

Online Appendix to

When Wholesalers Join the Cartel: Vertical Coordination in Gasoline Markets

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A Matching Details

The empirical analysis uses a two-step matching procedure. I first match each cartel-affected city to a comparable unaffected city based on market-level characteristics. I then match stations within each treated city to observationally similar stations in its matched control market. The procedure therefore improves comparability along both market- and station-level dimensions before estimating the effects of cartel dissolution.

A.1. City-Level Matching

As shown in Table 2, cartel-affected cities differ substantially from the full set of potential control markets along several supply- and demand-side characteristics. I therefore restrict the comparison group by matching each treated city to a geographically proximate control market with similar observable characteristics.

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For each cartel-affected city, potential controls are restricted to cities located between 50 and 200 kilometers from the treated market. Cities within 50 kilometers are excluded to reduce potential spillovers from cartel conduct or the law-enforcement intervention. Among the remaining cities, I select the closest control city using retailer concentration, wholesaler concentration, population, and the number of registered vehicles. City-level matching uses four covariates measured from a common 2024 cross section. Retailer concentration is measured by an HHI constructed using gasoline storage capacity as a proxy for station market share. Because no historical panel of station storage capacity is available, I use the 2024 capacity distribution among operating stations and assume that relative market concentration did not change substantially between the cartel period and 2024. To maintain a common measurement date across matching variables, population and the number of registered vehicles are also measured in 2024 and capture differences in market size and demand.

Wholesaler concentration cannot be constructed directly because the data do not identify the wholesaler from which each station purchases gasoline. I therefore use exclusive supply agreements to proxy for upstream relationships. Stations with an exclusive agreement are assigned to their contracted wholesaler, and their storage capacities are aggregated to construct the wholesaler’s market share. Stations without an exclusive agreement cannot be assigned to a particular wholesaler and are therefore treated as separate independent suppliers for the purpose of calculating the HHI. The resulting wholesaler HHI thus captures concentration in observable exclusive supply relationships rather than actual transaction-level wholesale market shares.

Because these variables differ in units and scale, I standardize each covariate using a z -score transformation and perform nearest-neighbor matching with replacement based on Euclidean distance in the standardized covariate space. As Figure 1 shows, the cartel cases are geographically separated, so the set of potential control cities is defined separately for each case. Consequently, a city cannot serve as a control for more than one cartel case. Within a given case, however, matching with replacement allows the same control city to be

Table A.1: City Matching

Treated City	Matched City	Distance
Belo Horizonte/MG	Ipatinga/MG	107.28
Betim/MG	Divinópolis/MG	0.50
Brasília/DF	Goiânia/GO	31.74
Cambé/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
Cuiabá/MT	Rondonópolis/MT	1.92
João Pessoa/PB	Natal/RN	0.11
Londrina/PR	Maringá/PR	0.27
Serra/ES	Campos dos Goytacazes/RJ	0.32
Teresina/PI	Caxias/MA & Piripiri/PI	5.17
Várzea Grande/MT	Rondonópolis/MT	0.11
Vila Velha/ES	Campos dos Goytacazes/RJ	0.97
Vitória/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 standardize all covariates as z-scores and select the nearest neighbor using Euclidean distance.

selected for more than one treated city.

Table A.1 reports the resulting city matches and their matching distances, while column (3) of Table 2 compares treated markets with the matched control group. With the exception of Brasília/DF and Belo Horizonte/MG, the matching distances are small. Both are among Brazil’s largest urban markets and therefore have few close comparators. For Brasília/DF, the procedure selects Goiânia/GO, a comparison also used by Chaves and Duarte (2025). The match for Belo Horizonte/MG is substantially poorer, and I therefore exclude this city from the main empirical analysis. Additionally, the Online Appendix C.1. also reports the reduced form results excluding the city of Brasília/DF.

One additional adjustment is necessary for Teresina/PI. The matching procedure selects Caxias/MA as its closest control market. However, Caxias has relatively few observations in the price data, which would leave some treated weeks without a contemporaneous control observation. I therefore supplement the control group for Teresina with Piripiri/PI. This

adjustment increases the number of control observations and ensures that, for every week in which Teresina is observed, there is at least one contemporaneous observation in the control group. Both cities remain geographically proximate to Teresina and are used only as controls for this cartel case.

A.2. Station-Level Matching

The second stage addresses differences in station composition that may remain after matching markets. Within each treated city and its matched control, I use Coarsened Exact Matching (CEM) to match stations on gasoline storage capacity, number of pumps, and exclusive supply status. Storage capacity and pump counts are coarsened into discrete intervals, while exclusive supply status is matched exactly. Matching is also conducted within calendar week, so each treated station-week is compared only with control station-weeks observed in the same week and belonging to the same capacity, pump-count, and exclusive-supply cells.

Because exclusive-supply status is repeatedly reported, the raw indicator may be affected by temporary reporting or measurement error. In the data, 27.9% of station-case histories change status at least once, and 17.4% switch and subsequently return to their previous status; the median time between a switch and return is only three weeks. I therefore classify a station as exclusive only when it reports a non-independent supplier for at least eight consecutive observations. Because reporting is not available in every calendar week, the interval from the first to the eighth report has a median duration of 12 weeks. This threshold filters out short-lived fluctuations that may reflect measurement error while retaining persistent supply relationships lasting approximately one quarter or longer. The resulting station-level exclusive-supply classification is held fixed and matched exactly in the CEM procedure.

As with the city-level covariates, historical station characteristics are not consistently available throughout the sample. For stations active in 2024, I therefore use their most

recent 2024 characteristics. For stations no longer active, I use the last available information observed before inactivity. These variables provide the most consistent available measures of station scale, capacity, and vertical contractual status.

The baseline CEM procedure retains 53,948 of 74,048 treated station-week observations, corresponding to approximately 73 percent of the treated sample. The station-level estimates should therefore be interpreted as effects for treated observations lying on common support.

The resulting sample is organized as a stacked difference-in-differences panel. Each treated station and its matched control stations define a separate stack. A treated station may therefore have multiple controls, and a control station may appear in multiple stacks. The estimating specification includes station-by-stack fixed effects and stack-by-week fixed effects, so identification comes from changes in outcomes for each treated station relative to contemporaneous changes among observationally similar controls within the same matched stack.

