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Competition and Coordination in the Mexican Retail Market for Gasoline*

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Abstract: We document the following stylized facts for the Mexican retail market for gasoline using data for 2018-2019: (1) consumer prices adjust slower than wholesale prices; (2) more competition, in the form of a higher density of stations, implies lower markups and lower prices; and (3) more competition implies faster pass-through. However, we find geographical differences in the speed of pass-through that cannot be explained by differences in station density. We conjecture that coordination on high prices could be offsetting competitive pressure in some locations. We build a classifier that separates municipalities into two categories depending on whether the relative price concentration is on "high" prices or "low" prices. In the first type of municipalities, the price concentration is correlated positively with the price level and negatively with pass-through. For concentration in "low" prices the signs of the correlations are reversed.
Keywords: Gasoline, Pass-through, Geographic Competition, Price Coordination
JEL Classification: L4, L5, L13, D4, H25

Resumen: Se documentan los siguientes tres hechos estilizados en el mercado al por menor de gasolinas en México durante 2018-2019: (1) los precios al consumidor se ajustan más lento que los precios de mayoreo, (2) más competencia, medida como densidad geográfica de gasolineras, implica menores precios y márgenes, y (3) más competencia implica un traspaso de costos a precios más rápido. Sin embargo, a nivel regional se encuentran diferencias en la velocidad de traspaso que no se explican por la densidad de gasolineras. Conjeturamos que en algunas localidades una coordinación en precios altos podría estar contrarrestando la presión competitiva. Clasificamos a los municipios en categorías de concentración en precios "altos" o "bajos". En el primer tipo de municipios la concentración de precios está correlacionada positivamente con el nivel de precios y negativamente con el traspaso. Para concentración en precios "bajos", los signos de las correlaciones se revierten.
Palabras Clave: Gasolina, Traspaso, Competencia Geográfica, Coordinación de Precios

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1. Introduction

In this paper we study competition and coordination in prices in the Mexican retail market for gasoline. In particular, we study the degree to which spatial competition influences the price setting of firms. After controlling for demand and supply factors, relatively lower or higher levels of markups depend on how many neighboring stations there are in a particular location. Moreover, the number of neighboring stations also affects the speed with which firms adjust their markups when unit costs shift. Since gasoline is a global commodity, international wholesale prices are always fluctuating, and so it is important to understand how competition influences price adjustment in a world with volatile unit costs.[1]

The first main contribution of the paper is to establish standard stylized facts about price competition in the retail gasoline market that have been documented in the academic literature for other countries.[2] The presence of price competition is good news for a market where historically before 2017 prices were either fixed or subject to a maximum price chosen by the central authority,[3] and therefore firms had been setting their own prices for less than one year. In addition to documenting these stylized facts for a country where prices were recently liberalized, part of the contribution to the literature is the use of detailed and disaggregated data which makes the results robust and follows what the literature seems to support as best practices. Indeed, the use of daily station level prices is key for the correct identification of the stylized facts as discussed below. The disaggregation of our data permits us to run the same analysis grouping stations at the regional level, where in contrast to our national level results, we find some recurrent violations of the stylized facts in certain regions. We find suggestive evidence of price coordination overriding market competition. In this sense, a second main contribution of the paper is to develop a method to try to disentangle price coordination to keep prices at high levels from price concentration due to competitive pressures.

[1] We focus on regular gasoline. The average share of regular gasoline of total fuel consumption in Mexico was 85% in 2018.
[2] There is a very extense literature on empirical studies of gasoline retailing which is summarized in Eckert (2013). The stylized facts we document fall into the literature focused in price competition and pricing dynamics.
[3] The authority responsible was the Ministry of Finance, SHCP (Secretaría de Hacienda y Crédito Público). The administration that took office at the end of 2018 committed to keep retail prices below the level of November 30, 2018 in real terms.

In short, using daily station-level price data that allows us to control for possible confounding factors, we find evidence of the following stylized facts:

1) Rockets and Feathers: Retail prices adjust slowly after a drop in wholesale prices generating an increase in markups during the period of downward adjustment of wholesale prices. After increases in wholesale prices, retail prices adjust (almost) immediately, in such a way that markups remain stable.
2) Competition in price levels: Higher intensity of market competition reflects on lower markups and lower prices.[4]
3) Competition in pass-through: After a decrease in the wholesale price, the retail price decreases faster the more competition a gas station faces.

Regarding our first stylized fact and in relation to the literature, there is a considerable number of papers that test for the existence of *rockets and feathers* (pass-through of wholesale price changes into retail prices is faster for increases than for decreases). Bacon (1991) first documented this finding for the UK market. Borenstein et al. (1997) further documented that this behavior is present along the entire chain of gasoline production in the US, from crude oil price to refineries, wholesale and retail prices. While there has been some dispute on the existence of rockets and feathers,[5] the literature has settled in the need to use disaggregated and high-frequency data to be able to understand the responses of retail prices to changes in wholesale prices.

However, few papers make use of daily price data across different regions. Two of these papers (Chesnes (2016) and Remer (2015)) have used disaggregated and high-frequency data across several US cities and markets. They have clearly documented the existence of the

[4] We define the markup as the difference between the price payed by the consumer at the pump minus the price registered in the nearest Petróleos Mexicanos (Pemex) terminal (Terminal de Almacenamiento y Reparto, TAR) in terms of geodesic distance. This terminal price serves as the best publicly available approximation to the wholesale price payed by each gas station. In order to calculate the markup for each station, we assume that each station buys gasoline to the nearest TAR, considering geodesic distance. It could be the case, however, that a particular gas station has a supplier distinct from Pemex. Our gross measure does not separate the logistics costs from the TAR to the station, neither possible discounts that stations may receive for the fuel acquired or for the logistics. Neither the discounts nor transportation costs are public information.

[5] For example, Bachmeier and Griffin (2003) do not find evidence in favor of asymmetric pass-through and question the methodology followed by Borenstein et al. (1997). They propose the use of daily data, instead of bi-weekly or monthly data and show that this may lead to different conclusions. Other authors (Balaguer and Ripollés (2012), Godby et al. (2000), and Chen et al. (2005)) do not find evidence in favor of asymmetry. Remer (2015) exposes that some other reasons for the disparity of results are that the different studies use data covering only specific geographic regions, use low-frequency data, or use very aggregated data at the state or city-level.

rockets and feathers pattern, mainly in the wholesale-to-retail part of the chain. In particular, Remer (2015) uses daily station-level data and includes two different sources of wholesale prices which are the NY and LA harbors. Understanding the necessity and advantages of high-quality data, in this paper we collected every day the prices for the whole population of stations registered in Mexico, obtained from the regulator's webpage. Furthermore, not only do we include high-frequency station-level data for retail prices, but also conduct our analysis using daily wholesale prices for the existent 76 distribution terminals (TAR) owned by the state company Petróleos Mexicanos (Pemex).[6] This allows us to exploit the distinct local markets characteristics throughout the country by using prices that reflect more accurately the market dynamics of a particular region. A further difference between our paper and Remer (2015) is that he does not focus on the effect of competition on the speed of pass-through, but rather gives interesting and convincing evidence that the rockets and feathers pattern in pass-through is a result of consumer search behavior. [7]

Regarding the effect of competition on prices (stylized facts 2 and 3), the literature is more limited. In particular, Deltas (2008) uses 14 years of state average prices in the US and finds an association between higher average markups and a higher degree of asymmetry in pass-through. Following the same line but with more disaggregated data (at the station level), Verlinda (2008) shows that the degree of asymmetry is related to variables that in turn are indicative of market power, such as brand or geographic isolation.[8] In that sense, Verlinda (2008) is the first to document the stylized fact about competition in pass-through and is the paper most resembling of our analysis of competition, although only using hand collected data of weekly gas station prices in Southern California from September, 2002 to May, 2003 and therefore not having variation in the wholesale distributors across locations.

[6] Chesnes (2016) also addresses some of these concerns and uses daily price data for a long period of time although aggregated to city-level; he finds evidence of asymmetry in all the supply chain. In a regional analysis, Blair et al. (2017) also confirm asymmetric pass-through in the short and long run studying different PADDS across de US (Petroleum Administration for Defense Districts Source). Other authors have also found evidence of this pattern in several markets across Europe, Australia, Canada and Chile, to mention a few. Peltzman (2000) does not limit to the gasoline market but studies more than 200 products and finds a common asymmetric pattern in the majority, although he emphasizes that there is not a clear theoretical explanation of why this behavior emerges in the first place.

[7] Other interesting studies of the retail gasoline market are Houde (2012), who uses detailed price and quantity data of stations in Quebec, and estimates a structural demand model which incorporates the commuting paths of people as the location of gasoline consumers; and Hastings (2004), who studies a sample of stations in San Diego and Los Angeles and shows how a decrease in the share of independent stations increases average prices.

[8] Loy et al. (2018) analyze around 300 stations in Austria and suggest that competition is less intense in isolated regions, and this in turn is associated with a reduction in the speed of pass-through.

As a final note on this extense literature and the contributions of our paper, the most related previously-mentioned studies (Remer (2015), Verlinda (2008), Deltas (2008), Chesnes (2016)) rely on the error correction model proposed by Engle and Granger (1987) to test for asymmetric pass-through. In this paper the main specifications rely on a causal OLS framework where we estimate the effects of spatial competition (number of given neighboring stations in a given radius) on average markups controlling for station fixed effects and observe the behavior during the periods of wholesale price increases and decreases.[9] We believe this method lets the data speak for itself and is quite transparent about the behavior of the variables of interest. It is possible for us to perform such estimations because we have detailed daily station data and detailed wholesale (rack) daily prices and locations, combined with a particular feature of the wholesale price data which is that we observe a relatively long period (of months) during which wholesale prices increase or decrease monotonically.[10,11] Nonetheless, in the Appendix we include an exercise that relies on the error correction model proposed by Engle and Granger (1987) to test for asymmetric pass-through.[12] We also perform the extension of the error correction model of Verlinda (2008), to document competition in pass-through. The evidence of both models points in the same direction and is complementary.

After we show that competitive pressure on prices from nearby stations exists and leads to lower prices and relatively faster pass-through in denser station areas, we look at the prices and markups behavior at a regional level (Center, Center-North, South and North).[13] We find evidence of heterogeneity regarding the three stylized facts. In particular, while we document

[9] Another specification controls for station specific observable characteristics (that include supply and demand factors) and specific costs depending on geographic location.

[10] Furthermore, the main feature of the ECM models is to capture a long run relationship between two variables and correct for any deviations of the dependent variable from a long-run equilibrium. The ECM results add validity to our results by extending the stylized facts to the whole period not comprised between October 11, 2018 and January 10, 2019 but is not necessary to interpret the results in the main text. In other words, our OLS approach is easier to interpret.

[11] There is a particular feature of the context worth highlighting: there exists a period where wholesale prices decreased monotonically for over three months across the country, from October 11, 2018, to January 10, 2019. A period like this is unusual, has not been isolated in previous literature, and provides unique and unequivocal evidence of the stylized facts: we find that markups increased monotonically over the same period, and more so the less neighboring stations there are.

[12] This is the methodology used by Chesnes (2016), Remer (2015), Verlinda (2008), Bachmeier and Griffin (2003), Borenstein et al. (1997), to estimate asymmetric pass-through.

[13] Following the classification used by the Bank of Mexico: the North includes Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas; the Center-North Aguascalientes, Baja California Sur, Colima, Durango, Jalisco, Michoacán, Nayarit, San Luis Potosí, Sinaloa, and Zacatecas; Center includes Ciudad de México, Estado de México, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro, and Tlaxcala; and the South includes Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán.

a "feathers" dynamic in the four regions, pass-through of wholesale price changes to retail prices is considerably slower in the Center and Center-North than in the North and the South. Focusing in the period between October 11, 2018 and January 10, 2019 when wholesale prices monotonically decrease, we show that the national weighted pass-through between these two dates is 35%, while in the Center, Center-North, South and North are respectively: 25%, 27%, 42%, and 50%.

We decompose the regional differences in pass-through into two effects: i) a composition effect of how many neighboring competitors a station has on average; and ii) a within-group effect, which captures differences in pass-through across regions for groups of stations that have the same number of neighbors. We show that the within-group effect is largely driving the marked regional differences. To analyze these differences, we perform a more granular analysis at the municipality level and hypothesize that coordination on high prices could be playing a role offsetting the competitive pressure of spatial competition.

We identify municipalities where coordination is likely to be occurring, and control for the possibility that prices are concentrated after a process of stations undercutting each other. Intuitively, if in a local market we observe a high concentration of prices this could be due to one of these two reasons: prices might be the same if all gas stations are coordinated in a high price, or prices could be the same after a process of stations undercutting each other converges to low prices in all stations. To differentiate local markets where the concentration of prices is due to competitive pressure from local markets where the concentration of prices is due to coordination on high prices we develop the idea that the distance from the modal price to the maximum price should be higher on average for local markets where competitive pressure induces lower prices. We find the optimal cutoff and divide municipalities in two groups: modal price close to maximal price and modal price far from maximal price. For municipalities where the modal price is closer to the maximum price we find that if there are more stations setting the modal price (we use a price concentration index) then the markup will be higher.[14] Finally, those regions where the pass-through is slower (the Center and

[14] A reader of this paper points out that this evidence might be neither necessary nor sufficient to prove for collusion or other violations of competition law. We agree with this assessment. However, we believe our evidence is strong in favor of coordination in prices for the following reasons: first, municipalities classified as anticompetitive by definition contain a group of stations which: 1) sets the same price

Center-North) contain more of the municipalities where we identify "coordination at high prices". Although this evidence might be neither necessary nor sufficient to prove for collusion, it is consistent with the possibility of anticompetitive price coordination being more present in the Center and Center-North regions which could explain why stylized fact 3 does not hold in such regions.

In a recent paper, Byrne and de Roos (2019) study equilibrium selection and price leadership over 15 years in Perth, Australia. They are able to show how firms communicate through prices to initiate a collusive agreement. In our setting, there was a long period of communication between the regulator and the unique franchisor to establish consumer prices, which might have led to some retailers to find coordination natural in the post-liberalization period. Our coordination findings may be related in this sense.

The rest of the paper is organized as follows. Section 2 provides a brief historical overview of the Mexican gasoline market, and Section 3 describes the data. In Section 4, we introduce our competition measure and present the main national results. Section 5 discusses regional heterogeneity and introduces the classifier of local markets into competitive or anticompetitive. In Section 7, we conclude and discuss the main contributions of the paper.

2. Market Structure

As this is one of the first papers analyzing competition in the Mexican retail gasoline market we provide a review of the institutional background.[15] In 1938 Mexico's oil production was nationalized and Petróleos Mexicanos (Pemex), the state-owned company, was created. Through the 1950's Pemex consolidated as a vertically integrated multiproduct oil & gas company, including wholesale markets, refineries and petrochemical plants. Private gasoline stations multiplied as franchises, but contracts had to be done exclusively with Pemex. Most

to the cent, 2) that price is close to the maximal price set in the municipality by any other station, 3) this group is the largest group of stations setting the same price; second, while price concentration might be high or low relative to other municipalities, the concentration of prices in this group is strongly correlated with higher average prices per municipality and slower pass-through; third, the evidence on the location of anticompetitive municipalities is consistent with our finding that more municipalities in the Center and Center-North regions violate stylized facts 2 and 3.

[15] Davis, McRae and Seira (2018) provide a prospective economic discussion of the deregulation process in Mexican energy markets.

of the gas stations, or retailers, were privately owned Pemex’s franchises and sold fuel at controlled prices established by the government.[16] Since then, Mexico's retail gasoline market had been tightly regulated, except for a deregulation initiative in the early 90’s that eliminated some of the discretion in Pemex’s franchising practices. This allowed the number of gas stations to increase, but Pemex continued to be the unique brand displayed in stations.

