When Wholesalers Join the Cartel: Prices, Markups, and Rent Sharing

Bruno Amat

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Abstract

This paper studies how wholesaler participation affects cartel outcomes. I extend a capacity-constrained cartel model to allow upstream wholesalers to join a downstream retail cartel, discriminate in wholesale prices, and bargaining over the division of monopoly rents. Vertical collusion becomes fully inclusive and implements the monopoly price, with negotiated wholesale prices embedding retailer-specific bargaining weights. Using a novel station-level panel from the Brazilian gasoline market and eight cartel cases, I show that vertical cartels raise retail prices and margins by roughly three times as horizontal cartels, while wholesale margins increase only modestly. The inferred bargaining weights indicate that wholesalers capture most monopoly rents, yet retailers gain disproportionately from vertical collusion. The results challenge the view that vertical coordination is typically benign for the consumers and show that vertical cartels can generate substantially greater consumer harm.
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1 Introduction

Vertical integration and vertical coordination have long occupied an ambiguous place in antitrust analysis. Classic contributions emphasize that closer alignment between upstream and downstream firms may improve pricing efficiency and, in some environments, reduce final prices (Spengler, 1950; Rey and Tirole, 2007). By eliminating successive markups or facilitating coordination within the firm, vertical integration has often been viewed as benign or even welfare-enhancing relative to horizontal concentration.

At the same time, a large body of work recognizes that vertical arrangements can generate competitive harm. Vertical relationships may be used to foreclose rivals, soften downstream competition, or facilitate exclusion. More recently, theoretical and empirical research has shown that vertical links can play a central role in sustaining collusion, particularly in hub-and-spoke settings in which upstream firms help coordinate or discipline downstream rivals (Jullien and Rey, 2007; Van Cayseele and Miegielsen, 2013; Harrington, 2017; Clark et al., 2024; Chaves and Duarte, 2025).

What remains largely unexplored, however, is how vertical participation changes the *magnitude* of collusive outcomes. While the literature has focused primarily on whether vertical relationships make cartels more stable, much less is known about whether they make cartels more harmful. Does upstream participation increase retail prices and markups relative to a purely horizontal cartel operating in the same market? Does it change total cartel profits and the way rents are allocated across tiers?

This paper answers these questions. I show that when wholesalers actively join a downstream retail cartel, vertical coordination does not mitigate harm—it amplifies it. A vertically organized cartel internalizes pricing across tiers, implements the monopoly outcome, and then divides rents through Nash-in-Nash bargaining. In contrast to the standard vertical-integration logic—under which coordination may lower prices—vertical collusion raises retail prices relative to a purely horizontal retail cartel and redistributes monopoly rents across upstream and downstream firms.

The paper makes three main contributions.

First, I extend the capacity-constrained cartel model of Bos and Harrington (2010) to include an upstream wholesale tier that can collude and discriminate across retailers. Vertical collusion operates in two stages. Discriminatory wholesale pricing eliminates profitable downstream deviations and induces full participation, leading to the monopoly price. Conditional on monopoly pricing, monopoly rents are divided between wholesalers and retailers through Nash-in-Nash bargaining. The model yields sharp predictions: vertical cartels generate weakly higher retail prices and retail profits than horizontal cartels, wholesale profits are also weakly higher, and observed markups map directly into retailer-specific bargaining weights.

Second, I assemble a novel station-level panel dataset for the Brazilian gasoline market combining weekly retail and wholesale prices, station characteristics, and detailed legal records from CADE (Brazilian Antitrust Authority) covering eight adjudicated cartel episodes—four horizontal and four vertical—between 2004 and

2020. Using a two-step matching difference-in-differences design, I estimate firm-level treatment effects and compare vertical and horizontal cartels within the same industry. The results show that vertical cartels raise retail prices and retail markups by more than twice as much as horizontal cartels, while wholesale margins increase only modestly. The vertical cartel increases the deadweight loss by 531% relative to the horizontal benchmark. These findings demonstrate that upstream participation materially changes the size of overcharges and the damage caused by the cartel.

Third, embedding Nash-in-Nash bargaining inside a collusive structure allows me to recover retailer-specific bargaining weights from observed wholesale and retail markups. Estimating these weights provides new evidence on how cartel rents are divided across tiers, how bargaining power varies across firms and contracts, and how rent allocation evolves over the cartel lifecycle. This links the literature on vertical bargaining (Horn and Wolinsky, 1988; Berto Villas-Boas, 2007; Grennan, 2013; Crawford et al., 2018; Collard-Wexler et al., 2019) to the study of cartel organization (Asker, 2010; Genesove and Mullin, 2001) in a unified empirical framework.

Quantifying how much vertical participation amplifies cartel harm is crucial for both academic and policy reasons. Most of the literature treats vertical coordination as a structural feature that may affect stability, but rarely measures how much it changes the magnitude of price distortions. Showing that vertical cartels increase deadweight loss by more than fivefold relative to horizontal cartels provides an economically meaningful benchmark for enforcement. It moves the discussion beyond whether vertical links facilitate collusion and instead quantifies how much additional harm they generate. This distinction is central for optimal penalty design, merger assessment, and screening priorities: if vertical participation systematically magnifies welfare losses, then cartels with upstream involvement represent a qualitatively more severe threat to consumer surplus.

Estimating retailer-specific bargaining weights, is equally important because it opens the "black box" of how cartel rents are allocated. The bargaining weight is tightly linked to a firm's outside option: a higher bargaining power reflects stronger deviation incentives and therefore greater leverage in surplus division. Measuring the bargaining power allows one to identify, at the case level, whether wholesalers or retailers capture the bulk of monopoly rents—information that is directly relevant for targeting enforcement pressure. At the firm level, it provides a structural basis for thinking about fines and deterrence: penalties aligned with bargaining power may better discipline the firms with the strongest incentives to sustain collusion. Finally, the time variation in θ_{it} sheds light on cartel stability, revealing whether sustaining collusion requires reallocating surplus across tiers as enforcement risk evolves.

The remainder of the paper proceeds as follows. Section 2 presents the theoretical model and characterizes equilibrium outcomes under horizontal and vertical collusion. Section 3 describes the institutional setting and data. Section 4 presents the empirical strategy and estimates the differential price effects of vertical and horizontal cartels. Section 5 recovers bargaining weights and analyzes the distribution and dynamics of cartel rents. Section 6 concludes with implications for enforcement.

2 Theoretical Model

To provide a theoretical foundation for the empirical results, I extend the capacity–constrained cartel model of Bos and Harrington (2010). First, I summarize the horizontal benchmark and its key implications for prices, participation, and stability. Then, I introduce wholesalers and allow for discriminatory wholesale pricing that can support higher retail prices.

2.1 Horizontal Cartel

The model analyzes a market with N_r retailers competing in a homogeneous good through an infinitely repeated game with capacity constraints. Market demand is $D(p)$, twice differentiable, concave, and decreasing in p. Retailer i has capacity k_i, and total capacity is $K = \sum_i k_i$.

Bos and Harrington (2010) impose two standard assumptions on capacities:

Assumption 1: Let p^M be the price that maximizes $(p - w)D(p)$. $k_i < D(p^M)$ (no single retailer can serve monopoly demand)

Assumption 2: Let w be the marginal cost, then $\sum_{j \neq i} k_j \geq D(w)$ (the remaining $N_r - 1$ retailers can meet competitive demand).

In this environment, the one–shot pricing outcomes relevant for the repeated game are $p = w$ or $p = w + \xi$ for some $\xi > 0$ (the minimal undercut step). Let $\Gamma \subseteq \{1, \ldots, N_r\}$ denote the set of cartel members, $K_\Gamma = \sum_{i \in \Gamma} k_i$, and define the cartel's residual demand

$$R(p) \equiv D(p) - (K - K_\Gamma).$$

Two implications (see Bos and Harrington (2010)):

1. If the cartel sets $p^H > w + \xi$ with $R(p^H) > 0$, any non–member j prices at $p^H - \xi$ and sells k_j units.

2. Non–members price strictly below the cartel price with probability one.

Hence, a necessary condition for sustainability is $p^H > w + \xi$ and $R(p^H) > 0$.

When $R(p^H) > 0$, cartel members split profits proportionally to capacity:

$$\Pi_r(p^H, w, \Gamma) = (p' - w)\, R(p^H) \left(\frac{k_i}{K_\Gamma} \right). \tag{1}$$

With discount factor $\delta \in (0, 1)$, insider i's present value is

$$V_i(p^H, \Gamma, w) = \left(\frac{1}{1-\delta} \right) (p^H - w)\, R(p^H) \left(\frac{k_i}{K_\Gamma} \right) = k_i\, V(p^H, \Gamma, w). \tag{2}$$

Assuming that $\xi \to 0$, The Incentive Compatibility Constraint (ICC) for insiders is

$$k_i\, V(p^H, \Gamma, w) \;\geq\; (p^H - w)\, k_i, \tag{3}$$

which ensures that membership yields a present value at least as large as the one–shot deviation payoff.

The cartel chooses the highest sustainable price:

$$p^{H^*}(K_\Gamma) = \arg\max_p \; V(p, \Gamma, w) \quad \text{s.t.} \quad V(p, \Gamma, w) - (p - w) \geq 0. \tag{4}$$

$$p^{H^*} = \min\{D^{-1}(K - \delta K_\Gamma), p^o\}$$

$$\text{where } p^o \text{ solves } D(p^o) - (K - K_\Gamma) + (p^o - w)D'(p^o) = 0$$

Using this formulation, Bos and Harrington (2010) obtain the following results:

Result 1: A price above w is sustainable iff $D(p) > K - \delta K_\Gamma$.

Result 2: If $K_{\Gamma'} > K_{\Gamma''}$, then $p^{H^*}(K_{\Gamma'}) \geq p^{H^*}(K_{\Gamma''})$, with strict inequality whenever $p^{H^*}(\cdot) > w$.

Result 3: Cartel profits are maximized when the cartel is all–inclusive; incumbents have incentives to induce non–members to join.

Result 4: A cartel is stable iff (i) the smallest insider prefers to remain and (ii) the largest outsider prefers to remain out.

Together, these results imply that cartel prices are increasing in total cartel capacity and that profits are maximized under full participation. However, stability requires that large-capacity firms prefer to join while sufficiently small firms optimally remain outside. As a result, equilibrium horizontal cartels are typically not fully inclusive and implement prices below the monopoly level.

2.2 Vertical Cartel

I now extend the model by introducing wholesalers and examining how their participation can sustain higher retail prices. I first describe the vertical environment and show that, under vertical collusion, all retailers join the cartel and the monopoly price is implemented. I then model the division of monopoly rents via Nash bargaining between the wholesale cartel and individual retailers, derive the corresponding no–deviation conditions, and connect the model's implications to the empirical tests. Additional information about the model and a numerical example, are provided in Appendix A.

Let N_w denote the number of homogeneous wholesalers, each with marginal cost c and discount rate ϕ and let w denote the wholesale price. Because wholesalers sell only to retailers, their total quantity equals retail demand, $D(p)$. In the wholesale benchmark, the static outcome is either $w = c$ (Bertrand competition) or $w = c + \nu$ (a Cournot–like outcome). I adopt the Cournot–like setting with $w = c + \nu$ as the baseline in the absence of vertical coordination.

On the retail side, I maintain the same notation and setting as in Bos and Harrington (2010). Under vertical collusion, cartel members set a common price p^V, while non–members charge $p^V - \xi$, with $\xi \to 0$ capturing the minimal undercut step.

The central feature of wholesale participation is that wholesalers can discriminate between cartel and non–cartel retailers by posting different wholesale prices depending on membership. This mechanism is related to Van Cayseele and Miegielsen (2013), who analyze a single wholesaler and model punishment as exclusion from the market. In contrast, I assume multiple wholesalers that may collude, with a softer punishment: non–cartel retailers are not excluded, but instead face higher wholesale prices than insiders.

What follows describes the wholesale discrimination faced by non–cartel retailers and the implied punishment for remaining outside the cartel.

Vertical discrimination. Wholesalers post a pair of wholesale prices (w_i', w_i'') with $w_i'' > w_i' \geq c + \nu$, where w_i' applies to retailer i if it is a cartel member and w_i'' if retailer i is not a member. To ensure that non–members can still profitably undercut the cartel by a small amount $\xi \to 0$, the following feasibility condition must hold:

$$w_i'' \leq p^V - \xi \quad \forall i. \tag{5}$$

Relative to the horizontal cartel, vertical discrimination imposes a harsher punishment on non–participants. In the horizontal case, the only cost of staying outside is the need to undercut the cartel price by ξ. Under vertical collusion, however, non–members also face a higher wholesale price, increasing their cost of competing independently.

One may argue that the assumption that the wholesale cartel can perfectly discriminate between insiders and outsiders is too strong. However, I show that there exists a truth-telling mechanism such that, conditional on the presence of a downstream cartel, the largest retailer always has an incentive to reveal the true set of cartel participants. I provide the details of this mechanism in Appendix A.

From (5), as $\xi \to 0$ the outsider feasibility constraint converges to $w_i'' \leq p^V$ for each i. Conditional on a given retail price p^V, the wholesale cartel's profit is strictly increasing in w_i'' for any outsider. Hence it is optimal to set w_i'' at the feasibility frontier, $w_i'' = p^V$ for all outsiders. Using this condition for the outsider wholesale price, Proposition 1 illustrates the central result of the Verticalized Cartel.

Proposition 1. Under vertical collusion all retailers participate in the cartel. Therefore, $p^V = p^M$.

Proof. From (5), for each retailer i we have $w_i'' \leq p^V - \xi$. As $\xi \to 0$, the outsider feasibility constraint converges to $w_i'' \leq p^V$. Conditional on p^V, the wholesale cartel's profit is strictly increasing in w_i'' for any outsider, so it is optimal to set $w_i'' = p^V$ for all non–members.

A retailer that remains outside the cartel and sells at the collusive price p^V then faces a wholesale price $w_i'' = p^V$ and earns zero per–unit margin. Its profit as an outsider is therefore zero. By contrast, any retailer that joins the cartel obtains a strictly positive per–unit margin $p^V - w_i' > 0$ on a strictly positive quantity. Hence, for every retailer i, joining the cartel strictly dominates remaining outside.

Since this argument holds for all i, all retailers choose to participate in the cartel. With full participation, the vertical cartel can implement the monopoly allocation, and thus $p^V = p^M$. □

As a direct implication, since the vertical cartel attains the monopoly price while the horizontal cartel is not fully inclusive, the vertical collusion price must weakly exceed the horizontal one.

Lemma 1. The retail price under vertical collusion is weakly higher than the retail price under horizontal collusion.

Proof. Under horizontal collusion with wholesale cost c, the retail cartel is not fully inclusive, so the equilibrium price satisfies $p^H \leq p^M$. Under vertical collusion with the same wholesale benchmark, Proposition 1 implies full inclusion and hence $p^V = p^M$. Therefore,

$$p^V = p^M \ \geq \ p^H,$$

which establishes the result. □

Consequently, the vertical cartel eliminates the double–marginalization problem: retailers and wholesalers now cooperate to maximize total profits based on the upstream marginal cost c. Conditional on Proposition 1 (full participation and $p^V = p^M$), the remaining question is how these joint monopoly profits are shared between the wholesale cartel and the individual retailers.

To address this, I model the division of monopoly rents as a Nash bargaining problem between the wholesale cartel and individual retailers. Retailer i has bargaining weight θ_i, and the wholesale cartel's bargaining weight is $1 - \sum_{i=1}^{N_r} \theta_i$. At the monopoly price p^M, total quantity is $D(p^M)$, so each retailer i sells a share proportional to its capacity, k_i/K, and earns a per–unit margin $(p^M - w_i')$. The wholesale cartel, in turn, earns $(w_i' - c)$ on the units sold to retailer i. Under this setting, the Nash product is given by

$$W(w') = \left(D(p^M) \sum_{i=1}^{N_r} \frac{k_i}{K} (w_i' - c) \right)^{1 - \sum_{i=1}^{N_r} \theta_i} \prod_{i=1}^{N_r} \left(D(p^M) \frac{k_i}{K} \big(p^M - w_i'\big) \right)^{\theta_i}. \qquad (6)$$

However, to fully characterize the bargaining problem, in addition to the participation/feasibility condition in (5), it is also necessary to impose five additional constraints:

1. **Single Retailer Incentive Constraint (SRIC).** No individual retailer finds it profitable to deviate unilaterally from the vertical cartel. Comparing the

present value of collusive profits to a one–shot deviation that earns the current per–period margin at capacity, we require

$$\frac{1}{1-\delta}\left(D(p^M)\frac{k_i}{K}(p^M-w_i')\right) \;\geq\; k_i\big(p^M-w_i'\big)$$
$$\Rightarrow \quad \delta \;\geq\; 1-\frac{D(p^M)}{K}. \tag{7}$$

2. **Single Wholesaler Incentive Constraint (SWIC).** No individual wholesaler (with discount factor ϕ) finds it profitable to deviate unilaterally from the vertical cartel. Let the per–period cooperative profit per wholesaler be $\frac{1}{N_w}D(p^M)\sum_{i=1}^{N_r}(w_i'-c)$. The ICC is

$$\frac{1}{1-\phi}\frac{1}{N_w}\left(D(p^M)\sum_{i=1}^{N_r}\frac{k_i}{K}(w_i'-c)\right) \;\geq\; D(p^M)\sum_{i=1}^{N_r}\frac{k_i}{K}(w_i'-c)$$
$$\Rightarrow \quad \phi \;\geq\; 1-\frac{1}{N_w}. \tag{8}$$

3. **Vertical Cartel Incentive Constraint (VCIC).** The vertical arrangement must be jointly preferred to the horizontal (double–marginalization) benchmark by both tiers of the market. That is, aggregate retail and wholesale profits under vertical collusion must be weakly higher than the corresponding profits under horizontal collusion. Let $\Pi_r^V(p^M,w')$ and $\Pi_w^V(p^M,w')$ denote aggregate retail and wholesale profits under the vertical cartel, and let $\Pi_r^H(p^H,w)$ and $\Pi_w^H(p^H,w)$ denote the corresponding profits under the horizontal benchmark. The VCIC requires

$$\Pi_r^V(p^M,w') \;\geq\; \Pi_r^H(p^H,w), \qquad \Pi_w^V(p^M,w') \;\geq\; \Pi_w^H(p^H,w). \tag{9}$$

4. **Retail Cartel Incentive Constraint (RCIC).** Given the negotiated wholesale terms w', the retail cartel must prefer to implement p^M rather than deviate in the current period and trigger punishment thereafter. Let $\Pi_r^V(p,w')$ denote aggregate retail profit under the vertical arrangement when retailers charge p and pay w'. Let $p^D(w')$ denote the retail tier's one-shot deviation price given w', and let Π_r^P denote the per-period retail payoff under the punishment path (e.g. reversion to the horizontal benchmark). The retail-tier ICC is

$$\frac{1}{1-\delta}\,\Pi_r^V(p^M,w') \;\geq\; \Pi_r^V\big(p^D(w'),w'\big)+\frac{\delta}{1-\delta}\,\Pi_r^H(p^H,w).$$
$$\delta \;\geq\; \frac{\Pi_r^V(p^D(w'),w')-\Pi_r^V(p^M,w')}{\Pi_r^V(p^D(w'),w')-\Pi_r^H(p^H,w)}, \tag{10}$$

provided the denominator is positive.

