Competitive Effects of Entry in Gasoline Markets*

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Abstract

We use panel data on the location, prices, and quality of the universe of gas stations in Mexico to study the competitive effects of entry on incumbent firms. Using more than 1,000 entry events and defining local markets based on the road network, we find that the entry of a new station within three minutes driving time decreases regular gasoline prices by 6 percent of the retail price spread. Competitive effects decline with travel time and are largest in markets that previously had only one station. Entry of stations with the same owner as the incumbent has near-zero effects. The effect of competition on quality is less clear, with suggestive evidence of improved service quality in some specifications.

Keywords: market structure, competition, entry, quality, gasoline stations, Mexico.
JEL: D43, L10, L81, Q41, Q48

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1 Introduction

Increasing competition is the most common solution economists give to the problems of low quality and high prices in a market. Indeed, in most standard models in industrial organization, more competition in the form of more firms leads to lower prices. But this prediction is far from universal. Satterthwaite (1979) shows that in markets for reputation goods, prices could *increase* when there are more sellers, while Joskow (1980) argues that more competition may lead to excess capacity, excess quality, and higher cost. Nickell (1996) writes that the theoretical justifications for the beneficial effects of competition are "not overwhelming".

The relationship between quality and competition is even more complex and has received less attention in the theory literature. At least since Spence (1975), it has been understood that the level of quality with a monopolist may be higher or lower than with a perfectly competitive market. Moreover, price and quality competition may interact: distorted price signals may lead to higher or lower investment in quality. Imperfect quality observability further complicates the relationship. Dranove and Satterthwaite (1992) show that if price competition is sufficiently intense relative to quality competition, firms will select suboptimal levels of quality.

With no clear prediction from theory, empirical work on this issue is critical. This paper studies how increased competition in the form of entry affects prices and quality in the Mexican retail gasoline market. Several features of the gasoline market make it an excellent candidate for an empirical study of competition. First, while the product is homogeneous, markets are geographically local, allowing us to use driving times along the road network to define markets. Second, most consumer expenditure on each visit is for a single product, avoiding issues of aggregating prices across multiple categories. Third, gasoline retail markets are a major sector of the economy, representing in Mexico, for example, a $5+ billion annual market.

To study the competitive effects of entry, we assembled the most comprehensive dataset ever compiled on the Mexican retail gasoline market. Compiled from various administrative sources, these data describe the *universe* of gas stations in Mexico, including daily retail and wholesale prices for regular gasoline, premium gasoline, and diesel. The breadth of data allows us to observe more than 1,000 new stations entering from 2017 to 2022. We have 19.2 million station-day observations for regular gasoline, 17.1 million station-day observations for premium gasoline, and 13.4 million station-day observations for diesel, with the difference in the number of observations due to not all stations selling every product.

We proceed in several steps using a staggered difference-in-differences design. First, we define local markets using driving times along the road network around each station, with a three-minute radius for our base case market definition. Second, we compare prices of incumbent gasoline stations before and after a competitor enters the market, controlling for station, wholesale-terminal-by-month-of-sample, and day-of-sample fixed effects. As in Arcidiacono et al. (2020), the identification assumption is that the *exact* timing of competitor entry is exogenous. This assumption is reasonable because new stations must go through a long and idiosyncratic approval process before opening. Third, we validate our empirical design using event study analysis and a variety of alternative specifications.

We find that the entry of a new station within three minutes decreases the prices of incumbent firms by 0.36 percent for regular gasoline, 0.24 percent for premium gasoline, and 0.22 percent for diesel. Although they are small from the viewpoint of consumers, these price reductions are large from the firms' perspective, equivalent to 6.0 percent (regular) and 3.5 percent (premium and diesel) of the spread between retail and wholesale prices. Markets are very local, with significantly larger effects within a driving time of one minute and no evidence of an effect of entry for entrants located more than nine minutes away. In addition, we show that competitive effects are decreasing in the number of incumbent stations, with 20 percent larger effects in markets that initially had just a single incumbent station and near zero effects for markets with more than five incumbents. Finally, we find that the price decreases are highly persistent after several quarters, not the result of a newness effect.

A novel feature of our analysis is that we can separate the effect of entry based on the ownership of the entrant. We compare entry by stations with new owners to entry by stations with the same owner as the incumbent. Entry of a station with the same owner as the incumbent has near zero effect on prices. In some specifications, we even find evidence of a positive effect on the price of premium gasoline and diesel from the entry of a same-owner station. These results point to the importance of ownership structure for determining the competitiveness of local retail markets.

We then turn to a second set of findings on the effect of entry on quality. Service quality is a multi-dimensional concept that is notoriously difficult to measure and, thus, has yet to receive much attention in the empirical literature. We use three sources of data to measure station quality. Two are based on a distinctive aspect of the Mexican gasoline market: the illegal practice of selling *chiquilitros*. For years, it has been common in Mexico for gasoline station operators to manipulate their pumps to dispense incomplete liters to customers (Guerrero, 2012; Liu et al., 2018). Our first quality measure is complaints to the consumer protection agency about stations, most of which relate to the perceived sale of *chiquilitros*. Our second measure comes from data on repeated inspections of pump equipment over time by the consumer protection agency, using whether or not the station passes the inspection as a quality measure. Finally, we use data on recently implemented inspections of gasoline station bathrooms.

We find mixed results for service quality. Using the same staggered difference-in-differences design, there is suggestive evidence of improved service quality in some specifications. The entry of a new station decreases the probability of complaints about *chiquilitros* in incumbent gas stations by 18 percent. Point estimates also indicate 2 percent fewer failed inspections of pump equipment and 11 percent fewer failed bathroom inspections. However, these results are less precisely estimated than the results for prices, partly because we have sparser information on station quality. Also, as we discuss, there are some additional empirical issues with measuring quality which make this part of the analysis particularly challenging.

Our paper contributes to the literature on competition and prices. Earlier research on this topic provided descriptive correlations between prices and market concentration. To estimate a causal effect of competition on prices, several papers use mergers, studying industries such as banking (Sapienza, 2002; Allen et al., 2014), insurance (Dafny et al., 2012), healthcare (Dafny, 2009; Cooper et al., 2019), and gasoline (Hastings, 2004; Hastings and Gilbert, 2005).[1] In terms of methodology and identification assumptions, our study is similar to studies that have estimated the effect of the entry of Walmart on prices at incumbent stores (Atkin et al., 2018; Arcidiacono et al., 2020).[2]

We also contribute to the literature on the determinants of gasoline prices. Most earlier studies on the effect of competition in this industry relied on cross-sectional regressions (Barron et al., 2004; Clemenz and Gugler, 2006), aggregate data (Sen, 2005; Chouinard and Perloff, 2007), or station-level data from a small number of markets (Hosken et al., 2008).

1. For example, Hastings (2004) uses station-level data from San Diego and Los Angeles to show that retail gasoline prices increased in response to an independent gasoline retailer being acquired by a vertically integrated firm. Whereas these mergers all involved upstream and downstream operations, interpretation in our setting is particularly straightforward because only downstream operations were affected.

2. The literature on Walmart entry is fascinating, but also quite different from our context. In particular, the literature on Walmart is complicated by the fact that Walmart's size can impact the cost and availability of upstream suppliers. The supermarket industry is also much more complex. Strikingly, Arcidiacono et al. (2020) find that Walmart entry does *not* lead to a decrease in prices of other stores, despite large ex-ante variation in prices, a finding they attribute to menu costs. The higher overall density of gasoline stations allows us to examine entry separately for markets with different numbers of incumbents and to perform other alternative tests that would be more challenging in the Walmart context.

More recently, there has been an explosion of interest in this sector using administrative datasets with high-frequency, station-level pricing data, often for an entire country. This granular data has been used to study topics as varied as collusion (Byrne and Roos, 2019), algorithmic pricing (Assad et al., 2024), consumer search (Byrne and Roos, 2017; Pennerstorfer et al., 2020; Dorsey et al., 2025), cost pass-through (Genakos and Pagliero, 2022; Contreras Astiazarán et al., 2020; Montag et al., 2023), and information disclosure policies (Luco, 2019; Martin, forthcoming).

Focusing on the effect of competition on gasoline prices, the closest related paper to ours is Fischer et al. (2023). They study the effect of station entry on the distribution of prices in local fuel markets in Germany, finding that one additional entry reduces mean diesel prices by about 7 percent of the gross margin. This result is remarkably similar to our estimate for regular gasoline, despite the differences in market dynamics between Mexico and Germany. Competition among Mexican gas stations is a relatively recent phenomenon, with price changes occurring approximately once per week on average. In contrast, stations in Germany increasingly rely on algorithmic pricing and change their prices many times per day (Assad et al., 2024). Fischer et al. (2023) show a bigger effect of entry on the left side of the price distribution, providing greater benefits to informed consumers who search for low prices. Unlike our analysis, they do not study differences in the effect of entry by ownership structure, and their only non-price outcome is the opening hours, for which they do not find an effect.

Our paper also contributes to the smaller literature on competition and quality. As we mentioned earlier, quality is notoriously difficult to measure. Quality proxies that have been used include test scores for public schools (Hoxby, 2000), flight delays for airlines (Mazzeo, 2003), and survival rates for hospitals (Bloom et al., 2015). Economists have focused less on retail services given the challenge of measuring quality in this sector. Two exceptions are Matsa (2011), who uses product stock-outs in supermarkets to measure the effect of Walmart's entry on quality, and Busso and Galiani (2019), who use self-reported shopping experiences as proxies for quality. Our paper introduces several novel quality measures, including measures based on government-collected information rather than self-reports.

Our paper is novel in that we examine *both* prices and quality simultaneously. As we mentioned before, the effect of competition on these outcomes is theoretically ambiguous, and price and quality competition can have important interactions, particularly when quality is imperfectly observed. In our context, we can measure the effect of competition on prices and qualities using the same identification strategy. Studying both sets of outcomes provides a more comprehensive assessment of the effects of competition.

Finally, our paper has important implications for ongoing policy reforms in Mexico. As we discuss in Section 2, the previous decade has been a period of unprecedented change in Mexican petroleum markets, and there remains considerable uncertainty about the direction of competition policy moving forward. Our empirical framework, data, and results are directly relevant to these conversations, particularly regarding the role of competition in improving outcomes for Mexican consumers.

The paper proceeds as follows. Section 2 provides background about Mexico's retail gasoline market. Section 3 introduces our data, including price and quality measures and our approach for measuring driving time. Section 4 describes our empirical strategy. Sections 5 and 6 present the results for prices and quality. Section 7 concludes.

2 Background

Whereas much of the existing related literature focuses on high-income countries, Mexico is a middle-income country, with an annual GDP per capita of US$13,800 in 2023 (IMF, 2023). One of the implications of this setting is that gasoline expenditures are a significant share of household expenditures, representing 5 percent of total household expenditures in Mexico in 2022.[3] More broadly, gasoline and diesel are inputs into virtually all goods and services, so even Mexicans without private vehicles are significantly affected by changes in retail fuel markets.

The past decade has witnessed unprecedented change in Mexican retail gasoline markets. For almost 80 years, from 1938 to 2016, all gasoline stations displayed the brand of the Mexican state-owned petroleum company Pemex. Franchises were dealer-owned and dealer-operated, but all sold gasoline and diesel provided by Pemex at regulated retail prices, set to ensure a guaranteed markup of 5 to 6 percent (Davis et al., 2019).

One of the consequences of this long period of regulation is that Mexico has a relatively low density of gas stations. With regulated retail prices, new stations often had little incentive to enter, particularly in high-demand locations where stations would have otherwise been much more profitable. Historically, there were also significant barriers to entry for new gasoline stations, with municipal governments using zoning restrictions to protect incumbent station owners. According to COFECE (2018), in 2016, Mexico had

3. Calculations based on reported expenditures from a nationally representative household survey (INEGI, 2023b).

10,560 people per gas station, compared to 5,461 for Brazil and 2,677 for the United States. In terms of vehicles per gas station in 2015, Mexico had 3,326, while Australia, Canada, Spain, and the United States had 2,220, 2,760, 2,890, and 1,640, respectively.

Another interesting consequence of this long period of regulation is the practice of selling *chiquilitros* that we mentioned earlier. Faced with regulated retail prices, it became common in Mexico for gasoline station operators to increase their effective markups by manipulating electronic and mechanical equipment to dispense incomplete liters. These practices are illegal, with compliance regulated by the Mexican consumer protection agency (*Procuraduría Federal del Consumidor*, hereafter "PROFECO"), but the monetary and legal sanctions have historically not been high enough to deter this behavior.