In December of 2013 an important reform in the Mexican Constitution was enacted, and the whole upstream and downstream petroleum industry changed dramatically. Regarding gasoline, in 2016 gas station permits were allowed to have a different brand other than Pemex’s and wholesale imports were opened to private firms, and for the first time in decades, the law required prices to be determined by the market and not by the government after 2017. The Energy Commission (Comisión Reguladora de Energía, CRE) was the agency in charge of the process of deregulation of the retail prices of gasoline and diesel. For the year of 2017 the CRE mandated a sequential liberalization of retail prices by geographic area, from North to South. The first states that were deregulated completely on March 30, 2017, were Baja California and Sonora. On June 15, the other states bordering the US, Chihuahua, Coahuila, Nuevo León, and Tamaulipas were liberalized. Then, on October 30, Baja California Sur, Durango, and Sinaloa; and finally, the process concluded on November 30, 2017, with the liberalization of the remaining states in the country.

Before this deregulation process, the Ministry of Finance established retail prices, and the excise tax IEPS (Impuesto Especial sobre Producción y Servicios) with weekly determined variable exemptions that functioned as a buffer mechanism for sharp variations in the international prices. The main objective of the fiscal stimulus was to absorb the high volatility of the international price. Before the 2017 liberalization, consumer prices had few fluctuations and were mainly kept constant for prolonged periods of time. The netting operation was done between Pemex and the Ministry of Finance, and it created a burden for public finance, and increasing retail prices became a necessary matter when international reference prices remained high for prolonged periods. Along with the announcement of the liberalization of prices, the IEPS law was modified and a fixed tax was introduced for all the

[16] Since the early 1980’s, gasoline prices were determined by the Ministry of Finance.

country along with fiscal incentives, which were applied as a stimulus (reduction) to the IEPS. After the change, the stimulus did not have the goal of keeping consumer prices fixed in a certain level, but was a way to smoothen short term international price variations.

By 2017, gas stations from any brand could acquire their gasoline either from Pemex or wholesalers that either import it directly[17] or buy it from Pemex at wholesale. The wholesale market has two main levels and may take place at the refineries or maritime ports (Puntos de Venta de Primera Mano) and at Terminals for Storage and Distribution (Terminales de Almacenamiento y Reparto (TAR)). Despite the liberalization of retail prices, wholesale Pemex's prices were subject to asymmetric regulation up to 2019.[18] As of 2019, several participants in the retail market import their gasoline directly, for example Arco, Exxon Mobil, and Chevron buy the gasoline from their own sources. The Mexican regulation allows private firms to participate in auctions designed to allocate part of Pemex's storage and distribution capacity in order to incentivize competition and entry by letting firms import, store and distribute fuel to their own clients. Through this sort of auctions, only ARCO was assigned some capacity in Baja California, Sonora and Sinaloa, although many firms are now investing to build their own terminals and pipelines to have their own supply chains. However, the majority of stations in Mexico buy their fuel from Pemex's TARs.[19] The price paid by a retailer at the TAR is intended to reflect the international reference price of gasoline, the storage and logistics costs and the utility margin for Pemex. During the period we analyze, the wholesale price and sales are subject to a regulated formula to incorporate the factors above, however Pemex[20] has a wide degree of discretion providing discounts and setting the transportation fees.

The federal government changed in December 1, 2018, and the new administration announced a policy commitment for retail prices of gasoline not to increase above the value of November 30, 2018, in real terms; yet, retail prices continued without formal regulation. The new mechanism consisted in applying a fiscal stimulus whenever necessary with the aim

[17] Since April 1, 2016, anyone can import its gasoline after acquiring a permit given by the Ministry of Energy (Secretaría de Energía).
[18] CRE Resolution RES/2508/2017 and A/043/2019.
[19] Pemex´s TARs supplied 92% of gasoline on average between October, 2018 and March, 2019. Sistema de Información Energética, Secretaría de Energía. http://sie.energia.gob.mx/
[20] Pemex's discretion is under scrutiny with the CRE for there is a case to sanction Pemex. RES/2602/2018 and RES/349/2019.

that country average retail prices never exceeded the level of November 30, 2018 in real terms. Nevertheless, this mechanism was modified in March 2019 so that instead of focusing on retail prices which are set by stations, the authorities started following wholesale TAR average prices. Thus, SHCP substituted the formula's retail average price for a wholesale average price, and from March onwards, they focused on a ceiling for wholesale prices instead of a ceiling for retail prices. In this way, after March 2019 whenever the reference wholesale price is greater than the ceiling, a stimulus to IEPS is provided.

In addition to the country wide IEPS stimulus, the stations in municipalities bordering the US are allowed to apply for an additional tax reduction; that is intended to match the pump price in the bordering US cities to prevent arbitrage. It is a quota that varies depending on the distance to the border and the municipality, in bins of 5 kilometers and up to 45 kilometers from the border. The highest subsidy quota is for Texas-bordering municipalities and the lowest to California-bordering municipalities. However, it does not vary over time like the country-wide stimulus.

Moreover, as a separate fiscal policy, Congress enacted a new tax policy ordinance promoted by the government that entered into effect in January 1, 2019. This ordinance reduced the value added tax and the income tax for the municipalities contiguous to the US-Mexico border. Although both enactments may be unrelated from the retail gasoline price policy commitment, the reduction in the value added tax had an immediate impact on retail prices in US-bordering municipalities.

Despite these fiscal interventions, during the period October, 11, 2018 to January, 10, 2019, which is characterized by monotonous declines in wholesale prices throughout the country (due to declining international reference prices), we can observe a reduced fiscal stimulus, and while income tax and value added tax reductions were enacted in the border, they operated only for a few days at the very end of this period. In the subsequent sections we will focus most of our attention in this period.

As of April 2019, there were 12,279 gas station permits registered by CRE. Around three quarters were Pemex franchises. Several international brands like Shell, Exxon, British Petroleum, Total, Repsol, Chevron have entered the market along with national brands like

G500, Hidrosina, La Gas, OxxoGas, and many others. Although many stations are switching from being a Pemex franchise, only a small number of stations are being built (COFECE, 2019). This may be due, among other aspects, to some local regulations that impose restrictions for building new stations, like minimum distances or environmental regulations, so that it is easier for a firm to acquire or contract with a station and just ask for the modification of the permit to switch the brand from an existing station. Mexico has a very high density of people per station (Cofece 2019), about 10,500, compared to Brazil, where it is half that figure, or the US where it is a quarter; so, there are incentives for stations to enter a demanding market, especially in urban areas.

3. Data

We use daily station-level price data obtained from the CRE website. The data include geographic coordinates for every station, prices for regular and premium gasoline, as well as for diesel fuel, and brand of the gasoline sold.[21] Although current prices are publicly available on the CRE website, the full history of prices is not publicly available. We constructed a panel from December 1, 2017, to March 20, 2019 by collecting the prices of gasoline and diesel fuel on a daily basis. For wholesale prices, we also use data available from the CRE website that is reported daily by Pemex and periodically compiled and published by the CRE (the historical wholesale price series used to be found in the CRE website, but they discontinued this practice at the end of 2019). It includes daily wholesale prices for every TAR, for regular and premium gasoline, and diesel fuel.

Transportation costs from the wholesale point to the pump and possible discounts obtained by the retailer when buying at the TAR are not publicly available data. Even though a particular gas station may have a wholesale supplier distinct from Pemex, the TAR price serves as the best publicly available approximation to the wholesale price payed by each gas station, and Pemex´s TARs supplied 92% of gasoline on average between October, 2018 and

[21] The brand of the gasoline sold may differ from the brand that the station uses to allow the station operator to differentiate from his competition. The data from CRE does not include the latter brand.

March, 2019.[22] In order to calculate the markup for each station, we assume that each station buys gasoline to the nearest TAR, considering geodesic distance.

Every person who wishes to sell gasoline must have a permit issued by CRE. Up to April, 2019, there were 12,279 permits registered in CRE's web page. However, this does not mean that every permit represents an existing and operating station. It may be the case that a new station is just being built or construction will be started. Also, it may be the case that a gas station is no longer active, but it is still registered. Since we cannot identify which are these particular cases, we drop from the sample any gas station that has not reported a new price in 3 months. Station owners are required by law to notify CRE at least one hour in advance before applying any change in their retail price but need not report if there are no changes. With the information available to us, we cannot tell whether a station that has not reported in the last 3 months is closed down, in building process, has a constant price or is not reporting at all. In summary, excluding permits without reported prices or geographical coordinates, permits that did not report at least one new price in at least 3 months, and permits that did not report any prices before March 2019, the resulting panel contains 10,343 stations.[23]

[22] Sistema de Información Energética, Secretaría de Energía. http://sie.energia.gob.mx/

[23] The geographic distribution of the omitted permits with available coordinates is very similar to the distribution of the population of stations. Comparing the regional distribution of the kept sample with respect to the total, the percentage of stations' variation by state is less than 1%.

4. Stylized Facts

4.1 Competition Measurement

The retail market for gasoline is a local market. Therefore, our notion of competition needs to take this into account. We assume that a station that is near other stations faces higher competition than an isolated station because a consumer can easily switch from one to another at a low cost in order to obtain a lower retail price. We classify the stations in groups depending on the number of nearby "neighbors" in a determined radius of distance. Table *1* contains the definition of our 8 Competition Groups. Figure A1, in the Appendix, contains the histogram of stations by Competition Group and has a normal shape in spite of having chosen the number of groups somewhat arbitrarily. However, in Appendix A we show a robustness exercise corresponding to an alternative classification into 20 groups, which produces a histogram more closely resembling a uniform distribution. We expect our analysis to be robust to additional measures of distance such as ones depending on driving time or driving distance, but we focus on simple geodesic distance. Either measure serves as an approximation to consumer choices and information sets.

Figure 1 plots the location of the 10,343 stations under the analysis, their Competition Group and the 76 distribution terminals (TAR). Isolated stations face lower spatial competition, while the dense urban centers concentrate the majority of the groups of stations facing high competition. Also, the 76 terminals tend to be close to dense population and station centers, which could lead to lower wholesale prices for these stations given transportation costs.

Table 1

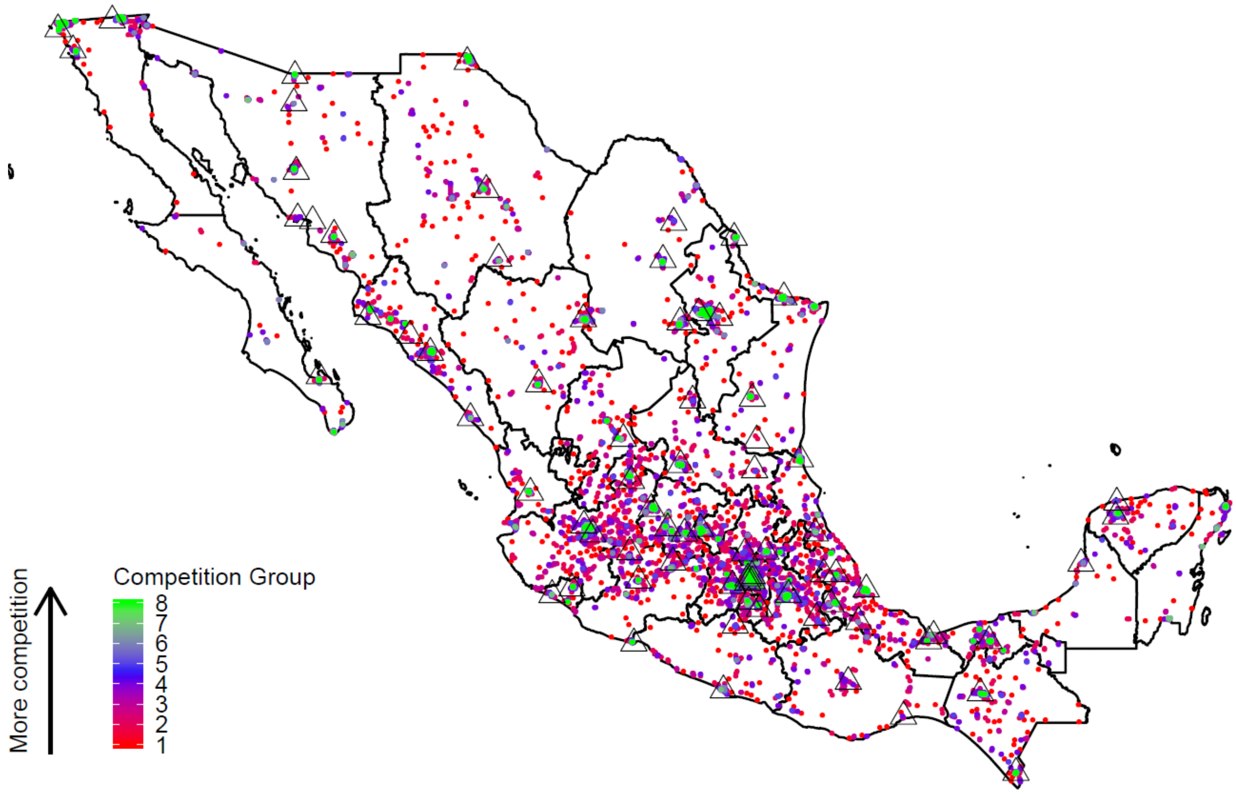
Competition Groups

	Group	Description
More competition ↓	1	No neighbors in 10km
	2	At least 1 neighbor in 10km, but no neighbors in 3km
	3	At least 1 neighbor in 3km, but no neighbors in 1km
	4	Exactly 1 neighbor in 1km
	5	Exactly 2 neighbors in 1km
	6	Exactly 3 neighbors in 1km
	7	At least 4 neighbors in 1km and at most 1 neighbor in 500m
	8	At least 4 neighbors in 1km and at least 2 neighbors in 500m

Notes: All the distance calculations were made using geodesic distance.

Figure 1

Location of Distribution Terminals and Stations by Competition Group



Note: Triangles represent the location of the 76 terminals (TARS) in the country.

4.2 Descriptive Evidence

As a descriptive exercise we present a first approximation to the three stylized facts:

1. Rockets and Feathers: Retail prices adjust slowly after a drop in wholesale prices generating an increase in markups during the period of downward adjustment of wholesale prices. After increases in wholesale prices, retail prices adjust (almost) immediately, in such a way that markups remain stable.
2. Competition in price levels: Higher intensity of market competition reflects on lower markups and lower prices.
3. Competition in pass-through: After a decrease in the wholesale price, the retail price decreases faster the more competition a gas station faces.

In Figures 2 and 3, we can observe the different paths for prices and markups, respectively, for each of the Competition Groups. Here we have plotted the average consumer prices including taxes as well as the average gross markup for each Competition Group which is calculated as the average of the difference of the posted consumer price including taxes and the TAR price of the closest terminal for each station. As we move from Group 1 to 8 (lower to higher competition) both prices and markups are lower, which seems to confirm stylized fact 2 (although we are not controlling for differences in demand, supply and transportation cost to each station).[24] In Figure 2 the two dates between which the wholesale prices decrease monotonically are marked by the red dashed lines (October 11, 2018 to January 10, 2019).[25, 26, 27] Between these dates it is possible to observe that prices for each of the Competition

[24] Alternatively, we calculated daily Spearman order correlations of the average price series for the 8 Competition Groups. The order correlation is always above 0.97 (at most 2 groups interchanged ranking in some days). This is also the case for the series in Figures 4 and 5.

[25] Most of this period is also characterized by the fact that the SHCP did not establish reductions in the IEPS, so it is cleaner in term of policy interventions.

[26] The federal government changed in December 1, 2018, and the new government announced a policy commitment for retail prices of gasoline not to increase more than inflation; however, retail prices continued without formal regulation. The SHCP intervenes through the IEPS stimulus as already described, however the stimulus was 0 for the period October 11 2018 to January 10 2019. In addition, new VAT rates entered into effect in January 1, 2019 for the Northern bordering municipalities, which we will control for as specified below.

