

The Inner Workings of a Hub-and-Spoke Cartel in the Automotive Fuel Industry

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This draft: Jun, 2022

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We analyze a hub-and-spoke cartel in the Brazilian automotive fuel industry. Based on court documents and detailed price and sales data, we discuss how gas stations owners (spokes) operating inside the federal capital received help from fuel distributors (hub) to reduce the dispersion and increase the level of the gasoline retail price. We provide evidence that distributors members benefited from the scheme by raising wholesale prices while excluding competitors from supplying to retail members. We also provide empirical evidence and theoretical ground for a new mechanism beyond information sharing that the hub can use to help spokes solve the obstacles of price coordination: smooth cost fluctuations.

JEL: K21, L12, D43

Keywords: Antitrust, Hub-and-Spoke Collusion, Vertical Restraints

A collusive arrangement in which an upstream supplier or downstream buyer helps firms in another level of the supply chain to coordinate market outcomes is called a hub-and-spoke cartel. Hub-and-spoke cartels have been reported since the Canadian sugar trust of the late 1800's and are recognized by the U.S. jurisprudence since 1939. Recently, numerous cases of hub-and-spoke cartels have

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been prosecuted by antitrust authorities of different countries. Examples include the recent cases of Apple and e-book publishers in the US, bread manufactures and retail chains in Canada, and other 14 cartels listed in [Garrod, Harrington and Olczak \(2020\)](#). A number of those cases generated significant damages to consumers, for example \$400 million in the case of Apple and \$5 billion in the case of bread.

Hub-and-spoke cartels pose theoretical and empirical challenges to researchers. First, since upstream firms have incentives to limit market power of downstream firms and avoid double marginalization, it is challenging to understand the motives behind the participation of an upstream hub in the agreement, and to rationalize why hub-and-spoke cartels form. Second, the scarcity of data on wholesale prices, costs and vertical practices makes it difficult for researchers and antitrust authorities to investigate the strategies employed by firms in a hub-and-spoke cartel and assess their impact on equilibrium market outcomes.

This paper is a detailed empirical and theoretical study of a known hub-and-spoke cartel in Brazil’s Federal District automotive fuel market.¹ We quantify the damages caused by the cartel and unpack the benefits obtained by firms in each level of the supply chain. After establishing the effectiveness of the cartel in raising prices, we present detailed empirical evidence on the motives behind the hub’s participation in the cartel. We also describe the strategies used by the hub to help coordination between the spokes. Lastly, based on our empirical analysis, we provide a theoretical foundation for the hub-and-spoke cartel and highlight a novel mechanism through which the hub helped coordination between spokes: smooth of cost fluctuations.

The automotive fuel market in Brazil’s Federal District is composed of around 300 fuel stations that buy gasoline and ethanol from 9 distributors and sell them to consumers. In Brazil gasoline and ethanol are competing products. Although one

¹**Legal disclaimer:** This paper analyzes the alleged cartel in Brazil’s Federal District from an economic standpoint. Our understanding is based on the documents that are available at the district attorney’s website and industry data. These documents provide a legal opinion. All the parties involved are innocent until proven guilty.

retail group is distinguishable by its size, the distribution level is significantly more concentrated than retail, with more than 90% of fuel being sold through one of the big three distribution companies. In November 2015, the Brazilian Competition Bureau and the police launched an operation to investigate an alleged cartel in the fuel market of the Federal District. Authorities seized documents and arrested both gas station owners and managers from the big three distributors. The documents and affidavits obtained by the investigation uncovered evidence that almost all gas station owners and the three fuel distributors *conspired together* to fix retail prices.

To understand how the three distributors benefited from collusion among the gas stations, and how distributors helped stations to collude, we complement the information produced by the investigation – wiretaps, text messages, emails, affidavits, plea bargain deal and internal documents produced by members of the cartel - with a detailed data set on prices and quantities for both the retail and wholesale level of the fuel supply chain. Those two sources provide us with a unique window into the inner workings of a hub-and-spoke cartel.

Our first contribution is to quantify the overall gains obtained by the cartel, and discriminate it between hub and spokes. Using a synthetic differences-in-differences approach ([Arkhangelsky et al., 2021](#)) we find that the overprice imposed by the cartel translates into a sizeable transfer of money from consumers to firms. Our estimate indicates an excessive gain of \$552 million, in 2015 purchasing power parity. More interesting, relative to the counterfactual trend implied by the synthetic control group, the retail Lerner index (markup’s fraction of price) increased in 2.9 p.p. and the wholesale Lerner index increased in 2.6 p.p. Considering that the average Lerner index in the synthetic control for gasoline distribution is 5% and for retail is 14%, our results are evidence that distributors were the main beneficiaries of the scheme.

Our second contribution is to provide a rationale for why distributors would have helped stations to collude. We highlight two changes in the supply relation-

ship after the cartel broke: (i) the market-share of the big three distributors in the Federal District decreased 5 p.p. relative to the trend observed in the synthetic control; and (ii) in line with what we observe in other markets, stations without exclusivity contracts started to pay significantly lower wholesale prices compared to stations with exclusivity contracts. Drawing from [Asker and Bar-Isaac \(2014\)](#), we argue that those facts are evidence that the three distributors helped stations collude in order to sustain their upstream dominant position while increasing wholesale prices during the cartel. Gas stations could be willing to pay higher prices and not buy from other potential suppliers if they perceive that doing so can trigger a response from distributors and make them lose the rents generated by the cartel.² We depart from [Asker and Bar-Isaac \(2014\)](#) in how the help from the hub takes place. Instead of standard vertical restraints such as resale-price-maintenance, in our case the help took the form of information sharing, subsidies to punish deviators, and smooth of cost fluctuations.

One important obstacle that a cartel between gas stations must overcome is the variability of fuel costs over time. Volatility in costs in the fuel industry can be large, and fluctuations can hinder the stability of the cartel for several reasons. First, changes in costs require firms to adjust prices frequently and coordinating price changes is costly. They involve more communication between cartel members and decrease the continuation probability of the arrangement.³ Second, in periods of low cost firms have stronger incentives to undercut the collusive price. This is the case as the expectation of higher costs in the future decreases the value of collusion relative to the current gains from deviating.⁴ To be incentive compatible, the cartel may need to constraint prices during low cost periods.

²The possibility of losing a dominant sales position was also the trigger for a hub helping spokes in other hub-and-spoke cases, for example the UK toys and ?? ([Garrod, Harrington and Olczak, 2020](#)).

³For example, it can increase the likelihood to be detected by the competition authority ([Harrington Jr, 2004](#)), increase the likelihood of disagreement between members as it creates the need to convince peers about a new focal point, and increase the need of side payments between members ([Clark and Houde, 2014](#)).

⁴This argument is analogous to [Rotemberg and Saloner \(1986\)](#) but instead of variation in demand we have variation in costs.

Our third contribution is to understand how the three largest upstream firms helped retailers overcome the obstacles from cost fluctuations. In Brazil, consumers can choose between two substitute products: gasoline, which is a mixture of pure gasoline with ethanol, and pure ethanol.⁵ Due to sugar price seasonality and political factors affecting the price of pure gasoline at refineries, the price of ethanol is more volatile than the price of pure gasoline at the production stage. The documentary evidence shows that distributors raised ethanol wholesale prices at a level that discouraged its consumption in favor of gasoline and did not transfer the sugar-cane seasonality to gasoline wholesale prices. These actions had a negative impact on the amount of ethanol sold and translated into much more stable retail costs for gas stations in the Federal District.

We provide theoretical ground for the incentives involved in distributors absorbing fluctuations and allowing gas stations to coordinate on a product with stable costs using a repeated pricing game framework under alternating costs. The equilibrium conditions imply that: (i) if knowledge of high costs in the future heavily constrain collusive prices due to incentive compatibility, then the cartel can increase the flow of profits if it faces stable costs; (ii) if coordinating price changes is costly and product differentiation is small, then a collusive equilibrium may only exist if the cartel face stable costs. Both conditions create a role for a hub that is able to absorb costs, increase cartel rents, and in exchange benefit from an exclusion condition against its competitors.⁶

This paper adds to different streams of the Industrial Organization and Antitrust literature. We add to an incipient theoretical literature that explains the incentives involved in hub-and-spoke arrangements. [Sahuguet and Walckiers \(2017\)](#) show how downstream firms can sustain collusion by sharing information on demand shocks with each other through the upstream firm. The upstream

⁵Gasoline sold by fuel stations is a mixture of 3 parts of pure gasoline with 1 part of pure ethanol.

⁶The documents also point for other mechanisms used by the hub to help spokes: facilitated information sharing between retail members (although explicit communication between retailers was also widespread); gave members of the cartel wholesale price discounts during episodes of price wars. Because of the available price evidence, we are going to focus on the ethanol mechanism.

benefits from this information sharing by being able to charge higher wholesale prices when demand is high. In [Van Cayseele and Miegielsen \(2013\)](#) one supplier and two buyers bargain over a transfer price after the supplier decides if it wants to sell to one or both buyers. The supplier helps buyers to collude on the resale price by refusing to supply buyers that deviate from the collusive agreement. The hub can benefit from a downstream coordination because it increases the transfer price it is able to negotiate. In this article we present a novel channel through which the hub can help collusion between the spokes beyond information sharing or deviation punishment.

On the empirical literature, [Garrod, Harrington and Olczak \(2020\)](#) presents an overview of 16 different cases where either a buyer or a supplier facilitated collusion between competitors. [Asker and Hemphill \(2020\)](#) is a historical example of a hub-and-spoke arrangement between suppliers and buyers on the Canadian and US sugar industry in the late 1880s. [Clark, Horstmann and Houde \(2020\)](#) is a recent work on a two-sided hub-and-spoke collusion in the Canadian bread industry.⁷ Although in most of those cases authors had access to investigation documents, detailed information on prices for all levels of the supply chain were not available. We contribute to the empirical literature by enhancing information from competition authority with fine level price data on all members involved.

We also add to the literature studying the internal organization of cartels. Despite the vast theoretical knowledge on market features that facilitate cartel stability, the secretive nature of cartels and the confidentiality involved in the prosecuted cases impose limitations on what researchers know in practice ([Levenstein and Suslow, 2012](#)). A few exceptions are [Genesove and Mullin \(2001\)](#); [Röller and Steen \(2006\)](#); [Asker \(2010\)](#); [Clark and Houde \(2013, 2014\)](#); [Igami and Sugaya \(2021\)](#). Among these, [Clark and Houde \(2013, 2014\)](#) are the most similar to ours. Although horizontal transfers are also present in our setting, we depart

⁷In [Clark, Horstmann and Houde \(2020\)](#) both upstream and downstream helped to soft competition in the other level of the supply chain.

from them by pointing out the role of vertical transfer in stabilizing downstream price coordination.

This article is organized in seven sections. The next section describes the institutional details of the Brazilian automotive fuel industry. In section II we describe the legal case and our data sources. Section III starts with a comparison between the Federal District fuel market and other fuel markets in the country, and ends with a description of the players involved in the scheme. In section IV we quantify the overprice charged by the cartel and discriminate the gains between retailers and wholesalers. In section V we argue on why distributors helped retailers to collude. In section VI we show evidence and discuss how the hub stabilizing costs helped the collusion between spokes. In the last section we present our conclusions.

I. The Brazilian automotive fuel industry

Four features of the Brazilian automotive fuel industry are markedly different from the automotive fuel industry worldwide: (i) both gasoline and ethanol are the main fuel alternatives for consumers; (ii) regulation mandates the gasoline sold at the pump to be a mixture of 3 parts of pure gasoline with 1 part of ethanol (iii) the presence of a state-owned monopolist in the oil refinement stage; and (iv) the prohibition of vertical integration between distribution and retail.⁸

Most automobiles in Brazil are bifuel, i.e. run with gasoline, ethanol or any combination of both. Ethanol became an option to Brazilian consumers in the 1970's as a result of a government program called *Proalcool*.⁹ However, only starting in 2003 automobile manufactures started investing heavily in the bifuel technology and in its proliferation. In 2015, 94% of the new cars sold were bifuel.

⁸In most countries, consumers have the option to buy automobiles that run on gasoline or diesel. In Brazil, the only vehicles that run on diesel and have access to the retail network are pick-up trucks. Since these vehicles account for a small fraction of consumers, we choose not to address the retail sales of diesel in this work. The share of vehicles sold in 2015 that runs on diesel was 1.3% (Anfavea, 2019).

⁹*Proalcool* was a response from the Brazilian government to the first oil shock in the mid 1970's and was designed to reduce the countries' dependence of imported oil.

This technological change also affected the fuel retail activity. In 2010 virtually every fuel station in the country offered two fuel alternatives: gasoline, which by regulation is a mixture of 3/4 pure gasoline and 1/4 ethanol (hereafter gasoline); and pure ethanol.

The automotive fuel supply chain in Brazil is composed of three stages: production; distribution; and retail.¹⁰ In the production stage, the state-owned monopolist, Petrobras, refines domestic and imported oil to produce more than 90% of the pure gasoline sold in Brazil.¹¹ Petrobras sells its production to distributors through 36 different supply points located across the country. Officially, Petrobras has been free to set prices since the early 2000's. However, until the end of 2016, the price Petrobras' charged distributors was regulated by the federal government. The government used Petrobras to absorb shocks coming from the international oil price and smooth domestic fuel price changes. In contrast, the production of ethanol is marked by small private distilleries dispersed across the country that buy sugar cane from local producers. The ethanol price in the production stage fluctuates with the sugar cane harvest season and the international sugar price. This difference translated into significantly more fluctuations in ethanol prices at distilleries compared to fluctuations in gasoline prices at refineries.¹²

Distributors buy pure gasoline at Petrobras' supply points and ethanol from the private distilleries, and stock them into private tanks.¹³ After mixing the pure gasoline with ethanol, distributors deliver the final gasoline and ethanol products to geographically dispersed gas stations according to buying orders initiated by the stations. The distribution stage in Brazil is characterized by a large concentration of sales between three firms: BR, Ipiranga and Raizen. They account for approximately 75% of national gasoline distribution and have storage tanks on

¹⁰ All the tax charged from the supply chain is collected in the production stage.

¹¹ The state-owned monopoly in the refinement is a remnant of dictatorship movements and industrialization policy during the 20th century.

¹² This condition is evident at graph A1 in appendix A.

¹³ Although distributors can import refined gasoline abroad, imports never accounted for more than 10% of the gasoline sold in the country.

virtually all the states.¹⁴ The other 25% is sold by small regional distribution companies.

There is no national player that owns a chain of stations at the retail level. Rather, each local entrepreneurs owns around two to three fuel stations at his city, and law mandates that it must buy fuel only through registered distributors. Regulation prohibits distributors to operate gas stations, but allow them to sign exclusive dealing contracts.¹⁵ A standard exclusive dealing contract mandates that a given gas station must buy only from the distributor it signed the contract with, and determines a minimum quantity that must be bought during the contract period.¹⁶ While the exclusive dealing is in place, the station benefits from the use of the distributor’s brand and advertisement campaigns. Stations that do not have exclusive dealing contracts are free to buy fuel from any distributor and search for better wholesale fuel prices. However, they cannot use the distributor brand to characterize the station and promote sales. Throughout this work we refer to stations without exclusive dealing contracts as unbranded stations and the ones with exclusive dealing as branded stations.

II. The Investigation and Legal Charges

Brazil’s Federal District is composed by the federal capital, Brasilia, and a set of neighboring cities, defined as Administrative Regions. Brasilia was planned and constructed by the state during the 1950’s in the midwest region of the country. The Administrative Regions grew and developed as people migrated to the Federal District. In 2010, Brasilia and the Administrative Regions had a population of 2.75 million people. Since they form a single urban area and network of commute paths, we treat the Federal District as a single automotive fuel market.

¹⁴Although Petrobras has 51% of BR’s stocks, there are no indications of political influence in BR’s price setting behavior. Based on conversations with insiders, the degrees of freedom that BR’s regional managers have while setting prices is similar to Ipiranga and Raizen’s.

¹⁵The law against vertical integration was created during the liberalization of the sector at the end of the 90s, with the intention to sustain competition along the supply chain.