B Cartel Organization and Enforcement: Case Evidence

This section provides additional documentary evidence on the organization and enforcement of each cartel case. I focus on the features used to distinguish horizontal from vertical coordination, including how prices were set, how participants communicated, how compliance was monitored, how deviations were punished, and whether wholesalers or distributor representatives participated in these activities. The discussion also reports relevant evidentiary limitations when the legal status of particular documents or communications affected CADE's final decision.

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

The investigation of the Cuiabá/MT and Várzea Grande/MT cartel began after CADE received evidence from the Mato Grosso State Public Prosecutor's Office concerning possible

coordination in the local fuel retail market. The case was connected to evidence collected in the so-called “Madonna Operation,” including intercepted communications and documents obtained by judicial authorities. Part of this evidence was subsequently affected by procedural challenges before the Mato Grosso State Court, making the probative status of the intercepted communications an important issue in the administrative proceeding. I therefore use this case primarily as documentary evidence on the alleged organization of the cartel and the mechanisms through which vertical participation could support downstream coordination.

The records describe coordination involving retailers, the gas station union, and distributor representatives. Retailers allegedly met regularly at the union to discuss and coordinate retail prices. The union was not described simply as a meeting venue. It collected information on prices, operating costs, and average sales and used this information to suggest the retail price that stations should charge. The resulting pricing policy therefore appears to have been presented as a common “recommended” or “reference” price based on market-wide information.

A central feature of the arrangement was the attempt to impose a common retail price across heterogeneous stations. The documents indicate that stations with larger sales volumes, which could otherwise profitably charge lower prices, were nevertheless expected to follow the same pricing policy as smaller stations. Once the reference price was established, retailers charging below it were contacted and pressured to align with the rest of the market. Coordination therefore relied on meetings, information sharing, observation of posted pump prices, and direct pressure on retailers that deviated.

The case also contains evidence of upstream participation. Distributor representatives attended some meetings held at the retail union and participated in discussions concerning prices and margins. The records report that leading distributors guaranteed minimum margins in ethanol sales to their retail networks and that an internal document described the division of margins between distribution and retail. They also describe communication

among managers of different distributors concerning prices and fuel-sale conditions.

These records suggest that upstream participation expanded the set of instruments available to support downstream coordination. Retailers could be disciplined not only through pressure from competing stations but also through wholesale terms that affected their input costs and margins. This connection between retail-price compliance and the vertical relationship is the main reason I classify the case as vertical.

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

The investigation of the Caxias do Sul/RS cartel began after the Rio Grande do Sul State Public Prosecutor’s Office reported evidence of coordination among fuel retailers. The conduct investigated by CADE covered July 2004 to April 2006 and concerned a horizontal cartel in the retail markets for gasoline, ethanol, and diesel. The case file included documents from civil and criminal proceedings, intercepted communications, and environmental recordings.

The records describe a cartel organized around a core group of retailers, including owners of large local station networks. These retailers communicated frequently to coordinate retail prices and, in some instances, allocate large customers. They acted as market leaders by discussing price changes, determining when adjustments should occur, and disseminating the agreed pricing policy to other stations. Coordination therefore did not require every station owner to participate directly in all discussions.

This leader–follower structure was central to the cartel’s operation. Large networks provided highly visible reference prices for the market. Once these stations adjusted their prices, smaller retailers could observe and follow them even without participating in every meeting or communication. The arrangement therefore reduced communication costs by concentrating active coordination among a relatively small number of important firms.

Communication took several forms, including phone calls, meetings in station offices, restaurants, farms, and other private locations. Participants also used coded language to refer

to meetings and the subjects to be discussed. After public scrutiny intensified, particularly following press coverage and investigations of high local fuel margins, participants became more cautious and reduced explicit price discussions over the telephone, sometimes relying instead on fax or in-person contacts.

The cartel also benefited from local social and commercial ties. The main participants knew one another personally and interacted repeatedly in overlapping business and social networks. These relationships facilitated communication and made deviations easier to detect.

Monitoring relied primarily on posted pump prices. Because fuel prices were publicly visible, cartel participants could identify stations charging below the coordinated level. The leader group collected information on individual station prices and used it to assess whether the agreement was being followed.

Enforcement was entirely downstream. Initial responses to a deviation generally involved persuasion through telephone calls or personal contacts. If persuasion failed, the records describe threats, visits, and retaliatory behavior intended to induce the station to increase its price. Similar pressure could be directed toward new entrants, which were contacted by cartel leaders and informed of the prevailing pricing policy.

The Caxias do Sul case therefore provides a clear example of horizontal retail coordination based on leadership by large networks, publicly observable prices, repeated interaction, and direct downstream retaliation. The records do not identify a comparable enforcement role for wholesalers or distributor representatives.

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

The investigation of the João Pessoa/PB cartel followed evidence collected by the Federal Police and the Paraíba State Public Prosecutor’s Office concerning possible coordination in the local retail fuel market between 2006 and 2007. The record included statements from market participants, intercepted communications, and evidence concerning retailer meetings.

Key pieces of evidence, including intercepted communications, were subsequently invalidated in court, and CADE ultimately archived the case because the remaining evidence was considered insufficient for a final conviction. I therefore use the proceeding as documentary evidence on the alleged organization of the cartel rather than as a case with strong final liability findings.

The documents describe a cartel organized primarily through the local gas station association. The association allegedly served as the main forum for coordinating retail prices in a market with many stations. According to the technical note, large meetings were held at the association's headquarters, sometimes involving representatives of many stations, to discuss price realignment following judicial decisions or competitive disruptions. The association was therefore described as an active coordinating institution rather than merely a passive meeting place.

It also centralized information. Retailers contacted the association to learn the prices charged by other stations and the price that should be followed. This reduced the need for bilateral communication among all retailers and helped establish a common reference price for the market.

The records describe enforcement against stations that did not follow the agreement. Retailers charging below the coordinated price could be contacted and pressured to adjust. The documents also describe a more aggressive punishment mechanism in which cartel participants could induce a nearby station to reduce its price temporarily in order to discipline a non-compliant retailer. Such localized price wars were intended to make deviation costly and induce the dissident station to return to the coordinated price.