5. **Wholesale Cartel Incentive Constraint (WCIC).** Given that the retail cartel implements p^M, the wholesale cartel must prefer to charge the negotiated terms w' rather than deviate in the current period and trigger punishment thereafter. Let $\Pi_w^V(p^M, w')$ denote aggregate wholesale profit under the vertical arrangement. Clearly, the best deviation in this case is to charge $w^D = p^M$ and if they deviate, they return to the horizontal cartel seetting, that is $\Pi(p^H, w)$. Hence

$$\frac{1}{1-\phi}\Pi_w^V(p^V, w') \geq \Pi_w^H(p^M, p^M) + \frac{\phi}{1-\phi}\Pi_w^H(p^H, w)$$
$$\phi \geq \frac{\Pi_w^H(p^M, p^M) - \Pi_w^V(p^V, w')}{\Pi_w^H(p^M, p^M) - \Pi_w^H(p^H, w)} \tag{11}$$

The SRIC and SWIC are standard individual no–deviation constraints within the vertical regime: the vertical arrangement is stable only if neither side of the market (upstream or downstream) has an incentive to deviate unilaterally from the collusive outcome. By contrast, VCIC compares total payoffs across regimes and guarantees that the vertical arrangement is jointly preferred to the horizontal benchmark. If VCIC failed, at least one side would strictly prefer to remain in (or revert to) the horizontal structure, sustaining the double markup because its payoff would be higher outside the vertical cartel.

Another important feature of VCIC is that it is defined in terms of aggregate retail profits rather than firm–specific payoffs. In other words, the constraint requires that the total profit of retailers under the vertical cartel weakly exceeds that under the horizontal benchmark, but it does not guarantee that every individual retailer is better off—some may experience lower profits even when VCIC holds.

In addition to these three restrictions, I impose RCIC and WCIC to ensure that it is optimal for both tiers to remain in the vertical arrangement. These conditions guarantee that the bargaining outcome is Nash-in-Nash: given the decision of one tier, the best response of the other tier is to continue participating in the vertical cartel rather than deviate. Moreover, VCIC requires that the thresholds implied by RCIC and WCIC are strictly below one. Consequently, for sufficiently high discount factors of both retailers and wholesalers, all incentive constraints can be jointly satisfied.

Putting the previous elements together, the Nash bargaining problem for the vertical cartel can be written as

$$\max_{\{w_i'\}_{i=1}^{N_r}} W(w') = \left(D(p^M) \sum_{i=1}^{N_r} \frac{k_i}{K}(w_i' - c) \right)^{1-\sum_{i=1}^{N_r}\theta_i} \prod_{i=1}^{N_r} \left(D(p^M)\frac{k_i}{K}\big(p^M - w_i'\big) \right)^{\theta_i} \tag{12}$$

$$\text{s.t. } \delta \geq \max\left\{1 - \frac{D(p^M)}{K}, \frac{\Pi_r^V(p^D(w'), w') - \Pi_r^V(p^M, w')}{\Pi_r^V(p^D(w'), w') - \Pi_r^H(p^H, w)}\right\}$$

$$\phi \geq \max\left\{1 - \frac{1}{N_w}, \frac{\Pi_w^H(p^M, p^M) - \Pi_w^V(p^V, w')}{\Pi_w^H(p^M, p^M) - \Pi_w^H(p^H, w)}\right\}$$

$$\Pi_r^V(p^M, w') \;\geq\; \Pi_r^H(p^H, w), \qquad \Pi_w^V(p^M, w') \;\geq\; \Pi_w^H(p^H, w).$$

Under the assumption that the individual and joint no–deviation constraints (7), (8), (9), (10), (11) are satisfied, the maximization problem in (12) delivers the following closed–form solution for the optimal wholesale prices.

Lemma 2. Assume that the SRIC, SWIC, RCIC, WCIC, VCIC all hold. Then, the optimal resale (wholesale) price charged to retailer i that solves the Nash bargaining problem in (12) is given by

$$w_i'^{*} \;=\; p^M \;-\; \theta_i \frac{K}{k_i}\big(p^M - c\big). \tag{13}$$

Equation (13) therefore provides a direct mapping from observed wholesale prices and cost proxies to retailer-specific bargaining weights θ_i, which I exploit in Section 5. Also, it implies that retailer i captures a fraction $\theta_i \frac{K}{k_i}$ of the monopoly markup $(p^M - c)$ on its capacity–weighted share of demand, while the remaining portion of the surplus is extracted by the wholesale cartel through the resale price $w_i'^{*}$. In this sense, the Nash bargaining solution allocates the monopoly surplus between the retailer and the upstream cartel as a function of the retailer's bargaining weight and relative capacity.

An important feature of the model is that it compares two distinct organizational structures. In the benchmark, wholesalers compete imperfectly and charge a positive markup due to upstream market power. In the vertical case, by contrast, wholesalers and retailers coordinate jointly with the objective of implementing the monopoly price and then bargaining over the division of rents.

One may ask whether an alternative arrangement could arise in which wholesalers form a cartel and retailers simultaneously form a separate cartel, but without coordinating across tiers. In Appendix A, I analyze this "double horizontal cartel," where the upstream and downstream tiers collude independently. In principle, such an arrangement may generate retail prices that are even higher than those under the vertical structure, because each tier internalizes only its own markup. However, I show that there is a vector of bargaining weights θ_i, the double horizontal outcome is Pareto dominated by the vertical cartel: joint coordination strictly increases total surplus and allows a mutually preferred redistribution of rents. Consequently, the double horizontal cartel is not an equilibrium outcome once vertical coordination is feasible.

Empirical Testable Results. Under the vertical cartel setting, the model delivers three empirical predictions relative to the horizontal benchmark:

1. Retail prices under vertical collusion are weakly higher than under horizontal collusion.

2. Retail profit under vertical collusion is weakly higher than under horizontal collusion.

3. Wholesale profit under vertical collusion is weakly higher than under horizontal collusion.

In Section 4, I use data from eight cartel cases (four vertical and four horizontal) in the Brazilian gasoline retail market to test these predictions. The evidence is consistent with all three: vertical cartels generate larger increases in retail prices and margins, and higher wholesale markup, indicating that vertical collusion both strengthens market power and resolves the double–marginalization problem.

In addition, the data allow me to estimate the bargaining parameter for each retailer using (13), and thus to track how the division of monopoly rents evolves over the life of the cartel (for example, as the investigation approaches) and how it varies with exclusive supply agreements (contracts that tie a retailer to a specific wholesaler). The results of this bargaining–parameter analysis are presented in Section 5.

3 Data and Institutional Background

Cartel investigations in Brazil are conducted by law-enforcement authorities in coordination with the Brazilian Antitrust Authority (CADE). Investigations are initiated based on legally verifiable evidence, such as information from regulatory agencies or third-party complaints, and aim to document explicit coordination among firms. Because cartel conduct constitutes a criminal offense in Brazil, cases are prosecuted in parallel before CADE and the civil courts. In this paper, I rely exclusively on documentation produced by CADE, which is publicly available and provides detailed information on cartel structure, geographic scope, and duration.

CADE defines cartel start and end dates based on legal evidence rather than economic indicators. The start date corresponds to the earliest documented proof of collusive conduct, while the end date is typically marked by the public disclosure of the investigation, such as arrests or document seizures. As a result, the treatment window used in this paper is conservative, since collusive behavior may have begun prior to the first legally recorded act. Importantly, because cartel timing is driven by legal procedures rather than contemporaneous price movements, the onset and termination of treatment are plausibly exogenous to short-run demand and cost shocks.

The gasoline retail market has been extensively studied in the cartel literature. Previous work documents price coordination, cartel stability, and enforcement outcomes in this industry, including detailed analyses of cartel behavior and punishment mechanisms (Clark and Houde, 2013, 2014; Chaves and Duarte, 2025). The empirical analysis in this paper focuses on eight gasoline retail cartel cases adjudicated by CADE between 2004 and 2020. Four cases involve purely horizontal coordination among gas stations, while four involve vertical coordination between gas stations and fuel distributors. Cases are included if firms were convicted or if legal proceedings formally recognized the existence of strong cartel evidence, even when convictions were later annulled due to procedural issues. Table 1 summarizes the main characteristics of each case, including cartel structure, geographic scope, and duration. Appendix B provides detailed descriptions of the underlying legal documents.

Table 1: Cartel Dating

Case Number	Case Legal Code	Cartel Start	Cartel End	Relevant Market	Structure
1	08700.003447/2015-40	Jul/01	May/07	Cuiabá/MT, Várzea Grande/MT	Vertical
2	08012.010215/2007-96	Jul/04	Apr/06	Caxias do Sul/RS	Horizontal
3	08012.007866/2007-07	Jan/06	Apr/07	João Pessoa/PB	Vertical
4	08012.008847/2006-17	Jul/06	Mar/07	Vitória/ES, Cariacica/ES, Vila Velha/ES, Serra/ES	Horizontal
5	08012.011668/2007-30	Jan/07	Aug/07	Cambé/PR, Londrina/PR	Horizontal
6	08700.010769/2014-64	Feb/07	May/08	Belo Horizonte/MG, Betim/MG, Contagem/MG	Vertical
7	08700.000547/2008-95	Sep/08	Dec/09	Teresina/PI	Horizontal
8	08012.008859/2009-86	Jan/11	Feb/16	Brasília/DF	Vertical

Note: This table refers to the dates defined by each legal proceeding. The Legal Code refers to the number attributed by the Antitrust Authority to that cartel case and contains all its documents. Cartel Start and Cartel End refer to the cartel period, while relevant market refers to the cities affected by the cartel.

An important institutional feature of the Brazilian fuel retail market is that vertical integration between wholesalers and retailers is legally prohibited: a firm cannot operate simultaneously as a fuel distributor and a gas station. Vertical relationships therefore arise through contractual arrangements rather than ownership. In particular, exclusive supply agreements require a retailer to purchase fuel from a single wholesaler and, in exchange, allow the station to operate under the wholesaler's brand. These contracts are the primary mechanism through which upstream firms structure downstream relationships and potentially influence retail pricing behavior. As a result, vertical coordination in this industry takes place through exclusivity and branding agreements, not through formal integration.

A second key feature concerns the geographic organization of firms. Gas stations are typically local operators, often active only within a single city or metropolitan area. By contrast, wholesalers are national firms that supply stations across multiple regions. Given Brazil's geographic scale, wholesalers commonly delegate pricing decisions to regional managers who set wholesale terms within specific local markets. This institutional detail is reflected in enforcement records: in several vertical cartel cases, penalties are imposed not on the distributor as a national entity but on the regional managers responsible for coordinating conduct in the affected locality. This separation between national ownership and local pricing authority helps explain how vertical collusion can be organized at the market level despite the broader geographic scope of wholesale firms.

Price data come from the weekly Fuel Price Panel collected by the Brazilian Oil, Natural Gas, and Biofuels Agency (ANP). These data report retail gasoline prices charged by individual stations and wholesale prices paid to distributors from May 2004 to August 2020. To proxy for wholesalers' marginal costs, I use regional gasoline production and import prices published by ANP for the period 2002–2025. As documented by Silveira et al. (2022), gas stations included in the ANP survey are selected to maximize geographic coverage rather than following a firm-specific sampling rule. Consequently, The panel daataset is strongly unbalanced, but the missing station-week observations arise from random survey rotation and are unlikely to reflect endogenous selection.

Gasoline demand in Brazil is highly inelastic. Using household-level data, Santos (2013) estimate a short-run price elasticity of gasoline demand of -0.399. This low elasticity implies that price increases translate almost one-for-one into higher revenues and profits. Accordingly, in the empirical analysis that follows, I use retail and wholesale markups as informative proxies for firm profits at the downstream and upstream levels, respectively.

Combining CADE legal records with ANP price data yields a novel station-level panel that tracks individual gas stations over time and across multiple cartel episodes within the same industry and institutional environment. I define the treatment group as gas stations located in cities identified by CADE as affected by cartel conduct. The control group consists of stations located in cities within a 50–200 kilometer radius of the cartel-affected market, following CADE's own market-definition practice. Stations located within a 1–50 kilometer radius are excluded to minimize potential spillover effects.

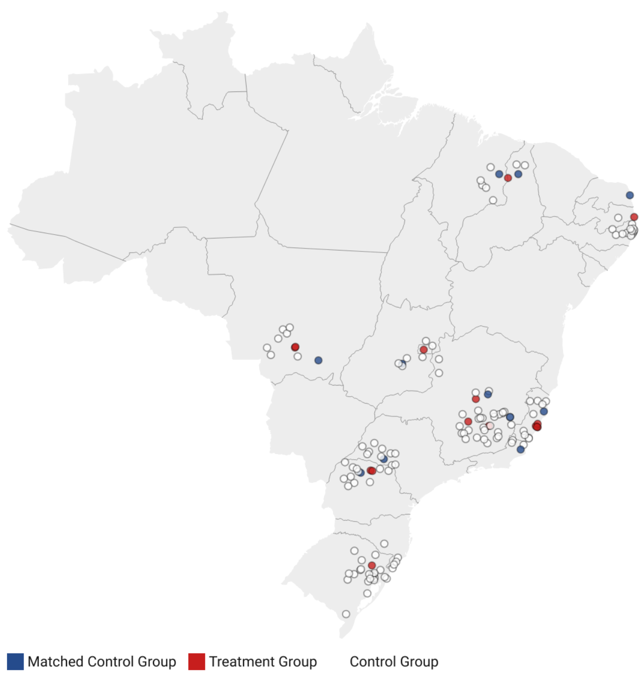
The final dataset includes 7,644 gas stations across 156 cities. Figure 1 illustrates the geographic distribution of cartel and control cities and confirms that no cartel-affected city appears in the control group of another case. Additional station-level characteristics, including gasoline storage capacity and exclusive supply agreements, are obtained from the PostoWeb platform. These data are combined with population and vehicle ownership statistics from the Brazilian Institute of Geography and

Statistics (IBGE) to construct the matching covariates used in the empirical analysis. Summary statistics are reported in Table 2.

Retail and wholesale markups are defined as

$$\text{Retail Markup}_{it} = \frac{\text{Retail Price}_{it} - \text{Wholesale Price}_{it}}{\text{Retail Price}_{it}},$$
$$\text{Wholesale Markup}_{jt} = \frac{\text{Wholesale Price}_{jt} - \text{Wholesale Cost}_{jt}}{\text{Wholesale Price}_{jt}}.$$

Figure 1: Cities



Note: The figure above illustrates the geolocation of the relevant market, the controls and the matched controls. I define the treatment group as the firms inside the cities affected by the cartel, while the control group is defined as firms inside the cities of a radius of 50 to 200 km from the relevant market.

Table 2: Summary of Statistics

	All Cities	Relevant Market	Matched Cities
Firm-level Data			
Retail Price (BRL)	2.78	2.73	2.83
	(0.592)	(0.596)	(0.636)
Wholesale Price (BRL)	2.41	2.41	2.45
	(0.540)	(0.541)	(0.573)
Wholesale Cost (BRL)	1.63	1.65	1.66
	(0.340)	(0.341)	(0.346)
Retail Markup	0.13	0.12	0.13
	(0.038)	(.042)	(0.036)
Wholesale Markup	0.47	0.46	0.48
	(0.088)	(.087)	(0.094)
Observations	902,854	261,507	139,960
City-level Data			
HHI retailer (2024)	1,204	317	418
	(1,486)	(240)	(411)
HHI wholesaler (2024)	2,023	1,586	1,329
	(1,524)	(623)	(724)
Number of Cars (2024)	78,823	362,738	147,292
	(200,037)	(519,144)	(180,855)
Population (2024)	213,067	815,219	401,542
	(384,151)	(799,909)	(398,884)
Observations	156	15	11

Note: This table presents the summary of statistics. The first column represents the information regarding all firms in the treatment and control group. The second column refers only to the treatment group (firms inside of the relevant market of a cartel). The third column displays the statistics for the firms in the matched control group as defined in Section 3. The standard deviation are in parasynthesis.