Mexico's retail gasoline market changed dramatically in 2017. As part of a broader set of energy market reforms, non-Pemex branded gasoline stations were allowed to enter the market, and price competition was allowed for the first time in almost 80 years. Price competition was introduced following a staggered schedule at the state level between March and November 2017. Thus, by December 2017, stations throughout Mexico could set prices freely for regular gasoline, premium gasoline, and diesel.[4]

As mentioned above, new gasoline stations have a long and somewhat idiosyncratic approval process. Opening a gas station requires an average initial investment of about US$750,000. Prospective station owners must obtain permits from seven different federal agencies, in addition to permits from state and municipal authorities (PETROIntelligence, 2021). Obtaining each of the required permits can take months or even years (López, 2022). The timing of approval is almost impossible to predict as it depends on the backlog and the priorities of regulators.

The Mexican government's views about the energy reforms have changed over time, with considerable lingering uncertainty about the direction of competition policy in the gasoline sector. Initially, there was considerable optimism that market reforms would increase competition, benefiting Mexican consumers. Former Mexican president, Enrique Peña Nieto, promoted market competition. Mexico's Competition Authority wrote at the time that "the opening to business models other than the Pemex franchise scheme provides the opportunity for new gas stations to be established in different markets. The competition

4. Davis et al. (2019) explains that these changes in the retail gasoline market were part of a broader set of energy market reforms. In December 2013, Mexico implemented a constitutional reform to allow foreign investment in the energy sector. Starting April 1, 2016, independent companies were granted the right to import, transport, store, distribute, and sell petroleum products in Mexico. During our sample period, however, the retail part of the market experienced the most change, with relatively less change to date in upstream petroleum markets. Independent companies have made limited investments in the infrastructure necessary to store and distribute gasoline and diesel. During our sample period, gasoline stations in Mexico continued to purchase most of their gasoline and diesel from Pemex.

among gas stations will benefit consumers through greater supply, with improved *quality* and *pricing* conditions" (emphasis added) (COFECE, 2018, p.39).

More recently, however, the Mexican government has grown skeptical about the benefits of competition. In particular, Andrés Manuel López Obrador, president between 2018 and 2024, has been critical of the energy reforms and argues that the entry of private companies has few benefits for consumers and hurts the state-owned Pemex (Webber, 2020). While retail gasoline prices remain deregulated at the time of writing, regulatory changes have made it more difficult to open new gasoline stations, and the entry rate has declined.[5]

Our paper has important implications for these ongoing policy reforms. In particular, our empirical framework, data, and results are relevant for understanding and quantifying the benefits of competition for Mexican consumers. To be clear, however, this paper should not be viewed as an evaluation of these market reforms. After 80 years of regulation, Pemex is still deeply entrenched along the entire petroleum supply chain in Mexico, and it will take more time for these market reforms to fully take effect, especially in the upstream refining, storage, and distribution sectors.

3 Data

For this analysis, we assembled what we believe is the most comprehensive dataset ever compiled on the Mexican retail gasoline market. This section describes our gasoline station panel (Section 3.1), calculations of driving times (Section 3.2), market definitions and ownership status (Section 3.3), wholesale and retail prices (Section 3.4), and service quality (Section 3.5).

3.1 Gasoline Station Panel

The core dataset in our analysis is a daily panel of the universe of gasoline stations in Mexico from 2017 to 2022. We observe several characteristics for each station, including the name, address, geographic coordinates, number of sets of fuel pumps, and the type of refined products sold (i.e., regular gasoline, premium gasoline, and diesel). We extracted

5. For example, the energy regulator has delayed the issuance of permits to construct new gasoline stations, with longer (and in some cases perpetual) delays for non-Pemex stations. In addition, the energy ministry has imposed burdensome and unnecessary regulatory requirements, such as minimum storage requirements, that are difficult for new entrants to satisfy. Finally, the asymmetric regulation of wholesale pricing that attempted to ensure a level playing field between the dominant firm Pemex and new entrants has been abrogated.

Table 1: Descriptive statistics

(a) Station characteristics

	Incumbents	Entrants
Total number of stations	11,645	1,072
Average number of stations within 3 minutes	3.305	2.774
Average number of same-owner stations within 3 minutes	0.242	0.101
Average number of sets of pumps	4.156	3.792
Fraction of stations in a metropolitan area	0.641	0.672
Fraction of stations on a main road	0.418	0.370
Fraction of stations selling regular gasoline	0.999	1.000
Fraction of stations selling premium gasoline	0.921	0.979
Fraction of stations selling diesel	0.728	0.888

(b) Average price by product (pesos/liter)

	Incumbents			Entrants		
Year	Regular	Premium	Diesel	Regular	Premium	Diesel
2017	15.68	17.60	17.06	16.22	17.94	17.11
2018	18.31	19.86	19.46	18.79	20.26	19.83
2019	19.34	20.73	21.13	19.46	20.84	21.09
2020	17.93	18.72	19.57	17.94	18.72	19.43
2021	20.02	21.64	21.37	20.03	21.67	21.29
2022	21.49	23.58	23.09	21.47	23.57	23.00

(c) Station quality

	Incumbents	Entrants
Consumer complaints		
Total number of complaints	36,689	1,284
Number of stations with complaints	7,521	335
Probability of complaint in a given month	0.046	0.024
Probability of complaint about liters	0.034	0.016
Probability of complaint about overcharges	0.008	0.005
Probability of complaint about price display	0.004	0.002
Pump inspections		
Total number of pump inspection visits	41,807	1,726
Number of inspected stations	10,332	740
Probability of pump inspection in a given month	0.049	0.037
Probability of passing pump inspection	0.814	0.787
Bathroom inspections		
Total number of bathroom inspections	23,327	2,552
Number of inspected stations	4,629	454
No bathroom (0/1)	0.032	0.076
Unclean bathroom (0/1)	0.066	0.053
Missing amenities (0/1)	0.105	0.060

Notes: This table reports descriptive statistics for station characteristics, average prices, and station quality. Stations are characterized as incumbents if they were operating at the end of November 2017 and entrants if they began operations during our sample period from December 2017 to November 2022. The number of stations within three minutes is measured using our measure of driving times. Same-owner stations share the same owner. Both "within 3 minutes" variables are time-varying but, for this table, are calculated using the last month observed in the data. Station quality is measured using three PROFECO indicators: consumer complaints to PROFECO, the outcome of pump verification visits, and the results of bathroom inspection visits. Passed inspections are those inspections that did **not** identify any malfunctioning pump or other issue requiring additional action by PROFECO. Stations with missing bathroom amenities were missing either toilet paper or soap during the bathroom inspection.

these variables from the text of the operating permits issued by the federal energy regulator (CRE, 2022a, 2022c).[6]

Panel A of Table 1 provides descriptive statistics for stations. As of November 2017, 11,645 stations were operating in Mexico. We refer to these stations throughout as "incumbents". Between December 2017 and November 2022, 1,072 new stations entered. We refer to these stations throughout as "entrants". Entrants are new stations opened in locations where there was previously no station. As illustrated in the table, entrants tended to be slightly smaller on average, as measured by the number of sets of fuel pumps, and slightly more likely to be in a metropolitan area (CONAPO, 2018). Virtually all stations of both types offer regular gasoline, and most offer premium gasoline and diesel.

Our identification strategy is based on station entry, so we determined the date each station opened as accurately as possible. Although we observe the date each station was initially permitted, there is a lag between when the permit is issued and when a station begins to operate. Instead, we use as the opening date the first day that the station reports prices to the regulator. Stations are legally required to report each price change to the centralized system of the regulator. We corroborated this information using historical images from an online mapping service and inspection data from PROFECO. In a small number of cases, this led us to use an earlier opening date for stations that, for whatever reason, failed to initially report price information as mandated by the regulator. Once a station is open, we assume it stays open unless its operating permit expires or is revoked, which occurred for 38 stations during our sample period.

Our identification strategy also depends on having accurate geographic information. Our data provide the latitude and longitude for each station. We confirmed the geographic coordinates of all entrants by hand using an online mapping service and corrected these in a small number of cases where necessary. Figure 1 maps station locations for two of the largest urban areas in Mexico: Mexico City and Guadalajara. Stations shown in blue are incumbents, whereas stations in red are entrants.

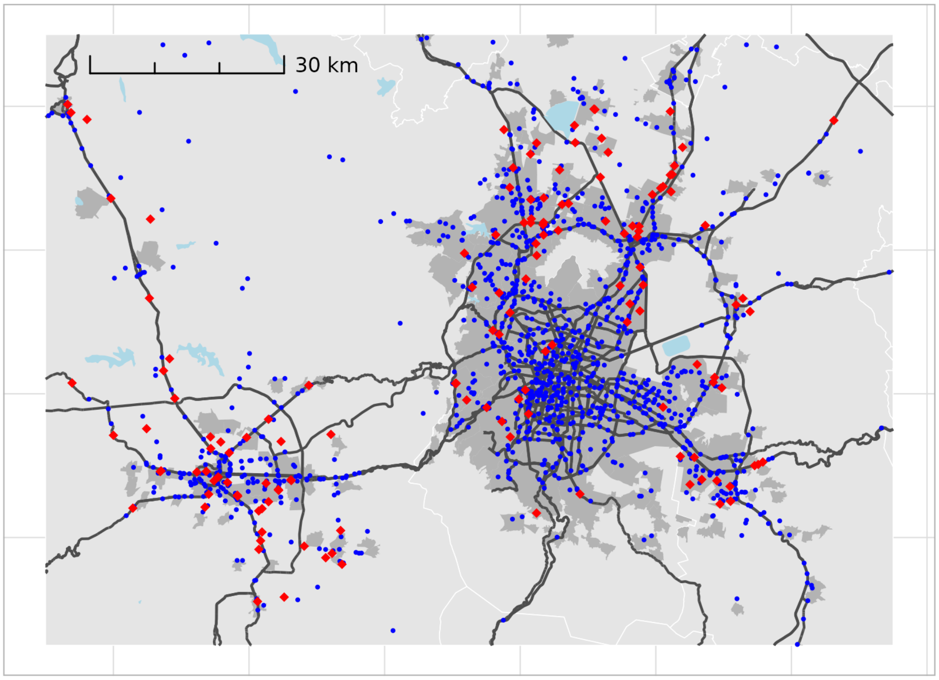
3.2 Driving Time

A key feature of our analysis is that we define local markets using driving time. We match each station to the road network and count the number of competitors within a given driving time. This market definition provides a more accurate measure of proximity than straight-line distance, especially in places where stations are on opposite sides of a divided

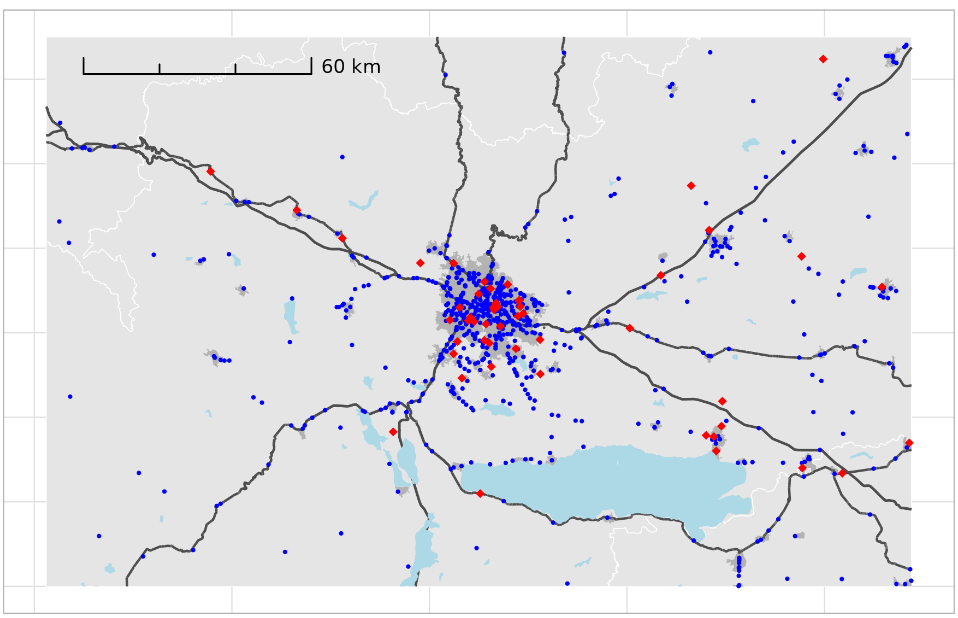
6. Appendix Table A1 shows each step in constructing our gasoline station panel.