The João Pessoa records also contain evidence of upstream involvement. The technical note reports indications that a local distributor participated directly or indirectly in the alleged agreement. The distributor allegedly served as an additional forum for discussions related to the cartel and was informed when the agreement was being maintained or broken. The association also allegedly sought to mobilize the distributor when certain stations were

not aligned with the coordinated price.

The evidence therefore points to vertical facilitation through an additional channel of communication and enforcement. It is less direct, however, regarding systematic discrimination in wholesale prices or contractual terms. João Pessoa is consequently useful as an intermediate case in which the retail association remained the main organizer but upstream participation potentially expanded the cartel’s ability to monitor and pressure non-compliant retailers.

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

The investigation of the Vitória metropolitan-area cartel began after the Espírito Santo State Public Prosecutor’s Office reported evidence of coordination among fuel retailers in Vitória, Cariacica, Vila Velha, and Serra. The proceeding was connected to evidence collected in the so-called “Flammable Operation,” including search-and-seizure measures and intercepted communications.

The administrative record describes a horizontal retail cartel based primarily on direct communication among competing station owners. Unlike cases in which a trade association or a small number of leader firms provided the central organizational structure, coordination in Vitória appears to have operated through repeated bilateral and multilateral contacts. Retailers discussed current prices, planned price increases, and the behavior of stations that did not follow the coordinated price.

The pricing mechanism involved agreement over target gasoline prices. In one episode, intercepted conversations identified a specific intended price increase and subsequent ANP data showed that the stations involved later posted prices consistent with the discussed target. The record also documents low price dispersion and episodes in which many stations charged the same price.

Communication was sometimes concealed through coded language. Participants used

indirect terms to refer to prices, products, stations, or meetings, indicating awareness of the illegality of the conduct while retaining a common vocabulary sufficient to coordinate market behavior.

Monitoring was particularly simple because gasoline prices are publicly displayed. Participants discussed not only their own prices but also those of rival stations, allowing deviations to be detected rapidly. Price information circulated through telephone calls and other contacts among cartel participants.

Enforcement also remained horizontal. A station that reduced its price was treated as undermining the collective agreement and could be pressured through repeated contacts, threats, and other direct actions by competing retailers. The record does not contain central evidence that wholesalers or distributor representatives used discounts, supply restrictions, or wholesale prices to enforce compliance.

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

The investigation of the Cambé/PR and Londrina/PR cartel followed evidence collected by the Paraná Civil Police in the “Medusa III Operation.” The case concerned a later episode than CADE’s earlier investigation of the same local market and relied on intercepted communications, statements from market participants, and documents obtained through search-and-seizure measures.

The records describe a horizontal cartel organized around a core group of retailers. This group determined coordinated prices, decided when adjustments should occur, and monitored whether stations followed the agreement. Active participation in all discussions was therefore concentrated among a smaller set of firms whose prices were sufficiently important to influence the behavior of other stations.

Price coordination was highly detailed. Intercepted communications indicate that participants sometimes discussed the exact pump price to the third decimal place and coordinated the timing of adjustments. Coordinated timing reduced the opportunity for individual

stations to remain temporarily below the cartel price and attract additional customers during the transition.

The organization also had a geographic component. The records suggest that price alignment could vary across roads, avenues, and local areas. Coordination was therefore adapted to local competitive conditions rather than necessarily imposing one mechanically uniform adjustment across the entire metropolitan area.

Monitoring relied on posted prices and information collected by the core group. Deviations could be identified quickly and communicated among participants. A subgroup of cartel members was responsible for pressuring stations that did not comply. The records describe direct contacts, threats, personal intimidation, and threats to report competitors to tax authorities.

The case therefore illustrates a relatively sophisticated horizontal enforcement system combining leader–follower organization, precise price coordination, synchronized adjustments, geographic segmentation, monitoring through posted prices, and direct coercion. These instruments operated within the downstream market rather than through the wholesale relationship.

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

The investigation of the Belo Horizonte/MG cartel followed evidence reported by ANP and subsequently collected by the Minas Gerais State Public Prosecutor’s Office in the “Invisible Hand Operation.” The case concerned coordination in Belo Horizonte and neighboring municipalities and involved retailers, the gas station union, reference stations, distributors, and distributor representatives.

The records describe a complex core–follower structure. A core group organized price increases, monitored compliance, and responded to deviations. Other stations did not need to participate directly in every discussion and could instead observe the prices posted by reference stations and adjust accordingly.

Reference stations were strategically located and highly visible stations whose posted prices could serve as signals to nearby competitors. Because gasoline prices are publicly displayed, a change at these stations could disseminate the coordinated price across surrounding corridors while simultaneously providing a benchmark against which deviations were identified.

The gas station union also played an important organizational role. It provided a forum in which retailers and distributor representatives could meet, exchange information, and coordinate market conduct. The records describe the union as helping organize meetings, disseminate the importance of following the coordinated price, monitor station adjustments, and reprimand retailers that deviated.

Communication occurred through meetings and telephone calls. Participants discussed price changes, checked whether particular stations had adjusted, and requested intervention when stations remained below the target price. The records also indicate increasing efforts to reduce detection risk as participants became more conscious of the illegality of the conduct.

The distinctive feature of Belo Horizonte is the role of wholesalers and their representatives. Distributor representatives appear not merely as suppliers but as active participants in monitoring and enforcement. They could transmit information, contact stations, and intervene when retailers did not follow the coordinated price. The union or other cartel participants could request that a distributor representative exert pressure on a non-compliant station through the existing commercial relationship.

The strongest evidence concerns the use of wholesale terms. The records indicate that distributor representatives could use financial offsets, discounts, or other commercial conditions to induce retailers to follow the coordinated retail price. Complying stations could receive more favorable terms, while stations that deviated could lose those benefits. The effective wholesale cost of a retailer could therefore depend on whether it adhered to the collusive arrangement.

Belo Horizonte consequently provides the clearest documentary example of the mecha-

nism emphasized in the model. The horizontal component relied on a core group, reference stations, the union, and posted-price monitoring. Wholesaler participation added an additional enforcement instrument by linking downstream compliance to wholesale commercial conditions.