¹⁶The length of the contract usually varies depending on how much the distributor helped financing the construction of the gas station, but according to conversation with insiders it average around 5 years.

In 2011, the Brazilian Regulatory Agency of Petroleum, Natural Gas and Bio-fuel (*ANP* hereafter) informed the district attorney office about an uncommon co-movement in the price of gasoline across fuel stations in the Federal District.¹⁷ With this information, the district attorney office, the police, and the Brazilian antitrust authority started to investigate possible collusive practices in the industry. The investigators wiretapped station owners and distributors' sales representatives during the year of 2015. After the police gathered enough evidence of wrong doing, a judge issued search and arrest warrants in November 2015.

The police investigation uncovered evidence that starting at some point between 2010 and 2011 gas station owners and managers from the big three fuel distributors – BR, Ipiranga and Raizen - conspired together to fix gasoline and ethanol retail prices. In the beginning of the agreement, stations used the trade association meetings to determine the price the cartel would charge. As the scheme evolved, the largest retail chain operating in the Federal District, Cascol, consolidated as a leader in the decision and coordination of the retail price changes.¹⁸ Records also show frequent conversations between distribution companies' managers and gas stations owners about cartel details, which shows that the the big three distributors were active members in the conspiracy.

The conspiracy did not end with the arrest of cartel members in November 2015. Police monitoring indicated that gas stations communicated to fix retail prices until January 2016. The resilience of the price fixing arrangement led the antitrust authority to intervene in the market by replacing the management from Cascol with a government appointee in February 2016. The goal of the appointee was to keep the largest retail chain operational while seizing any collusive practice.

During the investigation process a number of cartel members accepted the plea bargain deals offered by the antitrust authority. At the end, the District Attorney's office brought charges against 28 individuals: 16 station owners, 6 stations

¹⁷We use *district attorney office* as a translation for *Ministério Público do Distrito Federal e Territórios*.

¹⁸Two excerpts of the affidavit corroborating this point can be found in quote 3 and quote 4 in appendix C

employees, and 6 distributors employees. The charges were based on the material obtained by the police - wiretapped conversations, documents and depositions - and on the plea bargain deals. It also requested the payment of approximately \$266 million dollars in damages.¹⁹

Data

The documents seized by investigators together with the defendants testimonies are our main source of information regarding the inner workings of the cartel.²⁰ We complement the documents with data on the Brazilian fuel market provided by ANP, ESALQ (an energy sector think-tank), Petrobras and the Minister of Transportation. Our dataset is very detailed: it covers prices since 2007 for every level of the supply chain in the Federal District and for fuel markets located in state capitals. For gas stations at the Federal District, it has monthly information on prices, characteristics, geographic location and volume of fuel purchased during the cartel period and afterwards. For distributors, we observe monthly fuel sales at the Federal District and at state capitals from 2011 to 2017. A detailed description of the data is presented in appendix B.

III. The Federal District Fuel Market

In this section we contrast features of the Federal District fuel market with fuel markets of other state capital.²¹ We also describe the characteristics of the players involved in the cartel. This descriptive analysis provide some insight on why the hub-and-spoke cartel took place in the Federal District and not in other markets.

¹⁹This figure was obtained using the 2018 exchange rate.

²⁰These documents are available upon request.

²¹For historical reasons, most state capitals are also dense urban areas and thus provide a meaningful comparison group for the Federal District. See table A2 in appendix A for a comparison on demographics.

Market and Players Overview

Table 1 displays summary statistics for variables describing the market structure in the Federal District and state capitals. For the state capitals we display the median in the third column and the first and third quartile in the second and fourth respectively. The statistics are averages for the period between 2011 and 2015.

Table 1—: Fuel Markets - Summary Statistics

	Federal District	State capitals (n=18)		
		q1	median	q3
Number of stations	302	118	170	277
Car Fleet/Number of stations	3535	1545	2007	2530
Number unbranded stations/Number of stations	0.19	0.17	0.23	0.35
Avg. tank size (m^3)	41	28	31	33
Avg. number of pumps	7.2	4.7	5.1	5.2
Avg number stations in 3km range	15.5	22.4	29.4	35.1
Avg. number of orders in a month*	7.4	4.3	4.9	6
Yearly gas sale per liter/Number of stations	364	155	173	196
Yearly ethanol sale per liter/Number of stations	27	18	32	50
Ethanol Sale/Gas Sale	0.07	0.1	0.15	0.23
Number of distributors buying at closest supply point	8.6	9.2	12.3	14.6
HHI at distribution - Gas Sales	2995	2002	2518	2757
HHI at distribution - Ethanol Sales	3345	2156	2450	3003

Notes: Average between 2011 to 2015. q1 and q3 are respective quartiles of the state capital's distribution. *Approximation using monthly total sale divide by number of stations times average tank size.

Compared to state capitals, the Federal District has relatively few stations per vehicle and these stations face a small number of competitors in a 3km radius. Throughout our sample, most of the gas stations in the Federal District are branded. However, the share of unbranded stations in the Federal District has increased over time and reached a similar level to the median share of unbranded stations of other state capitals. Stations in the Federal District are also larger than stations in other state capitals in terms of tank size and number of pumps. Even so, the former submit more purchase orders per month to fuel distributors, reflecting the relatively large demand for fuel in the Federal District and the

geographical sparseness between fuel stations.

On the upstream level, we have that the Federal District’s fuel distribution is more concentrated on sales than other state capitals. This is evident when we look for the average number of fuel distributors selling to stations or when we consider the HHI measuring concentration in the sales of gasoline or ethanol. Even so, the number of distributors buying gasoline at Petrobras’ supply point located in the Federal District is not significantly different from other markets.

The retail market in the Federal District is characterized by one large player, Cascol, and a number of smaller station owners. The first column in table 2 describes the stations owned by Cascol. The second and third columns describe respectively the unbranded and the branded fuel stations that are not owned by Cascol.

Cascol is a family-owned and long-established company that owned around 90 stations during the cartel (approximately 30% of all stations), 60 of them operate with an exclusive dealing contract (45 are with BR and 15 are with Ipiranga) and 30 are unbranded. Cascol accounts for approximately 27% of the sales of gasoline in the Federal District. Cascol’s high sales performance and small station size translate into a higher number of purchasing orders sent to distributors. The network size and the frequent interaction with distributors is one potential factor explaining its leadership role in the cartel, as we discuss more in appendix E. Excluding Cascol, the average station owner in the Federal District owns 3 stations.

At the distribution level, the Federal District is characterized by the dominance of the three large national players previously mentioned. Table 3 displays the market share of BR, Ipiranga and Raizen. While in most of the state capitals across the country BR, Ipiranga and Raizen have to compete with a significant number of smaller distributors, in the Federal District they account for 92% of the total sales of gasoline and 87% of the sales of ethanol between 2011 and 2015. They also account for virtually all exclusive dealing contracts in the market. Between

Table 2—: Federal District Fuel Retail - Summary Statistics

	Cascol	Branded	Unbranded
Total number of stations in a month	88 (1.7)	175 (2.9)	42 (1)
Share of total monthly sales (%)	27.4 (0.8)	59.3 (0.6)	13.3 (0.6)
Number of stations owned by a retail firm	88.3 (1.7)	1.5 (1.5)	1.6 (1.6)
Monthly gas sold per station (10^4 liter)	27.3 (17.6)	29.5 (17.4)	27.5 (17.8)
Tank size per station (10^4 liter)	3.4 (1.2)	4.4 (4)	4.3 (2.7)
Number of pumps per station	5.3 (3.9)	7.8 (3.6)	7.9 (4.5)
Number of opponents in a 1km range per station	3.9 (3.7)	4 (3.7)	4.1 (3.5)

Notes: Information is either an average across month or across station-month, between 2011 to 2015. Number in parenthesis is the respective standard deviation.

those three distributors, all have more than 20% of aggregate sales and all buy from the same Petrobra's supply point located inside the Federal District. Overall, their symmetry in size and cost, their multimarket contact and operational scale is indicative of larger incentives to cooperate with each other when compared with the characteristics of the retailers in the Federal District.

Table 3—: Federal District Fuel Distribution - Summary Statistics

	Exclusive Dealing Contracts (%)	Gas Sale (%)	Ethanol Sale (%)
Ipiranga	22.9	25.5	25.2
BR	54.4	48.5	44
Raizen	22.7	17.9	18.1
Total	100	92	87.3
State capitals	[79.2, 92.9]	[67.9, 81.6]	[55.6, 72.8]

Note: Average across months, from 2011 to 2015. State capitals' information inside brackets refer to the first and third quartile of the distribution.

We draw five important points from the market, retail and wholesale summary statistics about the FD: (i) the large demand and geographical sparseness imply much larger potential gains from collusion (ii) Cascol is a natural candidate for

being a leader in any retail price coordination; and its network size provide an unusual bargain position to negotiate with distributors (iii) stations not owned by Cascol have enough aggregate capacity to contest unilateral decisions from Cascol to raise prices; (iv) the number of unbranded stations in the market is not significantly smaller than other markets, which raises the possibility of fierce competition between distributors; (v) there are significant asymmetries between stations, mainly due to geographic location, network size, stations capacity and vertical contract differences.

Why in the Federal District?

[Garrod, Harrington and Olczak \(2020\)](#) points out two important market conditions that make a hub-and-spoke scheme attractive: (i) sufficient retailer bargaining power, and (ii) retailers that are viewed by consumers as fairly substitutable. On one hand, retailer's bargaining power limits the ability of upstream players to unilaterally increase wholesale prices and achieve the monopolist level. On the other hand, substitutability between retailers imply that competitive retail prices are far from the monopolist solution. If collusion is not sustainable without the hub, those two conditions create room for a joint increase in wholesale and retail prices.

We argue that the two conditions were present in the Federal District fuel market. Since consumers perceive gasoline as a fairly homogeneous product, even with some differentiation may exist due to geographical location, the substitutability between retailers is a natural characteristic in the fuel market. In terms of retail bargain, the presence of Cascol, a large retail group with exclusive dealing contracts with different distribution companies, could have create a challenge for distributors to unilaterally increase wholesale prices. Add to it the large potential demand for fuel, we conjecture that market conditions in the Federal District were more favorable to a hub-and-spoke arrangement than in other fuel markets across Brazil.

IV. The Performance of the Cartel

The communication between retailers and distributors captured by the police presents evidence that firms attempted to fix prices. But, it does not imply that firms succeeded to do so. In this section, we show that firms were able to coordinate on an uniform price and charge a significant overprice throughout the period between 2011 and 2015. We also show that both fuel stations and distributors benefited from the scheme.

To quantify the overprice caused by the cartel, we need to obtain a measure of markups for the counterfactual scenario in which collusion did not take place inside the Federal District. The difference between the markups observed during the collusive period and the counterfactual markups is the estimate of the overprice caused by the cartel. We draw from [Arkhangelsky et al. \(2021\)](#) and use the synthetic differences-in-differences approach (SDiD) to select a control group that is informative about what markups would have been in the absence of collusion. The SDiD is a data-driven selection procedure that aligns pre-exposure trends in the outcome of control units with trends for the treated units, and is especially suitable when there is a small number of treated units. In contrast with the synthetic control (SC) approach of [Abadie and Gardeazabal \(2003\)](#); [Abadie, Diamond and Hainmueller \(2011\)](#), SDiD does not need to perfectly match trends, being sufficient that it makes them parallel.²²

We consider the fuel market located inside state capitals as the potential control units, and choose weights that match the trend in supply chain’s Lerner index observed in the FD *after* the Feb 2016 intervention. We define supply chain markup as the retailer’s selling price minus the wholesaler’s buying price, and compute the Lerner index by dividing the markups by the retail price. Our implementation of the SDiD builds on two main assumptions. The first assumption is that, although markup levels can be different, the competitive conduct of firms

²²Our implementation at the statistical software R use the prebuild packages `synthdid` (<https://synth-inference.github.io/synthdid/>) and `Synth` (<http://CRAN.R-project.org/package=Synth>).

in the Federal District is similar to the competitive conduct in state capitals after the end of the cartel. The second assumption is that markups charged in state capitals are informative about the counterfactual markup that would take place in the Federal District in the absence of a cartel. We present more details on the synthetic diff-in-diff exercise, such as the actual weights and a comparison with other case study approaches in appendix B.

Figure 1 and table 4 summarize the results of the SDiD. Figure 1 is illustrative of the success of the cartel in charging above normal prices for gasoline sales. During the cartel years the average Lerner index in the Federal District's gasoline supply chain kept increasing and was on average 5 percentage points above the trend implied by the synthetic control. Considering that the average index in the synthetic control is 17% and that aggregate quantity follows a positive trend through all the period, we can conclude that the existence of the cartel had an economic significant impact on profits. Holding aggregate sales fixed, we calculate excessive gains in the order of \$574.5 million.

Moreover, we leverage on the fact that we observe wholesale prices to compute the effect of the cartel separately for the retail and the wholesale level. In table 4 we show using the same synthetic control that retailers were able to sustain a Lerner index 2.9 percentage points above the after-cartel trend, while distributors sustained a 2.6 p.p. higher index on average.²³ If we take into account that the average Lerner index for gasoline distribution is 5% and for retail is 14% across the country, then our result is evidence that the cartel generated an economically significant gain not only for fuel stations but also for distributors.

In addition to the effects of the cartel on price levels, we investigate the effect of the cartel on the dispersion of retail prices. Figure 2 displays weekly retail price dispersion for gasoline from 2011 to 2018. As the figure points out, the cartel was successful in eliminating dispersion in retail prices across the Federal

²³Retail markups were higher than the average of other capitals even before 2011. It is possible that some price coordination existed before 2011, but the police investigation only supports the existence of a fully operational cartel starting in 2011.

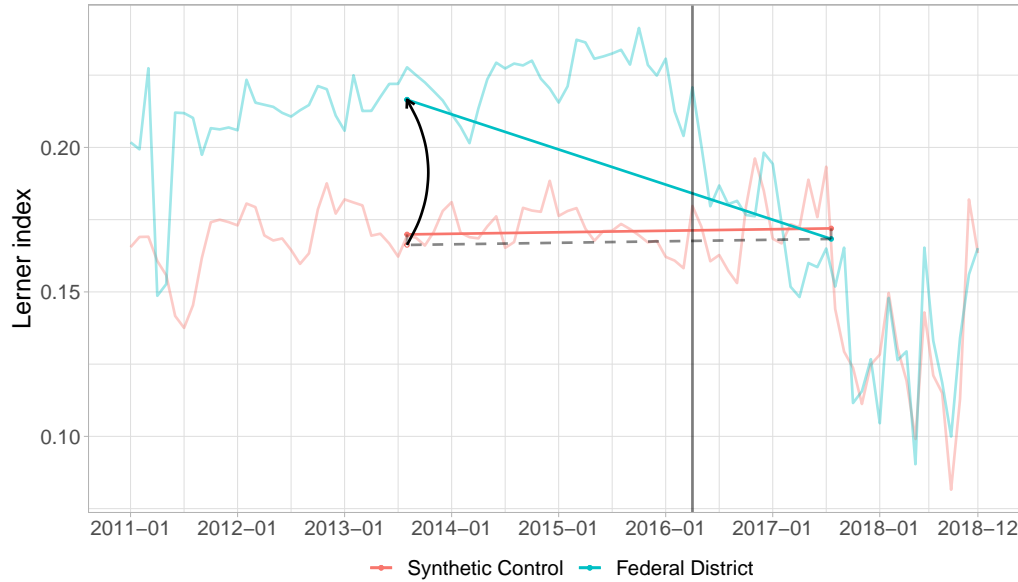


Figure 1. : Effect of the cartel on gasoline markups

Note: The vertical solid line refers to the month when the competition authority intervened in Cascol's management. Lerner index=(station's selling price - distributor's buying price)/station's selling price.