Figure 1: Geography of gasoline stations

(a) Mexico City metropolitan area

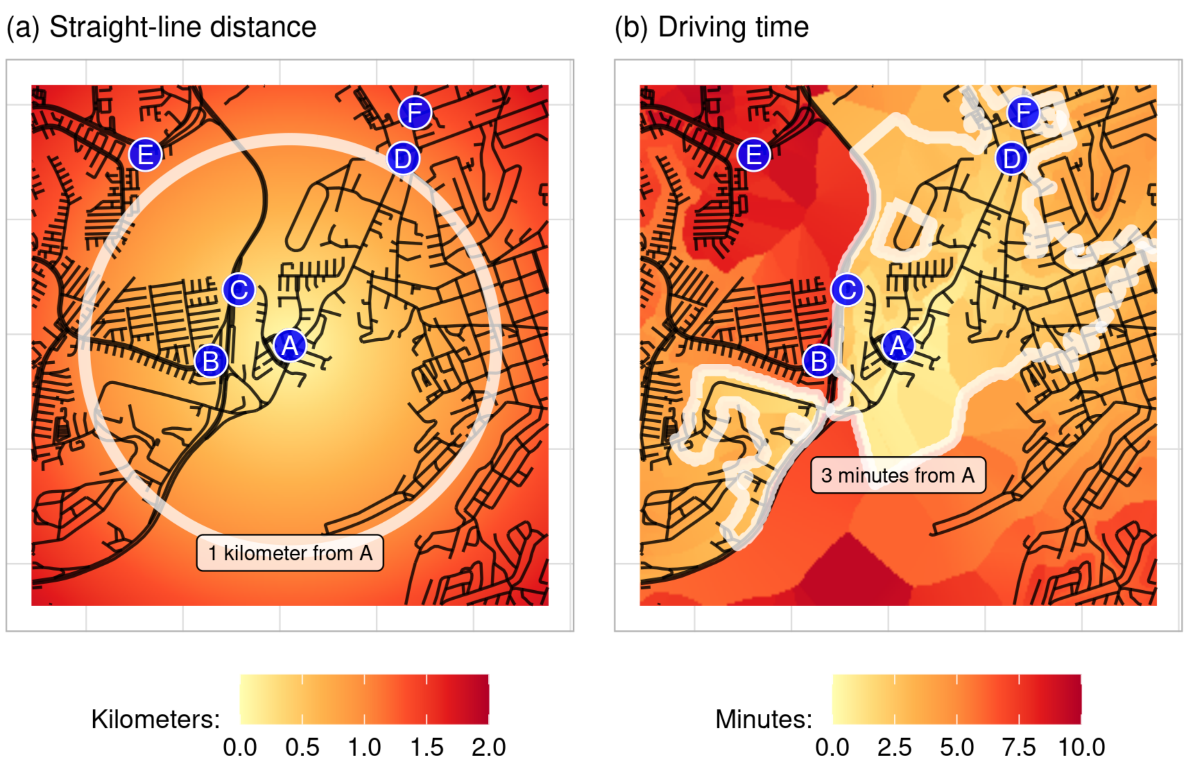


(b) Guadalajara metropolitan area



Notes: These maps plot stations in the Mexico City and the Guadalajara metropolitan areas. Stations shown in blue are incumbents, whereas stations in red are entrants.

Figure 2: Example of alternative market definitions



Notes: These maps illustrate the market definition measures for a station in La Joya, Baja California, labeled A on the map. Black lines show the road network and labeled circles are the station locations. Panel (a) shows the straight-line distance from station A, with the circle corresponding to locations within a 1-kilometer radius. Panel (b) shows the driving time from station A, with the irregularly shaped area corresponding to locations within a three-minute driving time.

highway or otherwise inaccessible.[7] This section describes our approach in more detail and provides an illustrative example.

We calculate driving times between stations using the Open Source Routing Machine (Luxen and Vetter, 2011) applied to the OpenStreetMap road network data for Mexico (OpenStreetMap contributors, 2021). OpenStreetMap is an open-source, open-content collection of global spatial data. We use the subset of data for Mexico, which describes all roads, highways, and other features, allowing us to calculate driving times between any two locations.

Figure 2 provides an illustrative example. These maps illustrate two alternative market definition measures for a station in Baja California, labeled A on the map. The figure also includes additional stations labeled B, C, D, E, and F. Panel (a) shows straight-line distance, while panel (b) shows a measure of proximity measured using driving time.

Using a market definition based on a straight-line distance of less than one kilometer, stations B and C are included in the market for A, and stations D, E, and F are not included. The market definition using driving time is very different, however. Even though station B is less than 400 meters from station A, it is on the opposite side of a divided highway, and the driving time from A to B is about seven minutes. Using our preferred driving time definition of three minutes, station B would not be in the same market as station A. In contrast, stations D and F, located along local roads near A, are included in the market for station A based on the driving time definition, but not when using straight-line distance.

Our road network data does not include information on traffic congestion, so our measure of driving time understates actual driving times with traffic. Thus, while we view our measure as an improvement over straight-line distance, it is still far from perfect. Incorporating traffic congestion would be a valuable feature for future research.

7. Stolper (2024) also calculates local competition measures using a driving time radius. Many studies rely on distance-based definitions of local markets, either straight-line distance (Lach and Moraga-González, 2017; Kim, 2018; Fischer et al., 2023; González and Moral, 2023) or driving distance (Luco, 2019; Pennerstorfer et al., 2020). A few papers define markets based on commuting routes (Houde, 2012; Pennerstorfer et al., 2020; Wu et al., 2024), although only Pennerstorfer et al. (2020) compute these markets for an entire country. Another recent approach for defining local gasoline markets is to use a hierarchical clustering algorithm to partition stations into non-overlapping markets based on straight-line distance, driving distance, or driving time (Carranza et al., 2015; Lemus and Luco, 2021; Montag et al., 2023; Assad et al., 2024).

3.3 Market Definition and Same-Owner Stations

Our primary measure of competition is the number of stations within a driving time of three minutes.[8] Table 1 reports that incumbents have an average of 3.3 nearby stations within three minutes, whereas entrants have an average of 2.8 stations within three minutes. We also report our results for a range of different driving time bins.

We use station opening dates and the location of stations to construct a time-varying measure of competition at the station level. As we explain later, our estimates are identified using changes in the number of nearby stations. Although these changes reflect both entry and exit, there are nearly 30 times as many entries as exits, so the coefficient estimates primarily reflect what happens when a new station enters.

Many stations in Mexico are owned by firms that own multiple stations, with 30 percent of stations belonging to a group with ten or more stations. We take advantage of the pattern of station ownership to compare entry effects for new stations with either the same or different owners to the incumbent. We assign stations to ownership groups using (i) the legal name of the station and (ii) ownership identifiers from the statistical registry of all business establishments in Mexico (INEGI, 2021). We supplement this information with publicly available data on legal transfers of station permits (CRE, 2020) to construct a panel of station ownership for our sample period. We also determine the relevant firm for entrants using the same data and approach. We use this information to calculate the number of stations with the same owner within three minutes. This variable allows us to test whether the entry of a station with the same owner has a different effect from the entry of an independent station.

3.4 Retail Prices

We are interested in how competition changes the way stations set prices. Our primary outcome variable is the retail price, in Mexican pesos per liter, for the three main refined products sold in Mexico: regular gasoline, premium gasoline, and diesel.

Our retail price data comes from the regulator (CRE, 2022b). Since January 2017, stations must report all price changes to the regulator within one hour of the change (CRE, 2018). Before March 2019, all price changes were posted on the CRE website with the exact

8. We treat all stations within three minutes equally, abstracting from potential heterogeneity in competitive effects due to differences in the information that consumers have about prices. Recent work has explored how drivers learn about gasoline prices as they pass each station (Wu et al., 2024; Dorsey et al., 2025) and how the share of informed consumers affects the dispersion of gasoline prices (Pennerstorfer et al., 2020).

date and time of the change. After March 2019, the prices posted on the CRE website have been updated only once daily in the late afternoon. We use these publicly available data to construct a panel of prices at the station-product-date level, using the last price reported on or before a given date.

To check the accuracy of our price data, we used images from an online mapping service to collect prices publicly displayed on price signs for a 10 percent random sample of the stations that experienced entry. More than 98 percent of these price sign observations exactly or partially matched the prices in our dataset.[9] This result provides reassurance that compliance with the price reporting regulation is high. Nevertheless, to reduce the potential for measurement error from any stations that fail to update prices, we keep price observations only when they fall within 30 days after a reported price change.[10] These observations are more likely to be accurate because they reflect information from stations regularly reporting price changes. In practice, this exclusion drops 12 percent of all station-product-date observations.[11] To be clear, this price sample restriction does not affect our measures of market competition; stations are counted among nearby stations even when price data are unavailable for them.

In addition, to limit the effect of outliers on our estimation results, we use an interquartile range (IQR) fence, excluding price observations that are less than $Q1 - 3IQR$ or greater than $Q3 + 3IQR$, where $Q1$ is the first quartile of price and $Q3$ is the third quartile of price. This procedure eliminates 0.12 percent of the price observations for regular gasoline (Table A2).

Our final dataset includes 19.2 million station-day observations for regular gasoline, 17.1 million station-day observations for premium gasoline, and 13.4 million station-day observations for diesel. Table 1 reports average retail prices by station type, product, and year. For example, the average price for incumbents in 2017 was 15.68 pesos per liter for regular gasoline, 17.60 pesos per liter for premium gasoline, and 17.06 pesos per liter for diesel. These prices increased by about 35 percent between 2017 and 2022.

9. Appendix C provides details of our price validation procedure and results.

10. Figure A1 shows the distribution of the number of price changes per week per station in our dataset. In 2018, gas stations changed their prices more than twice a week on average. This has subsequently declined to less than once a week on average. Our validation procedure in Appendix C confirms that this decline reflects a change in pricing practices, not in reporting behavior.

11. Appendix Table A2 describes the construction of our analysis sample in more detail. In Appendix E, we examine the sensitivity of our results to changes in the 30-day cutoff.

3.5 Quality measures

Our first quality measure comes from customer complaints to PROFECO. Since July 2019, PROFECO has offered a mobile app specifically for the retail gasoline market called "Liter for Liter" (*Litro por Litro*). Users can search for nearby locations, view current gasoline prices, and, if they wish, easily file a complaint against a particular station. The form for filing a complaint is short and provides a selection of nine reasons for dissatisfaction, along with an option to upload a photo as evidence. The app allows the user to include their name and contact details or to remain anonymous.

We obtained all complaints submitted through the app by way of a public records request. Table 1, Panel C, provides descriptive statistics for this and other quality measures. Nearly 38,000 complaints were submitted between July 2019 and November 2022, and 62 percent of stations were the subject of at least one complaint. Interestingly, the table also reveals that incumbents are more likely than entrants to be subject to complaints. For example, incumbents have a 4.6 percent probability of being the subject of a complaint in any given month, compared to just 2.4 percent for entrants.

The most common reason for a complaint is the perception of the station providing *chiquilitros*, with nearly three-quarters of complaints falling in this category. As we explained above, it is common in Mexico for stations to sell "liters" with less volume than an actual liter, a practice known as *chiquilitros*.[12] Apart from the complaints about perceived *chiquilitros*, other common reasons for complaints include the station not displaying the price, not respecting the posted price, or adding additional charges.

Our second measure of station quality is an indicator variable for whether a station passed the pump inspections by PROFECO. Inspectors from PROFECO visit stations to verify that they sell complete liters and otherwise comply with all federal standards. These unannounced inspections include accurate measurements of the quantity and quality of the products dispensed at each pump. We compiled inspection data from 2017 until November 2022 using publicly available station-level records from PROFECO (2022). We consider a station to have passed the inspection if the PROFECO inspectors did not immobilize any of the station's pumps. Inspectors seal off a pump if it fails to provide complete liters, if there is variation in the quantity between repeated measurements, or if there are leaks or other malfunctions. We consider all of these cases to be failing the inspection. In addition, we treat a refusal by the station to be inspected as failing the inspection.

12. Guerrero (2012) reports that in 2006, 30 percent of stations inspected had violations. Liu et al. (2018) tests for peer effects in compliance behavior, finding that when one Mexican station passes its inspection, this increases the probability that nearby stations pass their inspections.

The table shows that more than 11,000 stations were inspected at least once during our sample period. Incumbents and entrants were inspected at similar rates, 5 percent and 4 percent per month, respectively. Incumbents pass 81 percent of inspections, whereas entrants pass 79 percent.

We use our inspection data to show that PROFECO responds to customer complaints. Specifically, following Colmer et al. (2023), we estimate the following regression specification for different time horizons k:

$$\Delta y_{i,t+k} = \beta^k Complaint_{it} + \gamma_{st} + \epsilon_{it}. \tag{1}$$

The dependent variable $\Delta y_{i,t+k}$ is the difference between month $t + k$ and month $t - 1$ in the likelihood of station i being inspected or failing an inspection.[13] $Complaint_{it}$ is 1 if station i receives one or more complaints in month t, and 0 otherwise. The regression includes state-by-month fixed effects γ_{st}. Standard errors are clustered at the municipality level.