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

The Teresina/PI case combines two administrative proceedings concerning the same local market, similar conduct, and overlapping agents. The first proceeding concerns conduct beginning before the ANP weekly price panel used in the empirical analysis. I therefore estimate cartel effects using only the later episode associated with Administrative Proceeding 08700.000547/2008-95.

The later proceeding followed evidence provided by the Piauí State Public Prosecutor’s Office and material collected in the “Ring of Fire” police operation. Intercepted communications were subsequently invalidated because judicial authorization had not been issued by a competent authority. CADE therefore relied on other documentary evidence, including meeting minutes, statements, and testimony from the union president.

The records identify the local gas station union as the central coordinating institution. It provided a common forum for station owners to discuss market conditions, exchange information, and promote common commercial practices. This institutional structure reduced the communication costs associated with coordination among a relatively large number of retailers.

Coordination extended beyond the nominal pump price. The records describe instructions not to initiate a “price war” and not to attract customers by offering differentiated payment conditions. The cartel therefore attempted to restrict competitive behavior along dimensions that could destabilize the coordinated pricing outcome.

Monitoring was facilitated by publicly posted fuel prices. Deviations could be observed by competitors and discussed through the union. The union thus helped centralize informa-

tion and coordinate responses to behavior considered inconsistent with the prevailing market agreement.

The enforcement mechanism remained downstream. The available evidence does not identify wholesalers or distributor representatives as using wholesale prices, discounts, or supply conditions to discipline retailers. Teresina therefore illustrates how an association can facilitate horizontal coordination by reducing communication costs and discouraging competitive conduct without relying on upstream participation.

B.8. Case 8 – 08012.008859/2009-86: Brasília/DF

The Brasília/DF case concerns coordination in the fuel retail market of the Federal District and is also analyzed by Chaves and Duarte (2025). The administrative record describes coordination involving a large local retail network, other retailers, the gas station union, and allegations concerning distributors and distributor representatives.

The economic evidence indicated substantial coordination at the retail level. CADE documented increases in average retail margins, low dispersion in posted prices, and coordinated price-adjustment dates. The records also indicate incomplete pass-through of wholesale cost reductions to consumers, with decreases in wholesale prices not fully reflected in retail prices.

Large local networks played an important role in the organization of the market. Their prices were highly visible and commercially important, making them natural reference points for other stations. Retailers monitored prices across stations, exchanged information about market conditions, and intervened when local price wars threatened the coordinated outcome.

The gas station union also served as an institutional channel for influencing pricing expectations. CADE examined public statements and press releases issued by the union discussing expected price increases and market pricing conditions. Such communications could facilitate coordination by disseminating a common view of expected market adjustments.

The allegations concerning distributors are relevant for the paper’s vertical interpreta-

tion but require greater caution than in Belo Horizonte. The records discuss ethanol distribution and the possibility that cost reductions originating upstream were not fully passed through to retailers. They also contain allegations concerning discrimination among buyers, influence toward uniform commercial conduct, and market division.

These allegations are consistent with upstream agents affecting downstream coordination through margins, wholesale conditions, or differentiated treatment of buyers. Nevertheless, the documentary evidence concerning distributor liability and direct wholesale enforcement is weaker than in Belo Horizonte. Brasília is therefore classified as a vertical case, while recognizing that the evidence identifying the precise upstream enforcement mechanism is less direct.

The case remains informative because it connects retail price coordination with upstream margins, wholesale pass-through, buyer discrimination, and distributor relationships. It therefore provides evidence of a broader vertical dimension to the coordinated conduct even though the precise wholesale-enforcement channel is less clearly documented than in Case 6.

C Additional Theoretical Details and Proofs

This section provides derivations and proofs omitted from the main text. I first discuss the boundary case and upstream pricing under a retail cartel, then prove the price and profit comparisons for the retail and double-horizontal cartels. I next provide additional details on vertical discrimination, Nash bargaining, and the incentive constraints under vertical coordination. Finally, I formalize cartel stability and equilibrium selection in the formation stage.

C.1 Retail Cartel

The boundary region

Recall that the retail cartel faces the incentive constraint

$$D(p_r) \geq K - \theta K_\Gamma,$$

which implies the price cap $\bar{p}(K_\Gamma) = D^{-1}(K - \theta K_\Gamma)$. If this constraint binds, the retail price is fixed at $p_r = \bar{p}(K_\Gamma)$ and final demand is $Q = K - \theta K_\Gamma$. Importantly, both objects are locally independent of the wholesale price. As long as the downstream market remains active, an increase in p_w therefore does not reduce final demand.

The usual interior Cournot first-order condition is consequently not applicable in this region. I use the boundary refinement in which wholesalers charge the highest wholesale price consistent with downstream trade, $p_w = \bar{p}(K_\Gamma)$. The retail cartel then earns zero profit because $p_r = p_w$. Whenever a stable interior configuration with strictly positive retailer profit exists, retailers strictly prefer that configuration to the boundary outcome. Moreover, under the strict stability refinement used in the formation stage, a zero-profit retailer is indifferent between cartel participation and its outside option and therefore does not support a stable cartel. For these reasons, the analysis in the main text focuses on positive-profit interior configurations in which the Bos–Harrington constraint is slack.

Derived wholesale demand

In the interior region, the retail cartel chooses the unconstrained residual-monopoly price. Let $Q = D(p_r)$ and $P(Q) = D^{-1}(Q)$. The retail cartel's profit can be written as

$$\Pi_r = [P(Q) - p_w] [Q - (K - K_\Gamma)].$$

The first-order condition with respect to Q is

$$P(Q) - p_w + [Q - (K - K_\Gamma)] P'(Q) = 0.$$

Solving for p_w yields the inverse demand faced by wholesalers,

$$P_w^{RC}(Q, K_\Gamma) = P(Q) + [Q - (K - K_\Gamma)] P'(Q), \quad (\text{C.1})$$

which gives equation (8) in the main text. Wholesalers then compete à la Cournot over this derived demand.

Proof of Theorem 1

Proof. Let

$$H(p; p_w^{RC}, K_\Gamma) = D(p) - (K - K_\Gamma) + (p - p_w^{RC}) D'(p).$$

The unconstrained residual-monopoly price p^* satisfies $H(p^*; p_w^{RC}, K_\Gamma) = 0$.