Table 4—: Effect of the Cartel on Markups - Decomposition

	Supply Chain	Retail	Wholesale
<i>Gasoline</i>			
Average Effect (Lerner Index - p.p.)	5.0	2.9	2.6
Placebo's standard error (Lerner index - p.p.)	1.8	1.1	0.9
Average Effect (Margin - 2015 US ¢/liter PPP)	9.5	5.7	3.8
Illegal gains (2015 million US \$ PPP)	551.4	328.1	223.3
<i>Ethanol</i>			
Average Effect (Lerner Index - p.p.)	4.7	1.1	4.0
Placebo's standard error (Lerner index - p.p.)	2.6	2.4	1.8
Average Effect (Margin - 2015 US ¢/liter PPP)	7.0	2.2	4.8
Illegal gains (2015 million US \$ PPP)	23.1	7.2	15.9

Note: Standard errors are computed using the placebo method discussed in [Arkhangelsky et al. \(2021\)](#).

District. Throughout the entire period that the police investigation documented explicit communication between cartel members, we have the standard deviation of retail prices below 2 cents. The small retail price dispersion lasts until March of 2016, which is when the regulator started the intervention in the fuel retail

market. After the intervention dispersion went up to 12 cents and start following the dispersion observed in the synthetic control.²⁴²⁵

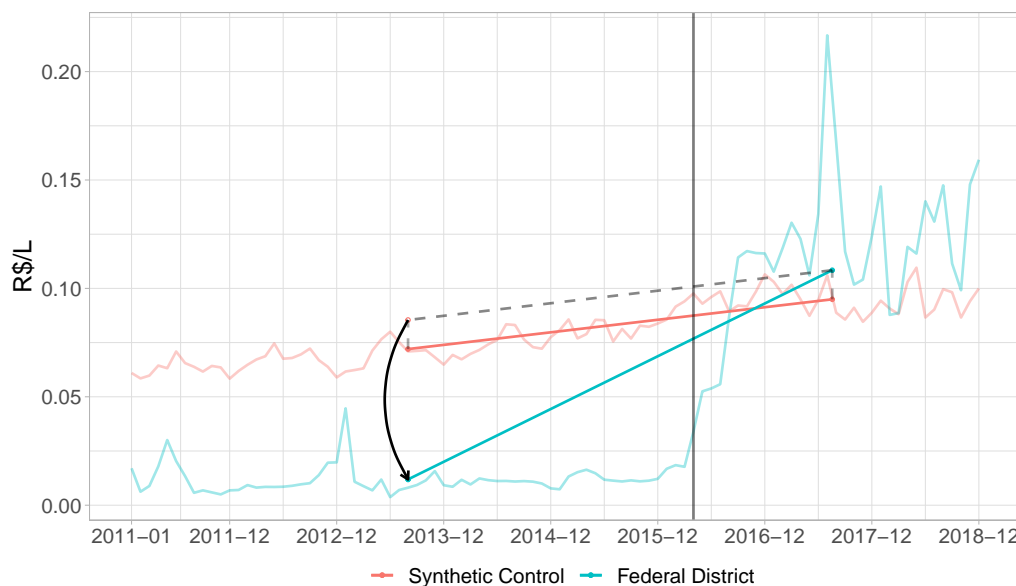


Figure 2. : Weekly Retail Gas Price Std. Dev.

Note: The vertical solid line refers to the month when the competition authority intervened in Cascol's management.

The overprice charged by the cartel, the ability to set uniform prices and the duration of the agreement show that stations solved the coordination and enforcement problems and were able to collude. Despite higher retail prices and the incentive to avoid double marginalization, the estimates also show that distributors benefited from the collusive agreement. Next, we rely on patterns in the data to argue about a possible mechanism that allowed the upstream firms to benefit from the hub-and-spoke scheme.

²⁴Clark and Houde (2013) also observe a gasoline cartel where members coordinate in a small number of retail prices.

²⁵We envision three main causes linked to the choice of a retail cartel for an uniform price strategy. The inability to control where consumers buy the product, the coordination costs involved in any more sophisticated price strategy specially when a large number of members are involved, and the benefits that a uniform price brings to monitoring compliance.

V. How does the hub benefit from the cartel?

The big three distributors (BR, Ipiranga, and Raizen) were able to extract part of the rents by charging higher wholesale prices during the scheme. Specially, during the years of 2014 and 2015 we observe a gradual and consistent growth of the gasoline supply chain markup's share appropriated by those distributors: it started from an average of 30% during the last quarter of 2013, and reached an average of 49% at the third quarter of 2015.²⁶²⁷ However, this increase in wholesale prices did not impact the dominant position in sales that the three distributors have during the cartel years, which kept steady around 92%. This phenomenon is puzzling when we consider that both large and small distributors buy gasoline from the same state-owned company which imply marginal costs that evolve in a similar fashion, and we observe the same small distributors charging lower prices in nearby markets outside the Federal District during the cartel periods which refutes the possibility of significant differences in cost.²⁸

In February of 2016, with the objective of terminating the illicit behavior, the Brazilian antitrust authority determined a legal intervention in the market. Even though the competition regulator did not directly intervene in the distribution level of the supply chain, we do see a significant change in the distributor's market share after the cartel broke.²⁹ From figure 3 we observe that the gasoline sales share of the big 3 distributors in the Federal District kept steady between 90% to 95% for most of period when the cartel was active. But, right after the intervention in February of 2016, this share plunges to as low as 80% at the end of 2017, and it stabilize around 85% in the subsequent months. Using our synthetic control weights and aggregate data at the state level, we are able to compare the

²⁶We define the share of the supply chain's markup appropriated by distributors as the ratio of wholesale markup over the supply chain markup, i.e., $(\text{wholesale price} - \text{refinery price})/(\text{retail price} - \text{refinery price})$.

²⁷In the plea bargain documents, gas station owners discussed the difficulties in passing to the retail price the small increases in the wholesale price charged by distributors, Appendix C quote 16.

²⁸During 2015, we observe the same small distributors charging prices up to 5% lower than the average wholesale price in the FD in close markets, such as GO-Goiania.

²⁹Judicial fines and arrests of distributor's sales representatives were determined only in August of 2018.

sales share from the big three distributors in the FD with their sales share in a synthetic state for a long period before and after the intervention. Although we do observe a negative trend, we don't observe a drop in shares with the same magnitude and timing in the synthetic control. Using the observed trend between periods where the market-share was most stable, we calculate an average effect of 5 percentage points on the big three's sales share in the FD due to the cartel.

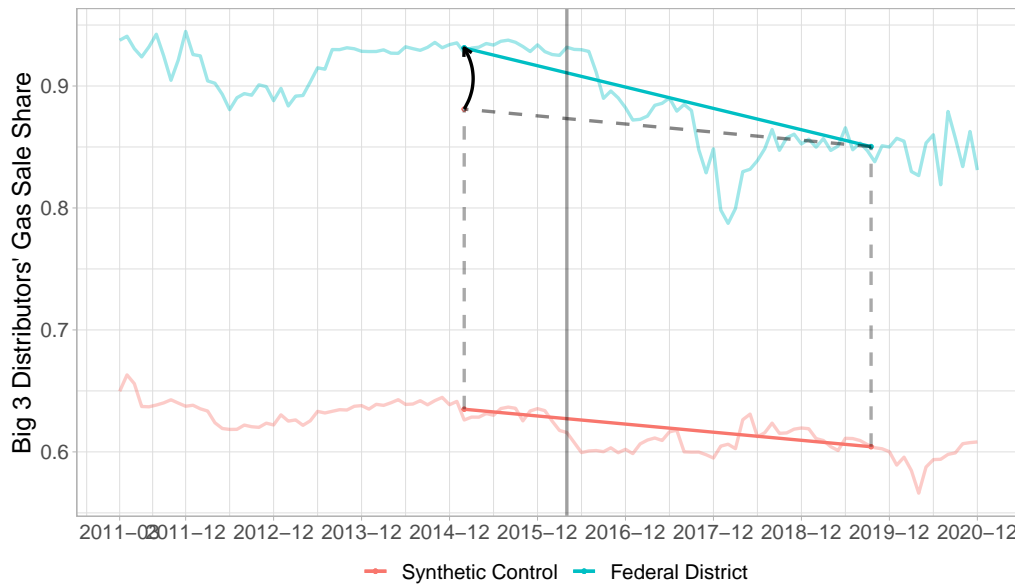


Figure 3. : Big 3 Distributors' Sales Share

Note: The vertical solid line refers to the month when the competition authority intervened in Cascol's management. Due to the lack of data at the state capital level after 2017, the market share for the synthetic control is construct using aggregate data at the state level. We show that a similar movement happened for shares at the state capital level until Dec-2017 in figure A3 at appendix A. Synthetic control weights are the same used in figure 2 and 1.

Using the data on quantity sold by distributors, we find that most of the reduction in gasoline sales share of the big 3 distributors is caused by an increase in sales of small incumbent distributors to incumbent gas stations, and not by the entry of new stations or distributors. Since the small distributors did not have exclusive dealing contracts with gas stations, almost the totality of this increase in sales by the smaller distributors is due to unbranded stations choosing to buy

from them.

The intervention also had an impact on the gasoline wholesale price difference between branded and unbranded stations. In table 5 we present the average difference in the FD for the period before, during and after collusion, and contrast it with what was charged in other markets. In markets across the country, stations without exclusive dealing contracts were able to search for better wholesale prices during the cartel period and have a cost advantage over branded stations. This fact was no different in the FD before the cartel, with the observed difference in wholesale prices inside the interquartile range. However, during the cartel period, this difference drops below the first quartile of the state capitals' distribution. It only start to be in line again with what we observe in other markets after the intervention from the competition authority.

Table 5—: Difference in wholesale price between Branded and Unbranded

	2007-2010	2011-2015	2016-2020
Federal District	-2.4	-0.2	-5.7
State capitals' median	-3.1	-3.9	-5.5
State capitals' 1st and 3rd quartile	[-4.4, -2.1]	[-5.7, -1.9]	[-7.5, -3.2]

Note: Numbers refer to the wholesale price difference in 2015 cents for the respective time period.

The gradual increase in wholesale prices, the reduction in market-share from the big 3 distributors after the intervention, and the inability of unbranded stations to search for better terms during the cartel raises the question of whether the upstream concentration was part of a coordinated equilibrium between retailers and the large distributors. Downstream players could be trading upstream exclusion for assistance with their collusive project. Although less recognized in the antitrust literature, this possibility can explain why in a large number of cartel cases we observe sophisticated buyers or sellers not actively working to dismantle cartel activities in another level of the supply chain.

We are not the first to raise the possibility of a exclusionary-collusive agreement

between firms in different levels of the supply chain. Another examples are discussed in [Asker and Hemphill \(2020\)](#) and [Garrod, Harrington and Olczak \(2020\)](#). In [Asker and Hemphill \(2020\)](#), sugar wholesalers from New York and New England at the end of the nineteen century approached a trust of sugar refineries with the proposal for the trust to help wholesalers to raise prices by building a minimum resale price maintenance scheme in exchange of exclusivity in sales for the trust. The agreement effectively excluded possible upstream rivals, such as import companies and domestic entrants. One example from [Garrod, Harrington and Olczak \(2020\)](#) is a hub-and-spoke arrangement discover in UK's desiccant industry, where a large producer, UOP, helped its four distributors to collude on higher retail prices by facilitating communication and giving price support during price wars. In exchange, UOP was able to charge higher wholesale prices and have exclusivity in the supply of desiccant for the four distributors.

[Asker and Bar-Isaac \(2014\)](#) rationalize this exclusionary coalition behavior. The authors discuss different vertical practices used by an incumbent wholesaler that can work as a transfer for retailers and increase their profits, e.g. resale price maintenance, slotting fees, and loyalty rebates. If those transfers significantly increase when the wholesaler enjoys a dominant upstream position, then retailers can internalize the effect of a new supplier on the incumbent profits and decide to exclude other wholesalers from the industry. Although [Asker and Bar-Isaac \(2014\)](#) refer to explicit vertical contracts, indirect actions from the distributors that help retailers sustain a collusive price can have similar effects. In a hub-and-spoke arrangement for example, those indirect actions can take the form of information sharing or helping punishing deviators. In the next section, we focus on one not yet study strategy used by wholesalers to help a collusion between retailers to succeed. We defer to appendix [E](#) for a detailed analysis of other horizontal and vertical strategies used by the Federal District's cartel.

VI. How does the hub help the cartel?

Current work on hub-and-spoke collusion points to information sharing as the main action taken by the hub to support collusion by the spokes (Sahuguet and Walckiers, 2017; Harrington, 2018). We provide evidence that the hub can take a more active role in the collusive agreement. Specifically, we show in our case that distributors pricing behavior is consistent with a hub smoothing cost fluctuations and reducing the need of spokes to coordinate price changes.³⁰

A distinct feature of the Brazilian fuel industry is the significant share of bifuel automobiles, i.e, vehicles that run on gasoline, ethanol or any combination of both. These vehicles account for half of the vehicle fleet in the Federal District.³¹ As a consequence, every gas station offers the two fuel alternatives and all distributors sell both ethanol and gasoline. Since ethanol has lower energy content, for the average consumer it is advantageous to choose ethanol instead of gasoline if their price ratio falls below 75% approximately. Moreover, as we point out in the industry description section, the price of ethanol at distilleries is more volatile compared to gasoline at refineries due to the natural seasonality from the sugar cane harvest period between May and August, and due to the predominance of small producers in the production stage.

A. No seasonality on gas price in FD

Because ethanol constitute 20% of the gasoline sold to consumers and because of the substitutability between ethanol and gasoline as fuel alternatives, we observe the seasonality on ethanol costs being transmitted onto the retail prices of gasoline for most fuel markets in Brazil.³² However, as can be seen in figure 4, when we compare the gasoline retail price charged in the FD with the retail price

³⁰In appendix F we discuss evidence that the hub also helped spokes sustain collusion through subsidies for local price wars.

³¹In January 2015, 47.3% of the vehicles registered in Brasilia were bifuel. We believe the figure is even higher if we consider only cars used for commute.

³²In appendix A table A3 we capture the seasonality of the retail gasoline price during ethanol harvest months using our data.

from a nearby market with similar tax and production cost structure, the lack of seasonality movements in the FD's gasoline price during the cartel periods is evident.³³ We confirm this pattern by computing the pass-through of ethanol distillery prices on the gasoline retail price for the Federal District and for state capitals in table A4 of appendix A

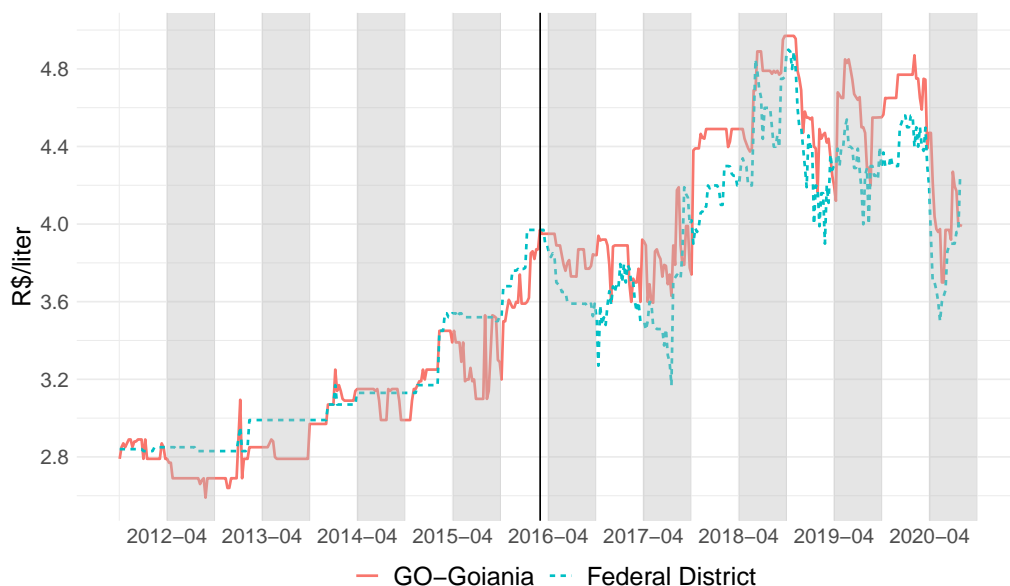


Figure 4. : Gasoline Retail Price Seasonality

Note: The vertical solid line refers to the month when the competition authority intervened in Cascol's management. Shaded regions refer to the sugar cane harvest period.