Figure 3 shows the estimates of equation 1. Receiving a complaint about a station increases the probability that the station is inspected by 3.2 percentage points in the month of the complaint and 8.5 percentage points in the following month, relative to the baseline inspection probability of about 5 percent. The total increase in the inspection probability in the six months after the complaint is more than 21 percentage points. Similar results are observed for the probability of failing an inspection, which increases by nearly 4 percentage points in the six months after a complaint. Reassuringly, there is no effect on the probability of being inspected or failing an inspection in the months before a complaint.

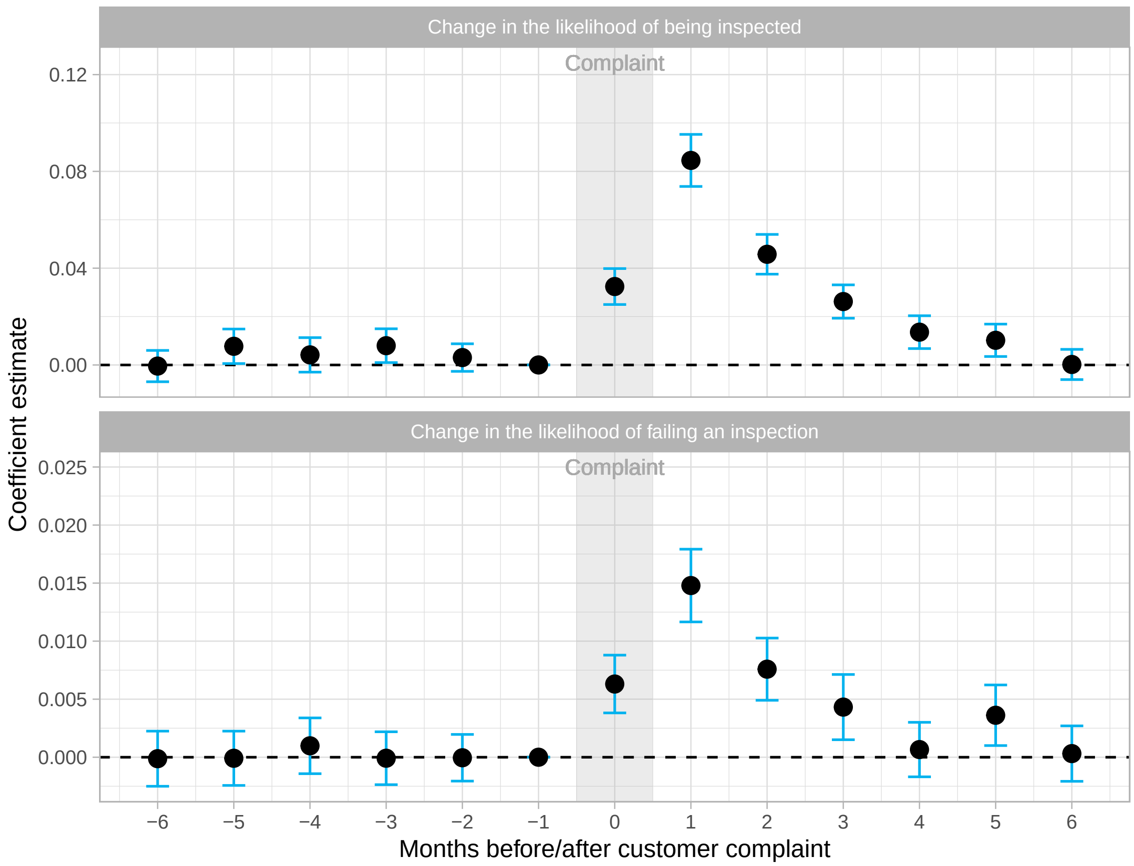
Our final measure of station quality is based on inspections of gasoline station bathrooms, also by PROFECO. These inspections began in October 2019 and are used by PROFECO to calculate summary statistics about bathroom conditions to include in a weekly presentation about gasoline stations by the head of PROFECO and the Mexican president.[14] The selection of stations for the bathroom inspections is independent of the pump inspections. Unlike the pump inspections, there are no legal sanctions for gasoline stations with unclean bathrooms. However, there is a small risk of public shaming if photos of the bathroom are included in the weekly presentation.

We obtained the results of the bathroom inspections through a public records request.

13. Colmer et al. (2023) suggest that this specification, known as a panel-data local projections estimator, is appropriate for a setting with a staggered, transitory, and repeated shock such as receiving a customer complaint.

14. Appendix Figure A2 provides an example of one of the bathroom quality slides from these presentations.

Figure 3: The effect of complaints on inspections



Notes: This figure plots coefficient estimates and 95 percent confidence intervals from estimating Equation (1) for the change in the likelihood of being inspected (top panel) and failing an inspection (bottom panel). Each coefficient represents a separate regression for a different time horizon before or after a complaint. The sample period for the regressions is January 2020 to June 2022, allowing six months of customer complaints before and after the inspections. During this period, the mean monthly inspection rate for stations was 0.055. The mean monthly inspection failure rate was 0.0085. Standard errors are clustered at the municipality level.

As shown in the table, there were nearly 26,000 bathroom inspections during our sample period and about 40 percent of stations received at least one inspection. The inspected stations received an average of five visits. Entrants were more than twice as likely as incumbents not to have bathrooms. However, conditional on having a bathroom, the quality of entrants was higher. 5.3 percent of the entrants had unclean bathrooms, compared to 6.6 percent of incumbents, and entrants were much less likely than incumbents to be missing toilet paper or soap.

Compared to our price data, a limitation of our quality data is that not all stations are included, and the sample period for the complaint and bathroom inspection data is shorter. Table A3 shows the characteristics of gas stations subject to inspections or customer complaints. Although stations that received a complaint have slightly more competitors and are more likely to be in a metropolitan area, the characteristics of the inspected stations are similar to the full sample. This is confirmed by Table A4, showing no economically meaningful effect of our competition measures on the probability of inspection. These results reassure us that sample selection bias is unlikely to be a problem for our empirical results on quality.

4 Empirical strategy

In this section, we describe our empirical approach for estimating a causal effect of competition on prices using difference-in-differences and event study designs. We then discuss how we adapt our analysis to estimate a causal effect of competition on service quality.

Difference-in-Differences

Our empirical strategy uses a staggered difference-in-differences design to isolate shocks to competition from the entry of new competitors. We exploit the rich geographical and temporal variation in the data to estimate the causal effects of a new entrant on both the pricing and quality choices of incumbent gas stations.

Our baseline estimating equation takes the following form:

$$P_{it} = \beta_1 NS_{it} + \beta_2 NS\ Same\ Owner_{it} + \alpha_i + \gamma_{st} + \phi_t + \epsilon_{it}. \quad (2)$$

The dependent variable P_{it} is the retail price for station i on day t. We estimate separate regressions for regular gasoline, premium gasoline, and diesel. The independent variable of interest is NS_{it}, the number of stations within three minutes of station i as of day t. Some specifications include $NS\ Same\ Owner_{it}$, the number of stations within three minutes with the same owner.[15] We also show results for alternative distance bins and interactions between NS_{it} and the initial level of competition.

We include a wide variety of control variables. Station fixed effects, α_i, control for time-invariant station characteristics like location, size, and whether a station has a store or bathrooms. Terminal-by-month-of-sample fixed effects, γ_{st}, control for regional changes over time in prices, for example, driven by regional trends in demand for refined products, or wholesale price discounts set by Pemex at a terminal level.[16] Finally, day-of-sample fixed effects, ϕ_t, control for national-level day-to-day price changes, for example, due to predictable changes in demand during holidays and weekends.[17]

Thus, the coefficient of interest β_1 is identified using within-station variation in the number of competitors. Controlling for terminal-by-month and day-of-sample fixed effects, the regression describes how prices change as entrants begin operation nearby or, less commonly, as existing stations cease operations. As we explained earlier, 1,072 stations entered the Mexican market during this period, providing the variation in NS_{it} we need to identify the coefficient of interest. In all regressions we include the thousands of gas stations that did not experience entry. These stations provide a pure control for estimating the terminal-by-month and day-of-sample fixed effects, avoiding many of the pitfalls of estimating treatment effects in staggered designs.

Event Studies

We also estimate an event study specification that exploits the exact timing of entry and allows us to test for parallel pre-trends. In particular, we are interested in the δ_τ estimates obtained from the following regression:

$$P_{it} = \sum_{\tau=-6}^{\tau=6} \delta_\tau \mathbb{1}[Event\ Time_{it} = \tau] + \alpha_i + \gamma_{st} + \phi_t + \epsilon_{it}. \tag{3}$$

15. Arcidiacono et al. (2020) use a similar specification in their study of Walmart entry, but they use straight-line distance (rather than driving distance) and, given their context, are not able to distinguish between same-owner and independent owners.

16. There are 78 Pemex terminals. Appendix B describes our procedure for matching each station to its corresponding wholesale terminal.

17. By including terminal-by-month and day-of-sample fixed effects, we control for several forms of price dynamics that have been explored in previous papers. For example, Borenstein and Shepard (1996) find that gasoline markups tend to be higher during summer months with anticipated increases in demand, consistent with collusive pricing. As another example, Borenstein et al. (1997) document that gasoline prices respond more quickly to increases than to decreases in crude oil prices.

This estimating equation is identical to equation 2, including all the same control variables, except the equation includes a vector of relative event time indicator variables. Event time ranges from -6 for six or more quarters before entry to $+6$ for six or more quarters after entry in incumbent station i's market.

A minority of the 2,130 incumbents that experience entry in their local market experience more than one entrant during our sample period. To avoid contaminating our pre-event trends with the effects of any previous entry, we only use the first entry as the event in our analysis. This implies that the post-entry coefficients include the effect of the first and any subsequent entries.

Quality Analysis

Our empirical strategy for the effect of competition on quality parallels the differences-in-differences specification for prices in Equation (2) and the event study specification for prices in Equation (3). The dependent variable is one of the three quality measures described in Section 3.5. We aggregate these measures to a station-month level. The customer complaint variable is one if there was at least one complaint about the station filed using the PROFECO application during the month and zero otherwise. The pump and bathroom inspection variables are one if there was at least one failed inspection during the month and zero otherwise. We aggregate the inspection variables to a monthly level to place less weight on repeated inspections following an initial failed inspection.

As in Equations (2) and (3), our quality regressions include station and terminal-by-month-of-sample fixed effects so that we identify the effect of competition using within-station variation created by the entry of new competitors. Given the monthly frequency of our data, day-of-sample fixed effects are not required, and the terminal-by-month-of-sample fixed effects absorb time-varying unobservables.

5 The Effect of Competition on Prices

This section describes our results for the effect of competition on gasoline prices. We start with our baseline difference-in-differences estimates (Section 5.1), event study analysis (Section 5.2), and robustness and heterogeneity analysis (Section 5.3), before finishing with an overall interpretation of our price results (Section 5.4).

5.1 Difference in Differences Results

Table 2 reports our baseline estimates of equation 2. Odd-numbered columns describe regressions with only the single measure of market competition, NS_{it}. One additional nearby competitor reduces prices by 0.069 pesos per liter for regular gasoline, 0.050 pesos per liter for premium gasoline, and 0.045 pesos per liter for diesel. The table reports standard errors clustered at the municipality level to account for serial and spatial correlation. All three point estimates are statistically significant at the 0.5 percent (half of 1 percent) level.

Although our estimated effects of competition are highly statistically significant, they are small from the perspective of gasoline consumers. An additional competitor reduces retail prices by 0.22 to 0.36 percent, with the largest effect on regular gasoline prices. Given the volatility in other components of gasoline prices, including wholesale oil prices and government tax rates, the effects of competition are unlikely to be particularly salient for consumers. However, from the perspective of the station owners, our effects imply large reductions in profitability from the entry of a nearby competitor. Our estimates imply that each additional competitor reduces the retail price spread (the difference between the retail and wholesale price) by an average of 6.0 percent for regular gasoline, 3.4 percent for premium gasoline, and 3.5 percent for diesel.[18]

Even-numbered columns in Table 2 describe regressions including the number of nearby stations with the same owner, $NS\ Same\ Owner_{it}$. As expected, the coefficient estimates corresponding to $NS\ Same\ Owner_{it}$ are positive in all three columns, consistent with same-owner stations having less effect than stations with independent owners. The effect of same-owner stations is less precisely estimated but nonetheless statistically significant at the 0.5 percent level for premium gasoline and the 5 percent level for diesel.