4 Horizontal vs. Vertical Cartels

The first part of the empirical analysis tests the three main predictions of the model:

1. Retail prices under vertical collusion are weakly higher than under horizontal collusion.

2. Retail profit under vertical collusion is weakly higher than under horizontal collusion.

3. Wholesale profit under vertical collusion is weakly higher than under horizontal collusion.

I evaluate these predictions using a two-step matching difference-in-differences (DiD) design that improves the plausibility of parallel trends and allows for heterogeneous treatment effects at the firm level. Since I do not observe quantities sold at the station level, profits cannot be measured directly. However, gasoline demand in Brazil is highly inelastic, so price increases translate almost one-for-one into higher revenues. Accordingly, I use retail and wholesale markups as informative proxies for downstream and upstream profits, respectively.

4.1 Matching Strategy

As shown in Table 2, cities affected by cartel differ substantially from the full sample of cities along key market-structure and demand dimensions. Using all cities as controls would therefore risk violating the parallel trends assumption. To address this concern, I implement a two-step matching procedure that ensures comparability at both the market and firm levels.

In the first step, I match cartel-affected cities to control cities based on predetermined supply-side characteristics (retailer and wholesaler concentration) and demand-side variables (population and number of vehicles). This step yields a set of control markets that closely resemble treated markets in terms of observable structure.

In the second step, I match individual gas stations in treated cities to stations in the matched control cities using firm-level characteristics, including gasoline storage capacity, number of pumps, and the presence of exclusive supply agreements. The matching is conducted within a balanced time window around cartel dissolution to ensure symmetric pre- and post-treatment periods. Table 3 presents the summarry of statistics of the matched dataset. Overall, out of 74,048 observations in cartel-affected markets, 951 observations (1.2%) could not be matched and are excluded from the analysis.

This approach is closely related to the exact matching strategies commonly used in the labor literature (Jäger and Heining, 2022; Goldschmidt and Schmieder, 2017; Smith et al., 2019). However, to the best of my knowledge, such methods have not been applied to the estimation of cartel overcharges. The paper most closely related to my approach is Arnold (2019), who first matches firms and then, within those matched firms, matches workers. I adopt a similar two-step structure here: I first match markets based on structural characteristics and then match firms within those markets.

This two-step design produces a matched panel that allows treatment effects to be estimated at the firm level while substantially mitigating concerns about non-parallel trends. By jointly accounting for market structure and firm characteristics, the approach is particularly well suited to studying vertical collusion, where wholesaler–retailer relationships play a central role. Additional details are provided in Appendix C.

4.2 City-Level Analysis

Before turning to the firm-level analysis, I first examine aggregate effects at the city level. The goal is to summarize the impact of cartel dissolution on prices and markups and to assess the plausibility of the parallel trends assumption using event-study graphs.

I use the cartel dissolution as the treatment event, as it is more precisely observable than the beginning of the cartel. Because CADE defines cartel start dates based on legal evidence, the exact onset of collusion is not directly observable. In contrast, the moment of law-enforcement intervention—typically marked by arrests or document seizures—provides a clear and consistent reference point across cases. Using cartel dissolution therefore reduces measurement error in treatment timing.

I estimate the following event-study specification:

$$\text{Outcome}_{ct} = \sum_{k=-10}^{-2} \lambda_k D_{ct}^k + \sum_{k=0}^{20} \lambda_k D_{ct}^k + \theta_c + \gamma_t + \epsilon_{ct}, \tag{14}$$

where Outcome_{ct} is the city-level average of log retail prices, retail markups, or wholesale markups in city c and week t. The indicators D_{ct}^k equal one if city c belongs to a cartel-affected market and week t is k weeks relative to the cartel dissolution.

Table 3: Summary of Statistics - Matched Firms Dataset

	Relevant Market	Matched Counterpart
Retailer Price (BRL)	2.66	2.73
	(0.408)	(0.398)
Retail Markup	0.14	0.15
	(0.048)	(0.036)
Wholesale Markup	0.31	0.31
	(0.030)	(0.028)
Exclusive Agrement	0.69	0.69
	(0.46)	(0.46)
Gasoline Pumps	5.05	4.52
	(2.80)	(2.08)
Gasoline Storage (m^3)	28.48	26.61
	(13.61)	(10.91)
Observations	74,048	73,097

Note: This table presents summary statistics for the matched firms dataset. The first column reports information for all firms in the treatment group, while the second column corresponds to the firms matched to those in the treatment group. The matching is based on the number of gasoline pumps, total gasoline storage and whether the firm has an exclusive agreement with a wholesaler. The standard deviation are in parasynthesis.

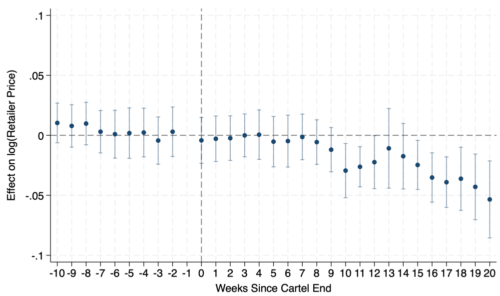
City and calendar-week fixed effects are denoted by θ_c and γ_t, respectively. Standard errors are clustered at the city and calendar-week levels.

I normalize the week immediately preceding dissolution ($k = -1$) as the omitted category, so each coefficient λ_k measures the difference between treated and control cities k weeks before or after cartel breakup. I use a relative-time window from $k = -10$ to $k = 20$, which is sufficient to evaluate pre-treatment trends and capture medium-run post-cartel adjustments. Because some cities appear multiple times as controls, observations are weighted by the number of repetitions.

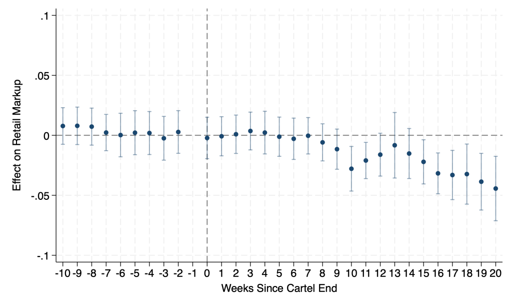
Fugure 2 present the event-study estimates for retail prices, retail markups, and wholesale markups, respectively. Retail prices and retail markups decline following cartel dissolution, while wholesale markups exhibit no statistically significant change when pooling all cartel types. This pattern reflects the fact that the pooled specification averages over horizontal and vertical cartels, which differ in their upstream implications.

Figure 2: City-Level Event Study Estimates

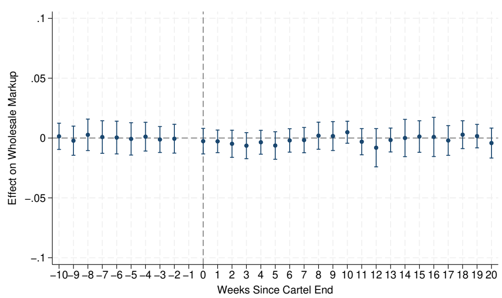
(a) Retail Price



(b) Retail Markup



(c) Wholesale Markup



Note: Dots plot estimated event-time coefficients from the two-way fixed effects specification (14), weighted by the number of repetitions in the city matching. Vertical bars represent 95% confidence intervals. Time 0 corresponds to the week the cartel was dissolved. Standard errors are clustered at the firm $\times$ calendar-week level. Pre-trend F-test p-values are 0.79, 0.91, and 0.99 for Panels (a), (b), and (c), respectively.

An additional feature of the estimates is that retail prices and markups do not adjust immediately following cartel breakup. Instead, reductions materialize gradually over several weeks. This delayed adjustment is consistent with evidence from other cartel settings documenting post-cartel hysteresis and residual coordination (Harrington Jr, 2004; Fonseca and Normann, 2014).

In Appendix C, I present some robustness checks over the estimates. Appendix C.2. is related to the heterogeneity between Vertical and Horizontal structures. The key heterogeneity pattern is that the post-dissolution declines are more pronounced and sustained in the vertical-cartel sample, consistent with vertical coordination sustaining higher retail margins during the cartel period. By contrast, wholesale markups exhibit little systematic movement around dissolution for either structure (with wider confidence intervals), suggesting that the main adjustment following cartel end occurs primarily at the retail level rather than through sharp changes in upstream markup.

The second robustness check addresses potential mismeasurement of the treatment date. If firms can anticipate the police intervention, behavior may start adjusting before the official cartel end; conversely, if coordination persists informally, the cartel may continue operating for some time after the intervention. Appendix C.3 re-estimates the city-level event studies excluding the eight weeks before and after the intervention (roughly two months on each side). The results are unchanged: pre-treatment coefficients remain close to zero, supporting parallel trends, and we continue to observe a clear post-period decline in both retail prices and retail markups. This indicates that the main findings are not driven by dynamics in the weeks immediately surrounding the intervention and are robust to reasonable alternative definitions of the cartel end.

The third robustness check concerns the timing and aggregation of the observations. In the main specification, outcomes are measured at the weekly level; however, because weekly prices are constructed from a random sample within each week, one might worry that sampling noise could introduce measurement error and add volatility to the event-study estimates. To address this concern, Appendix C.4 re-estimates the same design after aggregating the data to the monthly level, which smooths high-frequency variation and mitigates random sampling noise. The results remain qualitatively unchanged: the pre-treatment coefficients continue to be close to zero, supporting parallel trends, and the post-dissolution estimates still indicate a clear decline in retail prices and retail markups. If anything, the monthly aggregation strengthens the evidence by showing that parallel trends hold even over longer pre-period horizons.

In addition to the event-study graphs, I formally test at the city level whether vertical collusion generates larger effects on the main outcomes—log(retail price), retail markup, and wholesale markup—using a standard two-way fixed effects (TWFE) specification:

$$Y_{ct} = \alpha_c + \psi_t + \beta_1 \text{Post\_Cartel}_{ct} + \beta_2 \big(\text{Vertical}_c \times \text{Post\_Cartel}_{ct}\big) + \xi_{ct}, \qquad (15)$$

where Y_{ct} denotes the average outcome in city c at week t, α_c is a cartel-case (city) fixed effect, and ψ_t is a week fixed effect. The indicator Post_Cartel_{ct} equals one for cities in the relevant market after cartel dissolution. The variable Vertical_c equals one if the cartel in city c involved both retailers and wholesalers.

In this specification, β_1 captures the average post-dissolution effect for horizontal cartels, while β_2 measures the additional effect associated with vertical cartels relative to horizontal ones.

To improve identification and ensure symmetry around the treatment date, I restrict the sample to an 18-month window before and after cartel termination. Standard errors are clustered at the case–week level.

Table 4: City-Level: Effect of Cartel Dissolution

	(1) log(Retail Price)	(2) Retail Markup	(3) Wholesale Markup
Cartel	-0.016***	-0.011***	-0.006***
	(0.002)	(0.002)	(0.001)
Cartel × Vertical	-0.046***	-0.028***	-0.021***
	(0.003)	(0.003)	(0.002)
Constant	0.978***	0.141***	0.456***
	(0.001)	(0.000)	(0.001)
Case Fixed Effects	Yes	Yes	Yes
Week Fixed Effects	Yes	Yes	Yes
Clusters (case_week)	1,238	1,238	1,238
Observations	4,078	4,078	4,078

Cluster-robust standard errors (case_week) in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 reports the results from specification (15). Consistent with the theoretical model, all outcomes decline following cartel dissolution, indicating that cartels raise prices and markups while active. Moreover, the estimated effects are significantly larger for vertical cartels, confirming that wholesaler participation amplifies the impact of collusion. The next subsection turns to the firm-level analysis, where I estimate heterogeneous treatment effects across individual stations.

4.3 Firm-Level Analysis

Using the matched firm-level dataset described in Section 3.1 and summarized in Table 3, I now estimate the causal effect of cartel participation at the level of individual gas stations. For each treated firm, I compute an Average Treatment Effect on the Treated (ATT) by comparing the change in outcomes relative to its matched control station before and after cartel dissolution.

Specifically, the ATT for firm i is defined as

$$\widehat{\mathrm{ATT}}_i = \overline{\Delta Y}_i^{\mathrm{Cartel}} - \overline{\Delta Y}_i^{\mathrm{Post}}, \tag{16}$$

where

$$\overline{\Delta Y}_i^{\mathrm{Cartel}} = \frac{1}{T_i^{\mathrm{Cartel}}} \sum_{t \in T_i^{\mathrm{Cartel}}} (Y_{it} - Y_{i't}), \qquad \overline{\Delta Y}_i^{\mathrm{Post}} = \frac{1}{T_i^{\mathrm{Post}}} \sum_{t \in T_i^{\mathrm{Post}}} (Y_{it} - Y_{i't}).$$

Here, Y_{it} denotes the outcome for firm i at time t (log retail price, retail markup, or wholesale markup), and $Y_{i't}$ is the corresponding outcome for the matched control firm. The sets T_i^{Cartel} and T_i^{Post} refer to the weeks before and after cartel dissolution, respectively.

This procedure yields a cross-sectional dataset of firm-level ATT estimates, which captures substantial heterogeneity both across and within cartel cases. Table 5 reports summary statistics for these estimates where ATT_{rp},ATT_{rm}, ATT_{wm} refer to log retail price, retail markup and wholesale markup respectively. As expected, ATTs for log retail prices and retail markups are predominantly positive, indicating that cartels increased downstream prices and markup.

Non-parametric evidence. To illustrate these differences, I first compare the distributions of firm-level ATTs across vertical and horizontal cartels. Figure **??** display histograms of ATT estimates for log retail prices, retail markups, and wholesale markups. For both log retail prices and retail markups, the distribution of ATTs under vertical cartels is clearly shifted to the right and exhibits a thicker upper tail relative to horizontal cartels. In contrast, wholesale-markup ATTs are tightly centered around zero for both cartel types, with only a mild rightward shift for vertical cases. These patterns indicate that wholesaler participation substantially amplifies downstream price effects while having a more limited impact on upstream margins.

Average effects. To quantify these differences, I estimate the following regression:

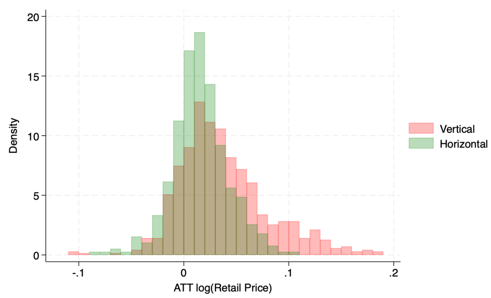
$$\widehat{\mathrm{ATT}}_i = \alpha + \beta\, \mathrm{Vertical}_i + \theta X_i + \gamma A_c + \xi_i, \tag{17}$$

Table 5: ATT Summary

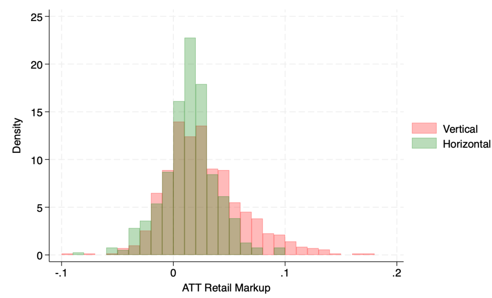
	ATT_{rp}	ATT_{rm}	ATT_{wm}	Vertical	HHI Retail	HHI Wholesale	Obs.
All Cases	0.030***	0.023***	0.003***	–	–	–	1,100
	(0.039)	(0.032)	(0.014)	–	–	–	–
Case 1	0.046***	0.034***	0.004***	1	189	650	158
	(0.025)	(0.024)	(0.013)	–	–	–	–
Case 2	0.017***	0.015***	-0.001	0	345	1,562	63
	(0.011)	(0.013)	(0.008)	–	–	–	–
Case 3	0.039***	0.040***	-0.006***	1	332	929	79
	(0.037)	(0.030)	(0.008)	–	–	–	–
Case 4	0.006**	0.012***	-0.005***	0	90	1,069	163
	(0.025)	(0.022)	(0.011)	–	–	–	–
Case 5	0.038***	0.026***	0.006***	0	146	1,060	88
	(0.026)	(0.026)	(0.012)	–	–	–	–
Case 6	0.012***	0.007***	0.004***	1	44	1,716	329
	(0.023)	(0.020)	(0.008)	–	–	–	–
Case 7	0.010***	0.006**	0.002	0	314	1,891	77
	(0.025)	(0.027)	(0.014)	–	–	–	–
Case 8	0.087***	0.062***	0.012***	1	132	2,847	143
	(0.049)	(0.043)	(0.024)	–	–	–	–

Note: This table reports average treatment effects on the treated (ATT) computed using Specification (16). ATT_{rp} denotes retail price effects, ATT_{rm} retail markup effects, and ATT_{wm} wholesale markup effects. The first row aggregates results across all cartel cases; subsequent rows report case-specific estimates. Standard deviations are reported in parentheses. The p-values correspond to tests of whether the average effect differs from zero. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

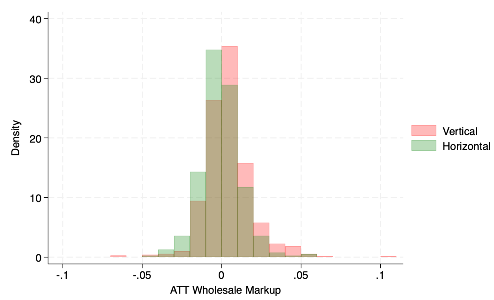
Figure 3: Firm-Level Distribution of ATT Estimates



(a) Log(Retail Price)



(b) Retail Markup



(c) Wholesale Markup

Note: This figure compares the distribution of firm-level ATT estimates between horizontal and vertical cartels for three outcomes: log(retail price), retail markup, and wholesale markup. In all panels, the distribution for vertical cartels is more dispersed and exhibits greater mass to the right relative to horizontal cartels, indicating that wholesaler participation is associated with larger treatment effects. ATT estimates are computed using Specification (16).

where Vertical_i is an indicator for whether firm i belongs to a vertical cartel, X_i includes station-level characteristics such as exclusive supply agreements, the number of pumps, and gasoline storage capacity, and A_c contains city-level characteristics such as the wholesale and retail HHI during the cartel period. Observations are weighted so that each cartel contributes equally to the estimation.