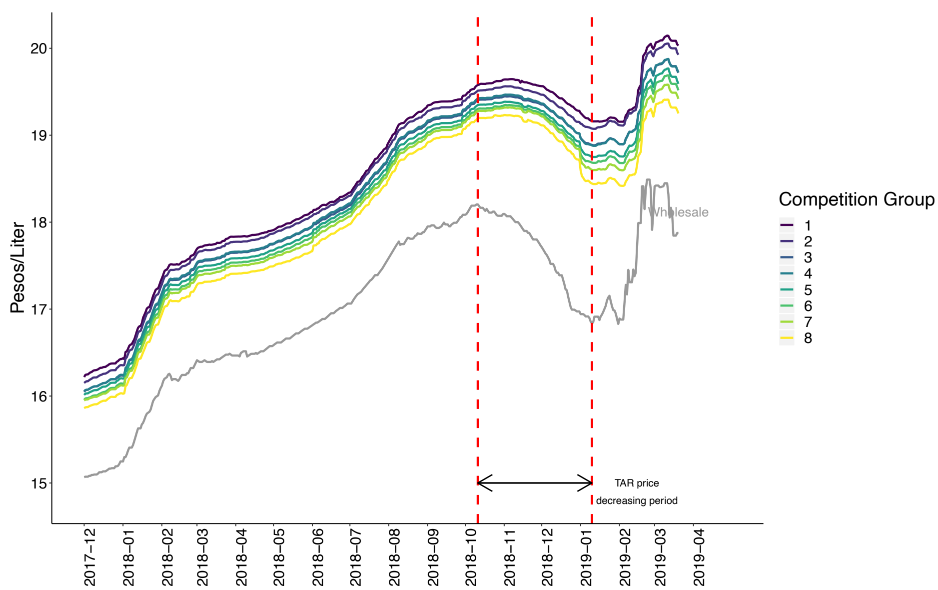
[27] For about 3 weeks during January-February of 2019 shortages affected some states. The federal government claimed it was part of a crime fighting campaign. These shortages affected mainly the Mexico City Metropolitan Area and the states of Querétaro, Guanajuato, Michoacán, and Jalisco after the first week of January, 2019. Our results should not be biased by the shortages since our period of interest has intersection with only the first four days of shortage, and only in a few locations.

Groups diminish less than the average wholesale price, this confirms stylized fact 1 on the national averages for all Competition Groups.

In Figure 3, we also appreciate how markups increase during the period in which wholesale prices decrease, this is related to the fact that cost decreases are not immediately passed through to the consumer. Moreover, we observe that markups remain stable in the period before October 11, 2018, and therefore we conclude that during this period of wholesale price increases retail prices adjust almost immediately.[28]

Figure 2

Price of Regular Gasoline by Competition Group and Average Wholesale Price

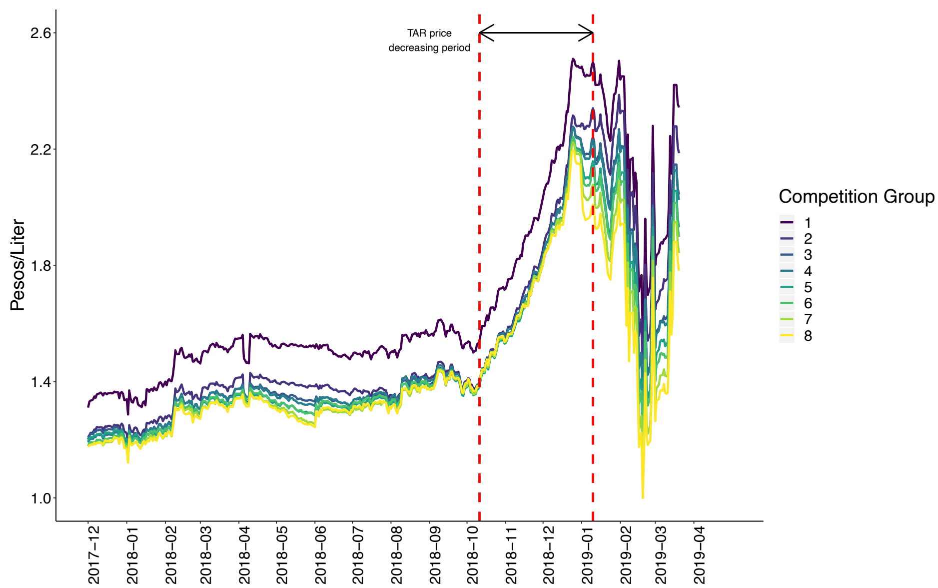


Notes: The prices are averages by group. The TAR average price is the average of the 76 terminals. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

[28] While the speed of pass-through of retail prices after decreases in the wholesale price is slower than for increases, we do not argue whether pass-through is complete or not. Since wholesale prices increase from February 2019 onwards, we do not observe the counterfactual in which wholesale prices stabilize in a level and retail prices stop decreasing before markups match the levels of the period prior to October 2018.

Figure 3

Markup of Regular Gasoline by Competition Group



Notes: The markups are averages by group. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

Finally, in Table 2 we report for each of the groups how much the price decreased. From left to right pass-through is increasing, which is the third and final stylized fact: competition in pass-through.

Table 2

Average Price Decrease by Competition Group

Pesos per liter

More competition

G1	G2	G3	G4	G5	G6	G7	G8	TAR
$0.41	$0.44	$0.52	$0.54	$0.59	$0.62	$0.68	$0.75	$1.37

Notes: The Groups are the ones defined in Table 1. The price decrease is calculated as the difference of the average price between October 11, 2018 and January 10, 2019, for each Competition Group. During this period, the 76 prices of the distinct TARs decrease monotonically. The TAR price decrease reported is the average for the 76 TARs.

4.3 Causal Effect of Competition

4.3.1 Supply and Demand Controls

To be able to interpret differences in levels and changes of both prices and markups as caused by the level of competition, we need to rule out the effects of variables that may be correlated with our measure of competition. First of all, we now calculate for each station the margin per liter sold net of taxes, this is more easily said than done since different tax rates apply depending on the location of the station (the most important difference being the distance to the border of the US). On top of that, since high density stations are close to distribution terminals our measure of competition is negatively correlated with transportation costs. Therefore, we need to implement an empirical strategy that controls for these costs. Intuitively, by comparing local markets with similar demand and supply characteristics—e.g. population density, willingness to pay, transportation costs—we can attribute the rest of the difference in prices and markups to competition.

We regress net markups on a set of demand and supply factors that characterize a particular local market, say a municipality. Among the demand factors, as a measure of the level of municipality income, we include formal workers' mean wages obtained from the Social Security Institute (Instituto Mexicano del Seguro Social (IMSS)) database. Also, we include a measure of vehicles per gas station in each municipality to control for station-level demand mass. We constructed this measure using publicly available data from INEGI on the number of vehicles by state in 2017, where we assign each municipality a number of vehicles proportional to its population and finally divide this number by the number of stations in each municipality. On the other hand, among the supply factors, we include a brand fixed effect and a linear cost proportional to the geodesic distance to the nearest TAR to control for transportation costs.

The specification we estimate is:

$$
\begin{aligned}
m_{it}^{retail} &= p_{it}^{retail} - p_{it}^{wholesale} \\
&= \alpha_{g(i)t} + \alpha_{brand(i)} + \beta_1 * y_{m(i)} + \beta_2 * cars_{m(i)} \qquad (1) \\
&\quad + \beta_3^{state(i)} * dist\big(TAR(i)\big) + \varepsilon_{it}
\end{aligned}
$$

where p_{it}^{retail} is the retail price before taxes for station i and day t, $p_{it}^{wholesale}$ is the TAR price before taxes for the closest terminal to station i in day t,[29] m_{it}^{retail} is the net markup for station i and day t, $\alpha_{g(i)t}$ are fixed effects for the duple of Competition Group of station i and day t, $\alpha_{brand(i)}$ is a gasoline brand fixed effect, $y_{m(i)}$ is income in the municipality as measured by IMSS-insured workers' mean wages, $cars_{m(i)}$ is the measure of vehicles per gas station, and $dist(TAR(i))$ is the geodesic distance from gas station i to the closest distribution terminal; we let the coefficient on distance to vary by state to account for transportation costs depending on local geography.

In Figure 4, we plot the time series for the difference $\widehat{\alpha_{g(i)t}} - \widehat{\alpha_{g8,t}}$ in markups between each of the Competition Groups 1 to 7 and Group 8 (the highest Competition Group). If we concentrate in the period from October 11 to January 10, we observe that the relative markups for Groups 1 to 7 with respect to Group 8 expand, this shows that pass-through of wholesale price decreases to retail prices is slower the lower the competition faced by stations.

The unconditional differences in price levels that were observed in Figure 2, are reduced considerably when using pre-tax prices and after incorporating supply and demand controls, mainly because isolated stations face less competition and more transportation costs. Nonetheless, markup differences between Groups 1 to 7, and Group 8 (Figure 4) are positive most of the time, indicating that the markups of Group 8 (the most competitive) are the lowest. Although the order in the series presented in Figure 4 is not strictly preserved over time, we can still observe that, on average, markups are lower for higher Competition Groups, or alternatively, interpret it as lower prices for higher Competition Groups.[30]

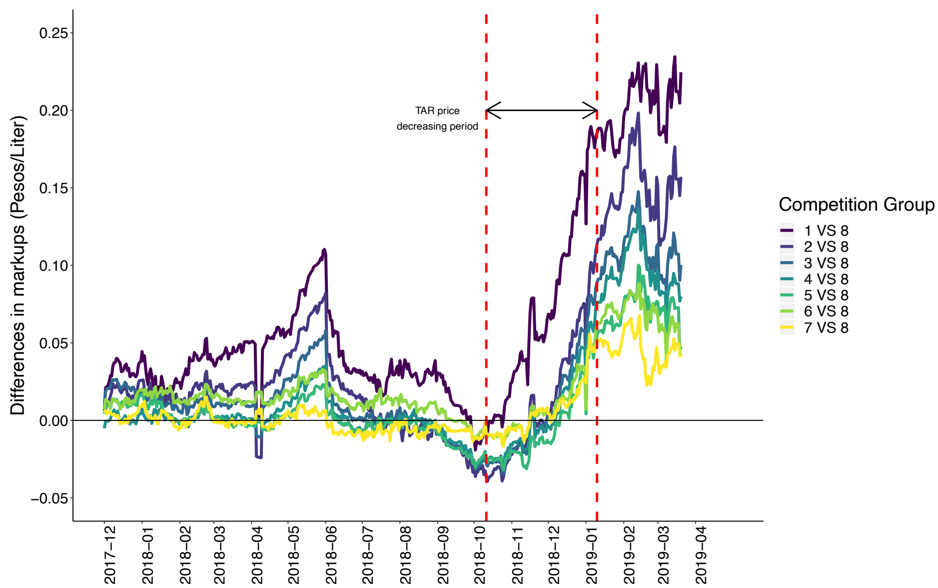
[29] Since each TAR price is posted after taxes with the national prevalent tax rate, we need to adjust this price depending on the date and the location of the final place the gasoline is sold to get the pre-tax rate that applies for each station. Tax rates vary by location and date, starting January 2019 there was a reduction in VAT for US bordering municipalities, and IEPS exemptions vary by distance to US border as well.

[30] Daily Spearman (order) correlations were calculated for the series in Figure 4. The Spearman correlation is above 0.85 from December 15, 2018, onwards with an average of 0.96 from December 2018 onwards. From December 2017 to November 2018 the average is of 0.59. The Spearman correlations are calculated by ranking every day the differences between Groups 1 to 7, and Group 8 from highest to lowest, and then taking the correlation between these daily rankings.

Figure 4

Difference Between each Competition Group Net Markup and the Net Markup of Group 8

Demand and Supply Controls



Notes: The TAR average price is the average of the 76 terminals. Controls include mean wage, mean of vehicles per station, both at municipality level. The Figure also includes controls for brand and distance from nearest TAR which is a proxy for transportation costs. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

4.3.2 Station Fixed-Effects

As an alternative specification, we introduce station fixed effects to control for all station characteristics —and therefore the local market demand and supply— that do not change over time. The fixed effects control for transportation costs, local willingness to pay and demand factors such as the mass of automobiles that are served by each gas station. This specification illustrates more robustly the stylized facts about rockets and feathers and competition in pass-through.

Our estimating equation is therefore:

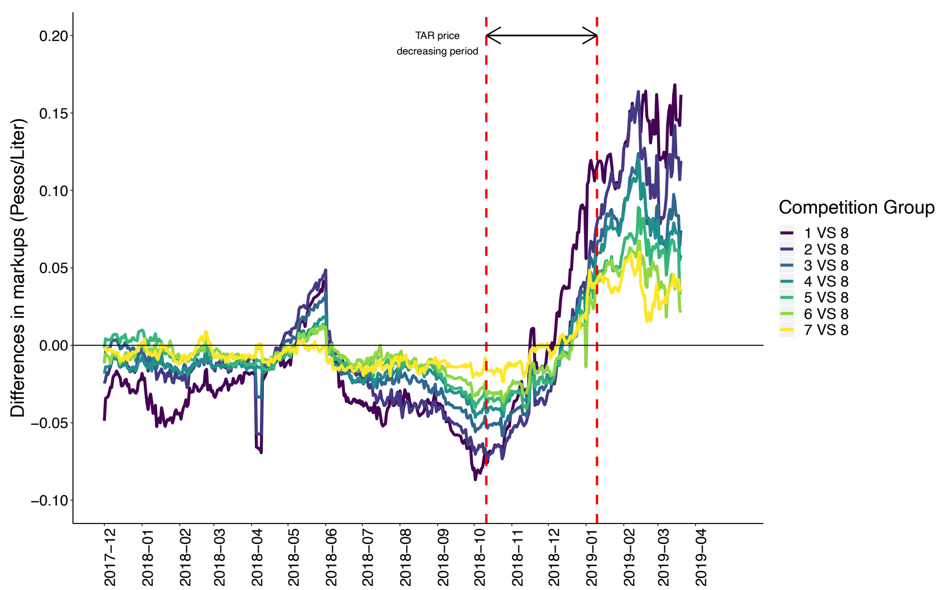
$$m_{it}^{retail} = p_{it}^{retail} - p_{it}^{wholesale} = \delta_i + \delta_t + \delta_{g(i)t} + \varepsilon_{it} \quad (2)$$

where p_{it}^{retail} is the retail price before taxes for station i and day t, $p_{it}^{wholesale}$ is the TAR price before taxes for the closest terminal to station i in day t,[31] m_{it}^{retail} is the net markup for station i and day t, δ_i are the station fixed effects, δ_t are day fixed effects, and $\delta_{g(i)t}$ are fixed effects for the duple Competition Group and day. We plot $\widehat{\delta_{g(\iota)t}} - \widehat{\delta_{g8,t}}$ in Figure 5. During the period where wholesale prices decrease monotonically (between the vertical red dashed lines), we observe that relative markups increase monotonically, which means the prices of Groups 1 to 7 are lowered less than the prices of Group 8, that is, pass-through is faster when the gas stations face more competition. This is the strongest evidence we can show for the existence of differentiated "feathers" for the Competition Groups.

Figure 5

Difference Between each Competition Group Net Markup and the Net Markup of Group 8

Station Fixed Effects



Notes: This Figure considers all stations in the country and calculates prices before taxes for each station using the local tax rates taking into account variation in time of these rates. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

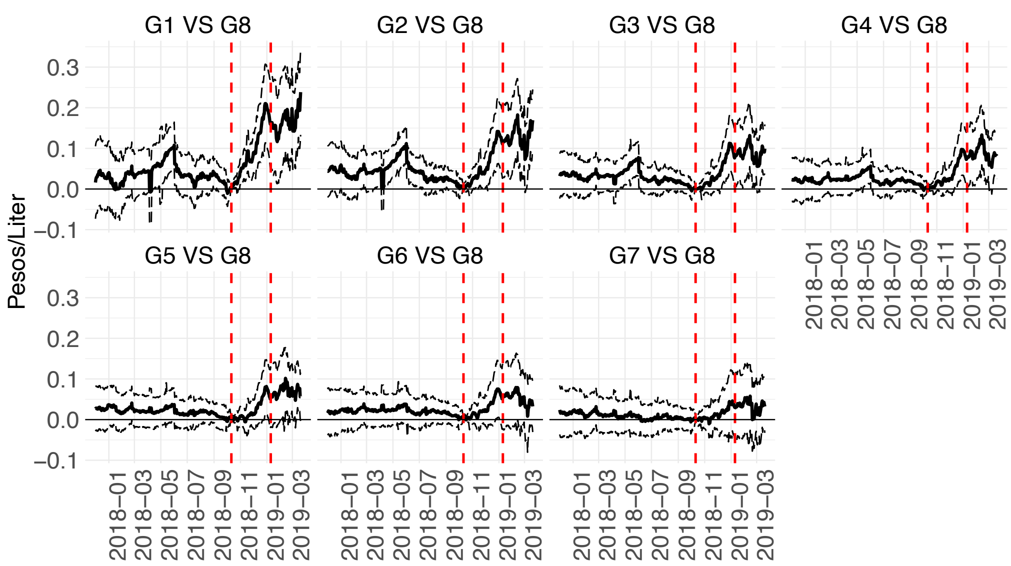
[31] Since each TAR price is posted after taxes with the national prevalent tax rate, we need to adjust this price depending on the location of the final place the gasoline is sold to get the pre-tax rate that applies for each station.