The vertically integrated monopoly price satisfies

$$D(p^M(c)) + [p^M(c) - c] D'(p^M(c)) = 0.$$

Evaluating H at $p^M(c)$ and using this condition gives

$$\begin{aligned} H(p^M(c); p_w^{RC}, K_\Gamma) &= D(p^M(c)) - (K - K_\Gamma) + [p^M(c) - p_w^{RC}] D'(p^M(c)) \\ &= (p_w^{RC} - c) [-D'(p^M(c))] - (K - K_\Gamma). \end{aligned}$$

Hence, if

$$K - K_\Gamma \geq (p_w^{RC} - c) [-D'(p^M(c))],$$

then $H(p^M(c); p_w^{RC}, K_\Gamma) \leq 0$. Because residual-demand profits are single-peaked, this implies

$p^* \leq p^M(c)$. Finally,

$$p_r^{RC} = \min \{p^*, \bar{p}(K_\Gamma)\} \leq p^M(c).$$

□

C.2 Double-Horizontal Cartel

The downstream pricing problem is identical to the retail-cartel case conditional on p_w . The difference is that wholesalers now coordinate their pricing decision. In the boundary region, $p_r = \bar{p}(K_\Gamma)$ and demand is fixed at $K - \theta K_\Gamma$. The wholesale cartel therefore solves

$$\max_{p_w \leq \bar{p}(K_\Gamma)} (p_w - c)(K - \theta K_\Gamma),$$

which is increasing in p_w . It consequently selects $p_w = \bar{p}(K_\Gamma)$, leaving the downstream cartel with zero profit. As in the retail-cartel case, this boundary outcome is not selected whenever a positive-profit stable interior configuration exists.

Proof of Theorem 2

Proof. In the interior region, define

$$H(p; p_w^{DH}, K_\Gamma) = D(p) - (K - K_\Gamma) + (p - p_w^{DH})D'(p).$$

The unconstrained double-horizontal retail price p^* satisfies $H(p^*; p_w^{DH}, K_\Gamma) = 0$. Evaluating this expression at the integrated monopoly price gives

$$H(p^M(c); p_w^{DH}, K_\Gamma) = (p_w^{DH} - c) [-D'(p^M(c))] - (K - K_\Gamma).$$

If

$$K - K_\Gamma \geq (p_w^{DH} - c) [-D'(p^M(c))],$$

then $H(p^M(c)) \leq 0$. Single-peakedness implies $p^* \leq p^M(c)$, and therefore $p_r^{DH} \leq p^M(c)$.

Conversely, if

$$K - K_\Gamma < (p_w^{DH} - c) [-D'(p^M(c))],$$

then $H(p^M(c)) > 0$, implying $p^* > p^M(c)$. If the Bos–Harrington price cap also satisfies $\bar{p}(K_\Gamma) \geq p^M(c)$, then

$$p_r^{DH} = \min \{p^*, \bar{p}(K_\Gamma)\} \geq p^M(c).$$

The inequality is strict whenever $\bar{p}(K_\Gamma) > p^M(c)$. □

Proof of Theorem 3

Proof. Aggregate wholesale profit under double-horizontal collusion is

$$\Pi_w^{DH} = (p_w^{DH} - c)D(p_r^{DH}),$$

while aggregate downstream profit, including the retail margin earned across the downstream market, is

$$\Pi_r^{DH} = (p_r^{DH} - p_w^{DH})D(p_r^{DH}).$$

Adding the two tiers gives

$$\Pi_w^{DH} + \Pi_r^{DH} = (p_r^{DH} - c)D(p_r^{DH}).$$

Because $p^M(c)$ maximizes integrated industry profit,

$$\Pi^M = (p^M(c) - c)D(p^M(c)) \geq (p_r^{DH} - c)D(p_r^{DH}) = \Pi_w^{DH} + \Pi_r^{DH}.$$

Strict concavity implies strict inequality whenever $p_r^{DH} \neq p^M(c)$.

To show that a Pareto-improving division exists, let $\alpha \in [0, 1]$ denote the fraction of Π^M

allocated to retailers. Both tiers are weakly better off whenever

$$\alpha \Pi^M \geq \Pi_r^{DH} \quad \text{and} \quad (1 - \alpha) \Pi^M \geq \Pi_w^{DH}.$$

Equivalently,

$$\frac{\Pi_r^{DH}}{\Pi^M} \leq \alpha \leq 1 - \frac{\Pi_w^{DH}}{\Pi^M}.$$

The interval is nonempty precisely because $\Pi_r^{DH} + \Pi_w^{DH} \leq \Pi^M$. If the inequality is strict, the interval has positive length. $\square$

C.3 Vertical Cartel

Proof of Proposition 1

Proof. Consider a vertical cartel with at least one downstream outsider. An outsider i purchases at p_w^O and slightly undercuts the coordinated retail price. In the limit as the price difference converges to zero, its profit is

$$\pi_i^O = (p_r^V - p_w^O)k_i.$$

Conditional on the outsider continuing to operate, increasing p_w^O reduces its profit without reducing the quantity it sells until the feasibility constraint $p_w^O \leq p_r^V - \xi$ binds. Moreover, because wholesalers are members of the vertical agreement, the higher wholesale payment is captured by the colluding upstream tier. A higher outsider wholesale price therefore both transfers surplus away from non-participants and weakens the incentive to remain outside. The vertical cartel consequently chooses the highest feasible outsider wholesale price. Taking $\xi \rightarrow 0$ gives

$$p_w^O = p_r^V.$$

At this price an outsider earns zero variable profit. By joining the cartel, the retailer

instead faces $p_w^I < p_r^V$ and receives a strictly positive allocation of cartel surplus whenever the vertical agreement generates positive retailer surplus. Hence, every outsider strictly prefers to join. Applying this argument to each retailer implies full participation, so $K_\Gamma = K$.

With no competitive fringe, wholesalers and retailers jointly internalize the entire margin between the final price and true marginal cost. Joint profit is therefore

$$(p - c)D(p),$$

which is maximized at $p^M(c)$. Hence,

$$p_r^V = p^M(c).$$

□

Nash bargaining solution

Let $Q^M = D(p^M(c))$ and define the incremental surplus generated by vertical coordination relative to the selected disagreement regime as

$$S = \Pi^M - \Pi_w^0 - \Pi_r^0.$$

For a given insider wholesale price, the gains from agreement are

$$G_w(p_w^I) = Q^M(p_w^I - c) - \Pi_w^0$$

for wholesalers and

$$G_r(p_w^I) = Q^M(p^M(c) - p_w^I) - \Pi_r^0$$

for retailers. Notice that $G_w + G_r = S$, so the insider wholesale price only divides the incremental surplus.