A natural concern is that the Vertical indicator may not be exogenous. The empirical specification implicitly treats cartel structure—vertical versus horizontal—as predetermined with respect to individual retailers. I argue that this assumption is reasonable for two main reasons.

First, from the perspective of a single retailer, the organizational form of the cartel is not an individual choice variable. Retailers do not independently decide whether the cartel will be vertical or purely horizontal; rather, this structure emerges from coordination at the group level and depends on the participation of upstream wholesalers. Thus, conditional on being part of a downstream cartel, the vertical nature of the arrangement is not something a single station can manipulate.

Second, the theoretical model provides additional support for this assumption. If the model's predictions are correct—as suggested by the estimates in Table 4—retailers would strictly benefit from vertical coordination whenever it is feasible, since vertical participation raises retail prices and margins relative to horizontal collusion. However, implementing a vertical cartel requires the active participation of wholesalers. Therefore, conditional on a retail cartel being formed, the decision to move to a vertical structure depends primarily on upstream incentives rather than downstream ones. From the retailers' perspective, the presence of wholesaler participation is effectively exogenous.

Under this interpretation, Table 6 presents the firm-level estimates under the assumption that, conditional on the existence of a downstream cartel, the vertical structure is exogenous to individual retailers. The results indicate that horizontal cartels increase retail markups and retail prices by approximately 1.8% and 1.5%, respectively. In contrast, vertical cartels raise retail markups by about 4.6% and retail prices by 3.6%. Using a short-run demand elasticity of -0.3, these magnitudes imply that vertical cartels increase deadweight loss by approximately 531% relative to the horizontal benchmark. In other words, wholesaler participation more than triples the downstream welfare impact of collusion. These effects remain stable after controlling for station-level covariates, reinforcing the conclusion that vertical cartels generate substantially stronger price and margin distortions than horizontal ones.

The effects on wholesale markups are considerably smaller. Horizontal cartels generate no statistically significant change in wholesale margins, while vertical car-

Table 6: Effect of Wholesaler Participation in the Cartel

	ATT_{rp}			ATT_{rm}			ATT_{wm}		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Vertical	0.028***	0.025***	0.026***	0.021***	0.019***	0.020***	0.003***	0.002*	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Constant	0.018***	0.007**	-0.007	0.015***	0.012***	-0.000	0.000	-0.005***	-0.004**
	(0.001)	(0.003)	(0.004)	(0.001)	(0.003)	(0.004)	(0.001)	(0.002)	(0.002)
Firm-level covariates	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
City-level covariates	No	No	Yes	No	No	Yes	No	No	Yes
Weight by case	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100

Note: This table reports estimates from Specification (17). *Vertical* equals one if the cartel involved wholesaler participation. Each cartel case receives equal weight. Firm-level covariates include exclusive supply agreements, gasoline storage capacity, and number of pumps. Standard errors (in parentheses) are HC2. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

tels are associated with a modest increase of roughly 0.3%. This asymmetric pattern aligns closely with the Nash-in-Nash bargaining framework: vertical collusion primarily operates by increasing retail prices and downstream margins, while wholesale prices adjust only marginally. Most of the additional surplus is therefore realized at the retail level, consistent with a structure in which bargaining determines rent division without requiring large upstream markups.

Overall, the firm-level evidence shows that vertical cartels substantially amplify the price and profit effects of collusion relative to horizontal cartels, with most of the additional surplus extracted at the retail level. Consistent with the theoretical model, the estimates indicate that vertical participation is associated with higher retail prices and markups, while wholesale markups adjust by a smaller amount, reflecting a reallocation of monopoly rents across tiers.

The relatively small increase in wholesale markups is closely related to the decentralized structure of wholesale pricing. Although distributors are national firms, wholesale prices in each locality are typically set by regional managers. These managers are the ones directly involved in cartel coordination at the local level and are often the parties held responsible in enforcement actions.

This organizational structure affects how surplus is extracted. Rather than raising wholesale margins substantially, the local manager can sustain collusion by charging a wholesale price only slightly above the competitive level, while allowing the retail tier to implement the higher monopoly price. In this configuration, most of the incremental overcharge is realized at the retail level, where quantities are sold and margins are visibly higher. The wholesale tier therefore captures rents primarily through its influence over the coordinated outcome and through the volume of gasoline sold, rather than through a large increase in the per-unit wholesale markup.

Appendix C presents a comprehensive set of robustness checks and additional implementation details for the firm-level analysis. Appendix C.5 reports alternative inference procedures and clustering schemes, including cluster-level t-statistics appropriate for settings with a small number of treated clusters, following Ibragimov and Müller (2010). As expected, inference based on clustering at the cartel level—where there are only eight clusters—is inherently weak and produces imprecise estimates. However, the main results remain robust across alternative clustering definitions that rely on a larger effective number of clusters.

Importantly, Chaves and Duarte (2025) show that exclusive supply agreements play a central role in gasoline markets, as wholesale cost shocks are not fully transmitted to retailers operating under exclusivity. For this reason, clustering at the case–exclusive level provides the most appropriate correlation structure for the error term. Under this specification, the estimated effects on log retail price and retail markup remain statistically significant at the 5% level, while the effect on wholesale markup becomes less precise, with a p-value of 0.14.

Appendix C.6 presents leave-one-cartel-out exercises that assess the sensitivity of the estimates to individual cartel cases. Overall, the results are robust: excluding any single cartel from the sample leaves the estimated effects on retail prices and retail markups positive and economically meaningful. By contrast, the estimates for wholesale markups are less stable and frequently lose statistical significance, consistent with the smaller magnitude of wholesale effects documented in the main analysis.

Finally, Appendix C.7 reports quantile regression results that characterize how the impact of vertical cartels varies across the distribution of outcomes. The estimates show that vertical cartels have positive and statistically significant effects on retail prices and retail markups at all quantiles, with the magnitude of the effect increasing toward the upper tail of the distribution. This pattern indicates that vertical collusion disproportionately amplifies large overcharges, further reinforcing the conclusion that wholesaler participation intensifies consumer harm.

5 Vertical Profit Distribution

This section brings the bargaining component of the model to the data and moves beyond reduced-form price effects to analyze how cartel rents are divided within the vertical structure. A central implication of the theoretical framework is that, once the monopoly price is implemented, negotiated wholesale terms encode retailer-specific bargaining weights. Using equation (13), which maps the negotiated wholesale price w_i' into the Nash bargaining weight θ_i, I recover retailer-level bargaining parameters at the weekly frequency. This step is important for two reasons. First, it provides a structural interpretation of observed wholesale prices and retail markups. Second, it allows me to quantify not only how much surplus vertical cartels generate, but how that surplus is allocated across tiers and across firms.

Identification relies on the incentive-compatibility conditions discussed in the model and on the reduced-form evidence showing that vertical cartels increase total surplus relative to horizontal ones. Under these conditions, the mapping from observed prices and costs to θ_{it} is one-to-one. I begin by documenting the distribution of the estimated bargaining weights across firms and cases. These descriptive statistics are informative in their own right: they reveal whether the downstream tier captures a negligible or meaningful share of monopoly rents and whether rent division is concentrated among a small subset of retailers.

I then examine cross-sectional determinants of bargaining power. Specifically, I relate θ_{it} to retailer size, exclusive supply agreements, chain affiliation, and local market structure. This analysis is motivated by both theory and policy. In the model, bargaining power reflects the strength of a firm's outside option and its capacity share. Empirically, identifying which observable characteristics are associated with higher bargaining weights sheds light on the internal organization of vertical cartels. From a policy perspective, it clarifies which types of firms benefit most from vertical collusion and therefore may have stronger incentives to sustain it.

This dimension is particularly relevant for antitrust enforcement. In practice, cartel penalties are often calibrated as a function of the total benefit obtained from collusion or as a percentage of affected revenues. While such rules are useful for compensating consumer harm, they may not fully account for differences in incentives across firms. Bargaining weights provide a direct measure of each firm's share of the monopoly surplus and, therefore, of its stake in sustaining the cartel. If penalties were designed not only to reflect total overcharges but also to account for the internal division of rents—captured by θ_{it}—enforcement could be better aligned with deterrence. Firms with greater bargaining power and larger shares of the surplus would face stronger incentives to comply with the law, while those with weaker outside options and smaller surplus shares could be treated differently. In this sense, estimating bargaining weights has direct implications for the design of more targeted and effective sanctioning policies.

Finally, I analyze the dynamics of θ_{it} over the life cycle of the cartel. Tracking bargaining weights in event time relative to cartel dissolution allows me to assess whether rent division is stable or adjusts as enforcement risk increases. If sustaining collusion becomes more difficult over time, the wholesale tier may need to reallocate surplus toward retailers to maintain participation. Observing systematic changes in θ_{it} as the cartel approaches its termination provides direct evidence on this mechanism and offers a new window into cartel stability.

Taken together, these analyses transform the model's abstract bargaining parameter into a measurable object with clear economic content. They allow me to quantify how vertical cartels allocate monopoly rents across tiers, to identify the firm characteristics that shape bargaining outcomes, to study how rent division evolves as collusion becomes more fragile, and to inform enforcement design by linking internal surplus allocation to deterrence.

5.1 Identification of θ_i

Under the assumptions SRIC, SWIC,RCIC, WCIC and VCIC, the maximization problem in (12) admits the closed–form solution in (13). While SRIC, SWIC, RCIC, WCIC cannot be tested directly in the data because they depend on the (unobserved) discount factors of retailers and wholesalers, VCIC can be assessed using the reduced–form evidence from the previous section.

The identification strategy therefore relies on two ingredients. First, I assume that SRIC and SWIC are satisfied, so that neither individual retailers nor individual wholesalers find it profitable to deviate unilaterally from the vertical cartel. Second, I use the empirical results on markups to support VCIC: the estimates show that both retail and wholesale markups are weakly higher under vertical cartels than under horizontal ones. This pattern is consistent with the requirement that total profits for both sides of the market are weakly larger under vertical collusion than under the horizontal (double–marginalization) benchmark, as required by VCIC.

Since the results from Table 6 indeed show that the profits are weakly higher under the Vertical arrangement, we have that the threshold determined by WCIC and RCIC are below 1. Therefore, I assume that the discount rates for both wholesalers and retailers are sufficiently large in order to the maximization problem (12) has an interior solution.

Thus, the optimal wholesale price in (13) can be inverted to recover the retailer–specific bargaining weight:

$$\theta_{it} = \frac{k_i}{K} \left(\frac{p_t^M - w'_{it}}{p_t^M - c_t} \right), \tag{18}$$

where θ_{it} is the bargaining parameter of retailer i in week t, k_i is its capacity, K is total market capacity, p_t^M is the (collusive/monopoly) retail price in week t, w'_{it} is the wholesale price charged to retailer i in week t, and c_t is the upstream marginal cost in week t.

The data contain all components of (18) for the weeks in which a station is observed: station–level capacities, total market capacity, weekly retail prices, station–specific wholesale prices, and regional production or import costs for gasoline (used as a proxy for c_t). Hence, under SRIC, SWIC, RCIC, WCIC and VCIC, equation (18) provides a one–to–one mapping from observed markups to bargaining weights, allowing me to recover θ_{it} for each retailer–week in the sample.

5.2 Properties of θ_i

After estimating θ_{it} at the weekly level, I aggregate over time and compute, for each retailer i, the average bargaining share $\bar{\theta}_i \equiv \frac{1}{T_i} \sum_t \theta_{it}$. Table 7 reports summary statistics for $\bar{\theta}_i$ across retailers, as well as the implied aggregate bargaining shares of the retail cartel, $\sum_i \bar{\theta}_i$, and of the wholesale cartel, $1 - \sum_i \bar{\theta}_i$, by case.

Table 7: Summary of Estimated Bargaining Shares by Case

	All cases	Cuiabá/MT	João Pessoa/PB	Belo Horizonte/MG	Brasília/DF
Retailer-level share $\bar{\theta}_i$	0.001	0.002	0.004	0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)
Retailer cartel share $\sum_i \bar{\theta}_i$	0.299	0.355	0.359	0.244	0.237
	(0.067)	(—)	(—)	(—)	(—)
Wholesale cartel share $1 - \sum_i \bar{\theta}_i$	0.701	0.645	0.641	0.756	0.763
	(0.067)	(—)	(—)	(—)	(—)
Retailer observations (N_r)	930	215	90	383	242

Notes: Standard deviations are reported in parentheses below point estimates. Cartel-level shares are constant within each case; standard deviations are therefore not defined within case. The standard deviation in the "All cases" column is computed across cartel cases.

Two patterns emerge. First, individual retailers have very small bargaining weights: the mean $\bar{\theta}_i$ is on the order of 10^{-3}, with case-level means ranging from 0.001 to 0.004. This reflects the fact that bargaining power is distributed across many downstream firms; small per–firm weights do not imply that retailers are unimportant, but rather that surplus is shared among a large number of relatively small players.

Second, once aggregated to the cartel level, retailers capture a substantial share of the monopoly surplus. Across cases, the sum of retailers' bargaining weights averages about 0.30, while the wholesale cartel retains roughly 0.70 of total rents. Thus, on average, the vertical cartel allocates about one–third of the surplus to the downstream tier and two–thirds to the upstream tier.

These magnitudes are consistent with market structure. As shown in Table 2, the average retailer HHI is approximately 317, whereas the average wholesaler HHI is about 1,586, indicating much greater concentration upstream. Greater concentration at the wholesale level naturally translates into stronger bargaining power for wholesalers, helping rationalize why the upstream cartel captures a larger share of the surplus.

Cross-case variation further supports this interpretation. For example, João Pessoa/PB exhibits a relatively high retail bargaining share ($\sum_i \bar{\theta}_i \approx 0.36$) in a market with fewer retailers, whereas Belo Horizonte/MG shows a lower retail share (about 0.24) in a much more fragmented downstream market. More dispersed retail structures weaken the collective bargaining position of retailers vis-à-vis the wholesale cartel.

Finally, combining these bargaining shares with the firm-level treatment effects from Section 4 yields a clear picture of how vertical collusion operates. Even though retailers capture a smaller fraction of total monopoly rents than wholesalers, they are the primary beneficiaries of moving from a horizontal to a vertical cartel. Vertical collusion substantially raises retail prices and retail profit margins, while wholesale markups increase only modestly. This pattern is consistent with a setting in which intense pre-cartel competition pushes retail prices close to wholesale costs, and the formation of a fully inclusive vertical cartel allows retailers to gain disproportionately from the resolution of double marginalization.

5.3 Cross-Sectional Determinants of Bargaining Power

To understand how bargaining power varies across retailers, I relate the estimated bargaining shares θ_{it} to observable station characteristics. Recall that θ_{it}

captures retailer i's share of the monopoly markup in week t implied by the Nash bargaining solution in Lemma 2. I estimate regressions of the form

$$\theta_{it} = \beta_1 \, \text{Exclusive}_{it} + \beta_2 \, \text{Pumps}_i + \beta_3 \, \text{Chain}_i + \text{Interactions} + \alpha_{c,t} + \varepsilon_{it}, \tag{19}$$

where $\alpha_{c,t}$ are case–week fixed effects. Identification therefore comes from cross-sectional differences *within* a given cartel and week. Standard errors are clustered at the case–week level. The variables *Exclusive* and *Chain* indicate exclusive supply agreements and chain affiliation, respectively, while *Pumps* measures station size. The interaction terms allow the effect of exclusivity to vary with physical capacity.

A potential concern with the baseline measure θ_{it} is that it mechanically incorporates the retailer's capacity share k_i/K. Since capacity is likely correlated with observable station characteristics—such as size, chain affiliation, or exclusivity—part of the estimated relationship between θ_{it} and these covariates could reflect this mechanical component rather than genuine bargaining power. To address this concern, I re-estimate the regressions using

$$\tilde{\theta}_{it} \equiv \frac{K}{k_i} \, \theta_{it},$$

which removes the capacity-share term from the bargaining expression and isolates the component of bargaining power that is orthogonal to relative size. Comparing results across θ_{it} and $\tilde{\theta}_{it}$ therefore provides a robustness check on whether the baseline findings are driven by capacity mechanically entering the construction of θ_{it}.