The documents indicate that gas station owners and distributors in the FD were actively trying to set the ethanol prices in a level that discouraged the consumption of ethanol. While it is not clear from the documents how this behavior would have helped the cartel, the investigation presents strong evidence that it indeed was happening. For example, one wiretapped phone call between Cascol managers and distributors' sales representatives shows Cascol helping distributors to share information on ethanol wholesale prices and directing one of them to set

³³GO-Goiania is the closest state capital from Brasilia, where the big 3 national players are also present and with similar fuel tax levels.

higher prices.³⁴

B. Killing ethanol

To investigate if distributors were smoothing seasonal shocks and setting price levels to discourage the consumption of ethanol, we focus on all the prices across the Federal District’s ethanol supply chain and compare them with the retail and wholesale prices in the same nearby market.

Figure 5 displays the evolution of the ethanol distillery, wholesale and retail price. The shaded bars highlight sugar-cane harvest periods. After the alleged time frame of the cartel, wholesale prices in both markets had similar responses to reductions in the distillery price. In contrast, during the time the cartel was operational reductions in the distillery price were not followed by reductions on the ethanol wholesale price in the Federal District. Because of this pricing pattern ethanol retail prices in the Federal District always stayed above the threshold of 75% of the gasoline price during the cartel time window, while in other markets and during years after the cartel dismantled we do observe periods of ethanol retail price below the 75% threshold.³⁵ This behavior had negative consequences for the total quantity of ethanol consumed in the Federal District.³⁶

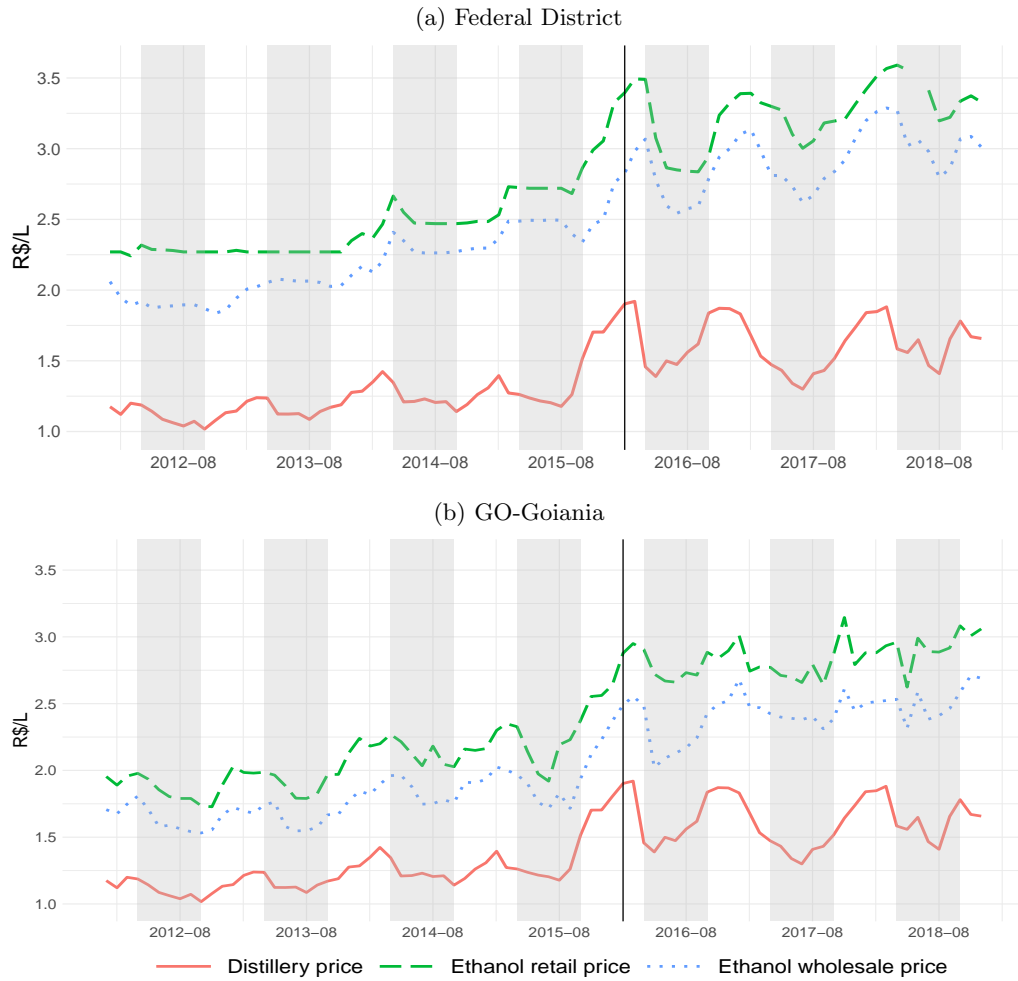
We extend the comparison of the ethanol prices in the Federal District to all other state capitals. To this end, we regress the week average ethanol wholesale price on the ethanol distillery price from one week before while allowing for different pass-through coefficient for the cartel period, for the Federal District, and for their interaction.³⁷ Table 6 displays the result of this regression. As the estimates indicate, on average, half of a distillery price shock passes through ethanol wholesale prices. Outside of the cartel period, the average pass-through

³⁴Quote 7. For another example, we refer to quote 8.

³⁵In appendix A figure A4 we present the comparison of the ethanol retail price and the 75% threshold of gasoline retail price

³⁶In appendix A table 1 we present the consumption per station of gasoline and ethanol in the FD and state capitals.

³⁷We refer to Miller, Osborne and Sheu (2017) as how to compute market-wide cost pass-through in imperfectly competitive markets.



Notes: The vertical solid line refers to the month when the competition authority intervened in Cascol's management. Shaded vertical bars refer to sugar-cane harvest periods

Figure 5. : Ethanol Cost Pass-through

in the Federal District is not statistically different than the average pass-through in other state capitals. However, the average pass-through decreases significantly for the Federal District during the cartel period. This decrease is not observed in the other state capitals. A Wald test for the sum of the coefficients fails to reject the hypothesis that during the cartel period, the average pass-through of distillery prices on the ethanol wholesale price in the Federal District is equal to

zero.

Table 6—: Ethanol Wholesale Price Pass-through

	Ethanol Wholesale Price
Distillery Price	0.510 (0.020)
Distillery Price \times FD	−0.053 (0.077)
Distillery Price \times Cartel period	−0.073 (0.008)
Distillery Price \times FD \times Cartel period	−0.568 (0.161)
Observations	6,043
Adjusted R^2	0.632

Notes: FD is a dummy for the Federal District market. Cartel period is a dummy for time between the years of 2012 and 2015. We control for market fixed-effects, demand characteristics (car fleet/population, percentage of bifuel vehicles), ethanol taxes (ICMS, PIS/COFINS) and a dummy for FD \times Cartel period. Standard errors are calculated using a Newey-West correction for autocorrelation within market with a maximum lag order of 4.

VII. Hub-and-Spoke Collusion under fluctuating costs

The documentary evidence and our statistical analysis point out the willingness of the big three distributors to absorb seasonal fluctuations of ethanol costs, increase ethanol wholesale prices up to a level that inhibit sales and, as a consequence, stabilize the wholesale prices faced by the spokes. The actions of the distributors are puzzling since they involve the opportunity cost of not adjusting wholesale prices according to the cost of ethanol, specially during the harvest months. In what follows, we rationalize distributors behavior with a simple model that captures the costs and benefits incurred by distributors. We point out that if knowledge of high costs in the future heavily constrain collusive prices due to incentive compatibility, then the cartel can actually increase average profits if it faces stable costs.

DOWNSTREAM COLLUSION WITH ALTERNATING PRICES: — Consider the simple setting with N symmetric retailers selling a homogeneous goods and competing on

retail prices p in an infinitely repeated game. Retailers face identical costs (wholesale prices) that can take only two values $\{w_L, w_H\}$, with $w_L \leq w_H$, and that evolve according to a deterministic alternating sequence. Retailers have time discount factor δ and can form a cartel by coordinating on a sequence of retail prices and by playing a grim trigger strategy with reversion to marginal cost. We assume a downward sloping demand curve, which implies that monopolist profits $\pi(p^m(w), w)$ are strictly decreasing and convex in the wholesale price. Finally, we abstract away from capacity or imperfect monitoring issues.

Similar to the standard textbook example, we can show that when firms face constant wholesale prices, i.e. $w_l = w_h$, then $\delta > (N - 1)/N$ guarantees that any price level above wholesale price is incentive compatible. We now focus on the case when $w_l < w_h$, and assume that retail firms coordinate on the efficient collusive equilibrium price, i.e. firms charge the monopolist price when the later is incentive compatible, otherwise they charge the maximum price that satisfy the incentive constraint.

It is easy to show that, if monopolist profits are decreasing on wholesale prices, then the incentive constraint during the low cost period always bind first.³⁸ Therefore, in a symmetric collusive equilibrium retailers always play the monopolist price during high cost periods. The incentive constraint (IC) faced by the cartel when setting prices during a low cost period is:

$$\frac{\pi(p_l, w_l)}{1 - \delta^2} + \delta \frac{\pi(p^m(w_h), w_h)}{1 - \delta^2} \geq N\pi(p_l, w_l)$$

Note that the time discount parameter can affect equilibrium stage profits through its effect on the incentive constraint. Let $V_{IC}^m(w_l, w_h, \delta)$ the cartel's discounted profits flow along the equilibrium path when the initial period is low cost. In proposition 1 we show that there exist a range of time discount factors where the cartel's profit flow is lower under the alternating wholesale price sequence compared to profits during a constant sequence with wholesale price as large as

³⁸INTUITION

the average cost:

PROPOSITION 1: *Let $\bar{w} = [0.5w_l + 0.5w_h, w_h]$. For given N and $\{w_h, w_l, \bar{w}\}$, $\exists! \hat{\delta} \in (\frac{N-1}{N}, 1)$ such that $\frac{\pi^m(\bar{w})}{1-\delta} > V_{IC}^m(w_l, w_h, \delta)$ if $\delta \in (\frac{N-1}{N}, \hat{\delta})$. In addition, $\hat{\delta}$ increases as $w_h - w_l$ increase while \bar{w} is hold fixed, and $\hat{\delta}$ is decreasing in \bar{w} .*

In figure 6 we present the intuition of the proof by plotting the incentive compatible profit function for two different values of δ . Note that, if firms are enough patient as in δ_1 , then fluctuating costs can increase average profits due to the convexity property of the profit function. This result is analogous to the results presented in Lemus and Luco (2020). In contrast, for small time discount factors such as δ_2 , profits during low cost periods must be constrained to satisfy incentive compatibility. This constraint can create enough concavity at the profit function that would make collusion to benefit from stable costs. Therefore, we can find a range of deltas $[(N-1)/N, \hat{\delta})$ where it is more profitable for a cartel playing the efficient strategy to face a constant wholesale price sequence than an alternating sequence.

HUB AND SPOKE COLLUSION WITH ALTERNATING COSTS — Now lets add an upstream segment to the game defined previously. The upstream segment is composed of two players, the distributor Hub and the distributor Fringe. Both distributors sell an homogeneous product to retailers downstream. Distributors' marginal cost evolves according to a deterministic alternating sequence $(c_H, c_L, c_H, c_L, \dots)$, with $c_L < c_H$, and players choose actions in each period according to the following order:

- 1) Distributors simultaneously choose wholesale prices;
- 2) After observing wholesale prices, gas stations simultaneously make buying decisions;
- 3) After observing buying decisions, gas stations simultaneously set retail prices.

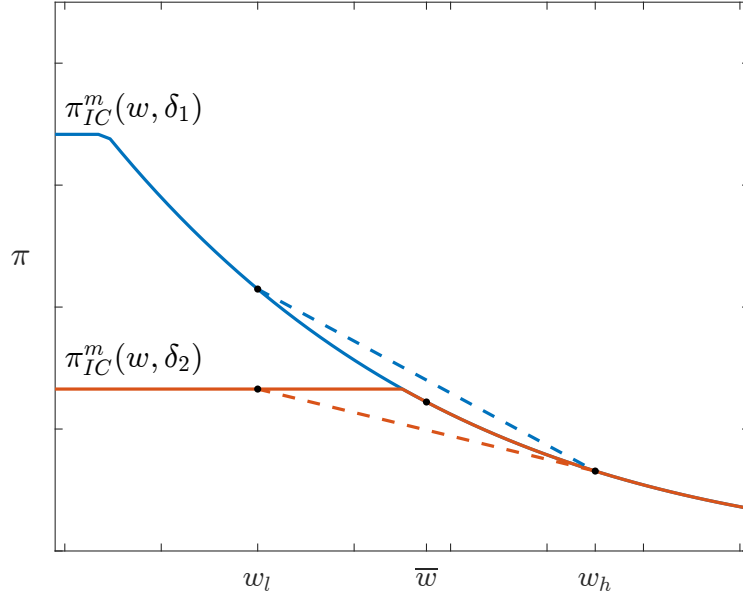


Figure 6. : Monopolist profits x Alternating costs

Note that, in this setting, the single period payoff if players play the Nash-Bertrand solution is zero for both retailers and distributors. If the strategy profile is such that retailers coordinate on the efficient collusive price while buying from the cheapest distributor, then equilibrium conditions are analogous to the ones discussed before, with wholesale prices perfectly reflecting the marginal cost sequence, i.e., $w_l = c_l$ and $w_h = c_h$. We call this collusive equilibrium a *retailers-only cartel*.

Now let's draw an equilibrium profile strategy with an upstream exclusion condition and constant wholesale prices. Retailers coordinate on the monopolist retail price, but also on only buying from the hub distributor. The hub distributor coordinates on charging retailers a constant wholesale price equal to $\hat{w} \geq 0.5c_l + 0.5c_h$. Cartel members keep playing in the equilibrium path while no deviation either on price or on buying decision is observed. The fringe distributor sets wholesale prices equal to marginal cost for every period. We call this collusive equilibrium the *vertical arrangement*.

In the *vertical arrangement* the hub distributor have no incentive to deviate since average profit is greater or equal to zero, and any deviation triggers an immediate response of retailers and led to zero profits. The incentive constraint of downstream firms in this case takes the form:

$$\frac{\pi(p^m(\hat{w}), \hat{w})}{1 - \delta} \geq \max\{N\pi(p^m(\hat{w}), \hat{w}), \pi^{BR}(\hat{w}, c_l)\}$$

where $\pi^{BR}(\hat{w}, c_l)$ is the profit of a retail firm that deviate on its buying decision, faces all other stations setting price equal to marginal cost during the pricing stage, and have cost advantage in the amount of $\hat{w} - c_l$. The range of time discount factors where retailers are better off under a *vertical arrangement* than into a *retailers-only cartel* is now $[\frac{N-a(\hat{c})}{N}, \hat{\delta}_{(c_l, c_h)}]$ where $a(\hat{c}) = \min\{N\pi(p^m(\hat{c}), \hat{c})/\pi^{BR}(\hat{c}, c_l), 1\}$.

A. Continuation argument for stable costs

We also envision arguments for stabilizing costs and avoid coordinating changes on the coordinated price because of the possibility of collusion disruption. First, cartels do not want to increase the competition authority's awareness of a possible collusive behavior. Since coordinating prices changes increase the need of more communication between members, as shown by [Clark and Houde \(2013\)](#) for another gasoline cartel, then adjusting collusive prices to fluctuating wholesale prices can increase the probability of getting caught.³⁹ Second, past papers have shown the importance of clear focal points for the stability of cartels ([Knittel and Stango, 2003](#); [Lewis, 2015](#)). However, the process of reestablishing a focal point after wholesale price changes can be costly, specially for the leader member, as members may disagree on what the new point should be. Third, even small delays by some members during coordinated price changes can imply significant horizontal transfers between players. Since deviations using delays could be harder to

³⁹In our case and in a large number of cartel litigations most of the legal evidence is collected from communications between members during price or quota adjustments.

detect compared to deviations from the agreed price level, frequent price changes by the cartel can create opportunities for members to free ride and destabilize the coordination.⁴⁰

Similar to [Harrington Jr \(2004\)](#), we can interpret the later arguments as a negative impact of coordinating price changes on the continuation probability of collusion. In appendix [H](#) we show how this interpretation affect the equilibrium conditions from the previous model and can create a subset of parameters where collusion may only be sustainable under a constant sequence of wholesale prices.