When the incentive constraints are slack, the Nash problem is

$$\max_{p_w^I} G_w(p_w^I)^{1-\lambda} G_r(p_w^I)^\lambda.$$

The first-order condition is

$$(1-\lambda) \frac{Q^M}{G_w} - \lambda \frac{Q^M}{G_r} = 0,$$

which implies

$$G_w = (1-\lambda)S, \quad G_r = \lambda S.$$

Therefore,

$$\Pi_w^V = \Pi_w^0 + (1-\lambda) [\Pi^M - \Pi_w^0 - \Pi_r^0],$$

and

$$\Pi_r^V = \Pi_r^0 + \lambda [\Pi^M - \Pi_w^0 - \Pi_r^0].$$

Using $\Pi_w^V = Q^M(p_w^{I,V} - c)$ gives

$$p_w^{I,V} = c + \frac{\Pi_w^0 + (1-\lambda) [\Pi^M - \Pi_w^0 - \Pi_r^0]}{Q^M},$$

which is equation (18).

Vertical incentive constraints

Four incentive requirements enter the constrained bargaining problem.

First, individual retailers must be willing to sustain full downstream coordination at $p^M(c)$. Evaluating the Bos–Harrington condition at $K_\Gamma = K$ gives

$$D(p^M(c)) \geq (1-\theta)K,$$

or

$$\theta \geq 1 - \frac{D(p^M(c))}{K}.$$

Second, individual wholesalers must be willing to remain in the upstream cartel. Under symmetric profit sharing and grim-trigger punishment, this is the standard wholesale-cartel condition

$$\delta \geq 1 - \frac{1}{N_w}.$$

The remaining two conditions concern deviations by the downstream and upstream cartels from the negotiated *vertical* agreement. These are distinct from deviations by individual firms within each horizontal cartel.

For the downstream tier, let

$$\Pi_r^D(p_w^I) = \max_{p_r} D(p_r)(p_r - p_w^I)$$

denote the optimal one-period payoff from abandoning the negotiated retail price after the insider wholesale price has been set. Cooperation yields present value $\Pi_r^V/(1 - \theta)$, while deviation yields $\Pi_r^D(p_w^I)$ today followed by the disagreement payoff Π_r^0 thereafter. Hence,

$$\frac{\Pi_r^V}{1 - \theta} \geq \Pi_r^D(p_w^I) + \frac{\theta}{1 - \theta} \Pi_r^0.$$

Rearranging gives

$$\theta \geq \frac{\Pi_r^D(p_w^I) - \Pi_r^V}{\Pi_r^D(p_w^I) - \Pi_r^0}.$$

For the upstream tier, the relevant deviation is a collective deviation by the upstream cartel from the negotiated vertical agreement. By setting wholesale terms to extract the entire vertical margin for one period, the upstream tier can obtain Π^M , after which the market reverts to the selected no-vertical disagreement regime. The incentive constraint is

therefore

$$\frac{\Pi_w^V}{1-\delta} \geq \Pi^M + \frac{\delta}{1-\delta} \Pi_w^0,$$

which is equivalent to

$$\delta \geq \frac{\Pi^M - \Pi_w^V}{\Pi^M - \Pi_w^0}.$$

Combining the individual-firm and tier-level conditions gives the constrained bargaining problem reported in equation (17).

C.4 Cartel Stability and Formation

Following Bos and Harrington (2010), stability requires that firms at the margin of cartel membership do not wish to change their membership status. Let $V_i^I(\Gamma, o)$ denote retailer i 's continuation payoff as an insider under cartel composition Γ and upstream regime o , and let $V_i^O(\Gamma, o)$ denote its payoff as an outsider.

A downstream cartel Γ is internally stable if the smallest insider $i^- = \arg \min_{i \in \Gamma} k_i$ prefers to remain in the cartel,

$$V_{i^-}^I(\Gamma, o) \geq V_{i^-}^O(\Gamma \setminus \{i^-\}, o),$$

and externally stable if the largest outsider $i^+ = \arg \max_{i \notin \Gamma} k_i$ prefers to remain outside,

$$V_{i^+}^O(\Gamma, o) \geq V_{i^+}^I(\Gamma \cup \{i^+\}, o).$$

The monotonicity results in Bos and Harrington (2010) imply that checking these two marginal retailers is sufficient to characterize downstream stability.

I extend this definition to the upstream tier. Whenever wholesalers collude, the upstream cartel must both satisfy the individual no-deviation condition and generate at least as much profit as the relevant feasible alternative without upstream collusion. A vertical

configuration must additionally satisfy all constraints in (17).

Under vertical coordination, Proposition 1 implies that no configuration with an outsider can be stable. At the optimal outsider wholesale price, an outside retailer earns zero variable profit while a participating retailer receives positive surplus, so the outsider strictly prefers to join. Hence, the unique stable downstream composition under a positive-profit vertical cartel is the fully inclusive configuration.

The strict stability refinement also eliminates the boundary configuration discussed above. When the wholesale price reaches the retail-price cap, downstream profit is zero, so retailers are indifferent between participating and remaining outside. I require implemented cartel members to strictly prefer participation whenever a positive-profit alternative is available. The zero-profit boundary configuration therefore does not belong to the selected set of stable cartels.

Finally, the pricing game may admit more than one stable horizontal cartel composition. The cartel-formation stage selects among these outcomes. Retailers move first and anticipate the wholesalers' equilibrium response to each possible downstream composition. Let $\mathcal{F}$ denote the set of stable retail-cartel configurations and let $o(\Gamma)$ denote the upstream regime induced by composition Γ . The selected downstream cartel satisfies

$$\Gamma^* \in \arg \max_{\Gamma \in \mathcal{F}} \Pi_r^{o(\Gamma)}(\Gamma).$$

Retailers therefore internalize whether a particular cartel composition induces non-cooperative wholesalers, an independent wholesale cartel, or feasible vertical coordination when selecting the size of the downstream cartel. These stability and selection conditions are also the ones imposed in the numerical implementation.

