire (1994). For tractability we assume that only one firm can enter every period, and that no more than  $\bar{n}$  firms can be active.

We follow Aguirregabiria and Mira (2007) and Doraszelski and Satterthwaite (2009) in defining a Markov-perfect Bayesian equilibrium. Because actions are stochastic (prior to observing  $\epsilon$ ), players use choice probabilities  $\sigma_j(a|\omega)$  to form beliefs about their opponents' actions. We focus on symmetric Markovian strategies. Therefore these probabilities are symmetric and depend only on the current observed state vector  $\omega$ .

Given beliefs  $\sigma$ , an incumbent's problem is described by the following Bellman equation:

$$V_j^\sigma(\omega, \epsilon) = \max_{a \in \{o, s, l\}} \pi_j(\omega) - F_j - K(j, a) + \epsilon_a + \beta \sum_{\omega'} EV_a^\sigma(\omega') F^\sigma(\omega'|\omega, a) \quad (12)$$

where  $EV_j^\sigma(\omega') = \int V_j^\sigma(\omega', \epsilon') f(\epsilon') d\epsilon'$ . The adjustment cost function  $K(j, a)$  incorporates both

<sup>23</sup>These conditions are implicit constraints on the cost and quality parameters. In particular, the cost efficiency of the large firm dominates the effect of quality on prices.

the cost of entering and reconfiguring an existing store, as well as the cleaning cost of leaving the market. We parametrize the function as follows:

$$K(j, a) = \begin{cases} 0 & \text{if } j \neq a \\ \kappa & \text{if } j = o \text{ and } a \neq o \\ \kappa + x & \text{if } j \neq o \text{ and } a \neq j \\ x & \text{if } j \neq o \text{ and } a = o \end{cases} \quad (13)$$

Once firms leave the market, they receive a payoff  $\epsilon_o$  and are not able to re-enter. The expected continuation value of being out of the market is therefore zero. The problem of potential entrants is described by:

$$V_o^\sigma(\omega, \epsilon) = \max \left\{ \epsilon_o, \max_{a \in \{s, l\}} -\kappa + \epsilon_a + \beta \sum_{\omega'} EV_a^\sigma(\omega') F^\sigma(\omega' | \omega, a) \right\}. \quad (14)$$

The transition probability matrix  $F^\sigma(\omega' | \omega, a)$  is constructed from the beliefs probabilities  $\sigma$  and the transition matrix for the outside option valuation  $G(\nu'_0 | \nu)$ . Let  $A_{-j}(\omega', \omega, a)$  be the set of possible actions that player  $j$ 's opponents can take in state  $\omega$  in order to reach state  $\omega'$ . The transition probability function is then given by:

$$F^\sigma(\omega' | \omega, a) = \Pr [\{n'_s, n'_l, \nu', p_f\} | \omega, a, \sigma] = \sum_{a_{-j} \in A_{-j}(\omega', \omega, a)} \prod_i \sigma_i(a_i | \omega) G(\nu' | \nu). \quad (15)$$

Given beliefs  $\sigma$  and the assumed distribution of the unobserved private information, the best-response choice probability of a firm of type  $j$  takes a multinomial logit form. A Markov-perfect Bayesian Nash equilibrium is defined as a fixed point in the belief choice probabilities:

$$\sigma_j(a | \omega) = \frac{\exp(v_j^\sigma(a | \omega))}{\sum_{k \in \{o, s, l\}} \exp(v_j^\sigma(k | \omega))}, \quad (16)$$

where  $v_j^\sigma(a | \omega) = \pi_j(\omega) \times 1(a \neq o) - K(j, a) + \beta EV^\sigma(\omega') F^\sigma(\omega' | \omega, a)$  is the choice specific value function prior to observe  $\epsilon_a$ .

### B.3 Numerical examples

In this section we discuss several numerical examples to illustrate the properties of the dynamic game and the impact of price floor constraints on the dynamics of the industry. Table 10 presents the two sets of parameters that are used. The first one illustrates an industry with moderate fixed-costs and little turnover, and the second one has larger fixed-costs and a higher turnover rate. We set the maximum number of firms to 5. Without large firms the long run average number of firms is always smaller than 5, so this constraint does not affect the results. Note also that in all examples we fixed the value of the outside option to  $-1.5$ . Therefore, only entry, exit and reconfiguration decisions generate randomness in the industry. Moreover, the adjustment cost parameters  $\kappa$  and  $x$  are set to relatively high levels which creates infrequent turnover in the industry.