Table 8: Determinants of Retailer Bargaining Share

	(1) θ_{it}	(2) θ_{it}	(3) θ_{it}	(4) $\tilde{\theta}_{it}$	(5) $\tilde{\theta}_{it}$	(6) $\tilde{\theta}_{it}$
Exclusive contract	-0.00009^{***}	-0.00011^{***}	-0.00002	-0.018^{***}	-0.018^{***}	-0.026^{***}
	(0.00002)	(0.00002)	(0.00003)	(0.002)	(0.002)	(0.002)
Number of pumps		0.00009^{***}	0.00009^{***}		-0.001^{***}	-0.003^{***}
		(0.00000)	(0.00001)		(0.000)	(0.000)
Chain station		0.00006^{***}	0.00018^{***}		0.000	0.005^{***}
		(0.00001)	(0.00002)		(0.001)	(0.001)
Exclusive × Chain			-0.00019^{***}			-0.007^{***}
			(0.00003)			(0.002)
Exclusive × Pumps			-0.00001			0.002^{***}
			(0.00001)			(0.000)
Constant	0.00154^{***}	0.00110^{***}	0.00105^{***}	0.364^{***}	0.369^{***}	0.375^{***}
	(0.00001)	(0.00001)	(0.00003)	(0.001)	(0.001)	(0.001)
Case–week fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,475	29,475	29,475	29,475	29,475	29,475

Standard errors clustered at the case–week level in parentheses.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 8 reports the results. Across all specifications and for both measures of bargaining power, exclusive supply agreements are associated with significantly lower bargaining shares. In the specifications using θ_{it}, exclusivity reduces a retailer's share of the monopoly markup by approximately 5–6 percent of the mean. When using $\tilde{\theta}_{it}$, the estimated effects are even larger in relative terms and remain highly statistically significant. This pattern indicates that the negative association between exclusivity and bargaining power is not driven by the inclusion of capacity shares in θ_{it}, but instead reflects a genuine shift in surplus toward the wholesale cartel.

This result is closely related to the findings in Chaves and Duarte (2025), who show that exclusive supply agreements reduce the pass-through of wholesale cost shocks into retailers' profits, thereby stabilizing retailers' costs. The estimates in Table 8 indicate that retailers obtain this benefit at the expense of bargaining power: by committing to exclusivity, they forgo leverage in negotiating over the monopoly price, which shifts a larger share of surplus toward the wholesale cartel.

Columns (2) and (3) of Table 8 indicate that station size is positively related to bargaining power when measured by θ_{it}. However, this relationship partly reflects a mechanical effect: the number of pumps is positively correlated with a station's storage capacity, which directly enters the construction of θ_{it} through the capacity share. Consequently, columns (5) and (6), which use $\tilde{\theta}it$ as the dependent variable, provide a cleaner assessment of how size relates to bargaining power once this mechanical channel is removed. When using $\tilde{\theta}it$, the coefficient on the number of pumps becomes negative. This sign reversal indicates that, conditional on capacity, having more pumps is no longer associated with greater bargaining leverage. Instead, the estimates suggest that larger retailers receive a smaller bargaining share per unit of capacity.

This pattern is consistent with the theoretical structure of the model. A key role of the vertical arrangement is to induce participation by smaller retailers that, under horizontal collusion, would have stronger incentives to deviate. Because these firms face weaker outside options and a higher temptation to undercut the monopoly price, sustaining full participation in the vertical cartel requires compensating them with a larger share of the monopoly surplus. As a result, bargaining power per unit of capacity is higher for smaller retailers. Once the mechanical effect of capacity is removed by using $\tilde{\theta}it$, this mechanism implies a negative relationship between pumps and bargaining power.

The interaction terms further support this interpretation. While exclusivity reduces bargaining power on average under both measures, the interaction between exclusivity and pumps is positive and statistically significant in the $\tilde{\theta}_{it}$ specifications. This indicates that among exclusive stations, larger physical scale partially mitigates—but does not overturn—the loss in bargaining power induced by exclusivity once capacity effects are removed.

When analyzing the effect of chain affiliation, the estimated coefficient is positive, as expected. Chains operating a larger number of stations within a given market exhibit greater bargaining power, reflecting their scale and ability to internalize profits across outlets. However, when chain affiliation is interacted with exclusivity, the estimated effect becomes negative. Once a chain is locked into an exclusive supply agreement, its ability to negotiate with alternative wholesalers is eliminated, weakening its outside options and reducing its bargaining power vis-à-vis the wholesaler without exclusive agreements. This loss of flexibility explains the negative interaction effect observed in the estimation.

5.4 Dynamics of θ

This subsection examines how retailers' bargaining power evolves as a cartel approaches its termination. The underlying data are weekly. To reduce high-frequency noise and focus on economically meaningful adjustment horizons, I aggregate θ_{it} to a monthly event-time frequency and restrict the analysis to the 12 months preceding cartel breakup.

For each cartel case c and retailer i, I compute the monthly mean of θ_{it} and define relative_month$_{cim}$ as the number of months relative to the end of the cartel, with $m = 0$ denoting the final month of cartel operation. Larger values of m correspond to months further away from termination. All estimates are normalized to the cartel-end month.

I estimate the following event-study specification:

$$\theta_{im} = \mu_i + \sum_{k=1}^{12} \beta_k \, \mathbb{1}\{m = k\} + \varepsilon_{im}, \tag{20}$$

where α_c and μ_i denote cartel-case and retailer fixed effects, respectively. The omitted category is $m = 0$, so each coefficient β_k measures the average difference in bargaining power k months before cartel termination relative to the final month. Standard errors are clustered at the retailer level.

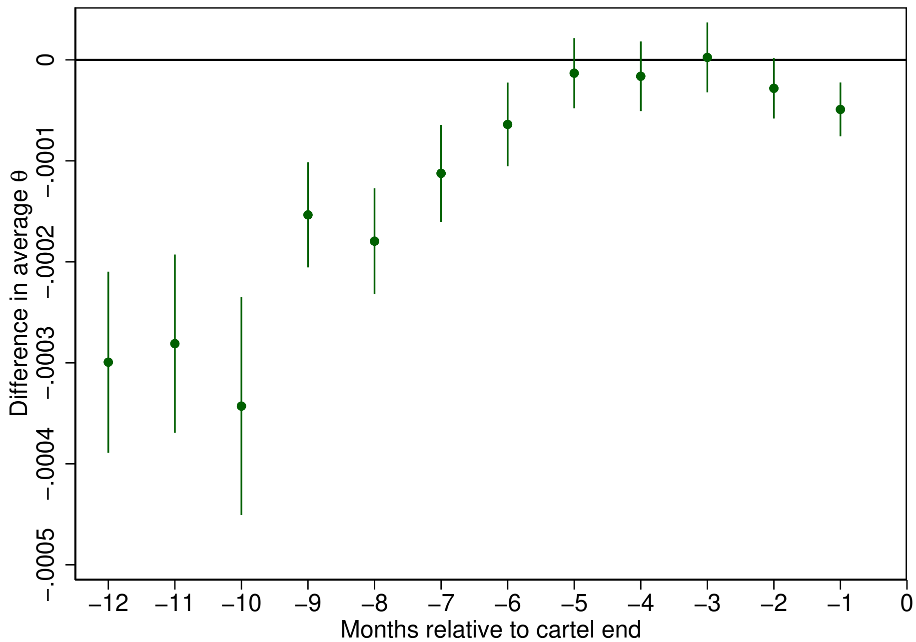
Figure 4 reports the estimated coefficients and confidence intervals. The results show a clear upward pattern: retailers' bargaining shares are lower farther from cartel termination and increase steadily as the cartel approaches its end. In other words, retailers capture a larger share of the monopoly surplus in the months immediately preceding cartel breakup.

A natural interpretation is that, as the cartel becomes more fragile and the continuation value of collusion declines, sustaining cooperation requires shifting surplus toward the downstream side. To prevent deviation, the wholesale cartel must concede higher rents to retailers. The observed increase in θ near cartel termination is consistent with this dynamic incentive mechanism.

6 Conclusion

This paper has examined how vertical participation alters both the mechanics and the consequences of collusion in gasoline retail markets. Starting from a capacity-constrained horizontal cartel in the spirit of Bos and Harrington (2010), I extend the

Figure 4: Retailer bargaining Power Dynamics



Note: This figure reports the results from estimation (20).Standard errors are clustered at case and retailer levels

framework to allow wholesalers to join the cartel and to discriminate between insiders and outsiders through wholesale pricing. The central insight is that once wholesalers participate, vertical collusion can sustain the monopoly outcome and then divide the resulting rents via Nash bargaining. In this environment, vertical coordination does not mitigate harm through the elimination of double marginalization; instead, it amplifies the consumer impact of collusion.

On the theoretical side, the model delivers two key implications. First, vertical collusion induces full cartel participation and implementation of the monopoly price, implying that retail prices under vertical cartels are weakly higher than under horizontal cartels and strictly higher whenever the latter fall short of the monopoly outcome. Second, the division of monopoly rents between wholesalers and retailers is governed by a Nash bargaining problem, yielding sharp comparative statics for how bargaining power and capacity shape the allocation of surplus and generating testable predictions for retail and wholesale margins.

Empirically, I bring these predictions to the Brazilian gasoline market using a new station-level panel that combines weekly retail and wholesale prices, rich station characteristics, and detailed information on eight cartel cases investigated by CADE. A two-step matching difference-in-differences design shows that vertical cartels raise retail prices and retail margins by more than twice as much as horizontal cartels, while wholesale margins increase only modestly. Distributional evidence further indicates that vertical cartels generate larger overcharges in the upper tail, consistent with the model's emphasis on bargaining-driven heterogeneity.

Building on the closed-form bargaining solution, I invert observed markups to recover retailer-specific bargaining weights. Although individual retailers have small bargaining shares, the downstream side collectively captures a meaningful fraction of monopoly rents—about one-third on average—while the wholesale cartel retains the remainder. Bargaining power varies systematically with observable characteristics: larger stations exhibit higher bargaining weights, exclusive supply agreements are associated with lower retailer shares, and retailers' bargaining power rises as cartels approach termination, consistent with dynamic incentive considerations.

Taken together, the results deliver a clear message: vertical cartels are not simply horizontal cartels with an upstream tier added. By replacing double marginalization with a single vertically coordinated collusive structure, vertical participation strengthens cartel stability, increases retail overcharges, and reshapes the division of surplus in ways that disproportionately harm consumers.

These findings have direct implications for antitrust enforcement. In collusive environments, the mechanisms that make vertical integration appear benign in competitive settings can instead serve to stabilize and intensify cartel conduct. Fining guidelines and enforcement practices that treat cartels as a homogeneous category—or that presume vertical arrangements to be pro-competitive—risk understating harm when wholesalers actively participate. Recognizing vertical cartels as a distinct and especially harmful form of collusion would improve the alignment between enforcement, deterrence, and consumer welfare.

More broadly, this paper shows that vertical links are not an innocuous organizational detail when collusion is at stake, but a central component of the mechanism through which firms amplify and sustain market power.

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Appendix A: Theoretical Model Appendix

A.1. Model Details

A.1.1 Reporting the Members of the Cartel

The assumption that the wholesale cartel can perfectly discriminate between retailers participating in the cartel and those remaining outside may appear strong. However, conditional on the existence of a downstream cartel, it is possible to construct a truth-telling mechanism in which the retailer with the largest capacity has an incentive to report the true set of cartel members.

The argument builds on **Result 3** of Bos and Harrington (2010), which establishes that insiders prefer to expand cartel membership because cartel profits increase with participation. Moreover, by **Result 4**, if a cartel exists, the retailer with the largest capacity is necessarily part of it. Hence, the largest retailer internalizes the effect of membership changes on aggregate cartel profits.

Consider first a retailer that is not participating in the cartel. If the largest retailer truthfully reports that this firm is an outsider, the wholesale cartel can assign it the outsider wholesale price, which leaves the firm with zero profit at the collusive retail price. As a result, the outsider optimally chooses to join the cartel. By increasing membership, the cartel can sustain a weakly higher price, thereby increasing total cartel profits. Since the largest retailer captures a positive share of these profits, truthful reporting strictly benefits it. Therefore, it has no incentive to conceal the presence of an outsider.

Now consider the opposite case, in which a retailer is already participating in the cartel. If the largest retailer falsely reports that this firm is an outsider, the wholesale cartel would treat it as such, effectively removing it from the collusive arrangement. In this case, the firm would either remain outside or be indifferent between participating and deviating. Either outcome reduces effective cartel membership and weakly lowers the sustainable collusive price. This, in turn, reduces aggregate cartel profits and lowers the payoff of the largest retailer. Hence, misreporting an insider as an outsider is also not optimal.

Taken together, these arguments imply that, conditional on the existence of a retail cartel, the largest-capacity retailer has an incentive to truthfully reveal the set of cartel participants.

A.1.2 Double Marginalization with Separate Horizontal Cartels

This subsubsection studies the benchmark in which wholesalers and retailers each collude horizontally within their own tier but do not coordinate vertically. I refer to this environment as a double horizontal cartel. The key implication is that wholesale pricing and retail collusion interact through standard double marginalization: the upstream cartel sets the input price anticipating how it affects the downstream cartel's best sustainable retail price, while the downstream cartel takes the wholesale price as its marginal cost when solving its repeated-game problem.

Timing of the Game.

1. **Retail membership stage.** Retailers decide whether to join the retail cartel, forming a set of insiders $\Gamma^H \subseteq \{1, \ldots, N_r\}$ with total insider capacity $K_{\Gamma^H} = \sum_{i \in \Gamma^H} k_i \leq K$.

2. **Wholesale pricing stage.** After observing K_{Γ^H}, the wholesale cartel chooses a uniform wholesale price w^H.

3. **Retail pricing stage.** After observing w^H, the retail cartel with capacity K_{Γ^H} chooses the retail price p^H (equivalently, the highest sustainable price given marginal cost w^H), while non-members optimally undercut by $\xi \to 0$ as in Bos and Harrington (2010).

This sequencing captures an empirically plausible hierarchy of commitments in fuel and similar input–output markets. Retail cartel formation is a relatively slow-moving decision (e.g., communication, monitoring arrangements, and the choice of participating stations), so it is natural to treat membership as predetermined within a pricing cycle. Wholesale terms, by contrast, are typically posted and revised at lower frequency than retail prices and can condition on observable downstream characteristics (such as the extent of downstream coordination or demand conditions). Finally, retail prices are the most flexible instrument and are chosen after observing current wholesale terms. As a result, the upstream cartel effectively acts as a Stackelberg leader in wholesale prices, anticipating the downstream cartel's optimal sustainable price response in the repeated game, which provides a clean benchmark for quantifying double marginalization absent vertical coordination.

Under this setting, the game can be solved by backward induction.

Stage 3: Retail Pricing Using (4), conditional on the wholesale price w^H and cartel capacity K_{Γ^H}, the retail price under the double-horizontal structure is given by

$$p^H(w^H, K_{\Gamma^H}) = \min\left\{D^{-1}(K - \delta K_{\Gamma^H}),\ p^o(w^H, K_{\Gamma^H})\right\}, \tag{21}$$

where $p^o(w^H, K_{\Gamma^H})$ solves

$$D(p^o) - (K - K_{\Gamma^H}) + (p^o - w^H)D'(p^o) = 0.$$

Stage 2: Wholesale Pricing From (21), two cases arise:

(i) $p^H(w^H, K_{\Gamma^H}) = D^{-1}(K - \delta K_{\Gamma^H})$;

(ii) $p^H(w^H, K_{\Gamma^H}) = p^o(w^H, K_{\Gamma^H})$.

In case (i), the collusive price is pinned down by the incentive constraint and does not depend on w^H. Since K_{Γ^H} is determined prior to the wholesale decision, the retail price is already fixed. The wholesaler then chooses w^H subject to the constraint that the retail price remains at $D^{-1}(K - \delta K_{\Gamma^H})$.

In case (ii), the retail price is interior and therefore satisfies the first-order condition characterizing the retail cartel's best response. Anticipating this response, the wholesale cartel chooses w^H to maximize upstream profits.

Fix cartel capacity K_{Γ^H} chosen in Stage 1. When the retail ICC is not binding, the retail price is determined by the interior condition

$$F(p^H, w^H; K_{\Gamma^H}) \ \equiv\ D(p^H) - (K - K_{\Gamma^H}) + (p^H - w^H)D'(p^H) \ =\ 0, \tag{22}$$

which implicitly defines the retail cartel's price as a function $p^H = p^H(w^H, K_{\Gamma^H})$. The wholesale cartel anticipates this best response and solves

$$\max_{w^H \geq c}\ \Pi_w^H(w^H) \ \equiv\ (w^H - c)\, D\big(p^H(w^H, K_{\Gamma^H})\big). \tag{23}$$

The wholesale first-order condition follows from the chain rule:

$$0 \ =\ \frac{d}{dw^H}\Pi_w^H(w^H) \ =\ D(p^H) + (w^H - c)\, D'(p^H)\, \frac{\partial p^H}{\partial w^H}, \tag{24}$$

where $p^H = p^H(w^H, K_{\Gamma^H})$.

To characterize the pass-through term $\partial p^H/\partial w^H$, implicitly differentiate (22) with respect to w^H:

$$\frac{\partial F}{\partial p}\,\frac{\partial p^H}{\partial w^H} + \frac{\partial F}{\partial w} \;=\; 0, \tag{25}$$

with

$$\frac{\partial F}{\partial w} \;=\; -D'(p^H), \qquad \frac{\partial F}{\partial p} \;=\; 2D'(p^H) + (p^H - w^H)D''(p^H).$$

Thus, the retail pass-through of the wholesale price is

$$\frac{\partial p^H}{\partial w^H} \;=\; \frac{D'(p^H)}{2D'(p^H) + (p^H - w^H)D''(p^H)}. \tag{26}$$

Substituting (26) into (24) yields an equivalent optimality condition for the wholesale cartel:

$$D(p^H)\Big(2D'(p^H) + (p^H - w^{H^*})D''(p^H)\Big) + (w^{H^*}(K_{\Gamma^H}) - c)\Big(D'(p^H)\Big)^2 \;=\; 0, \tag{27}$$

where $p^H = p^H(w^{H^*}(K_{\Gamma^H}), K_{\Gamma^H})$ is the induced retail price at the wholesale optimum.