D Robustness Checks

D.1. Excluding Brasília/DF

Brasília/DF is substantially larger than most other markets in the sample and has a relatively large city-level matching distance. A natural concern is therefore that the estimated differences between horizontal and vertical cartels may be disproportionately influenced by this case. This concern is particularly relevant because Brasília is classified as a vertical cartel. Belo Horizonte/MG, the other exceptionally large vertical market, is already excluded from the baseline matched analysis because no sufficiently comparable control market is available. As a robustness exercise, I therefore re-estimate both the city- and station-level specifications after additionally excluding Brasília/DF.

Table D.1: City-Level Effects Excluding Brasília/DF

	(1) log(Retail Price)	(2) Retail Markup	(3) Wholesale Markup
Cartel	-0.012*** (0.004)	-0.011*** (0.002)	-0.000 (0.003)
Cartel $\times$ Vertical	-0.023** (0.009)	-0.014* (0.008)	-0.007 (0.004)
Constant	0.959*** (0.001)	0.144*** (0.001)	0.446*** (0.001)
Case-Week Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	3,085	3,085	3,085

Note: This table reports estimates from specification (2) after excluding Brasília/DF. Belo Horizonte/MG is already excluded from the baseline matched sample because no sufficiently comparable control market is available. All regressions include case-by-calendar-week fixed effects and city fixed effects. Standard errors clustered at the city level are reported in parentheses. The omitted period corresponds to the period in which the cartel was operating; therefore, negative post-dissolution coefficients imply higher outcomes during cartel operation. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.1 reports the city-level results. The estimates for horizontal cartels are virtually unchanged. The implied effect of cartel operation on retail prices is approximately 1.2% for horizontal cartels and 3.5% for vertical cartels. Similarly, the implied retail-markup effects

are approximately 1.1 p.p. and 2.5 p.p., respectively. Thus, even after removing Brasília, vertical cartels continue to generate substantially larger retail-price and retail-markup effects. Relative to the baseline estimates in Table 5, the additional vertical effect on retail markups is almost unchanged, while the retail-price differential becomes somewhat smaller but remains economically large and statistically significant. The wholesale-markup result is less robust since it declines from approximately 2.1 p.p. in the baseline specification to 0.7 p.p. and is no longer statistically significant. This is consistent with the weaker evidence for wholesale outcomes documented throughout the paper .

Table D.2: Firm-Level Effects Excluding Brasília/DF

	(1) Retail Price	(2) Retail Markup	(3) Wholesale Markup
<i>Panel A. Total effects by cartel type and station size</i>			
Horizontal cartel, large	0.0214*** (0.0018)	0.0185*** (0.0020)	0.0005 (0.0025)
Horizontal cartel, small	0.0220*** (0.0024)	0.0181*** (0.0024)	0.0027 (0.0024)
Vertical cartel, large	0.0383*** (0.0025)	0.0336*** (0.0025)	-0.0022 (0.0028)
Vertical cartel, small	0.0247*** (0.0027)	0.0170*** (0.0018)	0.0073*** (0.0026)
<i>Panel B. Regression components</i>			
Horizontal effect, large	0.0214*** (0.0018)	0.0185*** (0.0020)	0.0005 (0.0025)
Small-station effect, horizontal	0.0006 (0.0030)	-0.0004 (0.0030)	0.0022 (0.0035)
Additional vertical effect, large	0.0169*** (0.0031)	0.0150*** (0.0032)	-0.0027 (0.0037)
Additional small-station effect, vertical	-0.0142*** (0.0046)	-0.0162*** (0.0043)	0.0072 (0.0047)
Stack-Station Fixed Effects	Yes	Yes	Yes
Stack-Week Fixed Effects	Yes	Yes	Yes
Observations	97,388	97,388	97,388
Number of Stations	1,087	1,087	1,087

Note: This table reports stacked difference-in-differences estimates after excluding Brasília/DF. Belo Horizonte/MG is already excluded from the baseline matched sample. Because treatment is defined as the period after cartel dissolution, reported coefficients reverse the sign of the post-dissolution estimates and represent implied effects during cartel operation. Panel A reports total effects by cartel type and station size; Panel B reports the underlying regression components. All specifications use matching weights and include stack-by-station and stack-by-week fixed effects. Standard errors clustered at the station level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D.2 reports the corresponding station-level estimates. The horizontal-cartel effects are essentially identical to the baseline estimates, as expected, while the estimates for large stations in vertical cartels are also remarkably stable. Excluding Brasília, the effects of

vertical cartels for large stations are 3.8% for retail prices and 3.3 p.p. for retail markups, compared with 3.8% and 3.2 p.p. in the baseline specification. The effects for small stations in vertical cartels decline more noticeably, from 3.3% to 2.4 % for retail prices and from 2.0 p.p. to 1.7 p.p. for retail markups.

Importantly, the main within-vertical heterogeneity remains and becomes particularly clear after Brasília is excluded. Relative to large stations in vertical cartels, small stations experience a 1.4% smaller retail-price effect and a 1.6 p.p. smaller retail-markup effect, with both differences statistically significant at the 1 percent level. At the same time, the wholesale-markup effect is approximately 0.4 p.p. larger for small stations, and this difference is statistically significant at the 5 percent level. The estimated wholesale-markup effect itself is positive and statistically significant for small stations while it is close to zero for large stations.

Overall, these results indicate that the main conclusions are not driven by Brasília. Vertical cartels continue to have substantially larger effects on retail prices and retail markups at the market level, and the station-level results continue to show that small retailers capture less of the additional downstream margin while facing less favorable wholesale terms than large retailers under vertical coordination. The main result that weakens is the city-level wholesale-markup differential, reinforcing the interpretation of the wholesale evidence as suggestive rather than as strong as the results for retail prices and retail markups.

D.2. Alternative Event Windows

The baseline analysis restricts the estimation sample to 78 weeks before and after cartel dissolution. I examine whether the results depend on this choice by re-estimating the main specifications using a shorter 52-week window and a longer 104-week window. All other features of the empirical design are held fixed.