VIII. Conclusion

We use the documents produced by a police investigation and detailed data on the supply chain to study a hub-and-spoke cartel in the automotive fuel market in Brazil’s Federal District. We quantify the rents obtained by the cartel and characterize the strategies used by firms to solve the obstacles to collusion.

We show that fuel distributors (hub) helped to solve the coordination and enforcement problems faced by gas stations (spokes). We depart from current work on hub-and-spoke cartels ([Sahuguet and Walckiers, 2017](#); [Harrington, 2018](#); [Clark, Horstmann and Houde, 2020](#)) by showing that the role of the hub in the cartel is not restricted to being an information transmitter between spokes. As indicated in the documents and consistent with wholesale pricing patterns, the hub acted to reduce the frequency of price changes between the spokes. To this end, the hub smoothed the cost shocks faced by stations.

Our analysis suggests that firms behavior is consistent with gas stations trading upstream exclusion for assistance with their collusive project. This type of exclusionary agreement is of interest to academics and antitrust authorities. It depicts a vertical arrangement that hasn’t been completely understood and it provides a potential explanation of why sophisticated buyers or sellers do not actively work

⁴⁰For example, in [Clark and Houde \(2013\)](#) the authors quantify an increase of around 4% to 6% in sales from a price change delay of 80 to 240 minutes by some gas station groups that were members of a gasoline cartel in Canada.

to dismantle cartel activities in another level of the supply chain.

Our case is also illustrative on how hub-and-spoke schemes can interchange coordination costs between levels of the supply chain and leverage on differences in market structure. We can make a strong argument that the upstream hub formed by the three large national distributors had a slacker incentive constraint, compared to the small, asymmetric and crowded downstream level. The actions from the hub could have shifted part of the costs involved in the downstream coordination to a level of the supply chain that was better able to absorb it without triggering deviations. Since this difference in market structure between levels is also observed in other hub-and-spoke situations ([Harrington, 2018](#)), the overall evidence strongly support for it being a necessary condition for a hub-and-spoke scheme.

Finally, the case analysed opens up questions on how antitrust authorities can define the culpability for each part of the hub-and-spoke agreement and the penalties each should face. In our case, managers were arrested, and fines were imputed to distribution companies. However, the bulk of penalties were directed to the gas station owners. In contrast to information sharing, which empirical assessment of its relevance can be challenging, we presented a helping channel in a vertical collusion that is more accessible to quantification through a structural model of pricing and incentive constraints. If it can be shown that with the absence of at least one of those channels the cartel could not have survived, then a legal argument on the imputation of fines could lean heavily on the hub.

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TABLES AND GRAPHS

Table A1—: Fuel Markets' Prices and Markups

	2007-2010		2011-2015		2016-2018	
	State capitals	FD	State capitals	FD	State capitals	FD
Retail Gas Price	3.65 (3.58,3.72)	3.73	3.18 (3.12,3.21)	3.33	3.3 (3.24,3.4)	3.4
Wholesale Gas Price	3.19 (3.11,3.24)	3.23	2.76 (2.71,2.81)	2.83	2.93 (2.9,3)	3.05
Retail Ethanol Price	2.47 (2.33,2.56)	2.64	2.53 (2.32,2.67)	2.57	2.68 (2.42,2.82)	2.78
Wholesale Ethanol Price	2.10 (2.03,2.2)	2.09	2.22 (2.03,2.34)	2.28	2.31 (2.17,2.47)	2.45
Retail Gas Markup	0.13 (0.12,0.15)	0.16	0.13 (0.11,0.14)	0.14	0.11 (0.09,0.12)	0.10
Retail Ethanol Markup	0.14 (0.13,0.15)	0.20	0.12 (0.11,0.13)	0.12	0.12 (0.1,0.13)	0.11
Wholesale Gas Markup	0.04 (0.04,0.06)	0.06	0.05 (0.04,0.06)	0.08	0.05 (0.04,0.06)	0.05
Wholesale Ethanol Markup*	0.01 (-0.01,0.04)	-0.01	0.07 (0.04,0.09)	0.08	0.08 (0.05,0.11)	0.07

Table A2—: Cities' Summary Statistics

	Federal District	State capitals (n=18)		
		p10	median	p90
Population (millions)	2.75	0.53	1.17	3.93
Car fleet/Population	0.37	0.18	0.28	0.42
Population growth (%)	1.88	0.45	0.81	1.65
Car fleet growth (%)	5.54	3.34	4.91	6.49
Income (R\$ 2015-01)	4,312.75	2,035.56	2,552.07	3,182.75
Urban area (km sq)	626.50	134.68	284.94	888.06

Note: Statistics refer to the years between 2007 and 2018. In comparison with state capitals, the Federal District is marked by a large potential demand for fuel. This is the case when we consider variables that affect the level of demand (e.g. population, car fleet per-capita and income), or variables that account for demand growth (e.g population growth and car fleet growth).

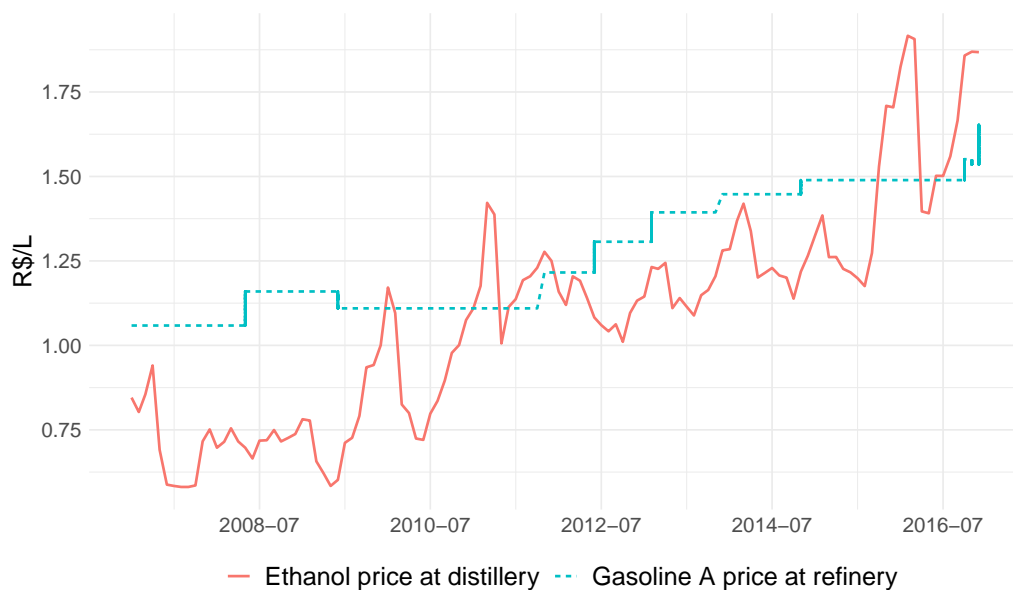


Figure A1. : Ethanol vs Gasoline Cost Volatility

Table A3—: Gasoline Retail Price Seasonality

Jan		Feb	Mar	Apr	May	Jun	Jul
3.308 (0.008)	+	0.003 (0.011)	-0.002 (0.011)	-0.028 (0.011)	-0.051 (0.011)	-0.076 (0.011)	-0.073 (0.011)

Jan		Aug	Sep	Oct	Nov	Dec
3.308 (0.008)	+	-0.06 (0.011)	-0.057 (0.011)	-0.028 (0.011)	-0.019 (0.011)	-0.016 (0.011)

Notes: Coefficients from a regression of the gasoline week average retail price (R\$2015-01 values) on dummies for months of the year, for observations during the period 2010-2019 in the FD and state capitals. The constant coefficient represents the average price in January. Months with negative and significant coefficients match with the ethanol harvest season months.

Table A4—: Gasoline Retail Price Pass-through

	(1)	(2)	(3)	(4)
ΔDP_t	0.139*** (0.032)	0.154* (0.076)	0.121*** (0.019)	0.268*** (0.084)
ΔDP_{t-1}	0.122*** (0.037)	0.055 (0.046)	0.100*** (0.025)	0.286*** (0.091)
ΔDP_{t-2}	0.116*** (0.037)	-0.069 (0.069)	0.0003 (0.039)	-0.219 (0.215)
ΔDP_{t-3}	0.056 (0.039)	0.012 (0.068)	0.113*** (0.035)	0.063 (0.116)
ΔDP_{t-4}	-0.055* (0.033)	0.005 (0.033)	-0.008 (0.026)	-0.412*** (0.118)
Market	State capitals	FD	State capitals	FD
Time Period	2012-2015	2012-2015	2016-2018	2016-2018
Observations	834	48	648	36

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors are calculated using a Newey-West correction for autocorrelation within market with a maximum lag order of 4.

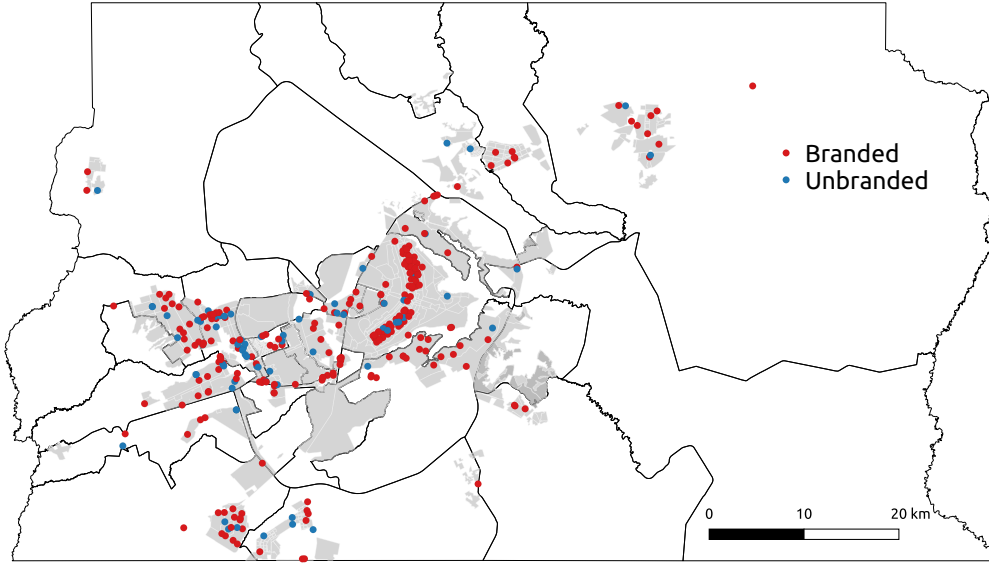


Figure A2. : Federal District Map

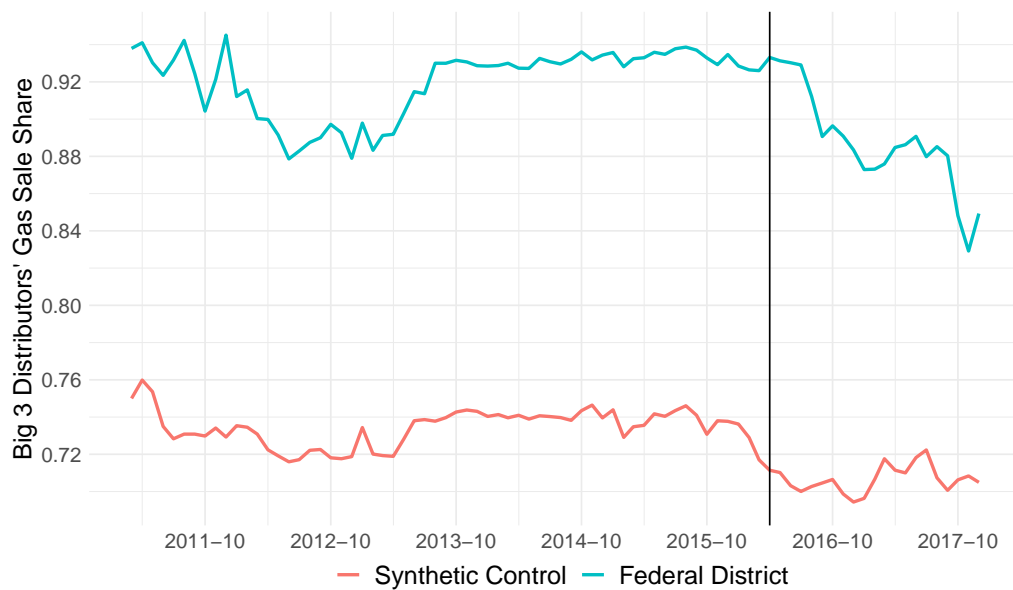


Figure A3. : Big 3 Distributors' Market Share Evolution

Note: Market share for the synthetic control is constructed using sales data at the state capital level.

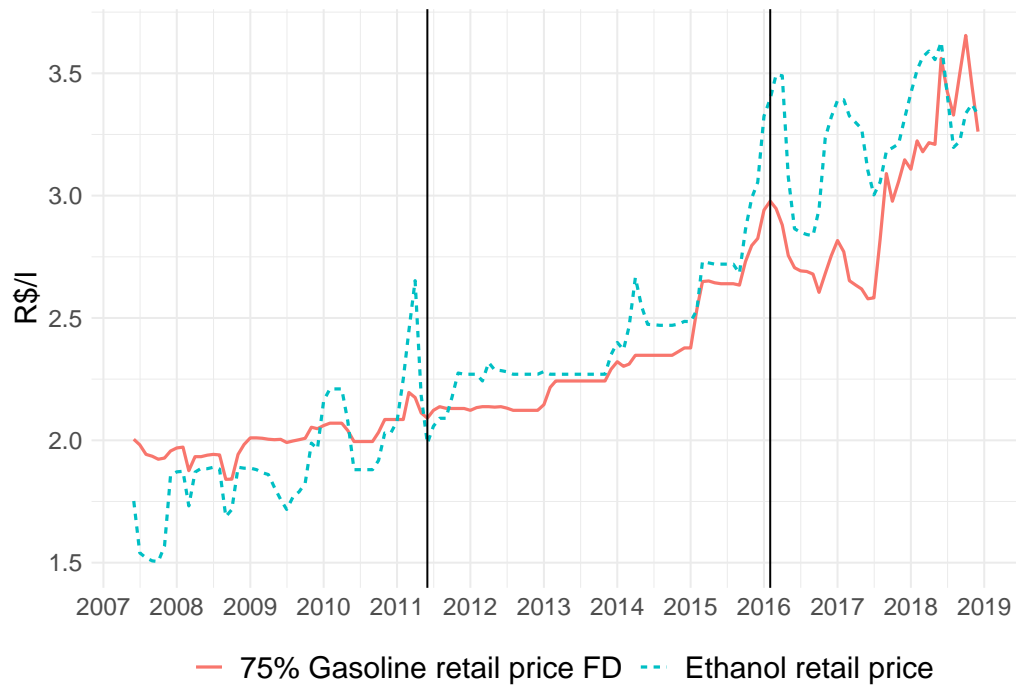


Figure A4. : Ethanol retail price vs 75% Gas retail price

Note: The 75% threshold should be understood as a rule-of-thumb for the fuel decision. The reference threshold can vary depending on engine performance, although it does not vary by much.