In Figure 6, we plot $\widehat{\delta_{g(\iota)t}} - \widehat{\delta_{g8,t}} - (\widehat{\delta_{g(\iota)t_0}} - \widehat{\delta_{g8,t_0}})$ where t_0 is October 11, 2018. Therefore, we are observing a daily coefficient which is the difference in markups between each Competition Group and Group 8, taking as benchmark the difference in markups registered on October 11, which is at the outset of the decrease in wholesale TAR prices. The Figure plots 90% confidence intervals for each markup time series. Since we are estimating 3,800 coefficients (475 days times 8 groups) —on top of the 10,343 fixed-effects corresponding to the stations in the panel—and obtaining the standard errors for those 3,800 coefficients is computationally intensive, the standard errors are estimated using the bootstrap, where we draw 1000 random samples with replacement from the original set of stations, estimate all the coefficients, and then calculate the standard deviation per day and group for $\widehat{\delta_{g(\iota)t}} - \widehat{\delta_{g8,t}} - (\widehat{\delta_{g(\iota)t_0}} - \widehat{\delta_{g8,t_0}})$.

Figure 6

Difference Between each Competition Group Markup and the Markup of Group 8 (High Competition), and Average Wholesale Price

Station Fixed Effects



Notes: This Figure considers all stations in the country and calculates prices before taxes for each station using the local tax rates taking into account variation in time of these rates. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively October 11, 2018 to January 10, 2019. All net markups are relative to Group 8 and specifically to its average net markup level on October 11, 2018. 90% confidence intervals are plotted along each time series.

We can observe striking differences in the speed of pass-through during the period of wholesale price decreases. For stations facing lower competition, pass-through is slower. The differences are statistically significant for Groups 1 to 4, and imprecisely estimated for Groups 5 to 7. We can also observe the confidence intervals become wider during the period of wholesale price decreases. This is a result from higher price dispersion during the period where wholesale prices decrease. In Table 3, we report the difference in markup increment $\widehat{\delta_{g(\iota)t_1}} - \widehat{\delta_{g8,t_1}} - (\widehat{\delta_{g(\iota)t_0}} - \widehat{\delta_{g8,t_0}})$ for each of the Competition Groups 1 to 7 with respect to Group 8 between October 11, 2018 and January 10, 2019, the period of interest with its appropriate standard error.

Table 3

Difference in Net Markup Increment in the Period of Interest

for each of the Competition Groups 1 to 7 with respect to Group 8

More competition $\longrightarrow$

	G1 vs G8	G2 vs G8	G3 vs G8	G4 vs G8	G5 vs G8	G6 vs G8	G7 vs G8
ΔMarkup	0.17	0.13	0.09	0.08	0.06	0.06	0.04
	(0.069)	(0.054)	(0.046)	(0.038)	(0.046)	(0.051)	(0.052)

Notes: The groups are the ones defined in Table 1. The values are graphed in Figure 6, where the markup increment reported is the one that happens between October 11, 2018 to January 10, 2019. Numbers in parentheses are standard deviations computed using bootstrap.

It is interesting to note that if we focus on the period from June 1, 2018 to October 10, 2018, we can observe the presence of differentiated "rockets": wholesale prices are going up, and markups decline more the lower competition the stations face. This means that wholesale price increases are passed faster to retail prices for higher Competition Groups. Putting together both of these observations we conclude that more competition implies faster pass-through both for increases and for decreases of wholesale prices.

As a complement to the analysis presented in this section, in Appendix B we estimate a flexible autoregressive error-correction model that captures differentiated coefficients for increases and decreases in wholesale prices, and calculate impulse response functions that determine pass-through over time to show that our results are robust to the specification commonly used in the literature.

5. Regional Heterogeneity

5.1 Stylized Facts at the Regional Level

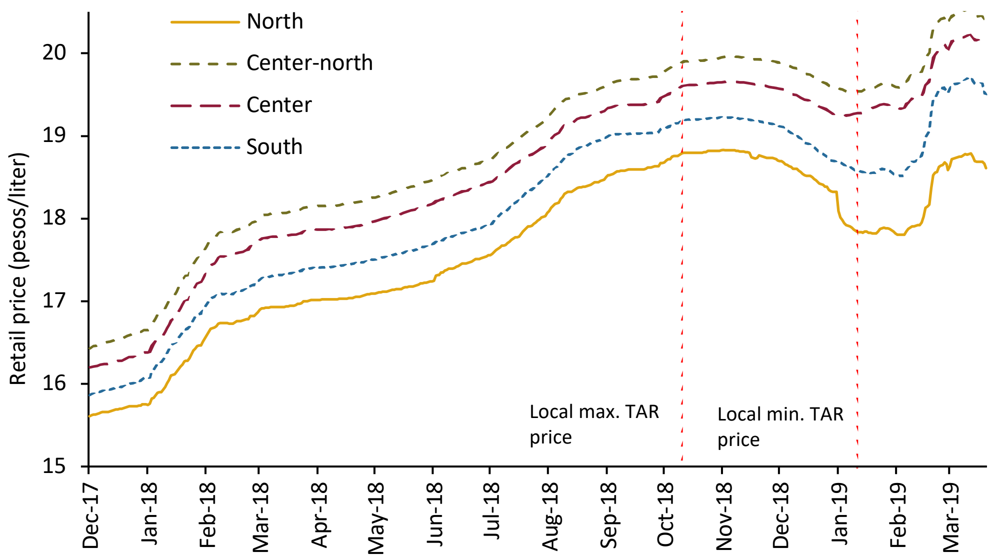
Retail prices and markups by region are shown in Figure 7 and 8, respectively. The North has the lowest average prices, which mainly reflects the enactment of additional tax breaks to IEPS with the objective of avoiding arbitrage between Mexican and US bordering cities. In Figure 8 it can be observed that the differences in prices across regions decrease substantially once we control for wholesale prices.[32] We find strong evidence of heterogeneity regarding the three stylized facts. In particular, while we document rockets and feathers in the four regions, pass-through of wholesale price changes to retail prices is considerably slower in the Center and Center-North than in the North and the South. Focusing in the period between October 11, 2018 and January 10, 2019, when wholesale prices monotonically decrease, the national weighted pass-through is 35%, while the Center, Center-North, South and North are respectively: 25%, 27%, 42%, and 50%. This is reported in Table 4.

Also, at a regional level, it is possible to observe differences in the distribution of Competition Groups. In Figure 9, we show the proportion of stations in every Group, for every region. The North has a higher concentration of high-competing stations, whereas the South and Center North have a distribution biased to low competition. Additionally, in Figure 10 we show for each Competition Group the relative weights across regions. For example, the highest Competition Group, Group 8, has around 41% of its stations in the North and 12% in the South. In particular, we observe that the South's share of stations in a Group decreases monotonically from left to right. North's share, in contrast, increases from Group 2 onwards.

[32] Following the classification used by the Bank of Mexico: the North includes Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas; the center-North Aguascalientes, Baja California Sur, Colima, Durango, Jalisco, Michoacán, Nayarit, San Luis Potosí, Sinaloa, and Zacatecas; center includes Ciudad de México, Estado de México, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro, and Tlaxcala; and the south includes Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán.

Figure 7

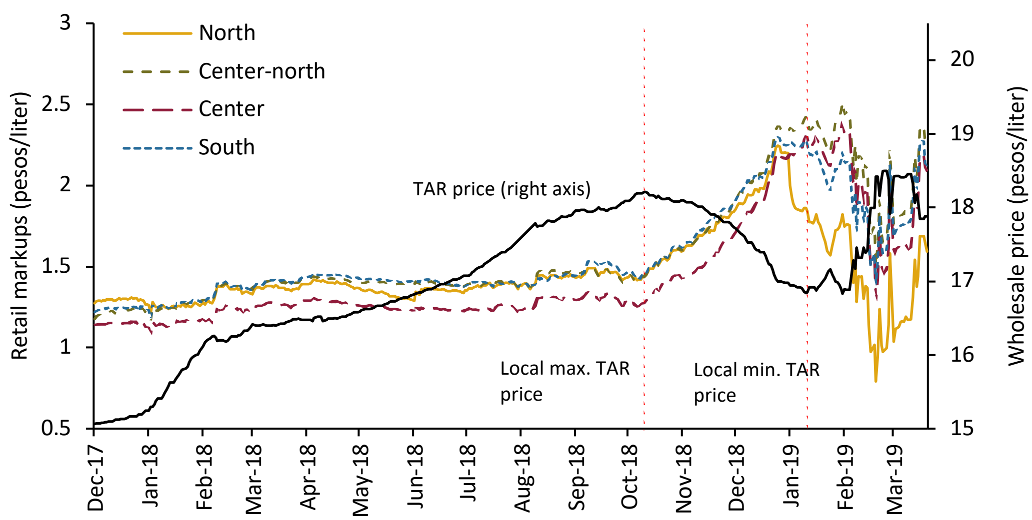
Retail Prices of Regular Gasoline by Region



Notes: Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

Figure 8

Retail Markups of Regular Gasoline by Region



Notes: Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

Table 4

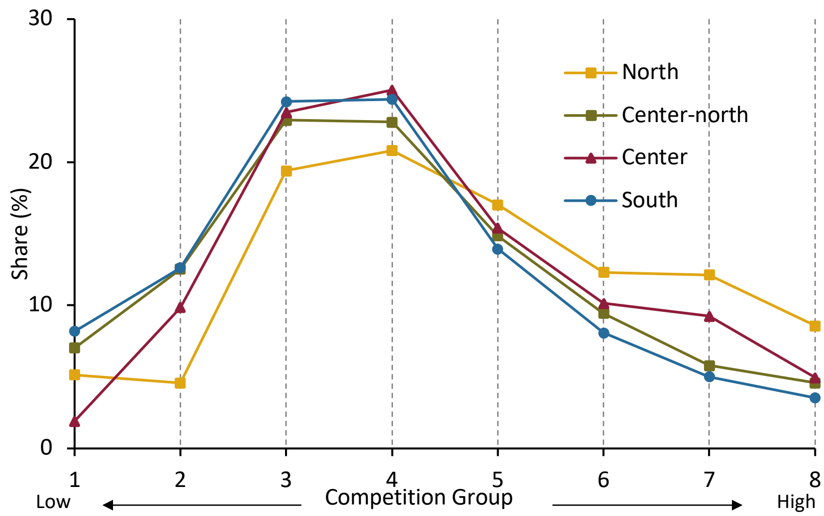
Retailer Markup Increases: Percentage of the Decrease in Wholesale Prices that is not passed through to Retail Prices by Region

	% of wholesale decrease		
	Retailer takes (markup increase)	Retailer passes to consumer	Sum
National	65%	35%	100%
North	50%	50%	100%
South	58%	42%	100%
Center	75%	25%	100%
Center-north	73%	27%	100%

Notes: The change in wholesale prices are from October 11, 2018 to January 10, 2019. This period is shown in Figures 7 and 8 and corresponds to a period in which all TAR prices decreased monotonically. Values are reported as a percentage of a one-peso TAR price decrease.

Figure 9

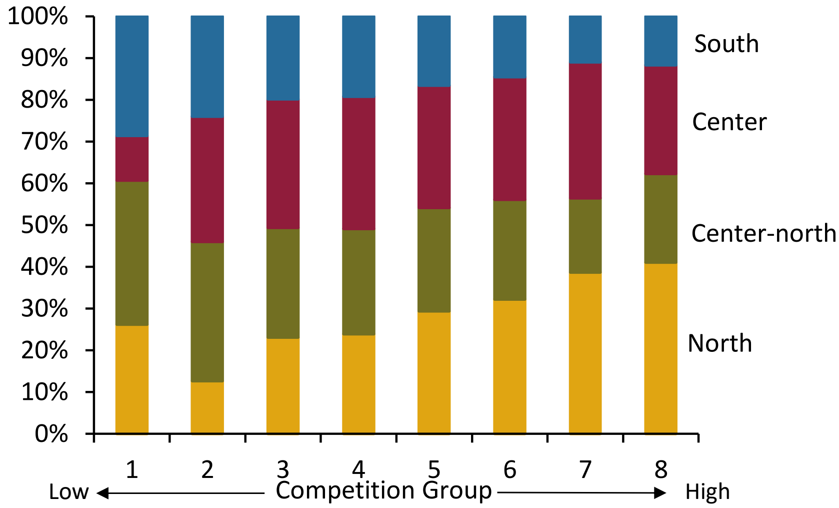
Distribution of Stations by Group of Competition in Each Region



Notes: For every region, the sum of the shares in each Group is 100%. Competition Groups are defined in Table 1.

Figure 10

Distribution of Stations by Group of Competition in Each Region



Notes: For every Group, the sum of the shares in each region is 100%. Competition Groups are defined in Table 1.

Given these findings regarding heterogeneity in both the stylized facts and in the distribution of Competition Groups across regions, we want to explain the difference in "feathers" as differences in density of stations per region and differences on the competitive pressure exerted by station density. Using our classification of stations into 8 different Competition Groups, we decompose the regional differences in pass-through into two effects: i) a composition effect of how stations within a region are distributed across Competition Groups; and ii) a within-group effect, which captures differences in pass-through within Competition Groups across regions.

With respect to the within-group effect, in Table 5 we report the change in markups for each Competition Group at the national level and separately for each of the regions during the period where wholesale prices monotonically decrease (October 11, 2018 and January 10, 2019). We report the average of the individual stations change in markups for each $1 that the wholesale price of the closest terminal decreases. Therefore, the numbers reported in Table 5 can be interpreted as the percentage of price decreases that is not passed through to consumers. We control for all aspects of demand and supply that do not change over time by introducing station fixed effects, as was done in equation 2.

We observe in Table 5 that all changes are positive, so that pass-through during the period is incomplete and markups increase for all Competition Groups in all regions. We can also note that for the North, South, and Center-North the markups increased less from left to right; that is, pass-through was slower for stations in lower Competition Groups (that is, stylized fact 3 about competition in pass-through holds for all regions except the Center). Moreover, we can interpret the difference in the change in markups between Group 1 and Group 8 within each region as the potential gross benefit for a consumer of driving from one low competition station to a high competition station. In Table 5, we can also observe that this difference is bigger for a consumer in the South (37 cents). [33]

Table 5

Increase in Markups by Region and Competition Group for a 1 Peso Decrease in TAR Prices

	More competition →									
	G1	G2	G3	G4	G5	G6	G7	G8	G1 - G8	Average Increase
National	$ 0.73	$ 0.70	$ 0.66	$ 0.65	$ 0.63	$ 0.62	$ 0.59	$ 0.55	$ 0.18	$ 0.65
North	$ 0.67	$ 0.63	$ 0.53	$ 0.51	$ 0.48	$ 0.43	$ 0.45	$ 0.40	$ 0.27	$ 0.50
South	$ 0.72	$ 0.60	$ 0.60	$ 0.59	$ 0.56	$ 0.53	$ 0.45	$ 0.35	$ 0.37	$ 0.58
Center	$ 0.73	$ 0.75	$ 0.73	$ 0.75	$ 0.77	$ 0.79	$ 0.75	$ 0.78	-$ 0.05	$ 0.75
Center-north	$ 0.78	$ 0.76	$ 0.74	$ 0.72	$ 0.70	$ 0.72	$ 0.70	$ 0.69	$ 0.09	$ 0.73

Notes: The change is from October 11, 2018 to January 10, 2019. This period is shown in Figures 7 and 8 and corresponds to a period in which all TAR prices start decreasing and stop decreasing, respectively. Changes are normalized to a 1 peso decrease and thus every number in the Table is interpreted as the change in the markup for a 1 peso decrease in TAR prices, after controlling for station fixed effects. The average increase is weighted by the number of stations in each group, according to the region.