The even-numbered columns also report estimates for the sum of the two coefficients. This sum reflects, everything else equal, the effect on prices of the entry of a same-owner station. In theory, stations belonging to the same ownership group should not compete with each other, so we expect that these estimates would be zero. If anything, we might expect a positive effect on incumbent prices from the entry of a nearby station with the same owner, as some customers lost due to a higher price will substitute to the new station. Indeed, the estimates for the sum are closer to zero than the estimates for NS_{it}, and statistically indistinguishable from zero in columns (4) and (6) for premium gasoline and diesel. In later sections, we will show stronger evidence for a zero or positive effect on price

18. Appendix B describes our wholesale price data and the calculation of the retail price spreads.

Table 2: The effect of competition on retail prices

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.069***	-0.070***	-0.050***	-0.053***	-0.045***	-0.046***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.022		0.064***		0.045*
		(0.018)		(0.022)		(0.019)
Sum of coefficients		-0.047		0.010		-0.001
p-value for sum of coefficients		0.020		0.633		0.958
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	19,153,395	19,153,395	17,063,321	17,063,321	13,409,833	13,409,833
Dep. variable mean	19.26	19.26	20.68	20.68	20.68	20.68
Number of stations:						
Total	12,612	12,612	11,777	11,777	9,431	9,431
Entrants	1,052	1,052	1,035	1,035	867	867
Experienced entry	2,130	2,130	2,079	2,079	1,487	1,487
Experienced same-owner entry	392	392	380	380	215	215

Notes: This table reports coefficient estimates and standard errors from six regressions of our baseline difference-in-differences specification described in equation 2. Regressions are estimated for three different refined products, as indicated in the column headings. In all regressions, the dependent variable is the retail price in pesos per liter. Regressions are estimated using station-by-day data from 2017 to 2022. The number of observations is smaller in columns 3-6 because not all stations sell premium gasoline or diesel. See the paper for details. For convenience, the table also reports the total number of stations, the number of stations that opened during our sample period ("entrants"), the number of stations that experienced at least one entrant within three minutes driving time during our sample period, and the number of stations that experienced an entry by a station with the same owner. Standard errors are clustered at the municipality level. *Significance codes: ***: 0.005, **: 0.01, *: 0.05* from same-owner entry for all three products. Overall, the results from our same-owner specification conform with expectations and demonstrate the importance of ownership structure for understanding competition between gas stations.

5.2 Event Study Evidence

Figure 4 plots coefficient estimates corresponding to the event study specification described in equation 3. We include plots for regular gasoline, premium gasoline, and diesel. The horizontal axis shows time in quarters before and after the entry of a competitor, normalized so that the quarter of entry is equal to zero.

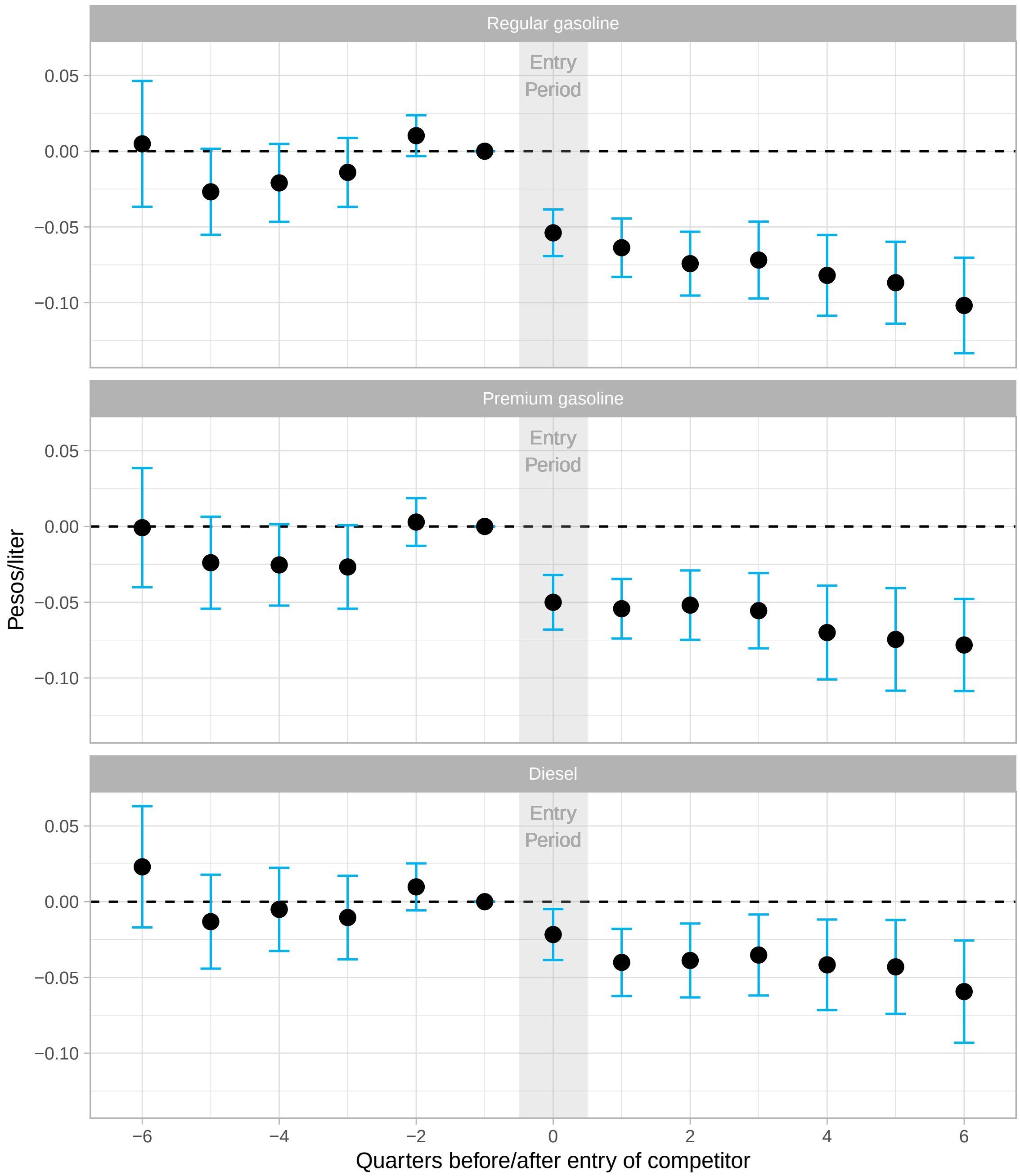
During the quarters leading up to entry, prices tend to be flat. There is no discernible pre-trend for any of the three products. After entry, prices decrease significantly for all three refined products. With regular gasoline, prices decrease sharply by 0.05 pesos per liter in the first quarter after entry and continue to decline in subsequent quarters. Similar decreases occur after entry for premium gasoline, while the decreases for diesel are somewhat smaller. The magnitude of the implied impacts in the event study figures is similar to the magnitudes in Table 2.

The figure also shows 95 percent confidence intervals. During the pre-period, the event time indicators are not statistically significant, and we cannot rule out the null hypothesis that those coefficients are equal to zero. However, after entry, the point estimates are consistently negative and statistically significant for all three refined products.

The event study figures provide reassurance that the impacts estimated in Table 2 are causal effects. If these results were instead driven by differential trends between locations with and without entry, we would expect to see pre-trends in the event study figures. Moreover, the timing of the price decrease aligns with entry, with significant drops in the first quarter after entry for all three refined products. Finally, the price decrease is persistent, with negative and statistically significant estimates throughout the six quarters after entry.

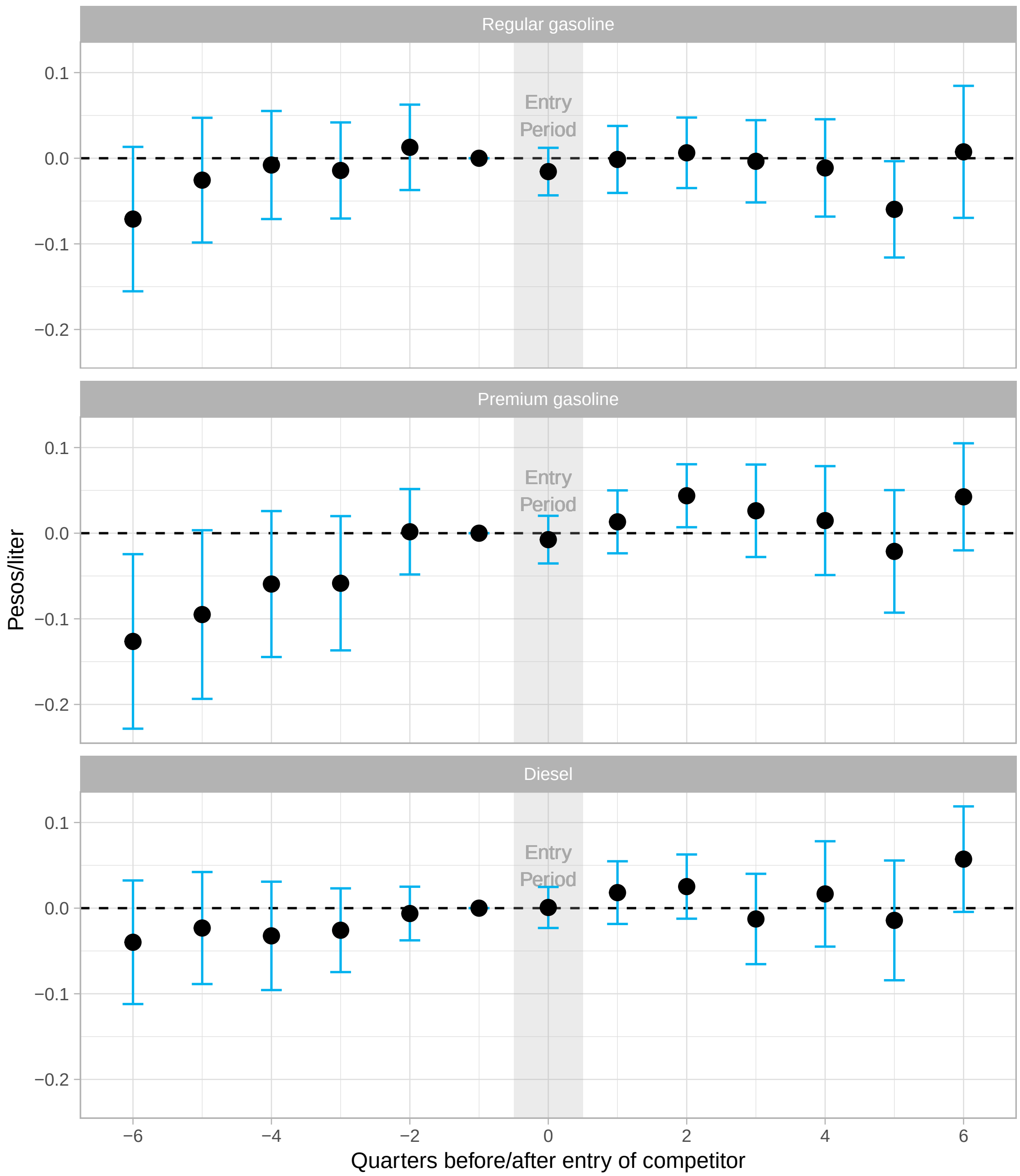
Figure 5 shows the event study results for the entry of a station with the same owner as the incumbent. All but one of the point estimates for the effect of same-owner entry on the price of regular gasoline are near zero. The point estimates for the effect on premium gasoline and diesel are mostly positive, with a long-run effect after six quarters of about 0.05 pesos per liter. There is evidence of an increasing trend in prices for premium gasoline the year before entry, consistent with existing firms knowing more about local market conditions and investing in additional stations where profitability is growing. Overall,

Figure 4: The effect of entry on retail prices



Notes: This figure plots coefficient estimates and 95 percent confidence intervals corresponding to the event study specification described in equation 3, where the event is the first entry of a new station within a three-minute driving time of an existing station. As described in the text, time is normalized relative to the quarter of entry ($\tau = 0$), and the excluded category is $\tau = -1$. The dependent variable is the retail price of the refined product (regular gasoline, premium gasoline, or diesel) in pesos per liter. Regressions are estimated using station-by-day data from 2017 to 2022, and all regressions include station, terminal-by-month, and day-of-sample fixed effects. Standard errors are clustered at the municipality level.

Figure 5: The effect of same-owner entry on retail prices



Notes: This figure plots coefficient estimates and 95 percent confidence intervals corresponding to the event study specification described in equation 3, where the event is the first entry of a new station with the same owner within a three-minute driving time of an existing station. See also the notes to Figure 4.

these results provide even stronger evidence than in Table 2 of the importance of ownership structure in determining competitive outcomes in retail gasoline markets, with new entries by existing firms not affecting prices.

5.3 Robustness and Heterogeneity

This subsection explores heterogeneity in our Table 2 results by driving time, initial market structure, and area. We then show the robustness of the main results to alternative sample criteria and estimation methodologies.

Heterogeneity by Driving Time

Figure 6 explores alternative market definitions. Whereas our baseline results use a three-minute driving time, this figure is based on a more flexible specification in which we define fifteen driving-time bins. The specification is similar to our baseline estimation in Column 1 of Table 2, except we replace the single measure NS_{it} with 15 separate variables corresponding to non-overlapping driving-time bins as indicated by the horizontal axis label.