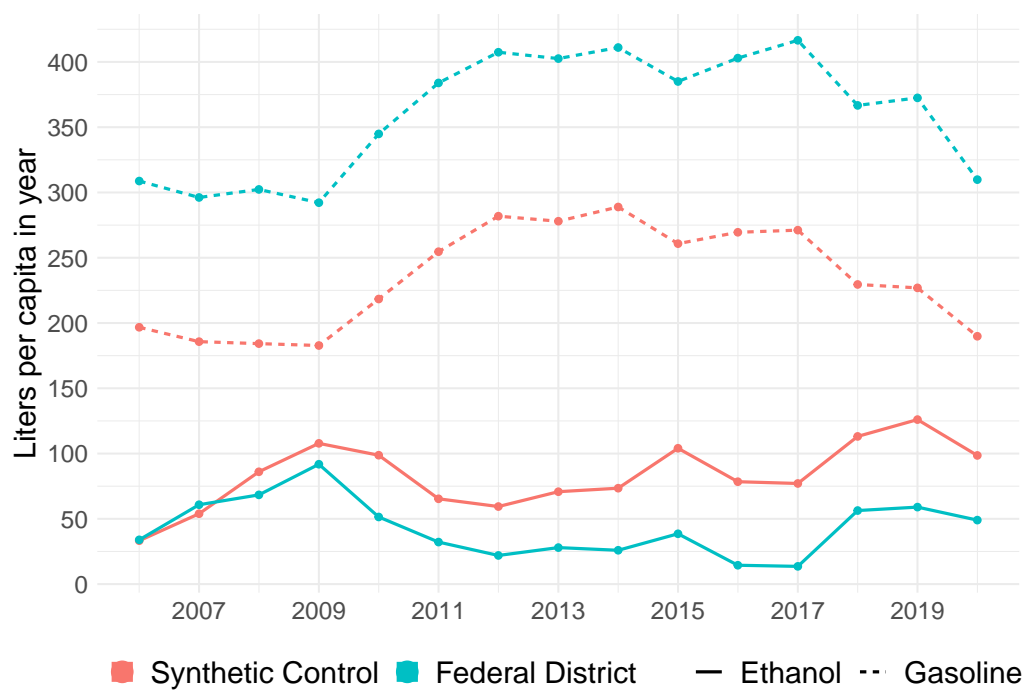


Figure A5. : Fuel Sales per capita

DATA

From ANP we obtained data on prices, stations characteristics and volume of fuel purchased by gas stations. Since July 2001, ANP runs a weekly survey covering 455 Brazilian municipalities that are representative of the country. In each municipality, ANP collects detailed price information from a random sample of stations while taking into account geographic coverage.⁴¹ The information collected includes the retail and wholesale prices of gasoline and ethanol, the name of the distributor that sold the respective fuel to the station, the brand affiliation (if any) and the address of the station.

The retail price information refers to the price observed by the interviewer during the survey, while the wholesale price refers to the unit price paid by the station for the last buying order sent to a distributor. The data on stations characteristics covers every station in the country. It includes measures of station capacity, like the size of the fuel tanks and the number of nozzles, and exclusive dealing contracts. For the distribution level, we obtained the list of distributors that operate in each state of the country as well as the monthly volume sold by each distributor in a given municipality. The data on monthly volume of fuel sold have two different levels of aggregation. For the Federal District, the data contains the monthly volume of each fuel that each station purchased from each distributor. For every other municipality, the monthly volume data is aggregated at the municipality level and thus contain the volume of each fuel sold by each distributor in every given municipality.

We complete our data by collecting information on the price distributors pay to producers. For gasoline, Petrobras makes available the location of every supply point in the country and the monthly average price it charged distributors in each point. For ethanol, we collect the monthly average ethanol price in distilleries from

⁴¹Since ANP execute a survey in each market, the identity of the stations that are surveyed may vary from week to week but eventually every station is surveyed. The sample coverage varies according to the size of the municipality. For large capitals, the sample covers between 10% and 25% of all gas stations. For small municipalities, the sample covers between 40% and 50% of all gas stations.

ESALQ. With these data, we have enough information to construct a reasonable measure of marginal cost for distributors.

To construct the sample used in our analysis, we keep the Federal District and the state capitals that are not located in Brazil's north region. We do so because with the Amazon jungle, the capitals of states located in Brazil's north region have an atypical fuel distribution when compared to the rest of the country. Our final sample covers the period from 2010 until 2018 and contains the Federal District and eighteen state capitals.

POLICE DOCUMENTS' QUOTES

Quote 1 - General Manager and owner of Cascol, plea bargain

"Even though the unbranded stations belonging to Jarjour, Alemão Canhedo and Marco Crioulo, paid a lower price for fuel, they were also part of the price fixing agreement. **As part of the agreement, they were able to set a price two cents below the price set by other stations.**"

Quote 2 - General Manager and owner of Cascol, plea bargain

"BR and Ipiranga goal during the 'price wars' was that the station that initiated the war couldn't sustain a price below the price set by the cartel members. This way, the station that initiated the war would have to realign their prices with the price set by cartel members and would not destabilize the agreement. Therefore, the high profitability of fuel distribution would not be affected. Fuel distributors did not give the station that initiated the price war the 10 cents discount they gave to other stations in order for them to face the 'price war'. That during 'price war' events, both BR and Ipiranga would subsidize retailers so they could force the 'rebel retailer' to raise prices again (...)."

...que já ocorreu de essas duas distribuidoras subsidiarem postos ao mesmo tempo, numa mesma área geográfica e no mesmo montante do valor de desconto

Quote 3 - General Manager and owner of Cascol, plea bargain

"(...) In the beginning of the price fixing arrangement all retailers met at the trade association; all retailers took part, but the leaders, the ones that were good doing the math - Cláudio Simm, José Carlos Ulhôa, people from Cascol management board, Marcelo Dorneles from JB - were the ones indicating the ideal price to be approved by all other retailers. In case of an unanimous decision, the price was set by all stations (...)" (affidavit 01, document 2017.01.1.024068-6).

Quote 4 - General Manager and owner of Cascol, plea bargain

"(...) After a while, the price fixing became automatic, with price changes happening when there was an increase in the price set by distributors, or a change in other external factors, like a change in taxes. During this period, there was no need for retailers to meet in order to fix prices, the price adjustments were made through phone calls or small meetings involving the cartel leaders - e.g. the meeting of the deponent with Cláudio Simm and José Carlos, or the contact exchange between Cláudio Simm and José Carlos - or when provoked other retailer. Usually, the message was transmitted by phone to other retailers in some sort of communication chain. Cascol employees were not part of the meetings in which prices were defined. Their only task was to spread the news, in other words, they were only messengers. This is so, that sometimes they even brought back price suggestions from other retailers (...)" (affidavit 01, 2017.01.1.024068-6).

Quote 5 - *Cascol employee, plea bargain*

“(...) small increases made by fuel distributors are not easy to be passed on the fuel pump, among the many reasons, one is that Gasol (Cascol) could increase their own price, but not necessarily the competitors would accept to do the same. For example, someone could not accept an increase of 2 cents and then generate a disequilibrium between retailers in the market between (...)” (affidavit 05, 2017.01.1.024070-8).

Quote 6 - *Police report referring to wiretap evidence*

“With the goal to impose barriers to competition, in particular the competition gasoline faces from ethanol, the defendant Cláudio Simm talked to a third party that the “cartel” was worried about how a state government plan to reduce the tax rate levied on ethanol would induce consumers to purchase ethanol and cannibalize gasoline sales. He told the third party that his concerns should reach the Federal District Secretary of Treasury.”

Quote 7 - *Police report referring to wiretap evidence*

According to the case files, in October 19th 2018, Antônio Matias (Cascol) talks to a BR employee about wholesale prices. Antônio Matias complains about the difference in wholesale prices set by BR and Ipiranga for both gasoline and ethanol. In this conversation, Antônio Matias states that he got in touch with Ipiranga and asked them to increase prices, allegedly to eliminate the aforementioned wholesale price difference.

Quote 8 - *Police report referring to wiretap evidence*

In a conversation with a local retailer, Márcio Barreiros, a BR employee under the supervision of the defendant Adão do Nascimento, when asked why BR was setting such high prices for ethanol, replied that BR set ethanol prices ‘following’ gasoline and that BR was not interested in selling ethanol.

Quote 9 - *Police report referring to wiretap evidence*

“(...) Considering that with the diffusion of bifuel cars, ethanol became a substitute to gasoline, it was necessary to control the price of ethanol to avoid consumers to substitute gasoline for ethanol. Apparently, the cartel alternative found by the cartel was to raise the price of ethanol to a point that it would not be worthwhile for consumers. The price of ethanol is detrimental to the cartel because of its variation throughout the year.” (Police report, 2183/2688, vols. 9 to 11, IPL 0889/2010).

Quote 10 - *Police report referring to seized document*

Regarding the prices suggested by Shell and documented in photographs, it should be registered that

in 02/02/2015, Raízen displayed to its stations a suggested price of R\$ 3,54. This price was the effective price implemented by the members of the criminal organization.

Quote 11 - *Wiretap - Dialogue between Station Owner (Rivanaldo) and Manager(Ricardo) regarding the motivations for starting a price war.*

Ricardo: Come on, aren't the other stations complaining?

Rivanaldo: They are, but I told them I need that price difference, right?

Ricardo: How much is it?

Rivanaldo: But they don't want, I only want 2 cents, just like Alemão had for a long time.

Ricardo: Two?

Rivanaldo: Yes, and they don't want, so I told those s... to f... off.

Quote 12 - *Police report referring to seized documents evidence*

Quanto ao Instituto Brasília Ambiental, o denunciado José Carlos Ulhôa Fonseca encaminhou e-mail, em 09/07/2014, às 16:51, ao denunciado Antônio José Matias de Sousa, informando-lhe ter adotado providências junto ao IBRAM, bem como perante administrações regionais, tendo por objetivo embaraçar a construção de determinado empreendimento imobiliário destinado à instalação de posto de combustíveis. Veja-se 62

Quote 13 - *General Manager and owner of Cascol, plea bargain*

Que a operacao de postos bandeira branca se justifica, primeiramente, como parametro de preco em relacao as distribuidoras, inclusive, durante a intervencao, pelo que o depoente tomou conhecimento, o interventor mudou um dos postos para bandeira branca para "pressionar" as companhias a vender mais barato.

Quote 14 - *General Manager and owner of Cascol, plea bargain*

Que o depoente afirma que, no Distrito Federal, ninguém ficava de fora do acordo de precos, mesmo a pessoa que tinha "apenas um postinho", porque, senao, se um revendedor baixasse o preco, a tendencia era que todos os demais diminuiriam, porque o vizinho desse posto reduziria seu preco, a tendencia era que todos os demais diminuiriam, porque o vizinho desse posto reduziria seu preco e o vizinho do vizinho tambem baixaria o preco, ate "dar a rodada do Distrito Federal", ou seja, ate alcancar todo o Distrito Federal

Quote 15 - *General Manager and owner of Cascol, plea bargain*

Que e do conhecimento generalizado dos revendedores o fato de que uma companhia nao entra na area da outra, ou seja, um revendedor de uma determinada bandeira nao consegue passar para outra bandeira, sendo necessario que, para trocar de bandeira, permaneca por um determinado tempo como bandeira branca.

Quote 16 - *General Manager and owner of Cascol, plea bargain*

Que e comum ao longo do mes, haver variacoes no preco praticado pela distribuidora. Que essas pequenas

variacoes, no entender do depoente, quando nao anunciadas pelo governo, ou nao sao devidamente justificadas pela companhia,..., nao podem ser repassadas ao consumidor, uma vez que nao tem uma justificativa para ser apresentada ao cliente, bem como a revenda de combustiveis e muito visada pelas autoridades publicas.

Quote 17 - *General Manager and owner of Cascol, plea bargain*

That the most interest in holding the collusive prices between retailers in the Federal District were the distribution firms, since the collusion generated high profits because retailers would pay for rent and fuel, and would not delay other payments due to the distributors.

Quote 18 - *General Manager and owner of Cascol, plea bargain*

Que a Petrobras, atualmente, esta pondo barreiras para vender combustivel para as pequenas distribuidoras, uma vez que as distribuidoras pequenas estao vendendo para os postos com diferenca de R\$0.15 a R\$0.20, por litro, a menos que a Petrobras, nao sendo dificil que, daqui a pouco, a BR nao queira vender para essas companhias, colocando, por exemplo, um preco mais alto para elas.

SYNTHETIC CONTROL

We use [Arkhangelsky et al. \(2021\)](#) synthetic differences in differences (SDiD) approach to evaluate the markup charged by during the cartel and what would have happen during the same period if there were no coordination. The method allows for a data-driven selection of the control group that aligns pre-exposure trends in the outcome of not treated units with those for the treated units, and is specially suitable when there is a small number of treated units. Moreover, different from the synthetic control (SC) approach of [Abadie and Gardeazabal \(2003\)](#) and [Abadie, Diamond and Hainmueller \(2011\)](#), SDiD is invariant to additive unit-level shifts.⁴²

The outcome of interest Y_{FD} is the federal district’s fuel supply chain markup, and we want to estimate the difference between potential outcomes $\tau_{FD,t} = Y_{FD,t}^C - Y_{FD,t}^B$ for months t between 01/2011 and 03/2016, where C stands for a collusive firm conduct and B for a competitive one. The main assumption for our comparative case exercise is that markup conditions from markets located in state capitals did not suffer a similar collusive environment and are informative about the unobserved competitive markup during the cartel period in the Federal District. The methods we use aim to find a selection of state capitals’ markets that are most informative about the Federal District’s market outcomes based on what we observed after the cartel broke, i.e., after 03/2016. Specifically, for a given month t , market i , and a set of weights $\{\hat{\omega}_i\}_{i=1}^N$ and $\{\hat{\lambda}_t\}_{t=1}^T$, we can write the average causal effect $\hat{\tau}_{FD}$ of the cartel on markups as:

$$(\hat{\tau}_{FD}, \hat{\mu}, \hat{\alpha}, \hat{\beta}) = \underset{\tau_{FD}, \mu, \alpha, \beta}{\operatorname{argmin}} \left\{ \sum_{i=1}^N \sum_{t=1}^T (Y_{i,t} - \mu - \alpha_i - \beta_t - D_{i,t} \tau_{FD})^2 \hat{\omega}_i \hat{\lambda}_t \right\}$$

where $D_{i,t}$ is a dummy variable with unit value for the Federal District during the cartel period, and μ , α and β are a constant, fixed effect for market and fixed

⁴²Our implementation at the statistical software R use the prebuild packages **synthdid** (<https://synth-inference.github.io/synthdid/>) and **Synth** (<http://CRAN.R-project.org/package=Synth>).

effect for month, respectively. The main difference between SDiD, SC and the standard Differences in Differences (DiD) approach is over the choice of weights. While DiD approach sets the same weight for all control units and time periods, SDiD and SC perform a data-driven choice of weights.

[Arkhangelsky et al. \(2021\)](#) propose to compute weights for SDiD and SC by roughly matching pre-treatment trends of exposed and unexposed units. This can be done by searching weights that minimize the squared difference between post-cartel markups in state capitals and in the Federal District. However, the SDiD differ from the SC by allowing for an intercept term on the minimization, i.e., weights on SDiD don't need to make pre-trends perfectly match but only to make them parallel. The SDiD and SC results we show below are computed using this approach.⁴³ Another possibility is to include predictors other than the outcome's pre-intervention values, as in [Abadie, Diamond and Hainmueller \(2011\)](#). Let X_{FD} a $k \times 1$ matrix with characteristics about the Federal District's fuel market that are potential predictors for the unobserved markups. This can include the markup in the post-cartel period 2016-2018, but also characteristics about the market structure such as distance between stations and the ratio of car fleet over the total number of stations. Let X_0 a $k \times 19$ matrix with the same characteristics but about the state capitals. For a given symmetric and positive semidefinite matrix V , we can solve for a vector of control unit's weights W^* that minimizes $\sqrt{(X_{FD} - X_0 W)^T V (X_{FD} - X_0 W)}$. We refer to this approach as SC-X.⁴⁴

⁴³We refer to [Arkhangelsky et al. \(2021\)](#) for the exact formula to compute weights.

⁴⁴We use [Abadie and Gardeazabal \(2003\)](#) data-driven procedure and choose a V that minimizes the mean squared prediction error of the outcome variable over the pre-intervention time period (post-cartel period). Let Z_{FD} the vector of markups for the Federal District during 2016 to 2018 and Z_0 the analogous for the state capitals, V^* minimize $(Z_1 - Z_0 W^*(V))^T (Z_1 - Z_0 W^*(V))$ across the set of positive definite diagonal matrices.