In Table 6, we compare the average change in markups for each region to the national average and decompose this difference into the composition and the within-group effects.[34] The composition of stations in the South and the Center-North relatively biased towards the low Competition Groups shown in Figure 9 suggests that the "composition effect" will be

[33] For the south, the behavioral effect is driven mostly by 4 states: Chiapas, Quintana Roo, Veracruz, and Yucatán, while for the other regions there is not much heterogeneity across states in the region.

[34] Mathematically, the composition effect is calculated as $\sum_{g=1}^{8}(w_{Rg} - w_{Ng})\Delta m_{Ng}$, while the within-group effect is calculated as $\sum_{g=1}^{8} w_{Rg}(\Delta m_{Rg} - \Delta m_{Ng})$, where w_{Rg} is the weight corresponding to group g in region R, and w_{Ng} is the corresponding national weight, and where Δm_{Rg}, Δm_{Ng} are the changes in markups reported in Table 6 for each group and region (and at the national level for each group). Finally, we obtain: $\Delta m_R - \Delta m_N = \sum_{g=1}^{8}(w_{Rg} - w_{Ng})\Delta m_{Ng} + \sum_{g=1}^{8} w_{Rg}(\Delta m_{Rg} - \Delta m_{Ng})$.

detrimental to consumers. In contrast, the relatively higher competition in the North and Center suggests faster pass-through and smaller increases in markups. Although this is what we find and show in Table 6, the overall composition effect is very small compared to the within-group effect. We actually observe that the within-group effect is largely driving the pronounced regional differences. Also, we note that the North has the strongest within-group effect, so that markups increase less than the national average (Column B). For the South, we can observe that although the composition effect is in detriment of the consumers, the favorable within-group effect is dominant and pass-through is faster than the national average. The Center has the worst average within-group effect but closely followed by the Center-North. In particular, whenever the regional within-group average effect dominates the national within-group average effect (implying faster pass-through within-groups), the regional markup increases less than the national markup.

Table 6

Contributions of the Composition Effect and Within-Group Effect to the Differential in the Regional Markup Increase VS National Increase

	A = B + C Margin Increase: Regional - National	B Within-Group Effect	C Composition Effect	B/A Within-Group Effect (%)	C/A Composition Effect (%)
	Cents (¢)			Percentage (%)	
North	¢ -15.02	-14.1	-0.9	94%	6%
South	¢ -6.53	-7.4	0.9	114%	-14%
Center	¢ 10.61	10.9	-0.2	102%	-2%
Center-north	¢ 8.34	7.8	0.6	93%	7%

Notes: Composition effect refers to the effect different regional shares of every Competition Group have inside the region. The within-group effect reflects differences in pass-through within group across regions. The green and red colors represent a positive and negative effect, respectively, for the consumers.

Summarizing, in Table 7, relative to the national mean, the South and Center-North have a composition of stations relatively biased to low competition, so that the composition effect implies that these regions have larger increases in markups relative to the national average when wholesale prices drop. In addition, in the Center and Center-North, within each Competition Group, the markups increase more than the national average, whereas in the

North and South, markups increase less than the national average. The net effect of these two effects combined implies that markups increased more in the Center and Center-North during the period October-January. These regional differences open the question of what the main driver behind the heterogeneous within-group effects is. In particular, we hypothesize that the consumer-detrimental within-group effect in the Center and Center-North showing very incomplete pass-through of wholesale price decreases, may be due to stations coordinating on high prices. We will explore the coordination question in the following section.

Table 7

Regional Markup Increases vs National Markup Increase after a Drop in Wholesale Prices And Decomposition into Composition Effect and Within-Group Effect

	Composition Effect	Within-Group Effect	Net Effect of the Increase in Margins: Regional VS National
North	more station density	faster pass-through	< National
South	less station density	faster pass-through	< National
Center	more station density	slower pass-thorugh	> National
Center-north	less station density	slower pass-thorugh	> National

Notes: The period of markup increases is October 11, 2018 to January 10, 2019, when wholesale prices are decreasing nationally. Composition effect refers to different regional shares of every Competition Group. The within-group effect reflects differences in pass-through within group across regions. The green and red colors represent a positive and negative effect, respectively, for the consumers.

5.2 Coordination in Retail Prices

To try to understand why the competitive pressure implied by a high number of nearby stations does not seem to be driving prices down in all regions—especially in the Center, where our stylized fact 3 (more competition implies faster downward pass-through) does not hold—we perform a more granular analysis, in which we seek to distinguish municipalities where there is evidence of anticompetitive coordination (on high prices) that could be playing a role offsetting the competitive pressure of spatial competition.

We first introduce our price concentration index (PCI) at the municipality level. We will use the PCI to show there is a variety of municipalities with either high or low price concentration, but where a high price concentration does not necessarily mean high prices or vice versa. Instead we hypothesize how the price level and the expansion in markups during "feathers" should correlate with this index under either competitive or anticompetitive circumstances and test those conjectures after we classify stations into competitive or anticompetitive. For every day t and municipality m in the country, we calculate how many n_{mt} distinct prices are reported by gas stations. Every distinct price (up to cents) determines a set $A_m(i)$ of stations with the same price in a particular day, in municipality m. For each day t in municipality m, we calculate the following price concentration index:

$$\boldsymbol{PCI_{mt}} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n_{mt}}} \frac{\boldsymbol{S_{imt}^4}}{\left(\sum_{i=1}^{n} \boldsymbol{S_{imt}^2}\right)^2} \in \left[\frac{\mathbf{1}}{\boldsymbol{n_{mt}}}, \mathbf{1}\right]$$

where $S_{imt} = \frac{|A_m(i)|}{\sum_{j=1}^{n} |A_m(j)|}$ is the share of all stations in municipality m in set $A_m(i)$ on day t. To obtain a single municipality price concentration index PCI_m, we take the average over time (for the period October 11, 2018 to January 10, 2019) of the rescaling $\frac{\boldsymbol{PCI_{mt}} - \frac{1}{n_{mt}}}{\mathbf{1} - \frac{1}{n_{mt}}}$. We rule out municipalities with less than 2 stations.

The index PCI_m has similar properties to the Herfindahl-Hirschman index (HHI): if two groups with different prices now post the same price tomorrow, the index increases.[35] This index is preferable to the HHI in this setting since it better captures price dispersion. For example, assume we want to compare two municipalities: municipality A has 10 stations while municipality B has 100 stations. Assume for each of the two municipalities, 50% of stations charge a price of 20, 20% of stations charge a price of 19 and the rest all charge different prices. Even though the proportion of stations coordinated in the two biggest groups is the same for municipalities A and B, it is sensible to say that it is more difficult to coordinate 80 stations than 8. Therefore our measure of price concentration should respect this ranking, while $HHI_A > HHI_B$, nonetheless our index ranks the two municipalities

[35] See García (1999) for a definition of a general family of indices and its properties. The index we adopted was used by the competition authority in Mexico from 1998 to 2015 as an auxiliary indicator in the context of merger review and market power, in addition to the HHI. The index was called Dominance Index. See Mexico´s Official Gazette (Diario Oficial de la Federación) of July 24 of 1998, COFECO (1998).

correctly, $PCI_{\boldsymbol{mtA}} < PCI_{\boldsymbol{mtB}}$.[36] In any case, our results are robust to using the HHI in place of the PCI.

Now, suppose each of the municipalities is of either one of two types: competitive or anticompetitive. If the price concentration is driven by competitive (anticompetitive) forces we should expect a negative (positive) correlation of our price concentration index with the price level. We summarize the implications for each type of municipality below.

> **Competitive Case:** Price concentration is driven by competitive behavior in which prices become concentrated after a process of stations undercutting each other converges to a low price. Therefore, in this type of municipalities the price concentration index $PCI_{m(i)}$ should be negatively correlated with the markup level $\widehat{m}_i$,[37] and negatively correlated with the increase in markups ΔMk_i[38] during the period October 11, 2018 and January 10, 2019 where wholesale prices decrease.

> **Anticompetitive Case:** Price concentration is driven by anticompetitive behavior in which stations are coordinating in a high price to increase their profits. Therefore, in this type of municipalities the price concentration index $PCI_{m(i)}$ should be positively correlated with the markup level $\widehat{m}_i$, and positively correlated with the increase in markups ΔMk_i during the period October 11, 2018 and January 10, 2019 where wholesale prices decrease.[39]

Figure 11 shows the relationship between the price concentration index and the average markup level of every station. There exists a positive and significant relationship of the average markup and the level of coordination in the municipality, which would support the idea that price concentration is driven by anticompetitive behavior. However, in Figure 12, we show a negative relationship between the index and the increase in markups during the period where wholesale prices decrease, suggesting that the concentration in prices is related

[36] In our particular example, the values are $HHI_A = 0.30$, $HHI_B = 0.29$, $PCI_{mtA} = 0.71$, $PCI_{mtB} = 0.76$.

[37] Where $\widehat{m}_i$ is the average over time of the estimated $\widehat{\alpha}_{g(i)t} + \widehat{\varepsilon}_{it}$ in regression 1.

[38] Where ΔMk_i is the difference of $p_{it}^{retail} - p_{it}^{wholesale}$ for the two dates October 11, 2018 and January 10, 2019, which would be equivalent to take the difference those two dates of the estimated $\widehat{\alpha}_{g(i)t} + \widehat{\varepsilon}_{it}$ in regression 2.

[39] See the two footnotes above.

to competitive behavior. These two results may seem contradictory, but this may be just the result of confounding competitive and anticompetitive local markets.

Figure 11
Relationship between the Municipal Price Concentration Index and the Level of Markups

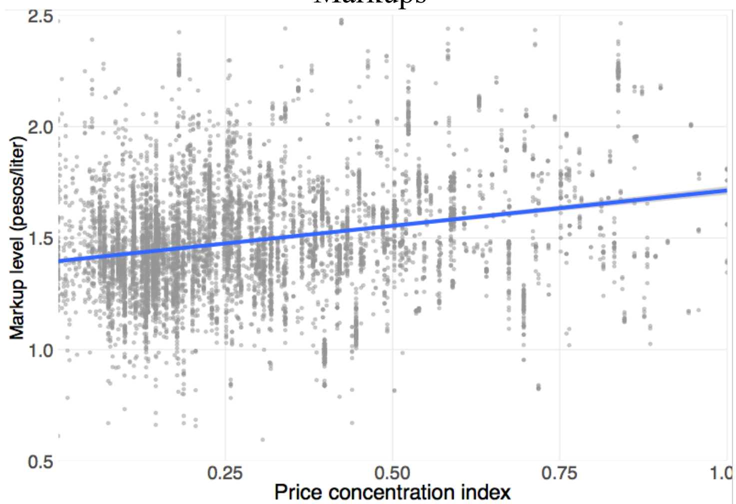
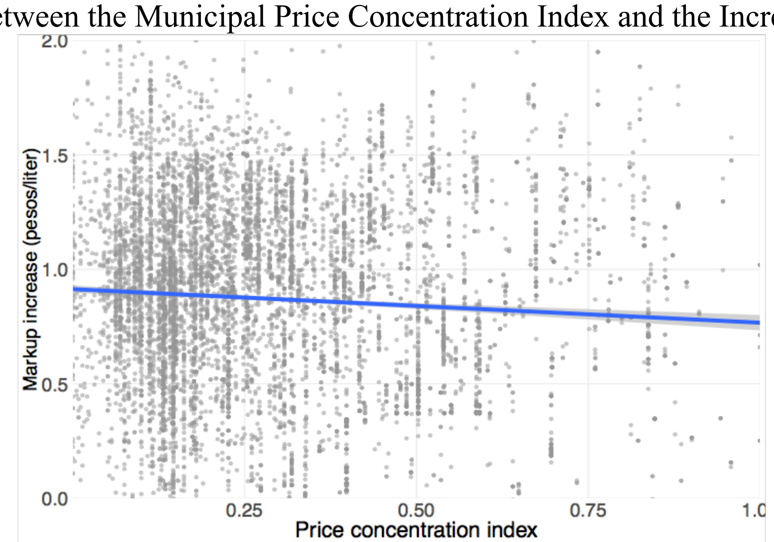


Figure 12
Relationship between the Municipal Price Concentration Index and the Increase in Markups



Notes Fig. 11, 12: each dot represents a gas station. The number of observations is 9,036. The municipalities with 2 or less stations are not included. Figure 11: A linear fit is shown between the price concentration index of the municipality to which a station belongs and its average markup level, calculated as the average of the daily markups during the whole sample period. Figure 12: A linear fit is shown between the price concentration index of the municipality to which a station belongs and the increase in its markup between October 11, 2018 to January 10, 2019. The slope is significant at the 95% level although 95% confidence intervals are depicted as a grey shade above and below the fit. The price concentration index is calculated as the average of the daily indexes during the wholesale price reduction period, October 11, 2018 to January 10, 2019. The markup increases are controlled by station fixed effects.

Figure 13

Relationship between the Municipal Price Concentration Index and the Level of Markups

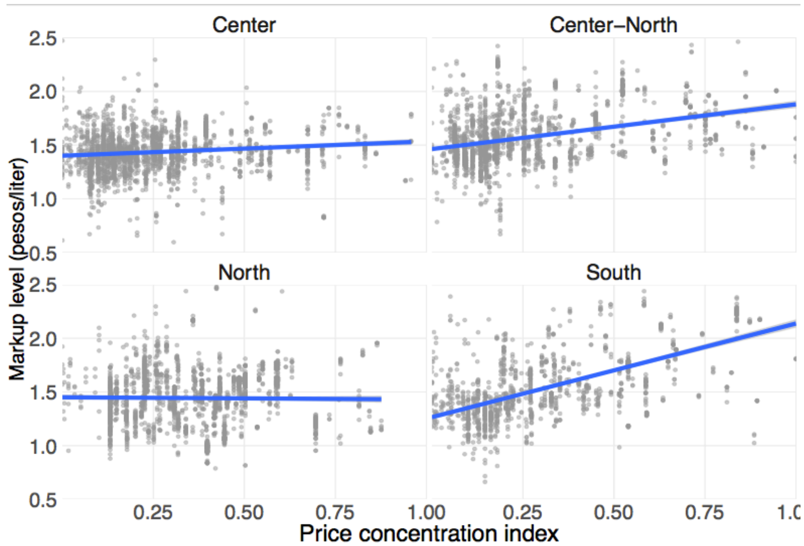
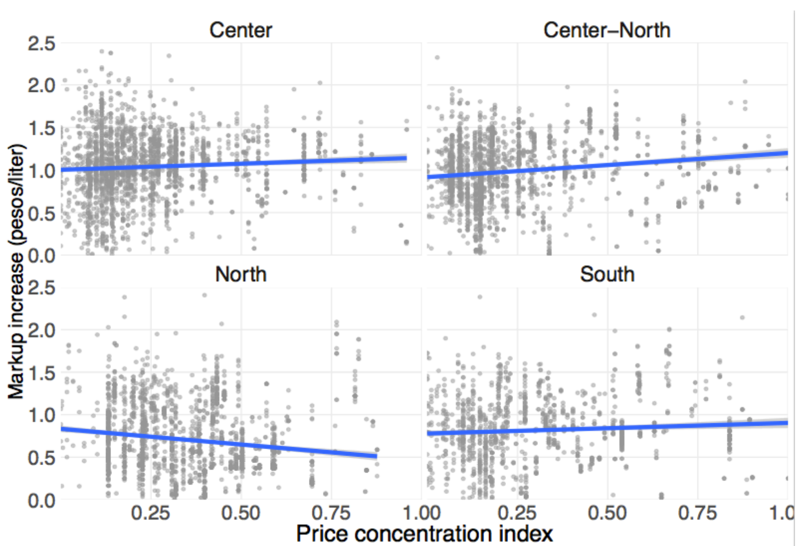


Figure 14

Relationship between the Municipal Price Concentration Index and the Increase in Markups



Notes Fig. 13, 14: each dot represents a gas station. The number of observations is 2,666; 2,271; 2,608; and 1,491, for the Center, Center-North, North, South, respectively. The municipalities with 2 or less stations are not included. Figure13: For every region, a linear fit is shown between the price concentration index of the municipality to which a station belongs and its average markup level, calculated as the average of the daily markups during the whole sample period. Figure 14: For every region, a linear fit is shown between the price concentration index of the municipality to which a station belongs and the increase in its markup between October 11, 2018 to January 10, 2019. The slopes are significant at the 99% level although 95% confidence intervals are depicted as a grey shade above and below the fit. The price concentration index is calculated as the average of the daily indexes during the wholesale price reduction period, October 11, 2018 to January 10, 2019. The increase in markups is controlled for station fixed effects.