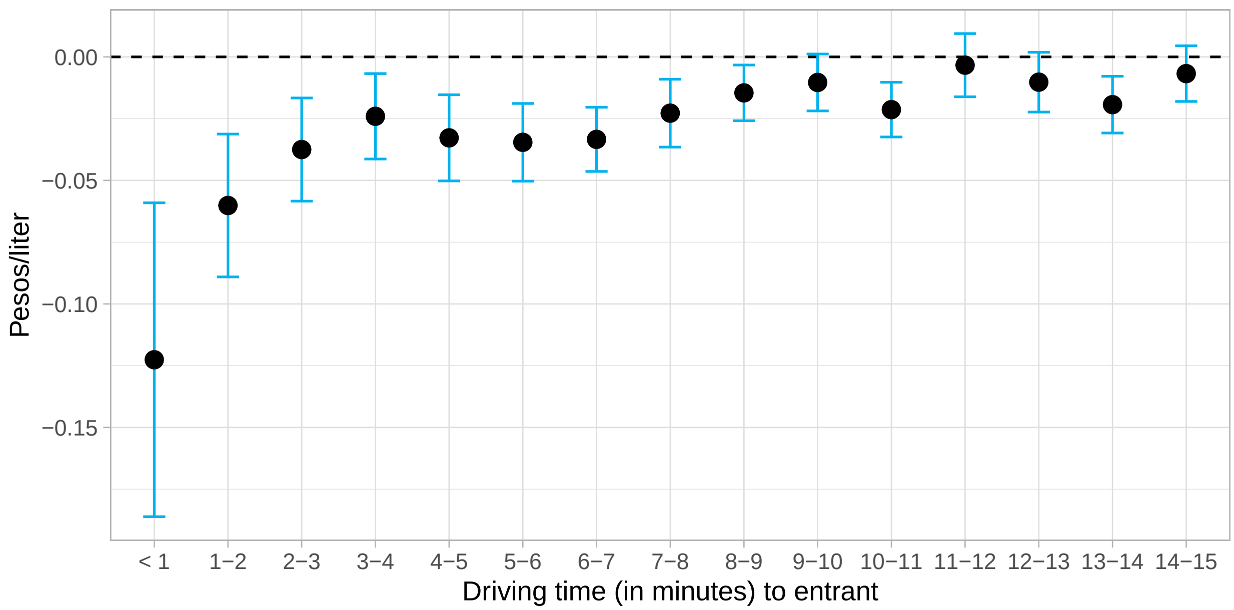
The figure illustrates a clear pattern, with the effect of entry attenuating with driving time. Within one minute, a new competitor reduces regular gasoline prices by more than 0.10 pesos per liter. The effect declines to 0.04 pesos per liter for new competitors within a two to three-minute driving time, the limit of our base case market definition. Effects are smaller but still statistically significant for entry up to nine minutes driving time. Past nine minutes, the effect of an additional competitor is close to zero and (in most cases) not statistically significant. These results corroborate our findings and provide further reassurance that the main estimates are not driven, for example, by differential municipal-level trends.

Heterogeneity by Number of Incumbents

Figure 7 explores the effects by initial market structure. The figure plots results for a similar regression to Column 1 of Table 2, in which the number of competitors is interacted with the initial number of competitors at the beginning of the sample period.[19] We might expect

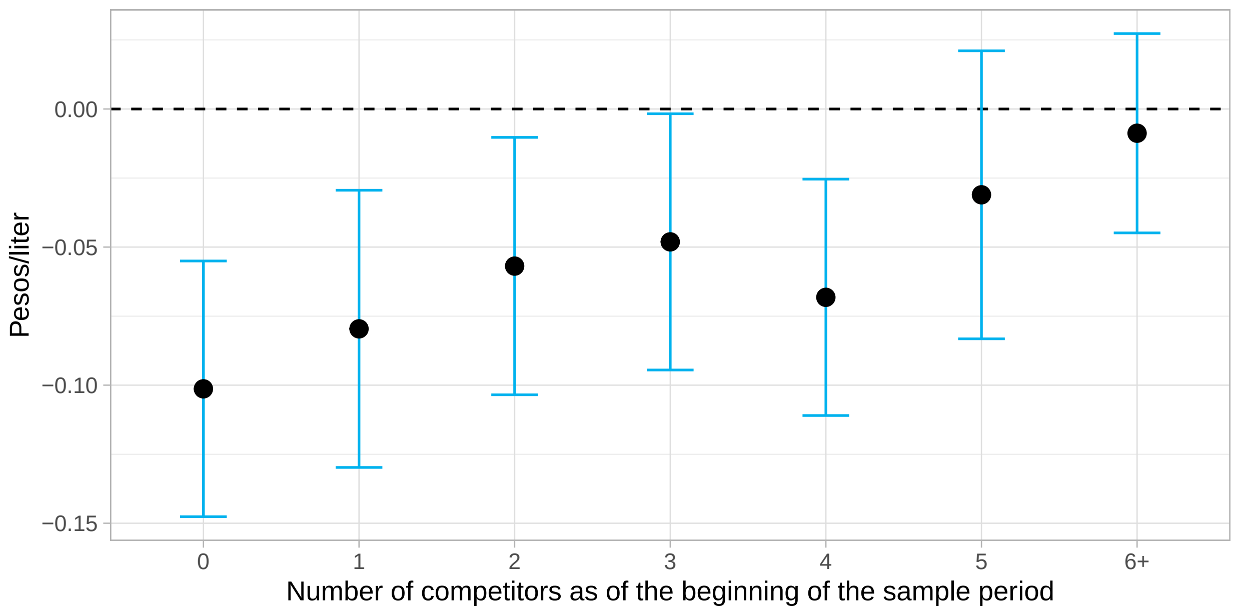
19. Because the markets in which the incumbent was initially a monopolist are likely to be different to the markets in which the incumbent initially had six or more competitors, we might expect very different time trends (say, between rural and metropolitan areas). For that reason, we also interact the day-of-sample and terminal-by-month-of-sample fixed effects with the number of initial competitors.

Figure 6: The effect of competition on the retail price of regular gasoline, by driving-time distance



Notes: This figure plots coefficient estimates and 95 percent confidence intervals from a single regression where the dependent variable is the retail price of regular gasoline. The specification is identical to our baseline difference-in-differences specification described in equation 2, except that instead of a single variable measuring the number of competitors within three minutes NS_{it}, we include 15 separate variables corresponding to non-overlapping driving-time bins as indicated in the horizontal axis label. The regression is estimated using station-by-day data from 2017 to 2022 and includes station, terminal-by-month, and day-of-sample fixed effects. Standard errors are clustered at the municipality level.

Figure 7: The effect of competition on the retail price of regular gasoline, by number of incumbents



Notes: This figure plots coefficient estimates and 95 percent confidence intervals from a single regression where the dependent variable is the retail price of regular gasoline. The specification is identical to equation 2, except that the number of competitors is interacted with the number of competitors at the beginning of our sample period in 2017. The "0" category comprises stations that were monopolists and thus faced zero competitors within their local market at the start of the sample period. Regressions are estimated using station-by-day data from 2017 to 2022, and all regressions include station, terminal-by-month-by-initial-competitors, and day-of-sample-by-initial-competitors fixed effects. Standard errors are clustered at the municipality level.

a nonlinear relationship between the initial number of competitors and the price effect of entry (Bresnahan and Reiss, 1991), with the largest effect when a market goes from zero competitors (that is, a monopoly incumbent) to one competitor (a duopoly).

The results in Figure 7 match these theoretical predictions. For the case of a monopoly incumbent, an additional entrant reduces prices by -0.101 pesos per liter. This effect declines by more than 20 percent for the case of a duopoly market (-0.080), and a further 20 percent for markets with three initial competitors (-0.057). The point estimate is similar in magnitude for markets with three, four, or five initial competitors. Additional entry has no effect on prices for markets with six or more initial competitors. Although the pattern of the point estimates is as expected, the confidence intervals on our estimates are wide, so we cannot reject a null hypothesis that several of the coefficients on initial market structure are identical.[20]

Heterogeneity by Area

Appendix D reports our Table 2 results separately for urban and rural areas. We classify stations as urban (71 percent of the total) or rural (29 percent) using a satellite-based definition of urban areas. The impact of competition on prices is smaller in urban areas but still statistically significant, with one additional station within three minutes reducing regular gasoline prices by 0.047 pesos/liter. Notably, an additional nearby station with the same owner has no statistically significant effect on incumbent prices for any fuel type in urban areas. Rural areas show larger competitive effects, particularly for diesel, where an additional nearby station reduces prices by 0.092 pesos/liter. The larger effect in rural areas may be due to more intense competition among stations located along a single highway, compared to the dispersed markets in urban areas.

Alternative Sample Definitions

Appendix E shows the robustness of the Table 2 results to alternative sample definitions. These include dropping the stations near the U.S. border, expanding the criteria for the definition of outlier price observations, keeping only the price observations from the same day as the price change, and keeping observations for up to 60 days after each price change. In all cases, these results are qualitatively similar to those in Table 2, and in most cases, the

20. Table A6 examines whether price responses to entry differ for stations that belong to a large holding group, defined as a retail chain with ten or more stations owned by the same firm. We find responses are similar to our base case estimates in Table 2.

quantitative values are almost identical too.

Alternative Estimation Methodologies

An extensive literature has documented the shortcomings of the two-way fixed effects estimator for estimating average effects in the presence of heterogeneous treatment effects (Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021). Many of these criticisms relate to the changing composition of the control group in a staggered adoption design. Although our "treatment" of gasoline station entry is staggered through time, and we show evidence of heterogeneity in the effects of entry on prices (Figures 6 and 7), we believe that our results are likely to be robust under the recently proposed estimation methodologies. Because we have a large group of stations that do not experience entry (more than 80 percent of our sample), the composition of our control sample changes little over time.

Nevertheless, for robustness, in Appendix F we replicate our results using the two-stage imputation estimator proposed by Gardner (2022) and Borusyak et al. (2024). Our results are even stronger using this alternative methodology. The effect of the first new entry on the price of incumbents is larger in magnitude than the competition results in Table 2. Importantly, for same-owner entry, we find positive effects on price from the entry of a new station with the same owner as the incumbent, for all three products. These positive effects are large in magnitude and statistically significant for premium gasoline and diesel. Event study analyses based on the same new methodology are also consistent with these findings for the competitive effects of entry and same-owner entry. Further details on the methodology and results are provided in the appendix.

5.4 Interpretation

Our results show small but precisely estimated effects of competition on the retail prices of gasoline and diesel. As discussed above, although our price effects are unlikely to be particularly salient for consumers, they indicate potentially large effects of increased competition on the profitability of gasoline stations.

Our results are consistent with the existing literature about the effect of competition on gasoline prices. Most of this literature finds small negative effects of competition on price (Eckert, 2013). Hastings (2004) studies the effect on incumbent retailers of a reduction in the number of independent competitors as the result of a merger. Although her original results are an order of magnitude larger than ours (a 4 percent increase in price from one less competitor), a subsequent analysis of the merger using a different price dataset finds a much smaller effect: the loss of a competitor increased prices by 0.3 percent (Taylor et al., 2010). In a similar setting to ours, Bernardo (2018) uses the deregulation of entry in the diesel market in Barcelona to study the effect of new entry on incumbents. Incumbents exposed to new entry reduced their prices by 1.0 percent, with a 0.6 percent reduction for each additional competitor. Finally, in Germany, Fischer et al. (2023) find that a gas station entry induces a 7 percent reduction in price margins, close to our estimate of a 6 percent reduction in the retail price spread for regular gasoline.

Although our results for the effect of competition on prices are close in magnitude to the previous gasoline market studies, they are small compared to several recent papers that estimate the effect of competition in the grocery market. Busso and Galiani (2019) use a randomized experiment to vary the number of competitors of small neighborhood grocery stores in the Dominican Republic. An increase in the number of competitors reduces incumbent prices by up to 6 percent, with the largest effects found for entry by more than one firm. Also in a middle-income country context, Atkin et al. (2018) use the entry of foreign supermarket chains, most notably Walmart, into the Mexican grocery market to estimate the effect on the prices of existing firms. The first foreign entry in a market leads to a long-run reduction in the price of incumbents of 3 percent. This result sharply contrasts with the results of Arcidiacono et al. (2020), who also study the effect of Walmart entry on the prices of existing supermarkets, this time for the United States. They find no effect of Walmart entry on the incumbent prices.

What explains the difference between our results for gasoline and the Busso and Galiani (2019) and Atkin et al. (2018) results for supermarkets? We first note that gasoline retailing is a lower margin business than food retailing. In the United States, the gross margin for supermarkets in 2021 was 27 percent compared to 17 percent for gasoline stations (U.S. Census Bureau, 2022). This difference was similar to that observed for Mexico in 2018, the most recent year that data is available: 24.6 percent for food retailers and 13.2 percent for gasoline retailers (INEGI, 2023a). Given the lower profit margins in gasoline retailing, a small reduction in the price of gasoline still translates into an economically meaningful effect on profits.