Table D1—: Average Causal Effect

	DiD	SC	SC-X	SDiD
Average Causal Effect (Lerner Index - p.p.)	4.2	4.6	4.8	5.0
Placebo's standard error (Lerner index - p.p.)	1.9	1.9	1.9	1.8
Average Causal Effect (Price - 2015 cents per liter)	16.3	17.6	18.3	19.2
Illegal gains (2015 million \$ PPP)	467.8	505.3	526.8	552.2

Table D2—: Weights

	DiD	SC	SC-X	SDiD
AL-MACEIO	0.056	0	0	0.041
BA-SALVADOR	0.056	0	0	0.055
CE-FORTALEZA	0.056	0	0	0.055
ES-VITORIA	0.056	0.126	0.520	0.065
GO-GOIANIA	0.056	0	0	0.056
MG-BELO HORIZONTE	0.056	0	0.278	0.063
MS-CAMPO GRANDE	0.056	0	0	0.041
MT-CUIABA	0.056	0.245	0	0.070
PB-JOAO PESSOA	0.056	0	0	0.046
PE-RECIFE	0.056	0.020	0	0.062
PI-TERESINA	0.056	0.163	0	0.061
PR-CURITIBA	0.056	0.066	0	0.065
RJ-RIO DE JANEIRO	0.056	0.380	0	0.069
RN-NATAL	0.056	0	0	0.039
RS-PORTO ALEGRE	0.056	0	0	0.046
SC-FLORIANOPOLIS	0.056	0	0.201	0.050
SE-ARACAJU	0.056	0	0	0.053
SP-SAO PAULO	0.056	0	0	0.061

Table D3—: SC-X Predictors' Balance

	Treated	Synthetic	Sample Mean
Car Fleet/Population	0.413	0.413	0.329
Car Fleet/Number of Stations	3,979	3,331	2,334
Median tank size	30	29.997	27.765
Avg. Number of Oppo (3km)	15.832	20.426	30.391
Percent bifuel cars	0.518	0.512	0.461
Markup post-cartel	0.154	0.155	0.151

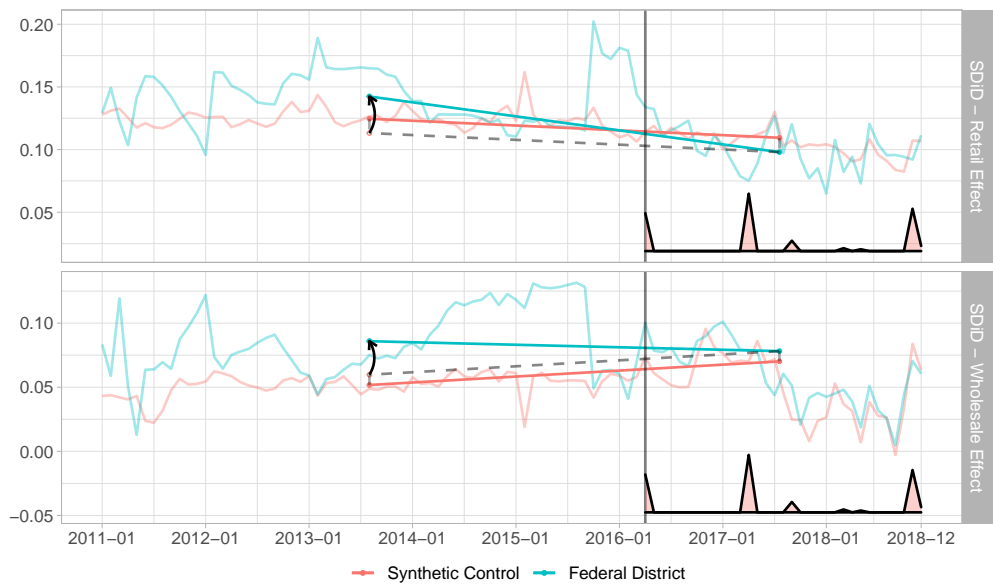


Figure D1. : Caption

HORIZONTAL STRATEGIES USED BY THE CARTEL

We build on the documents and the data to provide a detailed characterization of the strategies used by retailers to solve the coordination, enforcement and entry problems.

Leadership

According to the documents and the plea bargain deal, any change in the retail prices proceeded as follow:

- 1) The operations manager from the Cascol group was informed by distributors' sales representatives on any significant change in the next week wholesale price;
- 2) Based on this information, Cascol decided on the new retail price to be charged by its stations and other members of the cartel;⁴⁵
- 3) Before changing the price at the beginning of the next week, Cascol informed the new prices to the members of the cartel;
- 4) The other members were responsible for transmitting the information to stations in their vicinity. The new retail prices were posted on the beginning of the next week;
- 5) Cascol's employees drove around the city to make sure that the other stations were following the accorded price.

The modus operandi of the cartel indicates that Cascol is the responsible for coordinating price changes. The presence of a leader is important when we consider that heterogeneous retailers would have preferences for different collusive

⁴⁵Usually a few other members of the cartel were consulted by Cascol on what the next retail price should be. But it is clear from the documents that no decision on the retail price was made without the consent from Cascol managers.

prices. As such, Cascol acts to reduce the negotiation and bargaining costs between stations during the decisions of the focal point.⁴⁶ It also deal with most of the monitoring costs involved in the coordination, an aspect difficult to be incorporated by small network owners.⁴⁷ Even so, because of the large size of the market, Cascol relied on the help from geographically disperse members for the transmission and monitoring of information.

Horizontal transfers

Coordination among asymmetric firms requires them to implement implicit or explicit transfers between participants (Jacquemin and Slade, 1989). The mechanism used by the cartel members to implement implicit horizontal transfers is highlighted on the depositions. According to the cartel members, a group of retailers were allowed to charge 2 to 3 cents below the price proposed by Cascol.⁴⁸

Figure E1 captures the transfer mechanism used by stations to stabilize the cartel. The light bars display the distribution of retail prices minus the minimum retail price in the week, from 2011 to 2015. From the histogram, it is evident that most prices were chosen to be 2 to 3 cents above the minimum price in any given week. Figure E2 displays an analogous histogram, but considers the distribution of wholesale prices minus the minimum wholesale price in the week. Notice that both the spectrum and decay in frequency are different from the ones in figure E1. These patterns rule out cost explanations for the retail pricing patterns in figure E1.

Furthermore, we investigate if this pattern is in place after the antitrust authority intervened in the market. To this end, the dark bars displays the analogous distribution for prices during the years of 2016, 2017 and 2018. Notice that after the intervention, the distribution of retail price differences from the minimum

⁴⁶Byrne and De Roos (2019) show the importance of leadership in price coordination for a collusion in the Australian gasoline retail market.

⁴⁷Quotes 3 and 4 on appendix C exemplify the benefits of having Cascol as a leader.

⁴⁸Quote 1

does not have a peak on the value agreed by the cartel and have a much larger support.

Figure E1. : Difference of Gasoline Retail Price to Week Minimum Price

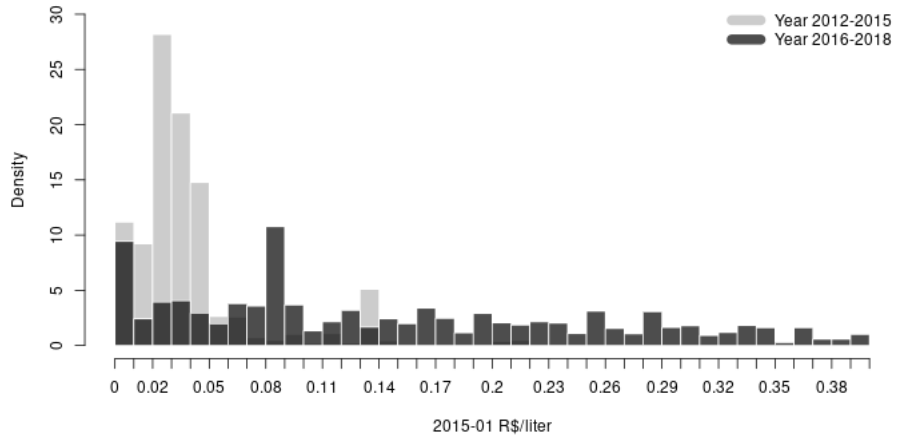
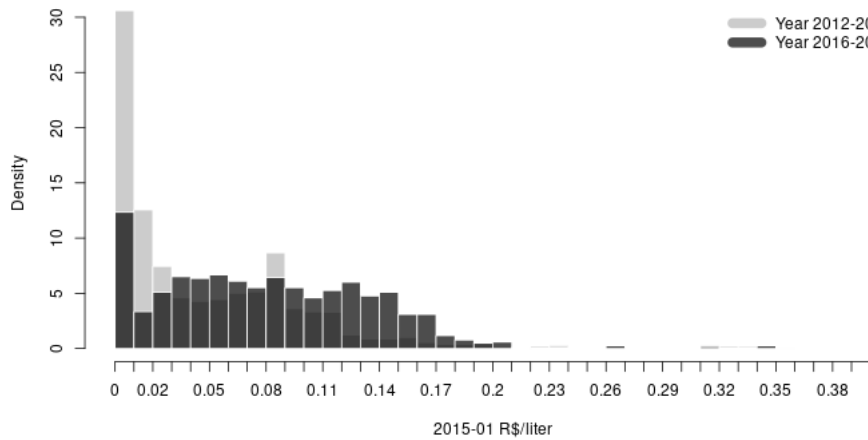


Figure E2. : Difference of Wholesale Price to Week Minimum Price



Motivated by the evidence presented in figure E1, we investigate the identity of the stations that were charging the minimum price in any given week. These chains are characterized by operating only unbranded stations or having business other than fuel sale as their main activity (car rental for example). Their distinct characteristics probably imply differences in marginal cost, and consequentially higher gains if deviating from the accorded price. As expected, we find that these stations belong to the chains cited in the depositions as the ones that were allowed to set retail prices below the one proposed by Cascol. Interestingly, this feature of the cartel in the Federal District is similar to the cartel studied in Clark and Houde (2013), where stations with business other than fuel sale (big-box retailers) also benefit from cartel’s transfers.

Political machinations and Entry

Table E1 displays the number of stations and the number of new entrants from 2007 to 2018. We observe a steady increase in the number of stations from 2007 until 2011. The entry rate declines in 2012 and there is almost no change in the number of stations until 2016. In 2017, after the cartel was dismantled, the number of stations starts to grow again.

Table E1—: Number of stations and entry in the Federal District

Year	2007	2008	2009	2010	2011	2012
Number of Stations	253	262	277	283	289	303
New stations from entrants	14	11	12	6	7	4
Car fleet per station	2,738	2,866	2,902	3,056	3,218	3,248
Year	2013	2014	2015	2016	2017	2018
Number of Stations	307	308	307	304	309	324
New stations from entrants	4	5	2	2	7	17
Car fleet per station	3,411	3,594	3,753	3,908	3,940	3,861

Notes: Number of stations refer to the total number of stations register as active in ANP during December of that year. A station is allocated to a group by its initial 8 digits of the cnpj, or when it has a group brand name as part of the register name. We define an entrant as a group that does not have stations in the FD during the previous year.

Despite the rents generated by the cartel, the entry patterns highlighted in

table E1 show that the period in which the cartel was operational is also the period in which almost no entry is observed. The conversations captured by the wiretaps, and the documents obtained by the police suggest one potential explanation for the entry patterns:⁴⁹ that incumbent retailers could have blocked the entry of new firms was by relying on political connections with members of the local government.⁵⁰

There are strict zoning laws regulating land use in the Federal District, specially in Brasilia, and the local government owns most of the current land that could be used to open new stations. On January 29th of 2015, the local government offered for sale a land tract located in the downtown area. The land tract was listed as an area proper for the installation of a gas station. On February 6th, two members of the cartel exchanged text messages regarding the sale of this land tract.⁵¹ During the text exchange, one of the cartel members told the other that he contacted the Governor in order to dissuade him from selling the land tract. According to the cartel member the Governor accepted the suggestion right away.

The conversations between the cartel members are hearsay and it is not a legal proof that the Governor was involved in any wrong doing. But, as a matter of fact the land was removed from the sales process without any justification. The documents also indicate that members of the cartel kept track of legislative bills that potentially impacted incumbent gas stations and had frequent meetings with aldermen. Moreover, information on political campaigns show Cascol as a large donor to local politicians.⁵²

⁴⁹Another explanation is the macroeconomic conditions at the time. Brazil entered into a recession in 2015, and we can observe a lower growth on the total number of gas station also in some state capitals.

⁵⁰Magnolfi and Roncoroni (2016) is an example on how political connections can affect market structure and perpetuate incumbents dominant position.

⁵¹Telephone Report number 16.

⁵²During the 2014 elections Cascol donated more than two hundred thousand reais to local politicians. This figure makes then one of the largest individual donors.

PRICE WARS SUBSIDIES

The conversations wiretapped by the police and the plea bargain signed by Cascol are clear when explaining how firms dealt with deviations from the agreed price. The cartel members proceeded in two steps. First they reached the station that deviated and tried to persuade it to come back to the agreement. If the conversations were not successful, then the members of the cartel started a punishing phase. Punishments were implemented by lowering the prices of stations located in the vicinity of the station that broke the agreement. Although it is not clear how frequent the occurrence of price wars was, the documents mention two occasions during the year of 2015.⁵³

Conversations between stations and distributors during the punishment phase are also documented by the police investigation. In the conversations, distributors offered wholesale price discounts to the gas stations involved in the price wars. The discounts were extended to everyone, except for the station that triggered the war. The discounts were of at most 10 cents per liter and were made to be fully passed to the retail price.⁵⁴ Furthermore, the discounts stopped as soon as the prices came back to “normal”.⁵⁵

The wholesale price discount given by distributors during the episodes of price wars provides a clear benefit to the stations. With the discount, stations are able to reduce retail prices while keeping markups unchanged. Hence, punishments are more credible and stations have less incentives to deviate from the agreement.⁵⁶

⁵³In one of the reported price wars, the wiretaps captured the motivations of the station that started the war, quote 11

⁵⁴In quote 2 on appendix C Cascol’s general manager described how the price war subsidies worked.

⁵⁵Since the price data comes from a survey of around 10% of the gas station population, it is hard to precisely capture a price war between stations.

⁵⁶In the Canadian sugar cartel described by [Asker and Hemphill \(2020\)](#) punishing defections were also made easier with the help from the hub.

PROOF OF PROPOSITION 1

Initial conditions

SET OF COLLUSIVE STRATEGY PROFILES FOR GIVEN $(N; w_l; w_h)$: — Symmetric grim-trigger strategy with Nash reversion with equilibrium path prices (p_l, p_h) s.t. $\pi_l \geq \pi_h \geq 0$.

EQUILIBRIUM CONDITION: — The incentive constraint during low cost of a SPNE is

$$(IC) \quad K(p, w) \equiv \frac{\pi_h}{\pi_l} \geq \left(N - \frac{1}{1 - \delta^2} \right) \left(\frac{1 - \delta^2}{\delta} \right) \equiv f(\delta, N)$$

$$\frac{\pi_l}{1 - \delta^2} + \delta \frac{\pi_h}{1 - \delta^2} \geq N \pi_l \iff$$

where $K(p, w)$ is a function of the wholesale prices and the retail prices played in the equilibrium path. Note that if $\delta \geq \sqrt{\frac{N-1}{N}}$ then any profile in the set is a SPNE. Moreover, if $\delta \geq \frac{N-1}{N}$, then any strategy profile in the subset where $\pi_l = \pi_h$ is a SPNE.

CLAIM 1: For given $N > 1$ and $K(p, w) \in (0, 1]$, $\exists \tilde{\delta} \in \left[\frac{N-1}{N}, \sqrt{\frac{N-1}{N}} \right]$ s.t. the IC is satisfy if and only if $\delta \geq \tilde{\delta}(N, K(p, w))$. In addition, $\frac{\partial \tilde{\delta}}{\partial N} > 0$ and $\frac{\partial \tilde{\delta}}{\partial K} < 0$.