When we observe the same linear fits at the regional level (Figures 13, 14) and compare them to the results in Table 5, we observe that the North presents negative slopes, supporting evidence from Table 5 that this is the region with more competition. All the other regions have positive slopes for both regressions, suggesting more anticompetitive behavior. This is somewhat surprising for the South since it has faster pass-through within-groups, shown in Table 5, and therefore more evidence of competitive behavior.

We are interested in looking at the relative importance of the anticompetitive cases in the Center of the country since the pricing behavior during a wholesale price decrease in this region seems does not vary across Competitive Groups: no matter the degree of spatial competition, retailers did not pass-through the cost decrease (in less proportion this also happened in the Center-North). The prices there seemed to decrease substantially less than the rest of the country and in order to disentangle whether some anticompetitive behavior, in terms of coordination on high prices, might play a role to explain this finding, we proceed to build a classifier of municipalities depending on a measure of the likelihood that a group of stations are setting the same high price. This should help us separate municipalities within each region into two categories regarding its behavior: competitive and anticompetitive.

We conjecture that if modal prices are on average higher with respect to some reference point, the concentration of prices is more likely to be driven by an anticompetitive process. The main difficulty is finding the relevant reference point for each municipality. We bypass this issue by taking the reference point to be the maximal price within that municipality. Therefore, if the modal price is closer to the maximal price, it is more likely that the concentration is driven by an anticompetitive process. Thus, the classifier we construct separates competitive and anticompetitive municipalities based on the daily distance of their modal price to their maximum price. A classifier is defined as the cutoff distance *c* between the modal and maximum price.

The classifier may be chosen as the solution to an optimization problem. The national version of the classifier is defined as

$$c_N^* = \arg\max_{\mathbf{c}} \quad \|\widehat{\gamma_{AC}}(c) - \widehat{\gamma_C}(c)\|$$

where $\widehat{\gamma_C}(c)$ and $\widehat{\gamma_{AC}(c)}$ are the estimated coefficients on $PCI_{m(i)}$ of the regression:

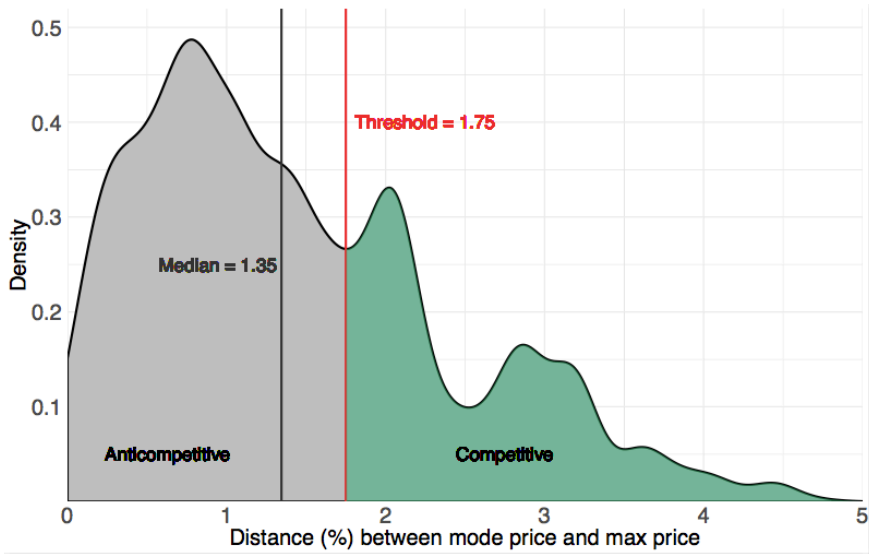
$$\widehat{m}_i = \left(\alpha_C(c) + \gamma_C(c) * PCI_{m(i)}\right) * 1\left[pmax_{m(i)} - pmode_{m(i)} > c\right] + (\alpha_{AC}(c) + \gamma_{AC}(c) * PCI_{m(i)}) * 1[pmax_{m(i)} - pmode_{m(i)} \leq c] + \varepsilon_i$$

where $pmax_{m(i)}$ is the average maximal price of the municipality where station i is located and $pmode_{m(i)}$ is the average modal price. Therefore, $\gamma_C(c)$ represents the relation between the price concentration index and the average markups for the competitive group, which we would expect to be negative if competition is lowering prices; and $\gamma_{AC}(c)$ represents the relation between the price concentration index and the average markups for the anticompetitive group, which we would expect to be positive if this indicates price coordination.

In Appendix D we plot the national objective function $\widehat{\gamma_{AC}}(c) - \widehat{\gamma_C}(c)$ as a function of the cutoff classifier c at the national level and the regional levels. The national objective function is not very sensitive to the choice of the cutoff, for all $c \in [0.3, 3.5]$ the value $\widehat{\gamma_{AC}}(c) - \widehat{\gamma_C}(c) \in [0.2, 0.8]$. Then we plot the regional objective functions $\widehat{\gamma_{AC}}^R(c) - \widehat{\gamma_C}^R(c)$, where the two coefficients are estimated separately for each of the four regions. A natural requirement for the cutoff c would be to have $\widehat{\gamma_{AC}}^R(c) - \widehat{\gamma_C}^R(c) > 0$ for every region R. However, $\widehat{\gamma_{AC}}^{center}(c) - \widehat{\gamma_C}^{center}(c) < 0$ for all c, which means there is no natural way to obtain two groups of stations for which we obtain the Competitive Case behavior and the Anticompetitive Case behavior. More on this below.

Figure 15

Distribution and Classification of Stations by Municipality's Average Distance between Mode and Maximal Price



Notes: to calculate the density, we only considered municipalities with more than two stations. For each municipality, for each day, we calculate the distance between the mode price and the maximum price. Then, we take the whole-sample-period average of these distances. We classify all the stations in a municipality to be either competitive or anticompetitive depending on the selected threshold of the average max-mode distance. We establish this threshold to be at 1.75% for the whole country.

Imposing the extra restrictions of $\widehat{\gamma_{AC}}^R(c) - \widehat{\gamma_C}^R(c) > 0$ for $R \in${Center-North, North, South} and 0.05%$\leq c \leq 2.15\%$, we obtain the cutoff classifier $c = 1.75\%$ as the solution to the restricted optimization problem.[40] Therefore, we classify a gas station to belong to the anticompetitive group if it is located in a municipality in which the difference between mode and maximum is less than 1.75%. The additional restriction for the cutoff to be less than 2.15% is because we do not want to have too few stations classified as competitive, in particular, this restriction is equivalent to the requirement that at least 25% of the stations are classified as competitive. Also, what we want is the classification to be exogenous to the regions, and choosing a national classifier is a way to achieve this condition. Figure 15 shows the distribution of the stations according to the distance between mode and maximum, and also plots the cutoff classifier. Table 8 shows the number of stations in each region that are

[40] The requirement that $0.05\% \leq c \leq 2.15\%$ ensures an interior solution. In fact, the values were chosen so that at least 25% of the stations would be allocated in each group.

located in each type of municipality. The Center has the biggest share (30%) of anticompetitive stations of the country and 65% of all its stations are classified as anticompetitive.[41] The Center-North has the second greatest share (25%) of anticompetitive stations of the country and 61% of all its stations are classified as anticompetitive.

Table 8

Classification of Stations Based on the Competitive/Anticompetitive Classifier, by Region

	Classification of gas stations		
	Competitive	Anticompetitive	Total
Center	953	1708	2661
% of region total	(35%)	(65%)	(100%)
% of national classification	(28%)	(30%)	(30%)
Center-north	889	1373	2262
% of region total	(39%)	(61%)	(100%)
% of national classification	(26%)	(25%)	(25%)
North	1242	1355	2597
% of region total	(47%)	(53%)	(100%)
% of national classification	(36%)	(24%)	(29%)
South	335	1154	1489
% of region total	(22%)	(78%)	(100%)
% of national classification	(10%)	(21%)	(16%)
National	3419	5590	9009
%	(38%)	(62%)	(100%)

Notes: Only municipalities with more than 2 gas stations are included in calculations. Gas stations are classified according to their municipality's average distance between the maximum and modal price in the October - January period.

Figure 16 shows the national level linear fits of the average markup on the price concentration index. For the competitive group a higher concentration of prices is related to lower markups and prices, this is consistent with the undercutting process. The opposite is true for the anticompetitive group: higher concentration of prices is related to higher markups and prices, which is consistent with coordination. Figure 17 shows the national level linear fits for the *changes* in markups. In the case of the competitive municipalities, more price concentration is negatively related to the increase in markups and this implies faster pass-through. Comparing this observation to our stylized fact 3 about competition in pass-through, our

[41] This does not mean a station is coordinating prices or participating in anticompetitive or illegal behavior, it just means the station belongs to a municipality classified as anticompetitive.

observations are consistent: more competition implies faster pass-through and price concentration. For anticompetitive municipalities, Figure 17 shows that more price coordination is not as related to pass-through as for competitive municipalities.

Figure 18 is the analogue of Figure 16 for the markup level and concentration index for different regions. The North shows the same behavior as the national. For the South and the Center-North both slopes are positive, so even the competitive groups show a positive relation between price concentration and average prices, nonetheless these slopes are lower than those for the anticompetitive groups. We discuss the Center in the next paragraph. Figure 19 is the analogue of Figure 17 for the different regions showing the correlation between the price concentration index and markup increases. The South and the Center-North follow the national results, while in the North both groups (competitive and anticompetitive) seem to be behaving quite competitively. This is not surprising if we remember from Table 6 that the North had the strongest within-group effect, and pass-through was faster for all Groups when compared to any other region. Figure 19, also shows a strong response of pass-through to competition in the South, which again should not be surprising considering the South's within-group effect reported in Table 6. To a lesser degree these observations apply to the Center-North, which satisfies our stylized fact 3 (competition in pass-through) but shows a weak within-group effect in Table 6, and a smaller difference in coefficients $\widehat{\gamma_{AC}}^R(c) - \widehat{\gamma_C}^R(c)$ as pictured in Figures 18 and 19.

Coming back to the Center. The Center has the lowest pass-through within-group as reported by Table 5. Indeed, stylized fact 3 (competition in pass-through) is violated. Previously we discussed that a natural requirement for the cutoff c would be to require $\widehat{\gamma_{AC}}^R(c) - \widehat{\gamma_C}^R(c) > 0$ for every region R. However, no matter the cutoff c chosen $\widehat{\gamma_C}^{center}(c) > 0$, $\widehat{\gamma_{AC}}^{center}(c) > 0$ and $\widehat{\gamma_{AC}}^{center}(c) - \widehat{\gamma_C}^{center}(c) < 0$. This means there is no natural way to obtain two groups of stations for which we obtain the Competitive Case behavior and the Anticompetitive Case behavior, in this sense either all the stations behave anticompetitively or the opposite. Once we observe Figure 18 and 19 we convince ourselves that Anticompetitive Case behavior is more likely. The evidence points out to possible coordination of retailers on high prices in this region.

Figure 16
Relationship between the Price Concentration Index and the Level of the Average Markup for every Station, by Classification

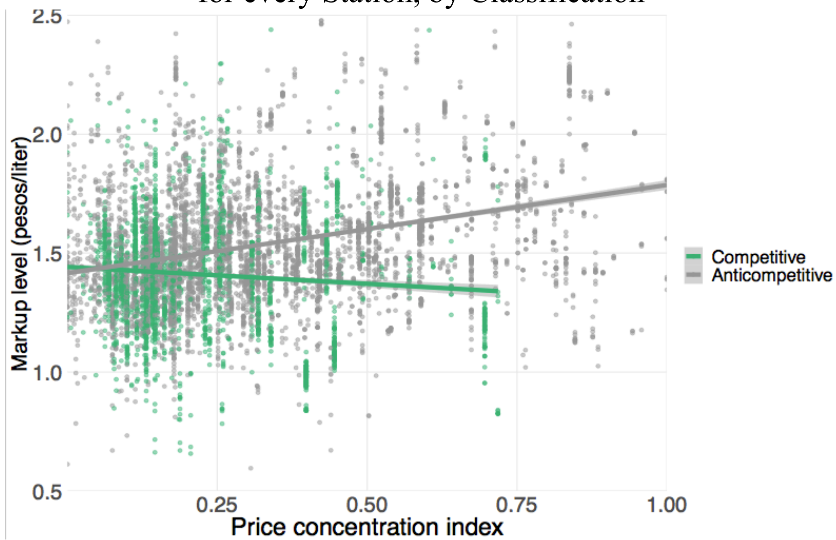


Figure 17
Relationship between the Price Concentration Index and the Increase in Markups for every Station, by Classification

Notes Fig. 16, 17: each dot represents a gas station. The number of observations is 9,036. These correspond 3,432 to the competitive classification and 5,604 to the anticompetitive one. The municipalities with 2 or less stations are not included. Every gas station is classified in either a competitive or anticompetitive municipality. A linear fit is shown separately for both sets of stations between the price concentration index of the municipality to which a station belongs and: (a) its average markup level (Figure 16), (b) its markup increase (Figure 17); in the period October 11, 2018 to January 10, 2019. The slopes are significant at the 99% level although 95% confidence intervals are depicted as a grey shade above and below the fit. The price concentration index is calculated as the average of the daily indexes during the wholesale price reduction period, October 11, 2018 to January 10, 2019. The increase in markups is controlled for station fixed effects.

Figure 18
Relationship between the Price Concentration Index and the Level of the Markups for every Station, by Classification and Region

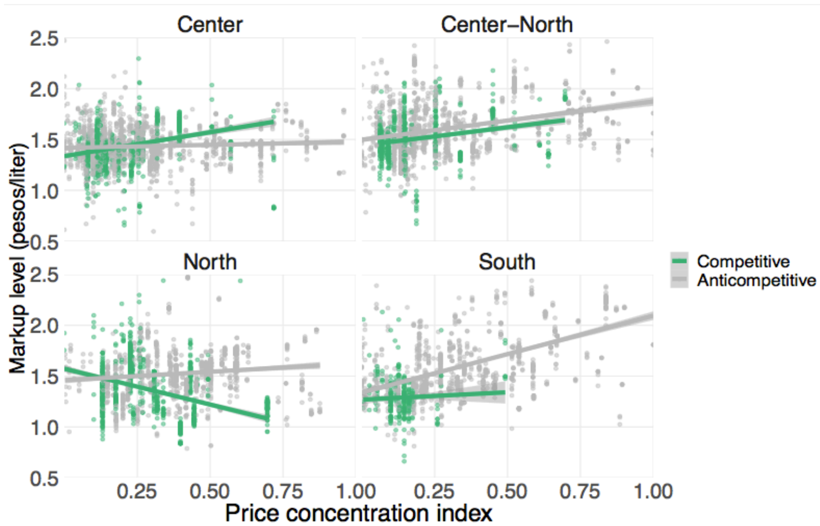
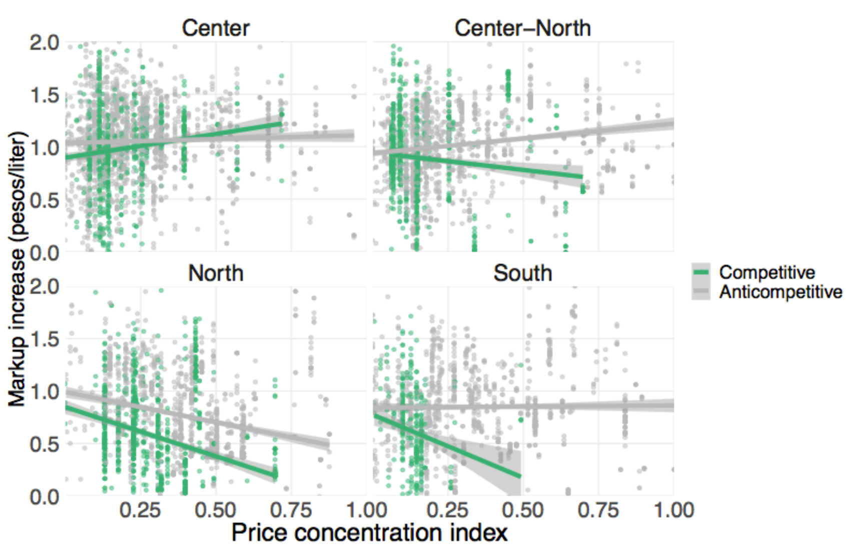


Figure 19
Relationship between the Price Concentration Index and the Increase in Markups for every Station, by Classification and Region



Notes Fig. 18, 19: each dot represents a gas station. The number of observations reported as (competitive, anticompetitive) is (954, 1712); (891, 1380); (1252,1356); (335, 1156), for the Center, Center-North, North, South, respectively. The municipalities with 2 or less stations are not included. Every gas station is classified in either a competitive or anticompetitive municipality. A linear fit is shown separately for both sets of stations between the price concentration index of the municipality to which a station belongs and: (a) its average markup level (Figure 18), (b) its markup increase (Figure 19); during the period October 11th, 2018 to January 10th, 2019. The slopes are significant at the 99% level except the competitive fit for the South, which is significant at the 95% level; 95% confidence intervals are depicted as a grey shade above and below the fit. The price concentration index is calculated as the average of the daily indexes during the wholesale price reduction period, October 11, 2018 to January 10, 2019. The increase in markups is controlled for station fixed effects.