In all specifications we set the price floor to 1. At this level, the price floor does not bind in

Table 10: Parameter values for the numerical simulations

	Specification 1	Specification 2
<b>Demand parameters</b>		
$M$	5	5
$\delta_s$	0	0
$\delta_l$	0	0
$\nu$	1.5	1.5
$\mu$	3/4	3/4
<b>Marginal costs</b>		
$c_s$	1/2	1/2
$c_l$	0	0
<b>Fixed costs</b>		
$F_s$	1.2	1.25
$F_l$	2.7	2.85
<b>Entry/exit costs</b>		
$\kappa$	5	5
$x$	5	5

equilibrium unless a large firm is active in the industry. Figures 3(a) and 3(b) graph the average market prices with and without a price floor. Because of the congestion term, prices fall sharply with the number of firms. In the unconstrained case, large firms set their prices very close to the marginal cost of the small firms when there are more than four firms active. The price floor regulation therefore protects the small type and restores the price that would be observed if large firms were not present in the industry (see top left corner of Figure 3(a)).

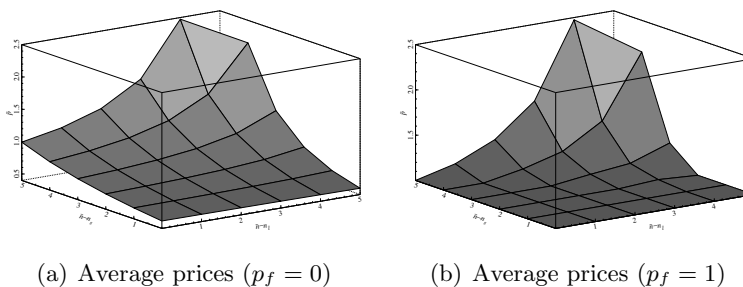


Figure 3: Equilibrium average price and market structure under specification 1

To analyze the long-run effect of a price floor constraint we simulate the evolution of the industry for 10,000 periods and calculate the proportion of time that the industry spends in each discrete state. In order to compare across specifications we use exactly the same sequence of random numbers.

The first panel of Table 11 illustrates the simulation results for the first specification. In this specification, the fixed costs of both types are relatively small and the steady state level of competition is important. Without the regulation (left panel), the most likely industry structure

Table 11: Long run distribution of industry structure (top four industry states)  
Specification 1

Unconstrained equilibrium				Constrained equilibrium ( $p_f = 1$ )			
Market structure	Freq.	Prices	Welfare	Market structure	Freq.	Prices	Welfare
$(N_s = 1, N_l = 2)$	0.73	1	2.11	$(N_s = 4, N_l = 0)$	0.59	1.11	2.32
$(N_s = 2, N_l = 1)$	0.1	1.16	1.88	$(N_s = 3, N_l = 1)$	0.16	1.08	2.38
$(N_s = 0, N_l = 2)$	0.06	1.25	1.32	$(N_s = 2, N_l = 1)$	0.16	1.2	1.82
$(N_s = 0, N_l = 3)$	0.06	0.84	2.33	$(N_s = 3, N_l = 0)$	0.04	1.3	1.65
Mean price		1.063	1.951			1.127	2.219
Median price		1.002	2.113			1.109	2.320

Specification 2

Unconstrained equilibrium				Constrained equilibrium ( $p_f = 1$ )			
Market structure	Freq.	Prices	Welfare	Market structure	Freq.	Prices	Welfare
$(N_s = 2, N_l = 1)$	0.86	1.16	1.88	$(N_s = 4, N_l = 0)$	0.71	1.11	2.32
$(N_s = 3, N_l = 1)$	0.06	1	2.58	$(N_s = 3, N_l = 0)$	0.27	1.3	1.65
$(N_s = 4, N_l = 0)$	0.03	1.11	2.32	$(N_s = 5, N_l = 0)$	0.01	1	2.92
$(N_s = 3, N_l = 0)$	0.02	1.3	1.65	$(N_s = 3, N_l = 1)$	0.01	1.08	2.38
Mean price		1.115	2.073			1.158	2.151
Median price		1.158	1.880			1.109	2.320

has one small and two large firms. Because the large firm is significantly more efficient, the average price in that state is 1.

The right panel shows that a price floor regulation can significantly distort the structure of the industry. Since fixed costs are relatively small, the equilibrium number of firms is large and competition is intense. This implies that the price floor binds for at least one firm in about 40% of the simulated periods. This offers a lot of protection for the small types.

This protection implies that in the most likely industry structure, no large firm enters the market. This is because the efficient technology has large fixed costs and is not profitable unless two or three small firms leave the market. Since the regulation protects the small types, firms correctly anticipate that they would not be profitable by entering with the most efficient technology.

Because competition is intense in both cases and the floor blocks entry of the more efficient technology, the regulation tends to raise prices on average. The bottom lines of the Table show that the average and median prices are about 10% higher with the price floor regulation. Therefore, in this example the regulation creates large inefficiencies both because consumers pay higher prices on average and because too many firms are active in the industry.