PROOF:

From the IC, $\lim_{\delta \rightarrow \sqrt{N-1}/N} f(\delta, N) = 0$, $\lim_{\delta \rightarrow 0} f(\delta, N) = +\infty$, f continuous and strictly decreasing in δ , and $0 \leq K(p, w) \leq 1$. Therefore, a unique $\tilde{\delta} \leq \sqrt{\frac{N-1}{N}}$ that satisfy $K(p, w) = f(\tilde{\delta}, N)$ exist. We can solve for it:

$$(G1) \quad \tilde{\delta} = \frac{\sqrt{K^2 + 4N(N-1)} - K}{2N}$$

Using the implicity function theorem we can show:

$$\frac{\partial \tilde{\delta}}{\partial N} = \frac{(1 - \tilde{\delta}^2)\tilde{\delta}}{N\tilde{\delta}^2 + N - 1} > 0 \quad \text{and} \quad \frac{\partial \tilde{\delta}}{\partial K} = \frac{-\tilde{\delta}^2}{N\tilde{\delta}^2 + N - 1} < 0$$

Moreover, since $K(p, w) \leq 1$, $\lim_{K \rightarrow 1} \tilde{\delta} = \frac{N-1}{N}$ and $\frac{\partial \tilde{\delta}}{\partial K} < 0$, then $\tilde{\delta} \geq \frac{N-1}{N}$ for any $K \in [0, 1]$.

In other words, for given N and (w_l, w_h) , any strategy profile is a SPNE if its correspondent $\tilde{\delta}$ is such that $\delta > \tilde{\delta}$.

Retail profits result

Now, for a given triple $\{N, \delta, (w_l, w_h)\}$ s.t. $\delta \in [(N-1)/N, \sqrt{(N-1)/N})$, we can easily characterize the efficient equilibrium strategy profile: agents play the monopolist price during high cost periods, and the minimum between the monopolist price and the maximum price that satisfy the incentive constraint during low cost periods.⁵⁷ Profits (π_l^*, π_h^*) in this case are:

$$\pi_h^*(w_h) = \pi_h^m(w_h) \quad \pi_l^*(w_l, w_h, \delta) = \min\{\pi_l^m(w_l), \frac{\pi_h^m(w_h)}{f(\delta, N)}\}$$

To easy notation, let $\tilde{\delta}^m$ the critical $\tilde{\delta}$ evaluated at N and $K(\{p_l^m(w_l), p_h^m(w_h)\}, \{w_l, w_h\})$, and define $V_l^*(\delta) \equiv \frac{\pi_l^*(w_l, w_h, \delta)}{1-\delta^2} + \delta \frac{\pi_h^*(w_h)}{1-\delta^2}$ as the cartel profit flow starting from a low cost period in the equilibrium path with alternating wholesale prices.

CLAIM 2: Let $\bar{w} \in [0.5w_l + 0.5w_h, w_h)$. $\exists! \hat{\delta} \in ((N-1)/N, \tilde{\delta}^m)$ s.t. $\frac{\pi^m(\bar{w})}{1-\delta} > V_l^*(\delta)$ if $\delta \leq \hat{\delta}(\bar{w}, w_h, N)$. In addition, $\hat{\delta}$ increases as $w_h - w_l$ increase while \bar{w} is hold fixed, and $\hat{\delta}$ is decreasing in \bar{w} .

PROOF:

By claim 1, we know that $\delta \leq \tilde{\delta}^m \Rightarrow \pi_l^*(w_l, w_h, \delta) = \pi_h^m(w_h)/f(\delta, N)$. Hence, $F(\delta) \equiv \frac{\pi^m(\bar{w})}{1-\delta} - V_l^*(\delta) = \frac{\pi^m(\bar{w})}{1-\delta} - \frac{\pi^m(w_h)A(\delta, N)}{1-\delta}$ where $A(\delta, N) \equiv \frac{1}{1+\delta}(\frac{1}{f(\delta, N)} + \delta)$.

⁵⁷Efficient in the sense that maximizes the cartel's profit flow.

Note that:

$$\pi_l^* \left(w_l, w_h, \frac{N-1}{N} \right) = \pi^m(w_h) \Rightarrow \frac{\pi^m(\bar{w})}{1 - \frac{N-1}{N}} > \frac{\pi^m(w_h)}{1 - \frac{N-1}{N}} = V_l^* \left(\frac{N-1}{N} \right) \Rightarrow$$

$$F \left(\frac{N-1}{N} \right) > 0$$

$$\pi_l^* \left(w_l, w_h, \tilde{\delta}^m \right) = \pi^m(w_l) \Rightarrow \frac{\pi^m(\bar{w})}{1 - \tilde{\delta}^m} \leq \frac{\pi^m(0.5(w_l + w_h))}{1 - \tilde{\delta}^m} < \frac{0.5(\pi^m(w_h) + \pi^m(w_l))}{1 - \tilde{\delta}^m} < V_l^*(\tilde{\delta}^m) \Rightarrow$$

$$F(\tilde{\delta}^m) < 0$$

and F is continuous on δ . Hence, F has at least one root. Let $\hat{\delta}$ a root of F . Note that,

$$(G2) \quad \frac{dF(\delta)}{d\delta} = \frac{1}{(1-\delta)^2} (\pi^m(\bar{w}) - \pi^m(w_h)A(\delta, N)) - \frac{1}{1-\delta} \pi^m(w_h) \frac{\partial A(\delta, N)}{\partial \delta}$$

where $\frac{\partial A(\delta, N)}{\partial \delta} > 0$ for any $\delta \in (\frac{N-1}{N}, \tilde{\delta}^m)$. Since the first-element of (G2) is zero when evaluated at $\hat{\delta}$, then $\frac{dF(\hat{\delta})}{d\delta} < 0 \Rightarrow F$ has a single root.⁵⁸

We can implicitly solve for $\hat{\delta}(\bar{w}, w_h, N)$:

$$\hat{K}(\bar{w}, w_h) \equiv \frac{\pi^m(\bar{w})}{\pi^m(w_h)} = \frac{1}{(1+\hat{\delta})} \left(\frac{1}{f(N, \hat{\delta})} + \hat{\delta} \right) = \frac{\hat{\delta}}{1+\hat{\delta}} \left(\frac{N}{N - \frac{1}{1-\hat{\delta}^2}} \right)$$

and easily show that $\frac{\partial \hat{\delta}}{\partial \hat{K}} > 0$. Therefore, as $w_h - w_l$ increase while \bar{w} is hold fixed, \hat{K} increase and, consequentially, $\hat{\delta}$ increases; as \bar{w} increases, \hat{K} decrease, and $\hat{\delta}$ decrease.

⁵⁸If there where more than one, $\hat{\delta}$ and $\hat{\delta}'$, with $\frac{dF(\hat{\delta})}{d\delta} < 0$ and $\frac{dF(\hat{\delta}')}{d\delta} < 0$, then because F is continuous there must exist a third root such that $\frac{dF(\delta'')}{d\delta} > 0 \Rightarrow$

The hub-and-spoke arrangement

We extend the game as we described in the text.

Note that, as before all players have zero profits in the Nash Bertrand solution. In a retailers-only collusion, where retailers buy from the cheapest retailers, equilibrium conditions are as before if we substitute w for c .

Lets evaluate the vertical arrangement with stable wholesale prices defined in the text. From the initial period, any constant sequence of wholesale prices above $\frac{1}{1+\delta}(c_h + \delta c_l)$ imply a positive expected flow of profits for the Hub in any period. Therefore, any such arrangement is preferred for the hub than the Nash-Bertrand solution. At the retail level, the only difference from the previous conditions is in the incentive constraint when facing a constant sequence of wholesale prices $\bar{w} \in [\frac{1}{1+\delta}(c_h + \delta c_l), c_h]$:

$$\frac{\pi^m(\bar{w})}{1-\delta} \geq \max\{N\pi^m(\bar{w}), \pi^{BN}(\bar{w}, c_l)\}$$

where $\pi^{BN}(\bar{w}, c_l)$ is the gains from deviating on supplier, i.e. the profit in the Bertrand-Nash solution for a player with marginal cost advantage of $\bar{w} - c_l$. We assume that $\frac{\partial \pi^{BN}(\bar{w}, c_l)}{\partial \bar{w}} \geq 0$ and $\frac{\partial \pi^{BN}(\bar{w}, c_l)}{\partial c_l} < 0$. The incentive compatibility condition implies:

$$(G3) \quad \delta \geq \frac{N - a(\bar{w}, c_l)}{N} \quad \text{where } a(\bar{w}, c_l) = \min \left\{ \frac{N\pi^m(\bar{w})}{\pi^{BR}(\bar{w}, c_l)}, 1 \right\}$$

Note that the right-hand side of inequality 2 increases as \bar{w} increases. Therefore, the condition for the existence of an equilibrium with vertical arrangement is that $\hat{\delta}(\bar{w}, c_l, N) \geq (N - a(\bar{w}, c_l))/N$.

A COLLUSION MODEL WITH CONTINUATION PROBABILITY

For each period that firms collude there is a probability $1 - \sigma$ that the cartel is terminated. This termination probability reflects members' expectation on being caught by the competition authority or any possible future disagreements about the focal point. Based on the discussion from the previous section, we assume that the termination probability is higher if firms adjust prices from the previous to the present period, i.e., $\sigma(p_t, p_{t-1}) = \underline{\sigma}$ if $p_t \neq p_{t-1}$ and $\sigma(p_t, p_{t-1}) = 1$ otherwise, for $\underline{\sigma} < 1$. If the cartel is terminated, then agents must play the competitive outcome forever.

Under a symmetric subgame perfect equilibrium where cartel members play the price sequence $\{p_t\}_{t=0}^{\infty}$, a retailer's value function takes the form:

$$V(p_{t-1}, w_t) = Q(p_t)[p_t - w_t] + \delta\sigma(p_t, p_{t-1})V(p_t, w_{t+1}), \quad \text{subject to}$$

$$(IC) \quad Q(p_t)[p_t - w_t] + \delta\sigma(p_t, p_{t-1})V(p_t, w_{t+1}) \geq NQ(p_t)[p_t - w_t]$$

Lets focus on characterizing the steady-state collusive conditions when stations play an alternating retail price sequence $\{p_L, p_H\}$ with profits non-increasing on the wholesale price.⁵⁹ In the case of retail price changes, $p_L \neq p_H$, we can write the incentive constraint faced by retailers at the steady-state during a low cost period as:

$$\frac{Q(p_L)(p_L - w_L)}{1 - \underline{\delta}^2} + \frac{\underline{\delta}Q(p_H)(p_H - w_H)}{1 - \underline{\delta}^2} \geq Q(p_L)(p_L - w_L)N.$$

where $\underline{\delta} \equiv \delta\underline{\sigma}$. Note that, if $N \leq 1/[1 - \underline{\delta}^2]$ then any alternating retail price

⁵⁹One example would be retailers playing the monopolist price function. Note that if profits are decreasing in the wholesale price, then the IC always binds first under wholesale price w_L : $IC_L - IC_H = \frac{\delta}{(1-\delta^2)(N-1/(1-\delta^2))} \left(\frac{\pi_H}{\pi_L} - \frac{\pi_L}{\pi_H} \right)$. Hence, $w_H > w_L \Rightarrow IC_L < IC_H$

sequence satisfies the IC. In the case where the number of players is not small, $N > 1/[1 - \underline{\delta}^2]$, we can rewrite the IC condition under the low cost period as:

$$(H1) \quad \frac{Q(p_L)(p_L - w_L)}{Q(p_H)(p_H - w_H)} \leq \frac{\underline{\delta}}{(1 - \underline{\delta}^2)(N - \frac{1}{1 - \underline{\delta}^2})} \equiv \underline{\psi}_N.$$

We can write analogous conditions for an constant price policy $p_L = p_H = p^*$: if $N \leq 1/[1 - \delta^2]$, then any p^* satisfy the IC; if $N > 1/[1 - \delta^2]$, then a constant price policy p^* must satisfy:

$$(H2) \quad \frac{p^* - w_L}{p^* - w_H} \leq \frac{\delta}{(1 - \delta^2)(N - \frac{1}{1 - \delta^2})} \equiv \bar{\psi}_N.$$

Inequalities (H1) and (H2) make clear that the cartel is sustainable only if profits in the low wholesale price period are not too large compared to profits in the high period. If the difference is large, then the anticipation of lower profits in the future period creates enough incentive for cartel members to deviate during the high profit period and enjoy larger deviation gains.

The first point we make is that because of the discrete impact of price changes on the termination probability, we can have a situation where only constant price policies are incentive compatible. If the number of members is large and coordinating changes in the cartel price triggers a large enough increase in the termination probability such that $\underline{\psi}_N < 1$, then there is no alternating price sequence that satisfies the IC. But there can still be a constant price policy that is incentive compatible if $\bar{\psi}_N > 1$.

Assume that, because of the decrease in the continuation probability, the only possible option for the cartel is to charge the same retail price in every period.⁶⁰ In this case, the cartel is not able to adjust price levels according to the difference in deviation gains from one period to another, as in Rotemberg and Saloner (1986).

⁶⁰In reality, the cartel would wait for bigger changes in wholesale price that justify the payment of the coordinated price adjustment costs. We observe the cartel coordinating price changes after significant changes in tax or in the gasoline refinery price, but not for the seasonal changes in the ethanol price.

The second point we make is that if the difference in wholesale prices through time is large, then a collusive equilibrium may only exist for a cartel facing a constant sequence of wholesale prices. Specifically, let $\bar{p} > w_H$ the maximum uniform price level the cartel is able to coordinate on, and $R \equiv (\bar{p} - w_L)/(\bar{p} - w_H)$ the implied profit ratio.⁶¹ If $N \in [\frac{R+\bar{\theta}}{R(1-\bar{\theta}^2)}, \frac{1}{1-\delta}]$, then there is no constant price strategy that is incentive compatible, but any constant price level is incentive compatible under a constant sequence of wholesale prices.

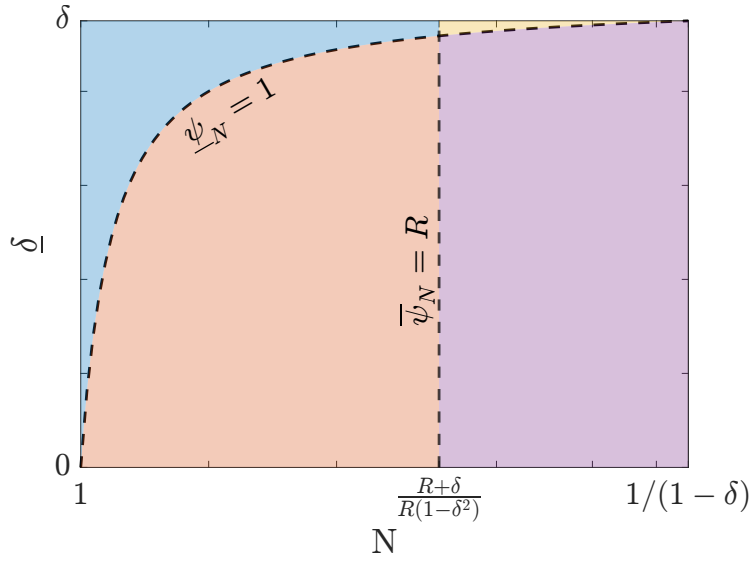


Figure H1. : Equilibrium conditions

For a given wholesale price sequence, in figure H1 we plot the equilibrium conditions for a grid of continuation probabilities(δ) and number of players (N). We focus on the region where $N \leq 1/(1 - \delta)$, i.e., any retail price sequence is incentive compatible if the cartel faces a constant wholesale price sequence. The area below the line representing the condition $\psi_N = 1$ contains all the (δ, N) pairs that implies alternating price sequence strategies are not incentive compatible.

⁶¹It can always be the case that the price level that the cartel can coordinate on is large enough such that the difference in wholesale price is irrelevant and the IC holds. In our discussion, we focus on situations that the set of possible prices the cartel can coordinate on is bounded above in a way that the difference in wholesale prices through time matters.

The area at the right of the $\bar{\psi}_N = 1$ condition contain the pairs that implies constant price strategies are not incentive compatible. Our conjecture is that the market conditions of the gasoline cartel in the Federal District place it in the intersection of those two areas (purple area). At this intersection, a wholesaler able to absorb part of the fluctuations in cost can negotiate with the retail cartel and smooth wholesale price fluctuations in exchange of part of the rents.