6. Final Remarks

Until the beginning of 2017, Mexican consumers had not been exposed to different brands and prices of gasoline. Since then, consumers gradually started to experience the introduction of several new brands, fuel quality, and price variation, providing them with a span of several consumption alternatives that could enhance their welfare. In this order of ideas, from studying daily prices of nearly all the population of stations in the country, after December of 2017, date in which prices in all regions of the country were liberalized, we find the following stylized facts: (1) consumer prices adjust slower than wholesale prices; (2) more competition results in lower prices and markups, and (3) more competition implies faster pass-through both for wholesale price increases and decreases.

When we perform the same analysis at the regional level, we find some regions in which pass-through of wholesale prices to consumer prices is considerably slower for equivalent levels of competition. Therefore, we perform a more granular analysis at the local level. We propose a way to identify municipalities depending on a measure of the likelihood that a large group of stations are setting the same high price. Coordination at high prices in some localities could be offsetting the competitive pressures one should expect from higher concentration of gas stations.

Compared to other countries, Mexico has a very low density of gasoline stations relative to both population and number of vehicles.[42] Our results show that a higher density of stations exerts competitive pressure and lowers prices. Increasing the number of stations requires the elimination of regulatory barriers to entry as well as to enforce competition law and promote competition advocacy. In addition, it is necessary to promote upstream investment in infrastructure and the services required to serve stations. On the other hand our results seem to suggest higher density of stations would not be enough to improve consumers' welfare without compliance with the competition regulatory framework.

[42] Cofece (2019) and Cofece (2017).

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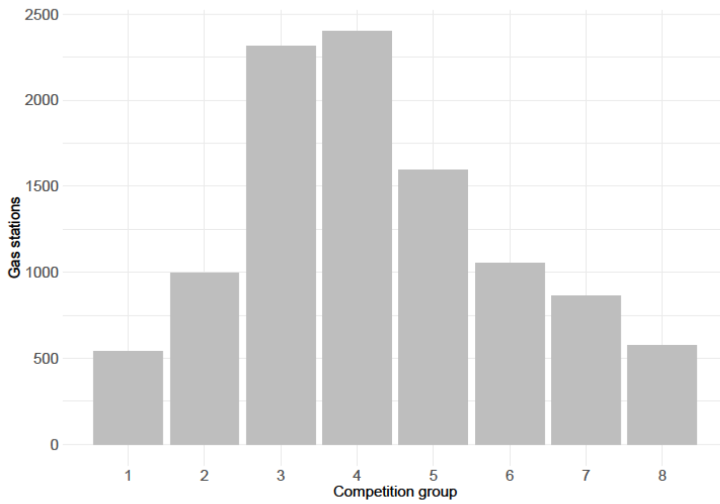
Appendix A

Figure A1. Histogram of the stations by competition group (8 groups)



Notes: The histogram plots the distribution of all the country stations in the Competition Groups defined in Table 1.

Table A1. Classification of stations in 20 competition groups

	Group	Description
More competition ↓	1	No neighbors in 10km
	2	Exactly 1 neighbor in 10km, but no neighbors 3km
	3	At least 2 neighbors in 10km, but no neighbors 3km
	4	Exactly 1 neighbor in 3km
	5	At least 2 neighbors in 10km and only 1 in 3km
	6	Exactly 2 neighbors in 3km, but no neighbors in 1km
	7	Exactly 3 neighbors in 3km, but no neighbors in 1km
	8	Exactly 4 neighbors in 3km, but no neighbors in 1km
	9	At least 5 neighbors in 3km, but no neighbors in 1km
	10	At least 5 neighbors in 3km, only 1 in 1km, but no neighbors in 500m
	11	At least 5 neighbors in 3km, 1 in 1km, and exactly 1 in 500m
	12	At least 5 neighbors in 3km, 2 in 1km, and no neighbors in 500m
	13	At least 5 neighbors in 3km, 2 in 1km, and exactly 1 in 500m
	14	Exactly 2 neighbors in 500m
	15	At least 3 neighbors in 1km, but no neighbors in 500m
	16	Exactly 3 neighbors in 1km and exactly 1 in 500m
	17	Exactly 3 neighbors in 1km and at least 2 in 500m
	18	At least 4 neighbors in 1km, but no neighbors in 500m
	19	At least 4 neighbors in 1km and exactly 1 in 500m
	20	At least 4 neighbors in 1km and at least 2 in 500m

Figure A3. Histogram of the stations by competition group (20 groups)

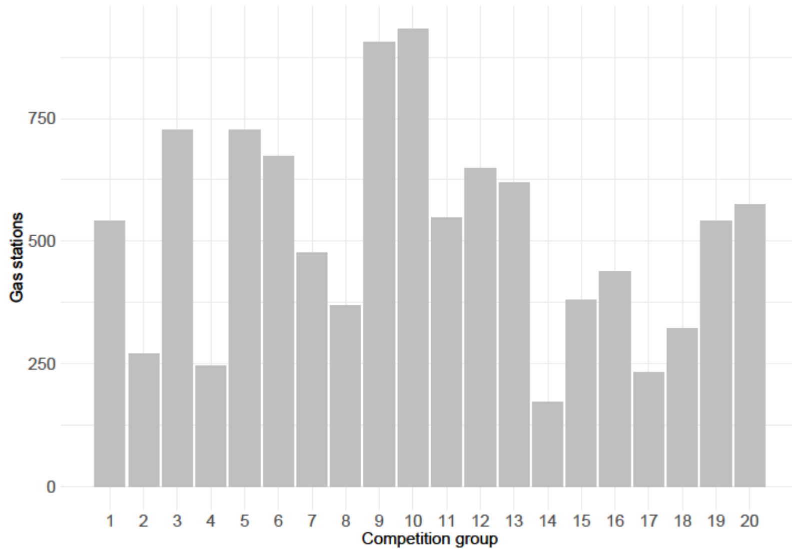
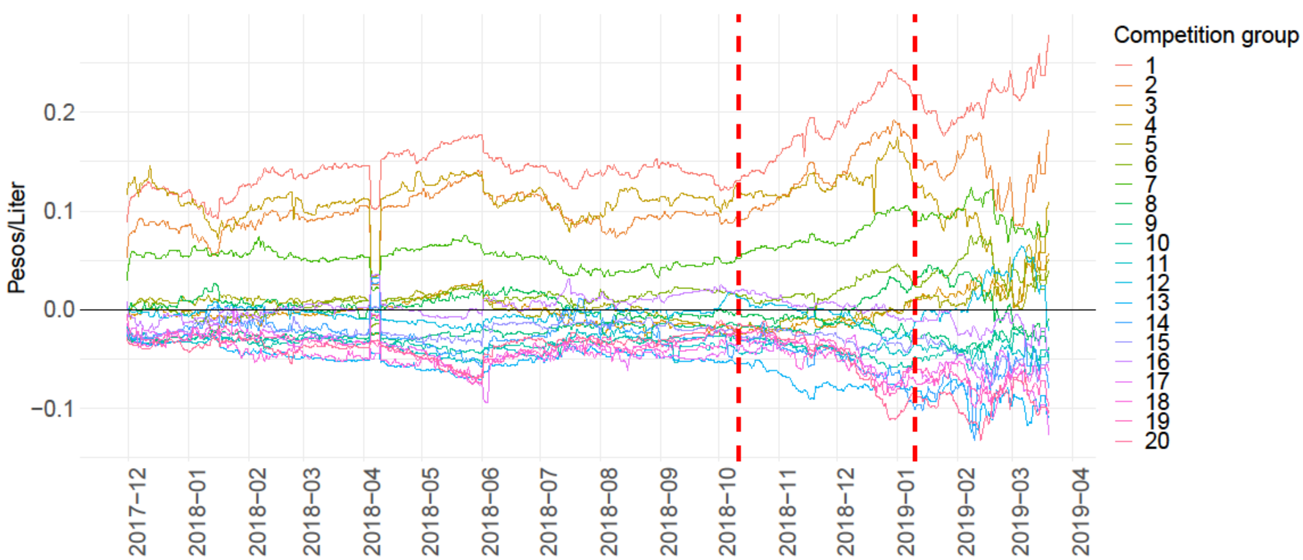


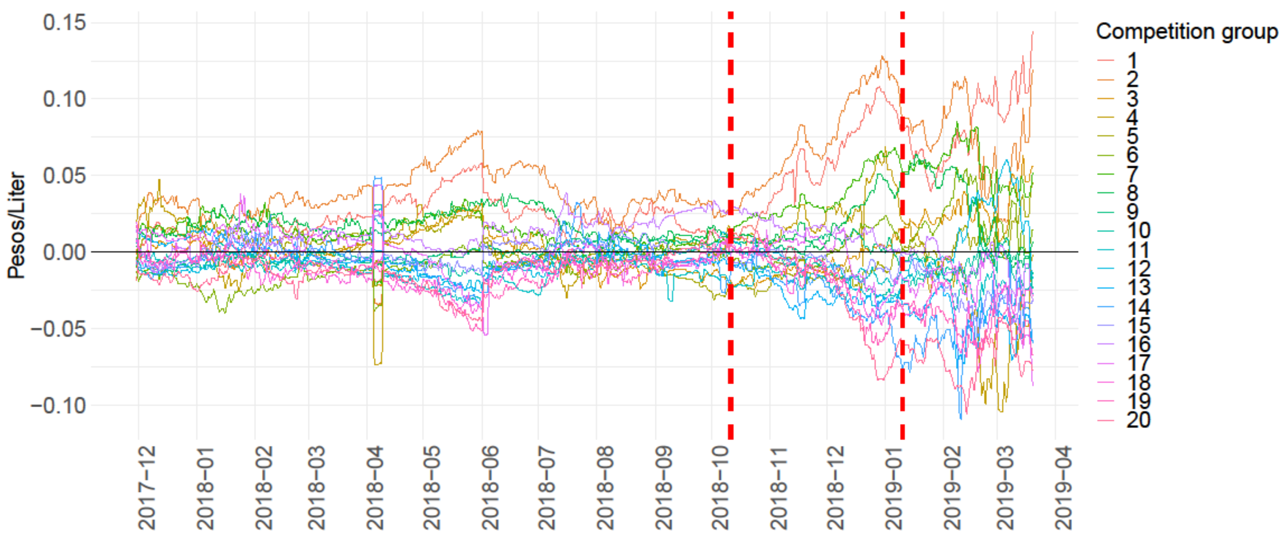
Figure A4. Price of Regular Gasoline by Alternative Competition Groups (20 groups), Centered at Zero



Notes: The prices are simple daily averages by group minus the daily national average (day fixed effect) to center the time series at zero. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

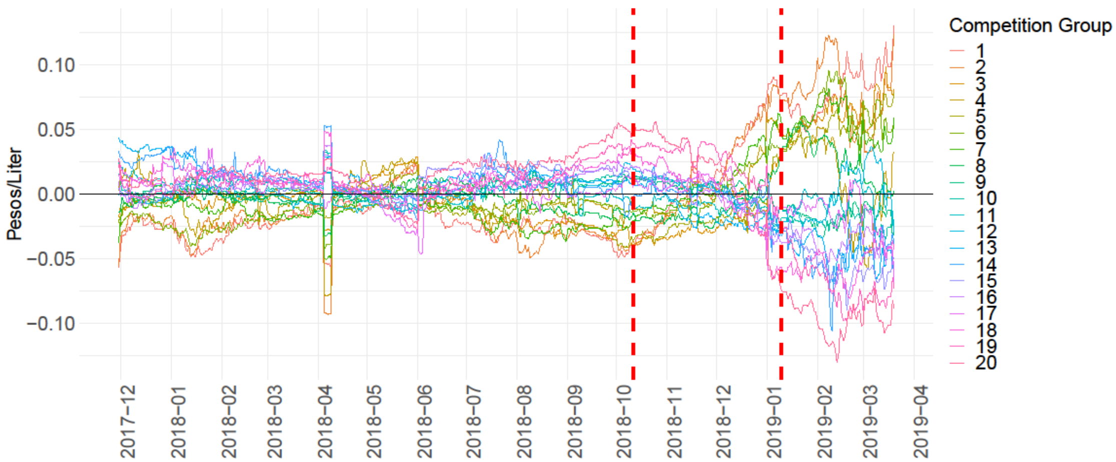
Figure A4 shows that prices are higher the less spatial competition stations face. Figures A5 and A6 show how, during the period where wholesale prices decrease monotonically (between the vertical red dashed lines), the markups of the lowest Competition Groups increase relative to the national daily mean, and the markups of the highest Competition Groups decrease relative to the national daily mean. This shows further evidence that more competition implies faster pass-through after a prolonged decrease of costs. Although somewhat noisier than the version of 8 Competition Groups, this serves as a robustness check for the results presented throughout the paper. The only reason for subtracting daily averages and center the series at zero is the visual benefit of distinguishing more clearly between lines (groups).

Figure A5. Markups of Regular Gasoline by Alternative Competition Groups (20 groups), Centered at Zero, Supply and Demand Controls, Centered at Zero



Notes: The markups are controlled by supply and demand factors (income, vehicles, brand, transportation costs) by group minus the daily national average (day fixed effect) to center the time series at zero. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

Figure A6. Markups of Regular Gasoline by Alternative Competition Groups (20 groups), Centered at Zero, With Station Fixed-Effects, Centered at Zero



Notes: The markups are controlled by station fixed-effects by group minus the daily national average (day fixed-effect) to center the time series at zero. Vertical lines represent the period in which all TAR prices start decreasing and stop decreasing, respectively. This is from October 11, 2018 to January 10, 2019.