The lower profit margins in gasoline may reflect structural differences between the gasoline and food retailing markets that increase the competitiveness of gasoline markets. For example, price comparisons are simpler for gasoline consumers than for grocery purchasers. There are only three products and the prices of each are posted on a sign that is visible without having to enter the store. In contrast, supermarkets sell thousands of products, and consumers would have to enter multiple stores in order to compare their prices. Moreover, from the viewpoint of the firm, menu costs are lower in gasoline, as it is relatively cheap and simple to change prices. Because gasoline markets are already more competitive, we might expect that the marginal effect of an additional competitor is likely to be smaller.

One way to reconcile our results with the previous literature on grocery entry is by differences in transportation costs (Ramos-Menchelli and Sverdlin-Lisker, 2022). Busso and Galiani (2019) and Atkin et al. (2018) study settings in which most consumers do not have their own car. Higher transportation costs reduce the effective market size, increasing the market power of incumbent retailers and creating more scope for larger price reductions when a new competitor enters. For our gasoline retail setting, all customers have their own transport, so the effective market size is larger than for food retail markets in middle-income countries. By contrast, in the U.S. grocery markets studied by Arcidiacono et al. (2020), almost all consumers have their own car, so incumbents already faced competitive pressure from other retailers that were located further away.

A novel contribution of our analysis is that we show that the entry of an additional nearby station with the same owner has no effect on the incumbent price (Figure 5). The existing papers on the effect of entry either do not consider the ownership of the entrant (Busso and Galiani, 2019), or study settings in which all entrants are owned by a different firm from the incumbents (Arcidiacono et al., 2020; Atkin et al., 2018). Conversely, the papers studying the decrease in competition caused by a merger are unable to compare their results to the change in competition due to the entry or exit of unrelated firms (Hastings, 2004). Our results demonstrate how cross-ownership of nearby stations reduces the competitiveness of gasoline markets. This finding implies that ownership structure is a crucial input for merger and antitrust analysis in local retail markets.

6 The Effect of Competition on Quality

Table 3 reports difference-in-difference estimates for the three measures of service quality discussed in Section 3.5. The unit of observation in these regressions is station-by-month and all regressions include station and terminal-by-month fixed effects. Overall, the results for station quality are mixed, with considerably less statistical precision than the results

Table 3: The effect of competition on station quality

	Customer complaints	Pump inspection	Bathroom inspection
	One or more (1)	Failed (2)	Failed (3)
Stations within 3 minutes	-0.008*	-0.004	-0.018
	(0.003)	(0.010)	(0.035)
Fixed effects			
Station	Y	Y	Y
Terminal-by-Month	Y	Y	Y
Observations	513,031	43,224	12,856
Dep. variable mean	0.045	0.187	0.170
Number of stations:			
Total	12,684	11,071	4,844
Entrants	565	1,076	487
Experienced entry	1,207	1,382	57

Notes: This table shows results for two-way fixed effects regressions of quality measures on the number of nearby competitors and station and terminal-by-month-of-sample fixed effects. Each column shows a separate measure of station quality (higher values correspond to lower quality). Column 1 shows results for an indicator variable for having at least one complaint in the month. Column 2 shows the results for pump verification inspections. Column 3 shows the results for bathroom inspections, where failure is considered to be an unclean bathroom or one with missing toilet paper or soap. Columns 2 and 3 exclude station-by-month observations without inspections. The sample period for complaints begins in July 2019, for pump inspections in 2017, and for bathroom inspections in October 2019. The sample period for all three regressions ends in November 2022. Standard errors in all regressions are clustered by municipality. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

for prices.

Column 1 shows that an additional nearby competitor reduces the probability of receiving at least one customer complaint by 0.008. The baseline rate of complaints is 0.045 (i.e. 4.5% of stations receive at least one complaint in a given month), so this is an 18 percent decrease. Column 2 reports a point estimate of -0.004, indicating that one additional nearby competitor reduces the probability of failing a pump inspection by 0.4 percent (i.e. less than 1 percent). The baseline failure rate is 18.7 percent, so this is a 2 percent decrease. Finally, column 3 shows that each additional nearby competitor reduces the probability of failing a bathroom inspection by 0.018. The baseline failure rate for this measure is 0.170 (17%), so this is an 11 percent decrease. Only the first of these three estimates is statistically significant at the 5% level.

The appendix includes additional results. Appendix Figure A3 provides event study figures for all three measures. The event study figures tend not to show pre-existing trends, but they also do not show definitive visual evidence of a shift in service quality. Appendix F shows our results for quality using the imputation estimator of Borusyak et al. (2024). Using this alternative methodology, the estimate for customer complaints is larger in magnitude and remains statistically significant. The estimate for pump inspections is larger in magnitude, but remains statistically insignificant, and the estimate for bathroom inspections changes sign and becomes less precisely estimated.

Our results suggest that quality, measured by customer complaints about *chiquilitros*, increases as a result of greater competition. The magnitude of our complaints result is larger than the results of Matsa (2011) for the effect of Walmart entry on stockout rates of incumbent supermarkets. Using a similar empirical methodology to ours, he finds that stockouts decline by 0.52 percentage points, or 12 percent of the mean, after entry by Walmart into a market. For comparison, our results show a decline in complaints by 18–27 percent after an additional competitor enters.

Perhaps a surprising aspect of our results is that we find a significant effect of competition on a seemingly unobservable component of quality (complaints about *chiquilitros*) but not on an observable component of quality (bathroom cleanliness). This is the opposite of what we might expect: if there are multiple dimensions of quality, an increase in competition may cause firms to overproduce the observable component of quality and underproduce the unobservable component (Dranove and Satterthwaite, 1992). One explanation is that, given the ubiquity of concerns about *chiquilitros* in the Mexican gasoline market, consumers are more attentive to purchase and consumption quantities than in other markets. Another possible explanation is that few drivers use station bathrooms so this is not, in practice, an effective means of differentiation. Alternatively, bathroom cleanliness may only matter for gasoline markets along highways rather than in metropolitan areas.

An important caveat for our quality results is that we do not observe station volumes, so we are unable to estimate the effect of increased competition on the number of customers or quantities. We expect that an increase in the number of competitors will reduce the number of customers per station. This reduction in customer traffic could mechanically lead to higher measured quality, even without a strategic response by the incumbent. For example, if each customer has a fixed probability of complaining after a station visit, then fewer customers from increased competition could lead to fewer complaints. Similarly, it may be easier to keep bathrooms cleaned and restocked with fewer customer visits. Separating the mechanical effect of fewer customers from the strategic response by the incumbent remains an open question for the literature on competition and quality.

7 Conclusion

Given that a large share of household consumption occurs at small local retail establishments, understanding the causes and consequences of market structure in retail industries has important implications for consumer welfare. The theoretical literature in economics on the effect of competition provides few definitive answers. There may be too much entry or too little entry, quality may be inefficiently high or inefficiently low, and competition can decrease or even increase prices. Consequently, empirical work is required in multiple settings to determine the characteristics of retail markets in which competition is most likely beneficial.

We contribute to the empirical literature on the causal effect of competition using a comprehensive panel dataset we compiled on the universe of gas stations in Mexico over five years. We exploit plausibly exogenous geographical and time variation in station entry to identify the causal effects of the entry of competitors on the prices and quality of incumbent stations. We find that each additional nearby competitor leads to lower prices for regular gasoline, premium gasoline, and diesel. We validate our results by showing that effects are largest for the entry of closer stations and decline to zero for more distant entrants, as measured by driving time along the road network. Moreover, we find larger effects for markets with fewer initial competitors. Our results for quality are less clear, with suggestive evidence of improved service quality in some specifications.

While our empirical estimates for the effect of competition on price are robust and statistically significant, they are small in magnitude compared to the overall level of fuel prices. This finding aligns with the earlier literature on competition in retail gasoline markets, which typically relied on a small number of markets over a short period. However, our results point to a large negative effect of competition on the profitability of gas stations, given the low margins in gasoline retailing. The corollary of this result is that anticompetitive behavior by firms may be highly profitable—but challenging to detect if the price increases are small. A related novel contribution of our empirical work is distinguishing between entries by stations with the same owner and with a different owner to the incumbent. We find that same-owner entry has no effect and, in some cases, even a positive effect on incumbent prices. This result implies that ownership consolidation in local retail markets, while often "below the radar" of antitrust authorities, can negatively affect consumers.

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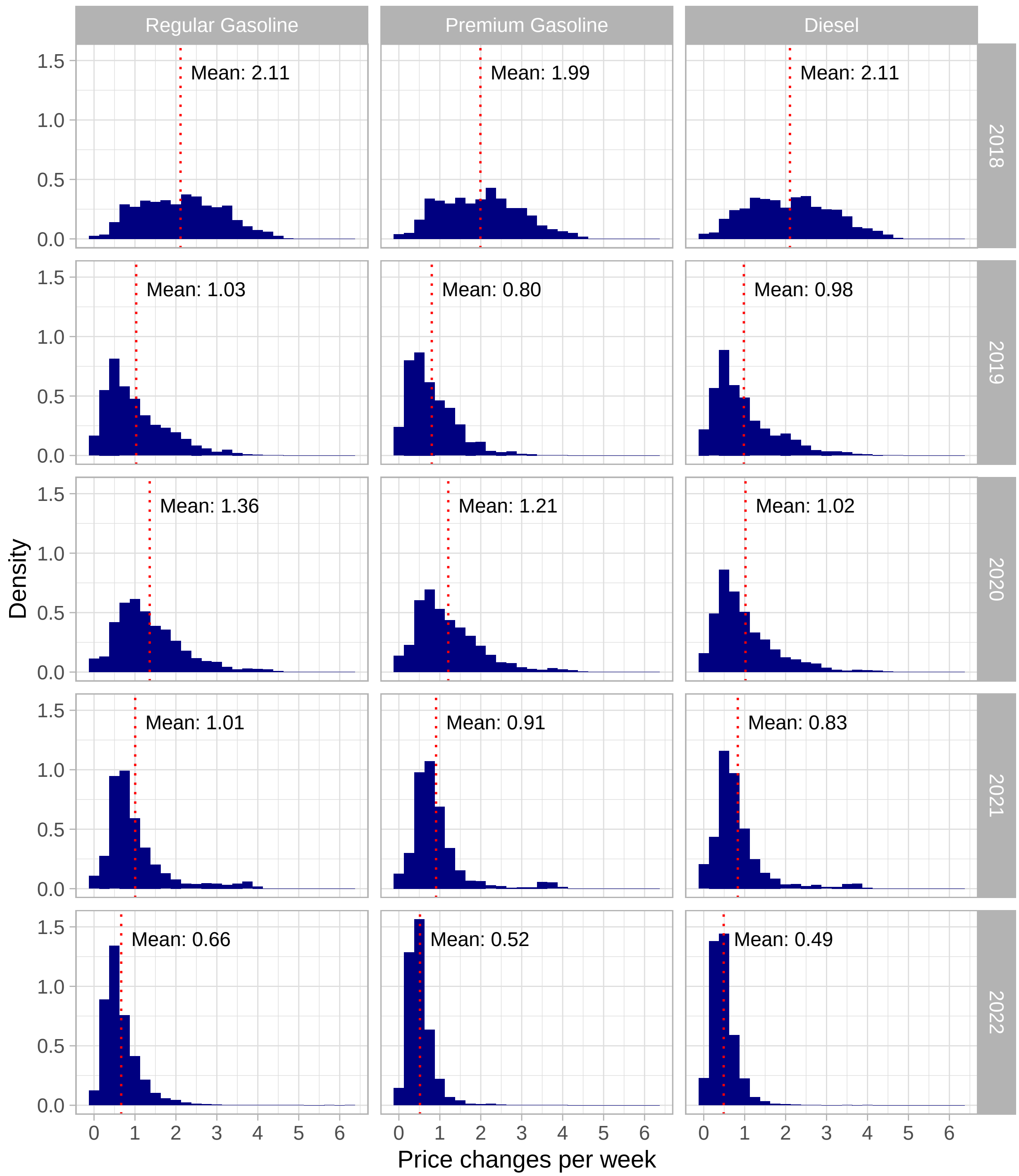
Appendix A Additional tables and figures referenced in paper