Equation (24) highlights the standard upstream trade-off between margin and quantity. The term $D(p^H)$ is the direct marginal benefit of increasing the wholesale price: holding the retail price fixed, a higher w^H raises upstream profit on all inframarginal units sold. The second term captures the indirect demand effect: increasing w^H raises the retail cartel's price through the pass-through $\partial p^H/\partial w^H$, which reduces quantity by $D'(p^H)\,\partial p^H/\partial w^H < 0$. Demand curvature governs the strength of this channel via (26): when demand is locally more curved (larger $D''(p^H)$), the retail price response to cost changes is amplified, increasing the demand loss from raising w^H and thereby disciplining the wholesale cartel's optimal markup.

Stage 1: Retail Cartel Membership. Stage 1 determines the set of retailers that coordinate on the collusive price, Γ^H, equivalently total insider capacity K_{Γ^H}. Given any candidate cartel capacity K_Γ, Stages 2–3 pin down the continuation outcome through the equilibrium mappings

$$w^{H^*}(K_\Gamma) \quad \text{and} \quad p^H(K_\Gamma) \;\equiv\; p^H\big(w^{H^*}(K_\Gamma), K_\Gamma\big),$$

and therefore the implied residual demand

$$R^H(K_\Gamma) \;\equiv\; D\big(p^H(K_\Gamma)\big) - (K - K_\Gamma).$$

Insider payoffs. Under the standard Bos–Harrington rationing rule, insiders split cartel profits in proportion to capacity. Thus, conditional on K_Γ, the per-period profit of an insider $i \in \Gamma$ is

$$\pi_i^{\text{in}}(K_\Gamma) \;=\; \Big(p^H(K_\Gamma) - w^{H^*}(K_\Gamma)\Big)\, R^H(K_\Gamma)\, \frac{k_i}{K_\Gamma}, \tag{28}$$

and the associated present value is $V_i^{\text{in}}(K_\Gamma) = \pi_i^{\text{in}}(K_\Gamma)/(1-\delta)$.

Outsider payoffs. If retailer $j \notin \Gamma$ remains outside, it undercuts the cartel by an arbitrarily small amount $\xi \to 0$ and sells its full capacity k_j whenever $R^H(K_\Gamma) > 0$. Hence the per-period outsider profit is

$$\pi_j^{\text{out}}(K_\Gamma) \;=\; \Big(p^H(K_\Gamma) - w^{H^*}(K_\Gamma)\Big)\, k_j, \tag{29}$$

with present value $V_j^{\text{out}}(K_\Gamma) = \pi_j^{\text{out}}(K_\Gamma)/(1-\delta)$. (When $R^H(K_\Gamma) \le 0$, the candidate cartel price is not feasible and the coalition cannot be sustained.)

Membership must be individually stable in the sense of Bos and Harrington (2010): (i) no insider wants to exit and become an outsider, and (ii) no outsider wants to join. For a candidate coalition Γ (capacity K_Γ), these conditions can be written as

$$V_i^{\text{in}}(K_\Gamma) \;\ge\; V_i^{\text{out}}(K_\Gamma - k_i) \qquad \forall i \in \Gamma, \tag{30}$$

$$V_j^{\text{out}}(K_\Gamma) \;\ge\; V_j^{\text{in}}(K_\Gamma + k_j) \qquad \forall j \notin \Gamma. \tag{31}$$

As in Bos and Harrington (2010), these constraints reduce to checking only two marginal firms: the smallest insider must prefer to remain in, and the largest outsider must prefer to remain out. Intuitively, if the smallest insider is willing to stay, all larger insiders (who obtain a weakly larger capacity-weighted share) are also willing to stay; similarly, if the largest outsider is unwilling to enter, all smaller outsiders are unwilling to enter.

Because Stages 2–3 make $w^{H^*}(K_\Gamma)$ and $p^H(K_\Gamma)$ functions of cartel capacity, Stage 1 amounts to selecting K_{Γ^H} (equivalently Γ^H) as a fixed point of the entry/exit conditions (30)–(31). Among all stable coalitions, the equilibrium horizontal cartel implements the one that yields the highest sustainable continuation value for its members, i.e., the coalition Γ^H whose induced $(w^{H^*}(K_{\Gamma^H}), p^H(K_{\Gamma^H}))$ maximizes aggregate insider profit

$$\Pi_r^H(K_\Gamma) \;=\; \Big(p^H(K_\Gamma) - w^{H^*}(K_\Gamma)\Big)\, R^H(K_\Gamma)$$

subject to stability. Relative to the baseline in which w is exogenous, endogenizing $w^{H^*}(K_\Gamma)$ changes membership incentives because a larger cartel affects not only the residual demand term $R^H(K_\Gamma)$ but also the upstream margin via the induced wholesale price.

Proposition A1 (Existence of Pareto-improving bargaining weights). Consider the double-horizontal structure (upstream and downstream collude separately) and the vertical cartel structure (full participation and implementation of $p^V = p^M$ as in Proposition 1). Assume (i) demand $D(p)$ is decreasing and such that $(p-c)D(p)$ is strictly concave in p (e.g. D is twice differentiable and concave), and (ii) the vertical cartel can implement p^M and choose a vector of bargaining weights $\theta = (\theta_1, \ldots, \theta_{N_r})$ with $\theta_i \geq 0$ and $\sum_{i=1}^{N_r} \theta_i \leq 1$. Then there exists a vector θ such that the vertical cartel Pareto dominates the double-horizontal outcome: every retailer and the wholesale tier (as a group) obtain weakly higher per-period profits under the vertical cartel than under the double-horizontal structure, with strict inequality for at least one party whenever the double-horizontal price differs from p^M.

Proof. Let the integrated (vertical) monopoly problem be

$$\Pi^M \;\equiv\; \max_p \,(p-c)D(p), \qquad \text{and let } p^M \in \arg\max_p (p-c)D(p).$$

Under the double-horizontal structure, let w^{H^*} denote the wholesale cartel's equilibrium wholesale price, and let p^{DH} denote the resulting retail price (the downstream cartel's best sustainable price given w^{H^*}). Total (joint) profit in the double-horizontal structure is the sum of wholesale and retail profits, which can be written as

$$\Pi_{\text{tot}}^{DH} \;=\; \Pi_r^{DH} + \Pi_w^{DH} \;=\; (p^{DH} - w^{H^*})D(p^{DH}) + (w^{H^*} - c)D(p^{DH}) \;=\; (p^{DH} - c)D(p^{DH}).$$

Since Π^M is the maximum of $(p-c)D(p)$ over p, we have

$$\Pi^M \;=\; (p^M - c)D(p^M) \;\geq\; (p^{DH} - c)D(p^{DH}) \;=\; \Pi_{\text{tot}}^{DH}.$$

Moreover, if $(p-c)D(p)$ is strictly concave and $p^{DH} \neq p^M$, then the inequality is strict: $\Pi^M > \Pi_{\text{tot}}^{DH}$.

Under vertical collusion, Proposition 1 implies full participation and $p^V = p^M$. Under Lemma 2, the negotiated wholesale price to retailer i is

$$w_i'^* \;=\; p^M - \theta_i \frac{K}{k_i}(p^M - c).$$

Therefore retailer i's per-period profit under vertical collusion is

$$\pi_i^V \;=\; D(p^M)\frac{k_i}{K}\big(p^M - w_i'^*\big) \;=\; D(p^M)\frac{k_i}{K}\left(\theta_i \frac{K}{k_i}(p^M - c)\right) \;=\; \theta_i\,\Pi^M,$$

and the wholesale tier's aggregate per-period profit is

$$\Pi_w^V \;=\; D(p^M)\sum_{i=1}^{N_r}\frac{k_i}{K}(w_i'^* - c) \;=\; \left(1 - \sum_{i=1}^{N_r}\theta_i\right)\Pi^M.$$

Hence the feasible set of (per-period) payoffs under the vertical cartel is exactly nonnegative splits of Π^M: choose any $\theta_i \geq 0$ with $\sum_i \theta_i \leq 1$, and retailers receive $\{\theta_i \Pi^M\}$ while wholesalers receive the residual $\big(1 - \sum_i \theta_i\big)\Pi^M$.

Let π_i^{DH} denote retailer i's per-period profit in the double-horizontal equilibrium (given its equilibrium membership status), and let Π_w^{DH} denote aggregate wholesale profit. Define

$$\theta_i \;\equiv\; \frac{\pi_i^{DH}}{\Pi^M} \qquad \text{for each } i = 1, \ldots, N_r.$$

Then $\theta_i \geq 0$ and the induced vertical retail profits satisfy

$$\pi_i^V \;=\; \theta_i \Pi^M \;=\; \pi_i^{DH} \qquad \forall i.$$

Next, note that

$$\sum_{i=1}^{N_r}\theta_i \;=\; \frac{\sum_{i=1}^{N_r}\pi_i^{DH}}{\Pi^M} \;=\; \frac{\Pi_r^{DH}}{\Pi^M} \;\leq\; \frac{\Pi_r^{DH} + \Pi_w^{DH}}{\Pi^M} \;=\; \frac{\Pi_{\text{tot}}^{DH}}{\Pi^M} \;\leq\; 1,$$

where the last inequality uses Step 1. Therefore the wholesale tier's vertical profit satisfies

$$\Pi_w^V \;=\; \left(1 - \sum_{i=1}^{N_r}\theta_i\right)\Pi^M \;=\; \Pi^M - \Pi_r^{DH} \;\geq\; \Pi_w^{DH},$$

again using $\Pi^M \geq \Pi_r^{DH} + \Pi_w^{DH}$ from Step 1.

Thus, this choice of θ makes every retailer weakly better off (in fact, exactly indifferent) and makes the wholesale tier weakly better off. If $\Pi^M > \Pi_{\text{tot}}^{DH}$ (equivalently $p^{DH} \neq p^M$ under strict concavity), then $\Pi_w^V > \Pi_w^{DH}$, so at least one party is strictly better off. This establishes Pareto dominance. $\square$

A.2. w' Comparative Statics

The comparative statics with respect to the bargaining weight are immediate. Holding capacities fixed, (13) shows that $w_i'^*$ is strictly decreasing in θ_i:

$$\frac{\partial w_i'^*}{\partial \theta_i} = -\frac{K}{k_i}(p^M - c) < 0.$$

A higher bargaining weight for retailer i shifts surplus away from the wholesale cartel and toward the retailer, resulting in a lower effective wholesale cost.

The relationship between the optimal resale price and the retailer's market share, $s_i \equiv \frac{k_i}{K}$, is more subtle. Holding θ_i fixed, (13) implies that $w_i'^*$ is strictly increasing in s_i:

$$\frac{\partial w_i'^*}{\partial s_i} = \theta_i \frac{p^M - c}{s_i^2} > 0.$$

Intuitively, when bargaining weights are constant, larger retailers internalize a greater fraction of the wholesaler surplus term in the Nash product, which leads the negotiated wholesale price to increase with market share.

However, if bargaining power itself depends on market share—i.e., if $\theta_i = \theta(s_i)$ with $\theta'(\cdot) \geq 0$, reflecting the idea that larger retailers may possess greater bargaining power—the net effect of market share on $w_i'^*$ becomes theoretically ambiguous. In this case,

$$\frac{\partial w_i'^*}{\partial s_i} = -(p^M - c)\,\frac{\theta'(s_i)s_i - \theta(s_i)}{s_i^2},$$

so the sign depends on whether the elasticity of bargaining power with respect to market share exceeds one. Consequently, larger market shares do not necessarily imply higher or lower wholesale prices once endogenous bargaining power is taken into account.

A.3. Numerical Example

This section provides a numerical illustration of the model with two retailer types. There are $N_r = 15$ retailers: 5 "large" firms with capacity $k_L = 10$, and 10 "small" firms with capacity $k_S = 2$. Hence total capacity is

$$K \ = \ 5 \cdot 10 \ + \ 10 \cdot 2 \ = \ 70.$$

Demand is linear,

$$D(p) = A - p, \qquad A = 90,$$

and wholesalers have constant marginal cost $c = 20$. In the absence of vertical coordination, the wholesale benchmark is $w = c + \nu$ with $\nu = 10$, so $w = 30$.

First, let's check if Assumption 1 and 2 holds. Under this setting, the monopoly results are given by $D(p^M) = 45$ and $p^M = 45$. Since $k_L = 10 < 45$ we have that no firm is able to provide the monopoly demand and then Assumption 1 hold.

To check if Assumption 2 holds, we have that the competitive outcome leads to $w = 30$ and $D(w) = 60$. Since, taking one large firm from the market would lead to $K - 10 = 60$ we have that indeed $N_r - 1$ firms are indeed able to provide the competitive demand and hence assumption 2 holds.

Horizontal Benchmark

Under the horizontal benchmark, I assume that only the large firms participate in the cartel, that is $K_\Gamma = 50$ and $K - K_\Gamma = 20$. Hence, the cartel residual demand is: $R(p) = D(p) - K - K_\Gamma = 70 - p$.

Therefore, under wholesale cost $w = 30$ the retail cartel choose p^H such that

$$\max_{p^H} \left(p^H - w\right) R\left(p^H\right)$$

$$p^H = 50, \qquad R(p^H) = 20, \qquad D(p^H) = 40$$

Note that for this result to hold we need that the retailer ICC holds, that is: $R(p^H) \geq (1-\delta)K_\Gamma \Rightarrow 20 \geq (1-\delta)50 \Rightarrow \delta \geq 0.6$.

In this case the aggregate retail profit is

$$\Pi_r^H = (p^H - w)D(p^H) = (50 - 30) \cdot 40 = 800$$

The wholesale profit is

$$\Pi_w^H = (w - c)D(p^H) = (30 - 10) \cdot 40 = 400$$

Vertical Cartel

Under the Vertical Cartel we have that firms charge the monopoly price based on the wholesale cost c, that is

$$\max_{p^M} D(p^M)(p^M - c) \Rightarrow \max_{p^M}(90 - p^M)(p^M - 20)$$

$$p^M = 55, \qquad D(p^M) = 35, \qquad p^M \cdot D(p^M) = 2275$$

Using Lemma 2, we know that

$$w_i' = p^M - \theta_i \frac{K}{k_i}(p^M - c)$$

Hence,

$$w_L' = 55 - 245\theta_L, \qquad w_s' = 55 - 1225\theta_s$$

Let $S = \sum_i \theta_i$, then VCIC will create bounds for θ_i such that it is optimal to firms participating in the cartel

$$\Pi_r^V \geq \Pi_r^H, \qquad \Pi_w^V \geq \Pi_w^H$$

$$S \cdot 1225 \geq 800, \qquad (1 - S) \cdot 1225 \geq 400$$

$$0.653 \leq S \leq 0.673$$

$$0.653 \leq 5\theta_L + 10\theta_S \leq 0.673$$

The inequalities in (**??**) pin down an admissible set for the aggregate retailer bargaining weight $S = \sum_i \theta_i$, and therefore for (θ_L, θ_S). To make the VCIC region concrete, I choose a simple type–specific calibration that lies strictly inside the bounds. Let

$$\theta_L = 0.10, \qquad \theta_S = 0.0165,$$

so that

$$S = 5\theta_L + 10\theta_S = 5(0.10) + 10(0.0165) = 0.665,$$

which satisfies $0.653 \leq S \leq 0.673$. Under this calibration, Lemma 2 implies the negotiated wholesale prices

$$w_L' = 55 - 245\theta_L = 30.5, \qquad w_S' = 55 - 1225\theta_S = 34.7875.$$

These values also satisfy the feasibility restriction $w_i' \geq c + \nu = 30$, ensuring that the negotiated terms remain weakly above the wholesale benchmark in the absence of vertical coordination.

Given full participation and $p^M = 55$, total monopoly profit is $\Pi^M = (p^M - c)D(p^M) = 35 \cdot 35 = 1225$. Since the Nash bargaining solution allocates a share S of this surplus to retailers, aggregate retail and wholesale profits under the vertical cartel are

$$\Pi_r^V = S \cdot 1225 = 0.665 \cdot 1225 = 814.625, \qquad \Pi_w^V = (1 - S) \cdot 1225 = 0.335 \cdot 1225 = 410.375.$$

Comparing to the horizontal benchmark values $\Pi_r^H = 800$ and $\Pi_w^H = 400$, both inequalities in VCIC are satisfied: $\Pi_r^V > \Pi_r^H$ and $\Pi_w^V > \Pi_w^H$. Hence, for this feasible pair (θ_L, θ_S), the vertical arrangement strictly dominates the horizontal benchmark for both tiers, and the vertical cartel can be implemented.

Appendix B: Information about each cartel case

B.1. Case 1 - 08700.003447/2015-40: Cuiabá/MT and Várzea Grande/MT

The investigation began after the CADE received information from the Mato Grosso State Public Ministry regarding a potential cartel affecting the cities of Cuiabá/MT and Vargem Grande/MT. Among the documents provided to the Antitrust Authority were call intercepts and other documentation obtained through the 'Madonna Operation' conducted by judicial bodies.

However, in April 2009, the Mato Grosso State Court partially validated the Habeas Corpus petition filed by one of the individuals under investigation. This decision was made because the authorization for the call intercepts and the extension of their duration were not based on a valid judgment.