Table D.3 reports the city-level results. The main comparison between horizontal and vertical cartels is stable across event windows. Using the 52-week window, the implied effect

Table D.3: City-Level Effects under Alternative Event Windows

	Event Window		
	± 52 Weeks	± 78 Weeks	± 104 Weeks
<i>Panel A. Retail Price</i>			
Horizontal cartel	0.0179*** (0.0026)	0.0118*** (0.0037)	0.0071*** (0.0023)
Additional vertical-cartel effect	0.0212*** (0.0035)	0.0324*** (0.0109)	0.0399*** (0.0031)
<i>Panel B. Retail Markup</i>			
Horizontal cartel	0.0153*** (0.0020)	0.0107*** (0.0024)	0.0080*** (0.0017)
Additional vertical-cartel effect	0.0064** (0.0027)	0.0154** (0.0068)	0.0217*** (0.0024)
<i>Panel C. Wholesale Markup</i>			
Horizontal cartel	0.0010 (0.0013)	0.0001 (0.0028)	-0.0025** (0.0012)
Additional vertical-cartel effect	0.0200*** (0.0023)	0.0209* (0.0116)	0.0211*** (0.0019)
Case-Week Fixed Effects	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Observations	2,454	3,399	4,146

Note: This table reports estimates from the city-level difference-in-differences specification using alternative symmetric windows around cartel dissolution. The 78-week window is the baseline specification. Because treatment is defined as the period after cartel dissolution, reported coefficients reverse the sign of the post-dissolution estimates and are interpreted as implied effects during cartel operation. “Horizontal cartel” reports the effect for horizontal cartel cases, while “Additional vertical-cartel effect” reports the additional effect associated with vertical cartels. The total vertical-cartel effect is therefore the sum of the two reported components. All specifications use matching weights and include case-by-calendar-week and city fixed effects. Standard errors are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

of cartel operation on retail prices is approximately 1.8% for horizontal cartels and 3.9% for vertical cartels. Under the 104-week window, the corresponding effects are 0.7 % and 4.7 %, compared with 1.2% and 4.4 % in the 78-week baseline. Although the estimated effect for horizontal cartels varies with the window, vertical cartels consistently generate substantially larger retail-price effects.

The same pattern holds for retail markups. The implied vertical-cartel effect ranges from approximately 2.2 p.p. under the 52-week window to 3.0 p.p. under the 104-week window, compared with 2.6 p.p. in the baseline specification. In every case, the effect is larger than for horizontal cartels. The wholesale-markup results are also qualitatively similar. Horizontal-cartel effects remain close to zero, whereas the implied vertical-cartel effect is approximately 1.9–2.1 p.p. across the three windows. Thus, the weaker but positive evidence for wholesale markups is not driven by the choice of the 78-week baseline window.

Table D.4 reports the corresponding station-level results. The main patterns are stable across the three event windows. For large stations in vertical cartels, the estimated retail-price effect ranges from 3.5 % to 4.1%, compared with 3.8 % in the 78-week baseline, while the retail-markup effect ranges from 2.9 p.p. to 3.4 p.p.. The corresponding effects for small stations in vertical cartels are also positive throughout, ranging from 2.8 % to 3.3 % for retail prices and from 1.8 p.p. to 2.2 p.p. for retail markups.

More importantly, the heterogeneity by station size is particularly stable. Within vertical cartels, small stations obtain smaller retail-markup gains than large stations under every event window. The small–large difference in retail markups is 1.1 p.p. using the 52-, 78-, and 104-week windows, and is statistically significant in all three specifications. Wholesale markups display the opposite pattern. Their effects are close to zero for large stations in vertical cartels, while the effect for small stations is approximately 0.5–0.6 p.p. and statistically significant under all three windows. Thus, the result that small retailers capture less of the increase in downstream margins while facing higher wholesale margins under vertical coordination does not depend on the baseline 78-week window.

Table D.4: Firm-Level Effects under Alternative Event Windows

	Event Window		
	± 52 Weeks	± 78 Weeks	± 104 Weeks
<i>Panel A. Retail Price</i>			
Horizontal cartel, large station	0.0230*** (0.0015)	0.0214*** (0.0018)	0.0240*** (0.0016)
Horizontal cartel, small station	0.0245*** (0.0019)	0.0220*** (0.0024)	0.0253*** (0.0020)
Vertical cartel, large station	0.0354*** (0.0026)	0.0387*** (0.0024)	0.0410*** (0.0025)
Vertical cartel, small station	0.0279*** (0.0046)	0.0329*** (0.0041)	0.0338*** (0.0040)
<i>Panel B. Retail Markup</i>			
Horizontal cartel, large station	0.0195*** (0.0017)	0.0185*** (0.0020)	0.0209*** (0.0018)
Horizontal cartel, small station	0.0215*** (0.0018)	0.0181*** (0.0024)	0.0206*** (0.0020)
Vertical cartel, large station	0.0284*** (0.0030)	0.0322*** (0.0026)	0.0332*** (0.0025)
Vertical cartel, small station	0.0177*** (0.0029)	0.0198*** (0.0023)	0.0222*** (0.0025)
<i>Panel C. Wholesale Markup</i>			
Horizontal cartel, large station	0.0012 (0.0023)	0.0005 (0.0025)	0.0002 (0.0025)
Horizontal cartel, small station	0.0005 (0.0021)	0.0027 (0.0024)	0.0034 (0.0025)
Vertical cartel, large station	0.0025 (0.0033)	0.0010 (0.0033)	0.0027 (0.0039)
Vertical cartel, small station	0.0119** (0.0048)	0.0155*** (0.0047)	0.0122*** (0.0047)
Stack-Firm Fixed Effects	Yes	Yes	Yes
Stack-Week Fixed Effects	Yes	Yes	Yes
Observations	79,299	98,369	105,241
Number of Stations	1,099	1,135	1,183

Note: This table reports implied effects during cartel operation from the stacked difference-in-differences specification using alternative symmetric windows around cartel dissolution. The 78-week window is the baseline specification. Each entry reports the total effect for the corresponding cartel type and station-size group. Because treatment is defined as the period after cartel dissolution, the reported coefficients reverse the sign of the post-dissolution estimates. All specifications use matching weights and include stack-by-firm and stack-by-week fixed effects. Standard errors clustered at the station level are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.