The simulation results from the second specification are reproduced in the lower panel of Table 11. In this example the fixed costs of both types are increased by 0.05, which leads to fewer large firms in equilibrium. In the unregulated market the more likely industry structure is the one with two small firms and one big firm, which leads to higher prices on average than in the first specification. With the price floor regulation, the distribution of equilibrium states in the long-run is similar to the previous example. In nearly 100% of the simulation periods, the industry has three or four small firm, but no large firm. As a result, the regulation completely blocks the adoption of the large technology.

In terms of average prices however, the two examples differ. The mean simulated prices are

almost the same with or without the regulation, but the median and the mode are smaller **with** the price floor. As before two opposite forces are in action. On the one hand the presence of the price floor makes the market relatively more competitive because it blocks the entry of large firms. On the other hand, firms tend to be more efficient in the unregulated market. In the first example, the efficiency gains were dominant and prices were higher with the price floor. The second example shows that when the fixed cost of the efficient type is large enough, the competitive effect can dominate and prices can be higher without the floor.

Another interesting feature of the second example is that the price floor binds only in 2% of the simulated periods. Therefore, the price floor can significantly distort the structure of markets without actually binding in equilibrium. This is an important feature of the model that we observe in the gasoline example.

The effect of the policy on consumer welfare is not trivial, however. Consumer welfare in the second example is likely to be higher with the policy since prices are typically lower. In addition to this price tradeoff, the welfare impact of the policy depends on consumers' valuation for variety. In all examples the number of products is larger on average with the policy. Since consumer valuation for variety is important in logit models, the average consumer welfare is larger with the policy in all cases.

## C Description of the clustering algorithm

In this appendix we describe the construction of local markets. Consider an isolated metropolitan area composed of  $L$  potential store locations. In the data we define  $n$  as the set of geographic coordinates and street intersection pairs that were ever occupied by a gasoline station between 1991 and 2001. Because of entry and exit,  $n$  is thus larger than the total number of active station at any point in time.

The clustering algorithm proceeds iteratively by grouping stations with similar spatial characteristics until the allocation of stores in groups is stable. We define the degree of similarity between two locations using the euclidian distance ( $d_{ij}$  expressed in Km), and an indicator variable equal to one if they share at least one street. Each location can be characterized by up to two streets.

The key parameter of the algorithm is  $\delta$ . It determines a threshold distance such that two locations are considered in the same local market even if they do not have street in common. This parameter is important since two stores can be very close in euclidian distance, but the survey company does not locate them along the same street. Intuitively this parameter is a penalty added to the euclidian distance between two stores that are not connected by a common street. We fix the value of  $\delta$  to 1/4 Km, which is a very small distance. Note that the number of stable clusters is rapidly decreasing in  $\delta$ .

We initiate the algorithm by defining initial local markets, as the set of possible street intersections in the city. Let  $\mathcal{M}^t$  be the allocation at iteration  $t$ .  $\mathcal{M}^t$  is a mapping from locations to local markets:

$$\mathcal{M}^t = \{m_1^t, m_2^t, \dots, m_L^t\}, \quad (17)$$

where  $m_i^t$  is the local market id associated with location  $i$ .

1. At iteration  $t$ , update the assignment of store  $i \in L$ :

(a) Calculate the distance between location  $i$  and the center of market  $m_i$  denoted by  $l_{m_i}$ <sup>24</sup>:

$$D(i, m_i) = \begin{cases} \delta & \text{if } |m_i| = 1, \\ d(l_i, l_{m_i}) & \text{otherwise.} \end{cases} \quad (18)$$

(b) Calculate the distance from  $l_i$  to all other local markets. For each market  $m \neq m_i$ :

$$D(i, m) = \begin{cases} d(l_i, l_m) + \delta & \text{if } s_i \notin S_m, \\ d(l_i, l_m) & \text{otherwise,} \end{cases} \quad (19)$$

where  $s_i$  is the vector of street indices of location  $i$  and  $S_m = \bigcup_{j \in m} s_j$  is the union of streets for all locations in market  $m$ . Let  $m_i^* \neq m_i^t$  the closest local market for location  $i$ .

(c) If  $D_i^* < D(i, l_{m_i^t})$  set  $m_i^{t+1} = m_i^*$ . Otherwise leave location  $i$  assignment unchanged.

2. Repeat the previous steps for all  $i \in L$ .

3. If  $\mathcal{M}^{t+1} \neq \mathcal{M}^t$  repeat step (1) and (2). Otherwise stop.

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<sup>24</sup>We definite  $l_m$  as the average latitude/longitude coordinate of locations belonging to  $m$ .