In any case, the CADE initiated an administrative proceeding in 2012 to investigate the potential cartel in that market, despite being unable to use the information from the Operation due to its invalidation by the State Court.

The economic evidence revealed minimal price dispersion in the relevant market between July 2001 and May 2007. Additionally, during this period, there was a consistent rise in profit margins for gasoline retailers.

However, the Antitrust Authority was unable to utilize the information from the intercepted calls and documents to support its decision. Consequently, it could rely solely on economic evidence to form its decision. However, under Brazilian law, the conviction of a cartel requires juridical evidence. As such evidence was unavailable, the CADE chose to exonerate the participants of the cartel.

In terms of organization, the cartel involved retailers, wholesalers, and the Gas Station Union. According to the documents, retailers held regular meetings at the Gas Station Union to coordinate price-fixing in the market. At some point, these meetings also included wholesalers.

The cartel's pricing strategy was based on operational costs and the total volume sold by each retailer. Furthermore, all firms, regardless of their market share, were required to adopt the same price. Failure to comply led to pressure from cartel members to align with the rest of the market.

According to the testimonials obtained during the investigation, the Union played a significant role beyond providing meeting infrastructure; it also encouraged and pressured retailers to adhere to the fixed prices. Additionally, the Union collected information about prices and average sales from each retailer to propose the fixed price.

Regarding the wholesalers' involvement, documents revealed that the two market leaders ensured a minimum profit margin on alcohol sales. Furthermore, it was not merely coincidental that both leaders maintained this minimum profit margin, as admitted by one wholesaler's manager, who acknowledged communication with the other distributor's manager.

Since all this information about the cartel organization was deemed invalid by the Mato Grosso State Court, the Antitrust Authority was unable to convict the cartel participants.

B.2. Case 2 - 08012.010215/2007-96: Caxias do Sul

The investigation began following a report from the Rio Grande do Sul State Public Ministry regarding a potential cartel during the period of July 2004 to April 2006 in the city of Caxias do Sul/RS.

According to the documents, the owners of the two largest gas station networks have been in frequent contact since July 2004, coordinating price-fixing and dividing the largest consumers between them.

Regarding communication methods, the participants developed codes to refer to meetings and discuss agenda items for these gatherings. The use of these codes intensified after becoming aware of investigations by the State Public Ministry in 2006, which potentially monitored calls between participants

The State Public Ministry's investigation was prompted by a news article highlighting the excessive profit margins in the fuel resale market, alongside the initiation of a parliamentary committee of inquiry by the Municipal Chamber to examine potential abuses of market power. As a result of increased scrutiny from consumers and the public sector, the participants began adopting more discreet communication methods, such as fax, in place of phone calls.

Additionally, the communication among participants was strengthened by their personal acquaintanceship and shared social circles in Caxias do Sul.

In terms of organization, the cartel comprised two distinct groups: the leaders and the followers. The former included the two largest stations and other retailers, responsible for setting the fixed prices and acting as focal points for the followers. The latter group simply adhered to the prices set by the leaders, as they would typically do even without cartelization.

The cartel leaders were tasked with setting prices and disseminating pricing policies to be followed in the market. Consequently, this group frequently convened in various locations such as restaurants, station offices, and farms. while the followers accepted the prices suggestions since it also benefited them.

In terms of punishing deviations from the agreements, initially, the leaders attempted to persuade the deviants through personal contacts or phone calls to adhere to the agreement. If this communication proved ineffective, they resorted to formal retaliation and threats to pressure the competitor into raising their prices.

Furthermore, the leaders would reach out to newcomer firms to communicate the pricing policy in the city and persuade them to join the agreement.

In terms of information sharing, the leaders' group was tasked with gathering all market information, including the prices charged by each station.

Based on all the documents regarding the cartel organization, the CADE decided to convict the stations for the cartel and uniform conduct adoption accusations.

B.3. Case 3 - 08012.007866/2007-07: João Pessoa/PB

The investigation began following a report from the Paraiba Federal Police Department regarding a potential cartel during the period of 2006 to 2007 in the metropolitan region of João Pessoa/PB. The documents sent by the police to the CADE included statements from market participants and call interceptions.

In April 2007, the police were authorized to conduct searches and obtain warrants to gather evidence against the alleged cartel members. However, the Brazilian Supreme Court accepted requests from some of the participants to nullify the evidence and the call interceptions. Therefore, the legal evidence related to the cartel was considered null, and the Antitrust Authority could not utilize the documentation to substantiate its decision.

Furthermore, due to the time taken to determine the validity of evidence related to other participants, the statute of limitations of five years had expired. Consequently, the CADE could not take action against the other participants. Therefore, the antitrust authority decided that all participants were innocent from the allegations.

Nevertheless, I delve into the analysis of the cartel organization in the subsequent paragraphs.

According to the documents, the Gas Station Association played a pivotal role in instigating and coordinating the cartel. Meetings among gas stations were held at the Association's office with the primary aim of determining the prices charged by each station.

This understanding is further supported by the intercepted calls, which revealed frequent conversations between the association's president and the retailers, aimed at ensuring the participation of the largest networks in the price agreement. Additionally, retailers also contacted the association to comprehend the price policies of their respective stations.

Furthermore, the association took on the responsibility of exerting pressure on stations that were not partaking in the agreement to raise their prices and adhere to the fixed prices set forth by the organization.

According to the documents, the primary strategy of the Association was to lower prices to a level where retailers not involved in the agreement would be compelled to raise their prices and refrain from challenging the agreement further.

In terms of the distributor's involvement, the documents indicate that one wholesaler participated in the cartelization. Its role involved serving as a venue for participants to discuss prices, monitor prices, and ensure compliance with the agreement by all firms.

However, the participation of this distributor does not constitute cartelization in the wholesale market or anything similar, as it is a local distributor and not one of the three major distributors (Vibra, Raizen, and Ipiranga).Consequently, I do not consider the participation of this distributor as a verticalized hub-and-spoke, since it is not able to increase the marginal cost for the retailers.

B.4. Case 4 - 08012.008847/2006-17: Vitória/ES, Cariacica/ES, Vila Velha/ES, Serra/ES

The investigation began following a report from the Espirito Santo State Public Ministry regarding a potential cartel operating between 2006 and 2007 in the metropolitan region of Vitória/ES.

The Antitrust Authority received documentation from the "Flammable Operation," which included requests for the pre-trial detention of gas station owners as well as search and confiscation warrants for gas station offices and owners' homes. Additionally, the documentation forwarded by the State Public Ministry included intercepted calls from individuals involved in the fuel retail market in the metropolitan region.

In terms of economic evidence, the Antitrust Authority found minimal price dispersion along with an increase in the prices charged by retailers, indicating a potential cartel in the market. Moreover, in one intercepted conversation, a gas station owner stated that 90% of the retailers were adopting the same price and expressed interest in maintaining this uniform pricing.

Another intercepted conversation revealed two participants discussing an increase in gasoline prices to BRL 2.59. The following week, ANP data showed that the new prices for those stations matched the suggested amount, indicating an artificial price increase.

The communication between the cartel participants was conducted via phone calls using codes to disguise the true content of their conversations. They adopted specific words to obscure their real messages, with code words referring to meetings, gas stations, prices, and fuel types.

According to the documents, conversations between competitors were frequent, where they discussed not only their own prices but also the prices of stations that deviated from the agreement. In one dialogue, two participants mentioned that decreasing prices would be an "aggression" against the "market welfare." Consequently, for those who deviated from the agreement, other members would often threaten them until they increased their prices.

In terms of information sharing, the CADE points that there was a familiar relationship between competitors. Consequently, they would often share sensitive information about each others prices.

However, according to the decision, there was no evidence of a cartel leader or the presence of a gas station association responsible for coordinating the cartel. Therefore, it should not be considered a hub-and-spoke cartel but rather a traditional one.

Using the documents about the cartel organization and the economic evidence, the antitrust authority decided to convict the retailers for the cartel and uniform conduct allegations.

B.5. Case 5 - 08012.011668/2007-30: Cambé/PR and Londrina/PR

The investigation began following a report from the Paraná Police Department regarding a potential cartel operating between 2006 and 2007 in the metropolitan region of Londrina, PR. The documents sent by the police to the CADE included statements from market participants and intercepted phone calls.

These documents were obtained through search and seizure warrants executed during the 'Medusa III' Operation, in which some of the suspects were arrested for their involvement in the cartel.

This relevant market was previously analyzed by CADE in the administrative proceeding 08012.001003/2000-41, which investigated cartel agreements during the period of 2000 to 2001 (prior to the beginning of my dataset). The main focus of that investigation was to analyze how the retailers' association assisted its representatives in standardizing prices in the metropolitan region of Londrina.

However, the present cartel case refers to information obtained during the 'Medusa III' operation, which investigated the retailers' activities in 2007. This investigation focuses on different conduct from the previous administrative proceeding. Moreover, according to the antitrust authority, there is no connection between the two cases.

In terms of the price-fixing agreements, intercepted calls revealed that all prices were meticulously set, even to the third decimal place. Additionally, the retailers discussed the timing of price changes to minimize the likelihood of any retailer deviating from the agreement.

The market had leaders who commanded a significant volume of sales through their stations. As a result, the price-fixing agreement did not require participation from every retailer. Convincing the market leaders to adhere to the agreement was sufficient, as smaller stations would follow suit and increase their prices accordingly.

These leader stations were consistently pressured by the cartel leaders to maintain the agreed prices, ensuring uniform pricing in the market.

Therefore, the cartel had two groups of agents: the core and the followers. The core was responsible for defining the fixed price as well as monitoring the prices charged by each station. The followers group consisted of a large number of gas stations that, although not initiating price-fixing, would often accept the fixed price to avoid a 'price war' in the market.

The organization of the core group was very sophisticated, allowing it to maintain coordination and systematize price agreements. Moreover, they facilitated mutual transfers between retailers and adapted prices in response to supply and demand shocks in each location.

Moreover, the cartel was able to divide the market by its roads and main avenues, allowing price alignment to be implemented in different ways simultaneously.

In terms of coercion directed at non-compliant stations, the documents reveal that a subgroup within the core was responsible for pressuring and threatening those who did not adhere to the agreement.

These threats often targeted the physical safety of the gas station owners and their families. Additionally, coercion could involve threats of reporting to the state tax authorities.

Basing its decision on all the documents related to the cartel organization, the CADE found the retailers guilty of cartel and uniform conduct allegations.

B.6. Case 6 - 08700.010769/2014-64: Belo Horizonte

The investigation began following a report from ANP regarding a potential cartel operating between 2007 and 2008 in the metropolitan region of Belo Horizonte/MG.

In 2010, the Minas Gerais State Public Ministry forwarded documentation about the "Invisible Hand" operation by the police department. This documentation contained information from call interceptions conducted between October 2007 and April 2008, as well as documentation obtained through search warrants. Ultimately, the police executed 24 arrest warrants.

According to the documentation, the cartel had a complex organization with two groups: the core and the followers. The core was responsible for defining and monitoring the price agreement, while the followers simply adopted the same price as defined by the core. Additionally, the cartel included participation from retailers, the gas station union, and wholesalers to ensure price increases.

The core included the gas station union and "reference stations," which were strategically located stations with high visibility and customer traffic. This setup allowed followers to easily obtain information about the prices set by these reference stations, leading to a general increase in prices.

In terms of communication, the documents show that core members primarily communicated through in-person meetings and phone calls. The CADE highlighted significant communication between the gas station union and the distributors.

These conversations focused on informing and monitoring the prices charged by each station. Additionally, they developed a system to penalize those that attempted to deviate from the agreement.

To better understand the role of each agent in the cartel, I first analyze the actions of the retailers. According to the intercepted calls, they frequently discussed price agreements, scheduled in-person meetings, monitored the prices charged by each gas station, and attempted to coerce other stations into accepting the fixed price.

According to the CADE, the investigation by the ANP began after a sudden increase in prices in March 2007. Consequently, in October 2007, call interceptions commenced, and there were no more complaints about low profit margins but rather an effort to monitor the prices charged by the gas stations.

At some point, the retailers became aware of the illegality of their actions and expressed concerns about being investigated. Therefore, they attempted to use different phone numbers to avoid being monitored.

In terms of the participation of the gas station union, the documentation showed that they played a central role in the cartel organization. They were responsible for organizing meetings with retailers and distributors, disseminating the importance of adhering to the agreement, making calls to ensure all gas stations followed the agreement, monitoring compliance, and reprimanding firms that deviated from the agreement.

Moreover, some owners of 'reference stations' were also members of the gas station union. This allowed them to implement the agreement at their respective stations, ensuring that the followers could adopt the same prices.

Therefore, in the decision, the CADE highlighted the role of the gas station union as facilitator of sensitive information sharing as well as disseminating the information about the fixed price.

In terms of the participation of the distributors, it is observed that representatives from all three major wholesalers were involved in the cartel organization. According to the documentation, their main duties were to assist in the implementation of uniform conduct, aid in defining price agreements, and create an agreement among themselves.

The wholesalers would typically pressure stations that tried to deviate from the agreement. According to the documentation, wholesalers often offered lower prices to those that adhered to the agreement compared to those that deviated. Additionally, they pressured retailers even if they did not have an exclusive contract with that wholesaler.

In terms of communication between the wholesalers, the documentation shows that they also used the gas station union to facilitate communication among themselves, ensuring the enforcement of price fixing.

Based on all the documentation regarding the cartel case, the CADE found the retailers, gas station union, and distributors guilty of cartel and uniform conduct allegations.

B.7. Case 7 - 08012.007301/2000-38 and 08700.000547/2008-95: Teresina/PI

The two legal proceedings were analyzed together by the antitrust authority as they investigated the same conduct carried out by the same agents at different times.

For case 08012.007301/2000-38, the investigation began after the antitrust authority received documentation from the Piauí State Public Ministry regarding evidence of cartel activities in the city of Teresina involving the gas station union. However, since these cartel actions started prior to the ANP price panel dataset, I am unable to accurately identify the overcharge.

Case 08700.000547/2008-95 was initiated after the Piauí State Public Ministry sent documents regarding a potential cartel in the city of Teresina, once again involving the city's gas station union. This documentation referred to the police operation called 'Ring of Fire,' which included intercepted calls from the participants in the agreement.

According to information from ANP, the cartel likely operated during two distinct periods: May 2004 to March 2006 and September 2008 to December 2009. Since I use the period after the end of the cartel as the control period, I focus only on the period from September 2008 to December 2009.

However, even though ANP found economic evidence of the cartel in the city, the Criminal Court of Teresina ruled that the call interceptions conducted by the police operation were invalid, as the authorization for the interceptions was not granted by a competent authority.

Therefore, CADE could not use the call interceptions in its decision-making process. Consequently, it based its decision on other documents such as meeting minutes and the testimony of the president of the union.

According to this documentation, the union was responsible for sharing sensitive information about the market and coordinating the cartel. Some of the measures adopted by the union included instructing members not to initiate a 'price war' and advising against attracting more clients by offering different payment terms.

Therefore, using this information, CADE found the gas station union guilty of cartel and uniform conduct allegations, even though they did not use the call interceptions to make this decision.

B.8. Case 8 - Brasília/DF

This cartel case was already analyzed by **?**. The investigation by the Antitrust Authority focused on analyzing a potential cartel in the fuel retail market in Brasília/DF. This cartel involved the participation of retailers, wholesalers, and the gas station union.

According to the data regarding prices and profit margins for the gas stations, the CADE found that there was an increase in the average profit margin and that the retailers had coordinated price adjustment dates. Moreover, when the wholesale price decreased, this reduction was not passed on to consumers.

Regarding the participation of the wholesalers, the antitrust authority observed an increase in their profit margins. Specifically related to ethanol distribution, they found that price cuts made by the sugar cane plants were not passed on to the retailers. Moreover, the wholesale market in Brasília is extremely concentrated, with only five competitors.

Regarding the participation of the gas station union, the Antitrust Authority analyzed press releases issued by the union and found that they typically announced price increases and market price policies. Therefore, according to CADE jurisprudence, this can be seen as an attempt to impose uniform conduct among the retailers.

In terms of the documentation, between 2011 and 2015 the police has done calls interceptions to obtain information regrading the cartel. Moreover, in 2015, the Operation "Dubai", by the Federal Police Department and the Federal District Public Ministry, performed search and seizure warrants as well as warrants of arrest against some of the cartel participants.

However, since the case has not been convicted yet, I am not able to establish the exact organization of the cartel and their communication. Therefore, I cannot analyze the legal evidence regarding this cartel.

Appendix C: Matching Details and Robustness Checks

C.1. Matching Procedure

This subsection provides additional details on the two-step matching procedure used in the empirical analysis, along with robustness checks that assess the sensitivity of the results to alternative matching choices.

C.1.1. City-Level Matching

As discussed in the main text, cartel-affected cities differ systematically from the full sample of cities along key supply- and demand-side dimensions. To improve the plausibility of the parallel trends assumption, I first match each cartel-affected city to a set of control cities with similar market characteristics.

City-level matching is performed using four covariates: (i) retailer concentration, measured by the Herfindahl–Hirschman Index (HHI) constructed from gas station storage capacities; (ii) wholesaler concentration, measured by an HHI constructed from distributor storage capacities aggregated using exclusive supply agreements; (iii) population; and (iv) the number of registered vehicles. Market shares for retailers and wholesalers are computed using gasoline storage capacity as a proxy for scale.