Appendix B. Impulse-response functions simulating a 1 peso increase and decrease by competition group

To estimate asymmetric pass-through we follow the methodology used by Chesnes (2016), Remer (2015), Bachmeier and Griffin (2003), Borenstein et al. (1997), which all rely on the error correction model proposed by Engle and Granger (1987). We first estimate the long-run linear relationship between the retail prices and the wholesale prices in a first stage, and then insert the lagged residuals into the autoregressive distributed lag model as the error correction term. Equation 1 presents the long run relationship between R_t, the retail prices, and W_t, the wholesale prices. This equation is estimated for every retail price series of every gas station j .

$$R_t = \phi_0 + \phi_1 W_t + \epsilon_t \tag{1}$$

The lagged residual, $\epsilon_{t-1} = R_{t-1} - \phi_1 W_{t-1} - \phi_0$ captures the extent to which retail prices and wholesale costs are deviating from their long-run equilibrium. Eq. (1) separately identifies the effect on retail prices of short-run changes in cost and own-price from the pressure for retail prices to return to their long-run relationship with wholesale price. To test for the presence of asymmetric pricing we then estimate Eq. (2), which allows us to capture different responses from upward shocks than from downward shocks by separating positive and negative coefficients, and its differentiated response on retail prices.

$$\Delta R_{jt} = \gamma_j + \sum_{i=0}^{L} (\alpha_i^+ \Delta^+ W_{t-i} + \alpha_i^- \Delta^- W_{t-i}) + \sum_{i=1}^{L} (\beta_i^+ \Delta^+ R_{jt-i} + \beta_i^- \Delta^- R_{jt-i})$$

$$+ \theta^+ (\widehat{\epsilon_{jt-1}^+}) + \theta^- (\widehat{\epsilon_{jt-1}^-}) \qquad (2)$$

Here, $\Delta^+ W_t$ takes the maximum value between ΔW_t and zero, and $\Delta^- W_t$ takes the minimum value between ΔW_t and zero; lagged retail price changes and the error-correction term are analogously defined. Eq. (2) allows for positive and negative cost changes to have a unique effect on current retail prices. Similarly, past changes in retail price and the error-correction term are allowed to asymmetrically affect current retail prices. We include a gas station fixed effect γ_j that controls for systematic changes in markups. In general, if $\alpha_i^+ > \alpha_i^-$ then rockets and feathers exists. However, since lagged terms are interacted, the coefficients of the lagged terms have no simple interpretation by themselves, and to fully assess the pass through, the entire lag structure must be taken into account. Thus, as suggested in the previously mentioned papers, we use the estimated parameters of Eq. (2) to calculate cumulative response functions (CRFs), which show adjustment of retail price over time in response to a one time, one peso change in wholesale price. After an initial one peso increase to costs at $t = 1$, the period k change in retail price, B_k^+ is determined by:

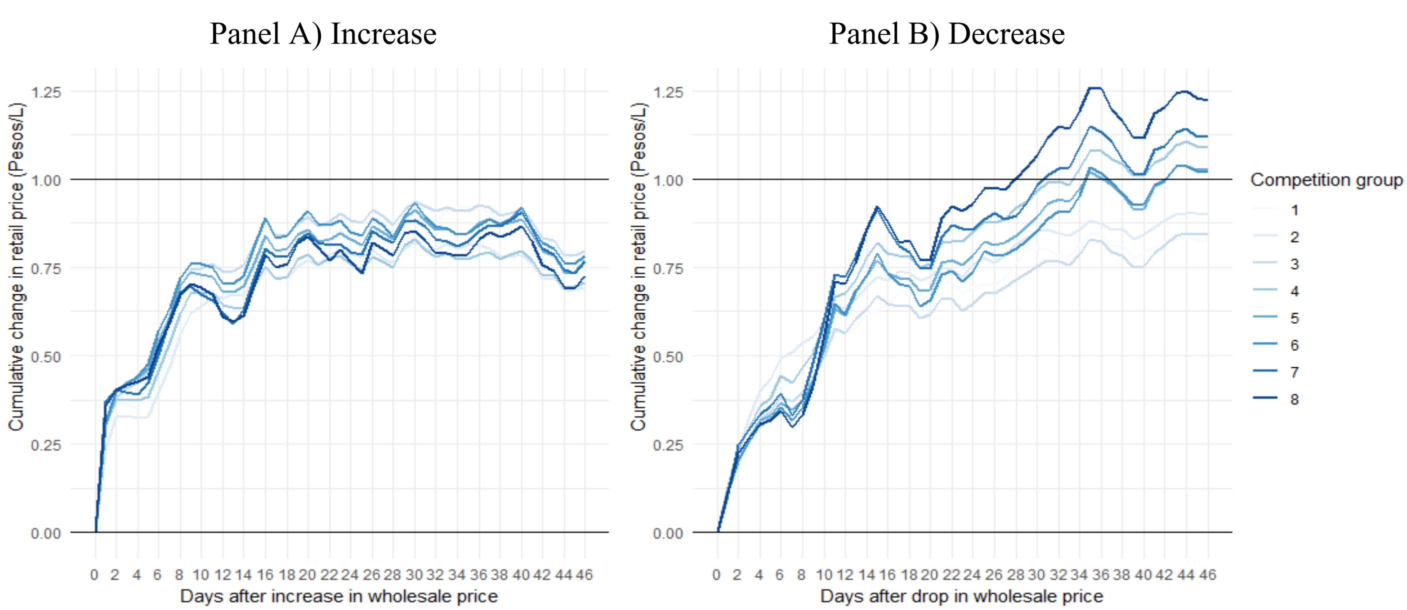
$$B_k^+ = B_{k-1}^+ + \alpha_k^+ + \theta^+ (B_{k-1} - \phi_1) +$$

$$\textstyle\sum_{i=1}^{k} (\beta_i^+ \, max \, \{0, B_{k-i} - B_{k-i-1}\} + \beta_i^- min \, \{0, B_{k-i} - B_{k-i-1}\}) \qquad (3)$$

Then, the CRF is a recursive function which sums L equations, where L is the number of periods it takes retail prices to completely respond to a one time change in cost, and the period $k \in \{1, \ldots, L\}$ cumulative adjustment is as stated in Eq. (3). The CRF detailing the response to a cost decrease is defined analogously to Eq. (3). Rockets and feathers pricing exists at any point in time if the value of the positive CRF is greater than the negative CRF.

Figure A1 presents the CRFs for simulating an increase and a decrease in retail prices a month and a half after a one peso increase and decrease in TAR price. In Panel B we show the heterogeneous speeds at which retail prices decrease from different groups and confirm the results presented in Section 6: prices decrease slower the less competition gas stations face. Point estimates show that about 28 days after a cost shock, the highest-competing group, Group 8, passes-through 1 peso whereas the least-competing group, 1, has passed-through about 70 cents. On the other hand, Panel A shows the adjustment process for a positive cost shock. It can be seen that the speeds of adjustment are less heterogeneous among groups. Overall, the pattern of asymmetric pass-through is observed in all groups during the first 10 days after the cost shock; after that, the effect is not distinguishable.

Figure B1. Cumulative Impulse Response Functions of Retail Prices to a One-Time One-Peso Increase and Decrease in Wholesale Prices by Competition Group

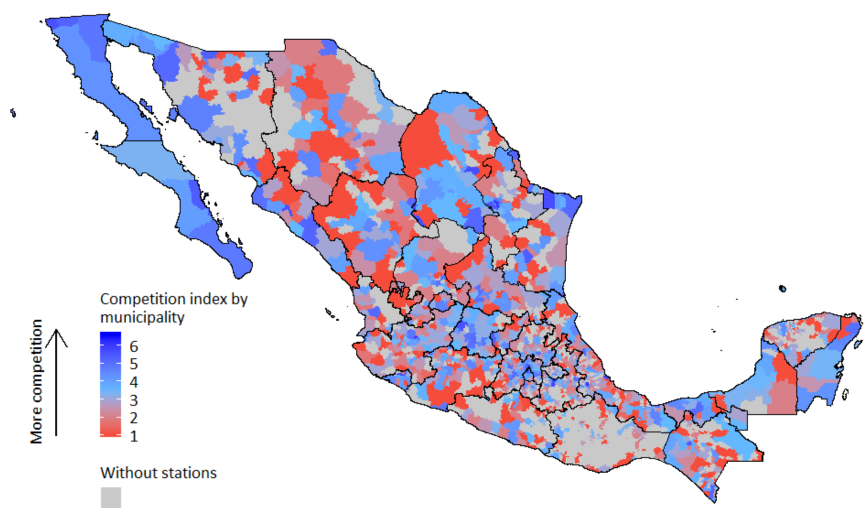


Notes: These IRFs were estimated using data from the period December 1, 2017 to January 10, 2019. In mid-January and early February, 2019, there was a shortage of fuel due to the president's strategy to fight fuel robbery. In order to avoid contamination of the estimates from this period, we use data before the shortage. For the estimation, 9,992 gas stations were included, only taking into account the stations that appeared reporting prices since the beginning of the sample periods in order to have a balanced panel. The IRFs shows a month and a half adjustment period.

Appendix C

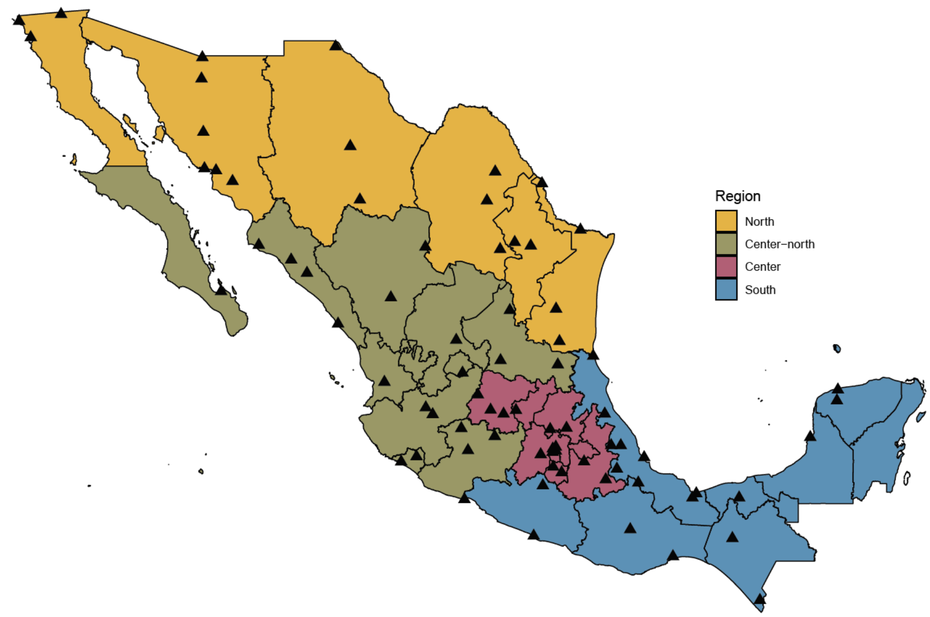
In Figure 1 we presented the location of every station in Mexico by competition group. In the map below it can be noted that urban zones, or the main cities, have higher concentration of stations that face more competition, whereas isolated stations across the rest of the territory are subject to lower competitive pressure. Given that there is a lot of heterogeneity in the stations' competing groups inside every state, we calculate an index of the degree of competition at a municipality level as the simple average of the number group that stations inside a municipality are assigned to. Figure C1 plots this index. Southern states have particularly low levels in our measure of competition, and some of them have several municipalities that do not even have stations. In fact, some of these states do not have Group 8 or 7 stations. Together, Figures 1 and C1, show that the low density of stations in the Southern states combines with a low share of stations facing competitive pressures, and in some cases, there are no stations at all. On the other hand, in the Northern part, although it is true that there is a higher proportion of stations facing higher competition levels, these are clustered in particular points, i.e. main cities, while the rest of the states present low density.

Figure C1. Competition Index by Municipality



Notes: The index is calculated as the average of the group of competition of all stations in a municipality.

Figure C2. Regions and TARs

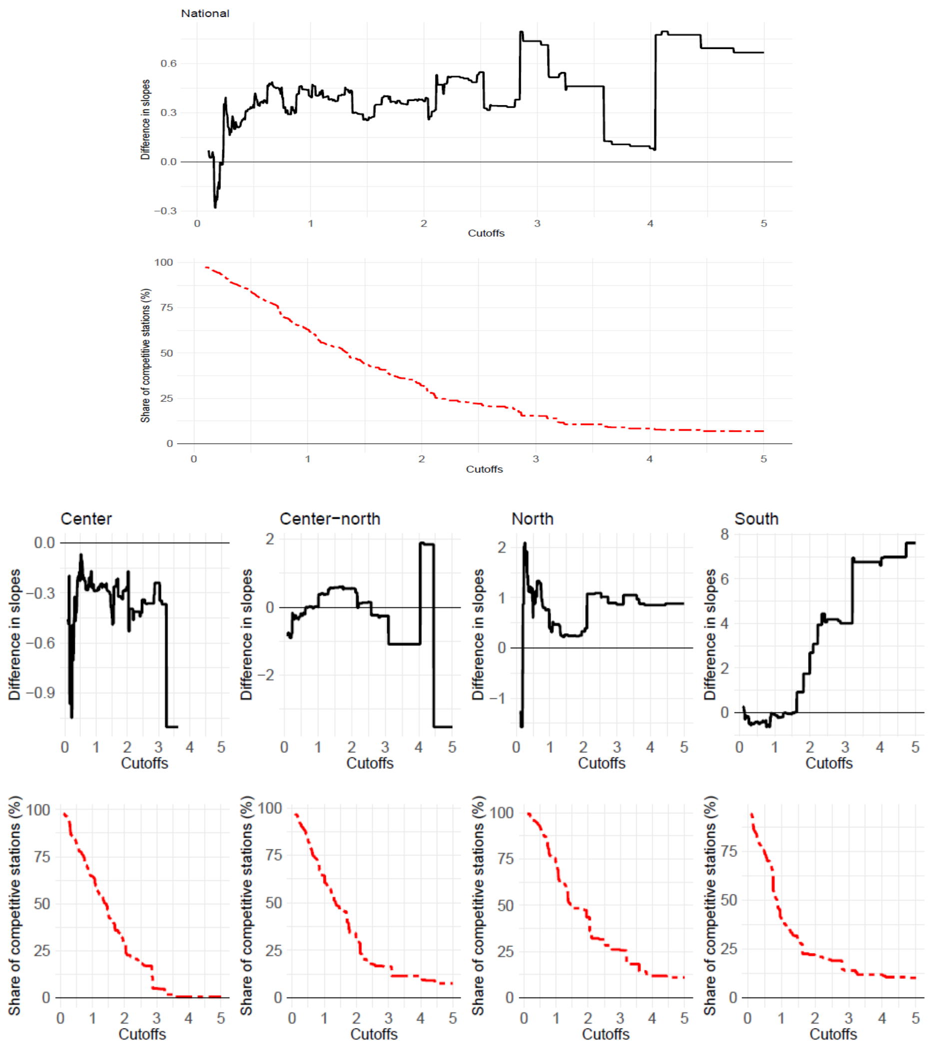


Notes: The figure shows the regions used in the analysis and the 76 TARs in the country. Following the classification used by the Bank of Mexico: the North includes Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas; the Center-North Aguascalientes, Baja California Sur, Colima, Durango, Jalisco, Michoacán, Nayarit, San Luis Potosí, Sinaloa, and Zacatecas; Center includes Ciudad de México, Estado de México, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro, and Tlaxcala; and the South includes Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán.

Appendix D

For each value of the cutoff, we compute one regression for each of the two sets of municipalities, competitive and anticompetitive, and then plot the difference between the slopes of the regressions. While Figures 16-19 were built with the national classifier, here we do the exercise for every region separately. The only region where the problem does not have a solution is the Center.

Figure D1. Robustness of classifier. Difference in regression slopes for different cutoffs of the classifier.



Notes: The black solid lines plot the difference in slopes $\widehat{\gamma_{AC}}(c) - \widehat{\gamma_C}(c)$ as a function of c, where $\widehat{\gamma_C}(c)$ and $\widehat{\gamma_{AC}(c)}$ are the estimated coefficients on $PCI_{m(i)}$ of the regression given c:

$$\hat{m}_i = \left(\alpha_C(c) + \gamma_C(c) * PCI_{m(i)}\right) * 1\left[pmax_{m(i)} - pmode_{m(i)} > c\right] + \left(\alpha_{AC}(c) + \gamma_{AC}(c) * PCI_{m(i)}\right) * 1\left[pmax_{m(i)} - pmode_{m(i)} \leq c\right] + \varepsilon_i$$

where $pmax_{m(i)}$ is the average maximal price of the municipality where station i is located and $pmode_{m(i)}$ is the average modal price. The black solid lines plots the difference in slopes between the anticompetitive and the competitive sets. The red dashed line plots the percentage of stations classified as anticompetitive.