Because these variables are measured on different scales, I standardize each covariate using a z-score transformation prior to matching. I then perform nearest-neighbor matching with replacement, using the Euclidean distance metric to identify the closest control city for each treated city. The matching is conducted using information from 2024, which provides the most comprehensive and consistent coverage of storage capacity and exclusive supply agreements. For stations that are no longer in operation, I use the most recently observed capacity information available in the PostoWeb data.

Table 9 reports the matching distances for each treated city, and column (2) of Table 2 presents summary statistics for the matched control group. With the exception of Brasilia/DF and Belo Horizonte/MG, the matching distances are small, indicating a high degree of similarity between treated and control markets. These two cities are among the largest urban centers in Brazil, making it difficult to find close comparators.

Table 9: City Matching

Treated City	Matched City	Distance
Belo Horizonte/MG	Ipatinga/MG	107.28
Betim/MG	Divinopolis/MG	0.50
Brasilia/DF	Goiania/GO	31.74
Cambe/PR	Assis/SP	0.03
Cariacica/ES	Campos dos Goytacazes/RJ	0.22
Caxias do Sul/RS	Canoas/RS	0.57
Contagem/MG	Ipatinga/MG	1.96
Cuaiaba/MT	Rondonopolis/MT	1.92
Joao Pessoa/PB	Natal/RN	0.11
Londrina/PR	Maringa/PR	0.27
Serra/ES	Campos dos Goytacazes/RJ	0.32
Teresina/PI	Caxias/MA & Piripiri/PI	5.17
Varzea Grande/MT	Rondonopolis/MT	0.11
Vila Velha/ES	Campos dos Goytacazes/RJ	0.97
Vitoria/ES	Linhares/ES	0.47

Note: This table presents the matching between cities using information about retailer and wholesaler HHI (2024), number of cars and population. I convert all variables in the z-score format so I can obtain all of them under the same scale and then, I use an Euclidean Norm to calculate the distance between cities and I take the first nearest neighbor matching.

C.1.2. Station-Level Matching

In the second step of the procedure, I match individual gas stations in treated cities to stations in their corresponding matched control cities. This step uses data from the weekly ANP price survey and is conducted within a balanced time window around cartel dissolution. Specifically, for each cartel case, I use an equal number of weeks before and after the cartel end date as defined by CADE. This ensures symmetry between the pre- and post-treatment periods and avoids contamination from long-run structural changes.

Station-level matching is conducted conditional on whether the station has an exclusive supply agreement with a wholesaler. Within this group, each treated station is matched to the control station with the closest gasoline storage capacity. If multiple candidates are available, ties are broken by selecting the station with the closest number of pumps. Matching is performed with replacement. When more than one control station satisfies the matching criteria, I compute the average retail price, retail markup, and wholesale markup across matched stations.

The resulting matched dataset includes the tax identification number of the treated station, the week of observation, the cartel case identifier, the associated wholesaler, retail prices, wholesale prices, and markups, along with the corresponding variables for matched control stations. Table 4 reports summary statistics for the matched control group. Out of 74,048 observations in cartel-affected markets, 951 observations (1.2%) could not be matched and are excluded from the analysis.

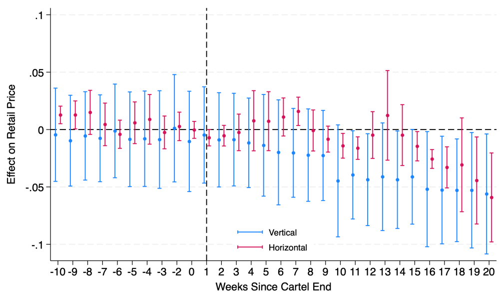
C.2. Event-Study Heterogeneity

In this exercise, I examine whether the parallel trends assumption continues to hold when the city-level sample is split into vertical and horizontal cartels. To do so, I re-estimate equation (14) separately for two subsamples: one containing only vertical cartels and another containing only horizontal cartels.

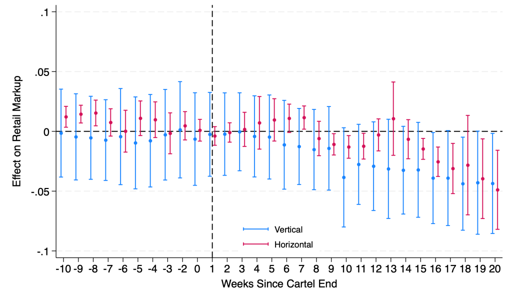
Figures 8, 9, and 10 present the event-study graphs for log(retail price),retail markup and wholesaler markup, respectively. Overall, the results mirror those obtained using the full sample: there is no evidence of a violation of the parallel trends assumption, and for both cartel types, retail prices and retail markup tend to decline following the end of the cartel period.

Figure 5: City-Level Event Study - Cartel Structure Heterogeneity

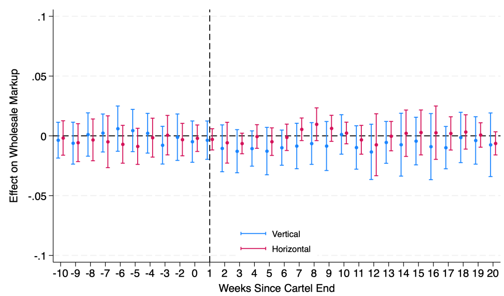
(a) Retail Price



(b) Retail Markup



(c) Wholesale Markup



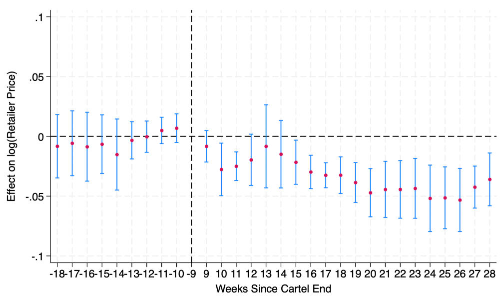
Note: Dots plot estimated event-time coefficients from the two-way fixed effects specification (14), weighted by the number of repetitions in the city matching. Vertical bars represent 95% confidence intervals. Time 0 corresponds to the week the cartel was dissolved. Standard errors are clustered at the firm × calendar-week level.

6.1 C.3. City-Level: Robustness to Event-Time Measurement

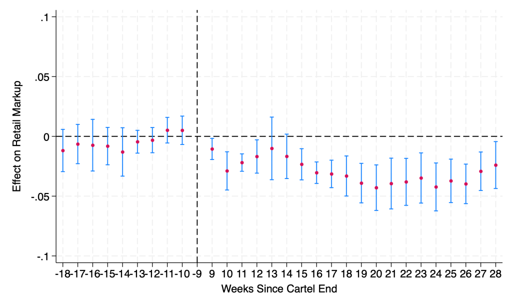
Some concerns may arise regarding the definition of the treatment. In particular, firms may anticipate the investigation and adjust their behavior in advance if they expect to be detected. In this case, using the exact timing of the police intervention may not accurately capture the true end of the cartel. To address this concern, I re-estimate (14) excluding the eight weeks (two months) before and after the police intervention, thereby mitigating potential bias arising from anticipatory behavior and imprecise cartel end dates.

Figure 6: City-Level Event Study - Treatment Time Robustness

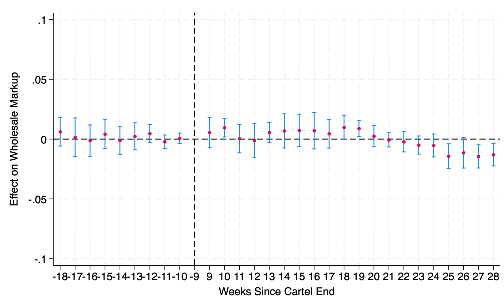
(a) Retail Price



(b) Retail Markup



(c) Wholesale Markup



Note: Dots plot estimated event-time coefficients from the two-way fixed effects specification (14), weighted by the number of repetitions in the city matching. Vertical bars represent 95% confidence intervals. Time 0 corresponds to the week the cartel was dissolved. Standard errors are clustered at the firm × calendar-week level.

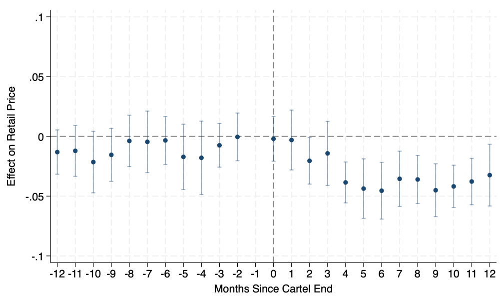
6.2 C.4. City-Level: Monthly Analysis

Another concern regarding the estimation relates to the use of high-frequency data. In particular, weekly observations may introduce additional noise due to idiosyncratic within-month variation, potentially affecting the stability of the estimates. Aggregating the data at the monthly level can mitigate this issue by smoothing short-run fluctuations and reducing sensitivity to week-specific sampling variation.

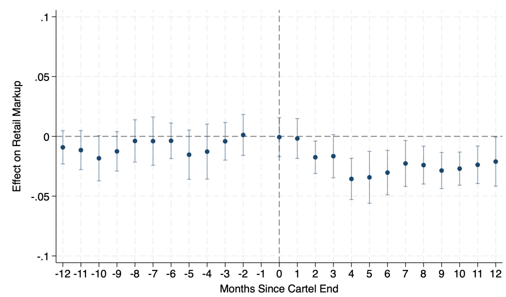
To address this concern, I re-estimate the specification in (14) using data aggregated to the monthly level. This approach improves the stability of the estimates and also allows for an assessment of whether the parallel trends assumption holds over a longer time horizon.

Figure 7: City-Level Event Study - Monthly Analysis

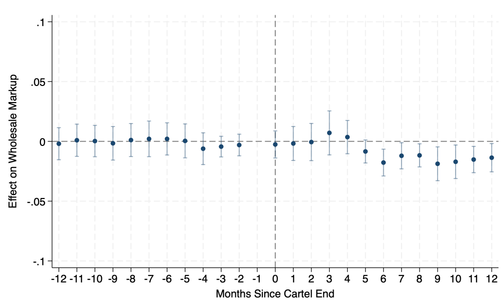
(a) Retail Price



(b) Retail Markup



(c) Wholesale Markup



Note: Dots plot estimated event-time coefficients from the two-way fixed effects specification (14), weighted by the number of repetitions in the city matching. Vertical bars represent 95% confidence intervals. Time 0 corresponds to the month the cartel was dissolved. Standard errors are clustered at the firm $\times$ calendar-month.

C.5. Inference and Clustering Robustness

A potential concern in the firm-level analysis is that statistical inference may be sensitive to the choice of clustering level, particularly given the limited number of cartel cases. As emphasized by Cameron and Miller (2015) and MacKinnon and Webb (2018), conventional cluster-robust standard errors may over-reject the null hypothesis when the number of clusters is small.

To assess robustness, I re-estimate the baseline specification under alternative clustering schemes, including clustering at the cartel level, the city level, and the firm level. Across all specifications, point estimates for log retail prices and retail markups remain stable in magnitude and statistically significant. Wholesale-markup estimates remain smaller and less precisely estimated, reflecting greater sensitivity to inference choices.

In addition, when the effective number of treated clusters falls below 50, I implement the cluster-level inference procedure proposed by Ibragimov and Müller (2010). This approach collapses the data to the cluster level and computes t-statistics based on variation across clusters, yielding conservative inference in settings with few treated units. Because collapsing the data substantially reduces the effective sample size, these specifications are estimated without additional covariates.

Table 10 reports the results from these alternative inference procedures. The estimated effects of vertical collusion on log retail prices and retail markups remain positive and statistically significant under all clustering and inference schemes. By contrast, the wholesale-markup effect becomes statistically insignificant under more conservative inference, which is consistent with its relatively small magnitude in the baseline results.

C.6. Leave One Cartel Out Estimate

In this exercise, I re-estimate specification (17) while excluding each cartel case one at a time to assess whether the results are driven by any single cartel. Table 8 presents the results from these regressions and shows how the coefficient on *Vertical* changes when each cartel is removed from the sample for log(Retail Price), retail markup and wholesale markup. Overall, the coefficient for retail price and retail markup remain positive and statistically significant in every specification, indicating that no single cartel case is driving the main findings.

Table 10: Sensitivity Analysis of Vertical Coefficient Using Different Cluster Definitions

	Case	City	Case–Exclusive	City–Exclusive	Case–Distributor	City–Distributor
Retail Price	0.028	0.029	0.030	0.030	0.028	0.028
	(0.017)	(0.013)	(0.012)	(0.010)	(0.008)	(0.007)
	[0.149]	[0.053]	[0.025]	[0.004]	[0.000]	[0.000]
Retail Markup	0.021	0.021	0.021	0.021	0.021	0.021
	(0.012)	(0.009)	(0.009)	(0.008)	(0.006)	(0.005)
	[0.137]	[0.042]	[0.041]	[0.011]	[0.000]	[0.000]
Wholesale Markup	0.0029	0.0029	0.0042	0.0045	0.0028	0.0028
	(0.0037)	(0.0037)	(0.0035)	(0.0030)	(0.0024)	(0.0022)
	[0.440]	[0.440]	[0.251]	[0.143]	[0.241]	[0.192]
Weight by Case	Yes	Yes	Yes	Yes	Yes	Yes
Method	I–M	I–M	I–M	I–M	CRVE	CRVE
Number of Clusters	8	15	16	30	68	112
Observations	8	15	16	30	1,100	1,100

Note: This table presents a sensitivity analysis based on alternative clustering definitions for specification (17) without covariates. Standard errors are reported in parentheses and p-values in brackets. *Case* clusters at the cartel level; *City* clusters at the municipality level; *Exclusive* refers to exclusive supply agreements; and *Distributor* identifies the wholesaler. All regressions are weighted by cartel case. The *I–M* method Ibragimov and Müller (2010) performs inference using cluster means, while *CRVE* denotes conventional cluster-robust variance estimation.

C.8. Quantile Regression

The quantile regressions of equation (17) for each outcome variable extend the results in Table 6 by identifying which parts of the distribution benefit most from the vertical effect. Figures 14 present the quantile regression estimates, where each cartel is equally weighted and robust standard errors are applied.

Figure 14 shows that the ATT for log(retail price) and retail markup are consistently higher under vertical collusion than under horizontal collusion, with the effect becoming stronger at higher quantiles. For wholesale markup, Figure 14 shows no significant difference between vertical and horizontal collusion at the lower and middle quantiles. However, the effect becomes significant and grows rapidly starting around the 90th percentile, pointing to substantial differences in wholesale pricing in the upper tail of the distribution.

Table 11: Leave One Cartel Out

Without	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
log(Retail Price)								
Vertical	0.023***	0.025***	0.027***	0.020***	0.032***	0.036***	0.023***	0.014***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Retail Markup								
Vertical	0.020***	0.019***	0.017***	0.018***	0.023***	0.029***	0.016***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Wholesale Markup								
Vertical	0.001	0.001	0.005***	-0.000	0.004***	0.002	0.003***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weight by Case	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	942	1,037	1,021	937	1,012	771	1,023	957

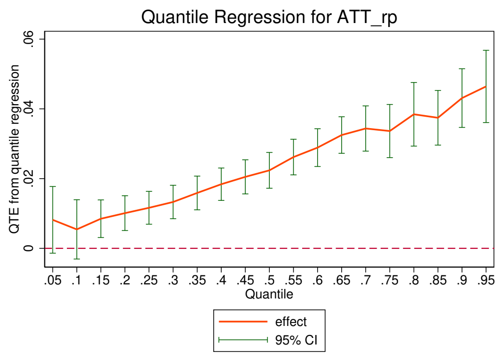
Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

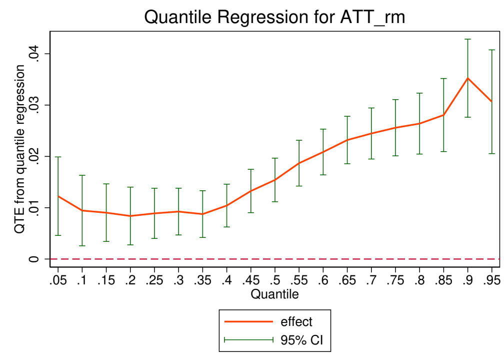
Note: This table reports the coefficient on *Vertical* from firm-level regressions from, specification (17), where each column excludes one cartel case from the sample. The covariates include, a dummy that indicates if the station has an exclusive agreement, number of gasoline pumps and total gasoline storage. Standard errors (HC2) are reported in parentheses.

Figure 8: Firm-Level Analysis: Quantile regression

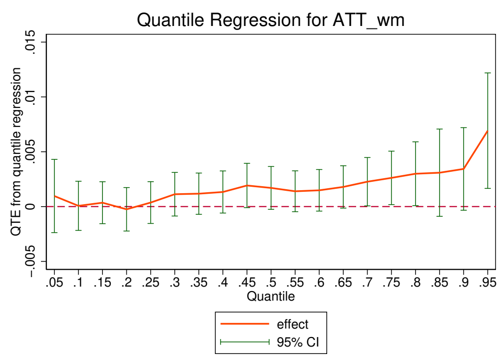
(a) Retail Price



(b) Retail Markup



(c) Wholesale Markup



Note: This figure displays the results from the quantile regression of equation (17), estimated for quantiles from 0.05 to 0.95 in increments of 0.05, using ATT_rp,ATT_rm, ATT_wm as the outcome variable, respectively. Robust standard errors were employed, and weights were applied so that each cartel contributes equally to the estimates. The results show that across all quantiles, vertical cartels are associated with higher treatment effects, reinforcing the conclusion that vertical collusion increases retail prices more than horizontal collusion.