Figure A1: Distribution of the number of price changes per week, 2018 to 2022

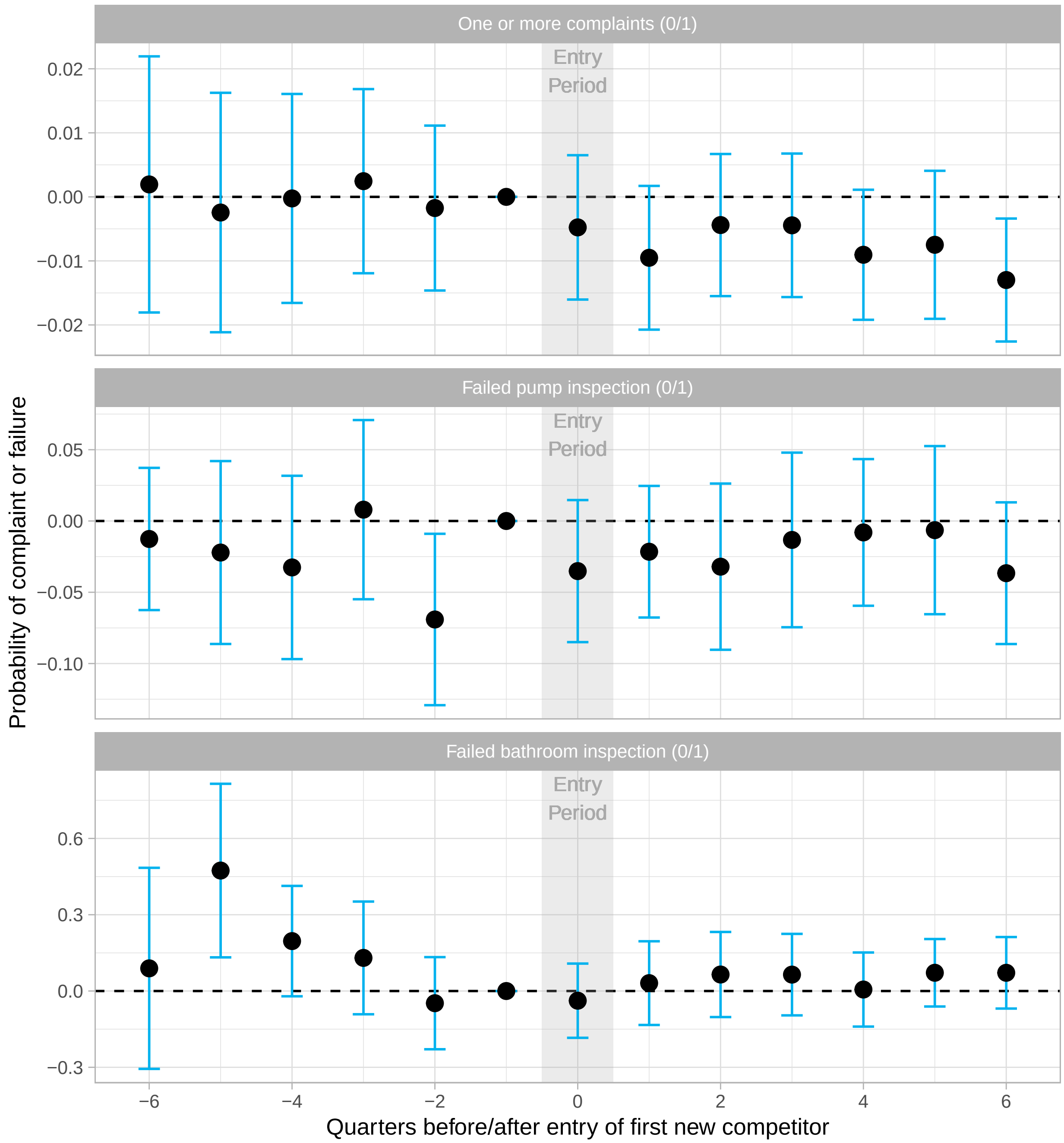


Notes: Each histogram shows the distribution of the mean number of price changes per week per station, by refined product type and year-of-sample.

Figure A2: Example of the bathroom conditions slide from the weekly presentation on gasoline stations

Source: https://combustibles.profeco.gob.mx/qqpgasolina/2022/QQPGASOLINA_120522.pdf

Figure A3: Effect of entry on station quality



Notes: Each panel is an event study corresponding to one of the three columns in Table 3. The outcomes are the occurrence of a customer complaint in a month (Panel A), failing a pump inspection (Panel B), and failing a bathroom inspection, defined as having an unclean bathroom or missing toilet paper or soap (Panel C). The "event" is defined as the first entry of an additional nearby competitor during the sample period. The coefficient at $t = -1$ (one quarter before entry) is normalized to zero. See also the notes to Table 3.

Table A1: Construction of analysis sample

	As of Nov. 2017	Entries	Exits	As of Nov. 2022	Total stations
Number of CRE fueling station permits	11,762	1,596	39	13,319	13,358
Less:					
Stations that are not yet open	98	616	0	620	620
Marine Terminals	19	2	1	20	21
Plus:					
Stations permitted that opened later	0	94	0	0	0
Number of stations in analysis dataset	11,645	1,072	38	12,679	12,717
Of which:					
Sells regular gasoline	11,639	1,072	38	12,673	12,711
Appears in final regular gasoline dataset	11,560	1,052	27	12,585	12,612
Sells premium gasoline	10,802	1,049	30	11,821	11,851
Appears in final premium gasoline dataset	10,742	1,035	21	11,756	11,777
Sells diesel	8,594	953	24	9,523	9,547
Appears in final diesel dataset	8,564	867	16	9,415	9,431
Appears in final complaint dataset	12,144	540	14	12,670	12,684
Appears in final pump inspection dataset	10,345	726	3	11,068	11,071
Appears in final bathroom inspection dataset	4,701	143	0	4,844	4,844

Notes: This table describes the construction of the analysis sample. The first column shows the observations present at the start of the sample period. Entries correspond to new appearances of stations in the dataset during the sample period. Exits are stations that close or stop operating during the sample period. The number of CRE fueling station permits is the number of permits granted by CRE. Stations that are not yet open are stations that, even with a granted permit, have never started operations and thus do not appear in any other datasets. Marine terminals are stations in ports that only sell marine diesel to boats, and so their driving-time distance to other stations is not relevant as a competition measure. Stations permitted that opened later are stations whose permit date is before the start of the sample period but that do not appear in the price data until partway through the sample period.

Table A2: Construction of price analysis sample

	Regular Gasoline	Premium Gasoline	Diesel
Number of stations in analysis dataset	12,612	11,777	9,431
$\times$ Number of days from Nov 2017 to Nov 2022	1,827	1,827	1,827
Initial station-by-day observations	23,042,124	21,516,579	17,230,437
Less:			
Dates before opening	735,671	742,033	667,233
Dates without updated price data	3,130,068	3,697,424	3,146,779
Outlier price observations	22,990	13,801	6,592
Final station-by-day price observations	19,153,395	17,063,321	13,409,833

Notes: This table describes the construction of the sample of daily prices for the three products. The first row matches the number of stations in the analysis dataset from Table A1 selling each product. The number of stations is then multiplied by the total number of days in the sample (from November 30, 2017 to November 30, 2022) to build the initial station-day observations. Then, the dates are removed when the station is not yet operating, when the prices have not been updated for more than a month, or when there are outlying price observations. The final total is the number of observations used for the estimation in Table 2.

Table A3: Descriptive statistics of stations in quality analysis

		Stations with at least one:		
	All stations	Complaint	Pump inspection	Bathroom inspection
Total number of stations	12,717	7,856	11,072	5,083
Average number of stations within 3 minutes	3.261	3.517	3.110	3.163
Average number of same-owner stations within 3 minutes	0.230	0.208	0.208	0.189
Average number of sets of pumps	4.125	4.294	4.177	4.115
Fraction of stations in a metropolitan area	0.644	0.689	0.633	0.634
Fraction of stations on a main road	0.414	0.428	0.423	0.425
Fraction of stations selling regular gasoline	0.999	0.999	0.999	0.998
Fraction of stations selling premium gasoline	0.926	0.949	0.935	0.942
Fraction of stations selling diesel	0.741	0.715	0.757	0.779

Notes: This table reports descriptive statistics for stations in the full sample (Column 1), for stations that received at least one complaint during the sample period (Column 2), for stations that received at least one pump inspection visit by PROFECO (Column 3), and for stations that received at least one bathroom inspection visit (Column 4). Station characteristics are the same as in the first panel of Table 1.

Table A4: Effect of competition on probability of inspection

	Pump inspection		Bathroom inspection	
	(1)	(2)	(3)	(4)
Stations within 3 minutes	-0.0004	0.0002*	-0.0001	0.0006
	(0.0014)	(0.0001)	(0.0037)	(0.0003)
Metropolitan area (0/1)		0.0044***		0.0132***
		(0.0012)		(0.0027)
Main road (0/1)		0.0009		0.0002
		(0.0006)		(0.0019)
Number of Sets of Pumps		0.0009***		0.0003
		(0.0002)		(0.0004)
Pre-deregulation incumbent (0/1)		0.0205***		-0.0063*
		(0.0011)		(0.0026)
Sells regular gasoline (0/1)		0.0316***		0.0154***
		(0.0046)		(0.0038)
Sells premium gasoline (0/1)		0.0044***		0.0100***
		(0.0011)		(0.0024)
Sells diesel (0/1)		-0.0034***		0.0099***
		(0.0009)		(0.0021)
Fixed effects				
Station	Y	N	Y	N
State-by-Month	Y	Y	Y	Y
Observations	703,989	703,989	448,896	448,896
R^2	0.096	0.083	0.143	0.023
Dep. variable mean	0.0622	0.0622	0.0306	0.0306
Number of stations	11,626	11,626	11,603	11,603
Number of entrants	1,072	1,072	483	483
Number that experienced entry	2,035	2,035	991	991

Notes: This table shows the estimates for the effect of entry on the probability of being inspected by PROFECO in a given month. An observation is a station-month. The sample period covers from November 2017 to November 2022 (for the pump inspections) and October 2019 to November 2022 (for the bathroom inspections). The regression specification for Columns 1 and 3 is: $Prob\,inspection_{im} = \alpha_i + \gamma_{sm} + \beta_1 Num.\,Stations_{im} + \epsilon_{im}$, where α_i are station fixed effects and γ_{sm} are state-by-month fixed effects. The second column includes as controls some specific station characteristics instead of the station fixed effects. The variable of interest is $Num.\,Stations_{im}$, which measures the number of stations within a three-minute drive that a given incumbent i faced in a given month. Standard errors are clustered at the municipality level. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table A5: The effect of competition on spreads

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.069***	-0.070***	-0.050***	-0.053***	-0.045***	-0.047***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.022		0.064***		0.045*
		(0.018)		(0.022)		(0.020)
Sum of coefficients		-0.047		0.011		-0.001
p-value for sum of coefficients		0.020		0.626		0.959
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	19,153,395	19,153,395	17,050,010	17,050,010	13,409,833	13,409,833
Dep. variable mean	1.15	1.15	1.47	1.47	1.27	1.27
Number of stations:						
Total	12,612	12,612	11,777	11,777	9,431	9,431
Entrants	1,052	1,052	1,035	1,035	867	867
Experienced entry	2,130	2,130	2,079	2,079	1,487	1,487
Experienced same-owner entry	392	392	380	380	215	215

Notes: This table reports coefficient estimates and standard errors from six separate least squares regressions of our baseline difference-in-differences specification described in equation 2. The dependent variable in each regression is the difference between the retail price and the posted price at the Pemex terminal corresponding to each station, in pesos per liter. The posted terminal price does not incorporate any quantity discounts. The number of observations for premium gasoline is less than in Table A2 because of a small number of missing terminal prices. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table A6: The effect of competition on retail prices, for retail chains with ten or more stations

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.063***	-0.063***	-0.040**	-0.042***	-0.044***	-0.046***
	(0.015)	(0.015)	(0.015)	(0.014)	(0.015)	(0.015)
Same-owner stations within 3 min.		-0.002		0.029*		0.021
		(0.015)		(0.015)		(0.017)
Sum of coefficients		-0.064		-0.013		-0.025
p-value for sum of coefficients		0.002		0.534		0.233
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	5,800,105	5,800,105	5,354,695	5,354,695	3,483,495	3,483,495
Dep. variable mean	19.19	19.19	20.72	20.72	20.72	20.72
Number of stations:						
Total	3,582	3,582	3,471	3,471	2,292	2,292
Entrants	293	293	292	292	228	228
Experienced entry	711	711	700	700	460	460
Experienced same-owner entry	346	346	340	340	184	184

Notes: This table reports coefficient estimates and standard errors from six separate least squares regressions of our baseline difference-in-differences specification described in equation 2. The sample is restricted to retail chains with ten or more stations owned by the same firm. The competition definition (number of stations within three minutes) is the same as before, including stations that are and are not part of a retail chain. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Appendix B Wholesale prices and retail price spreads

In this appendix, we describe supplemental data that we collected on the daily wholesale prices at Pemex terminals and how we use this data to calculate retail price spreads for each station. We also discuss the limitations of using these spreads as a measure of station profitability.

For the following results based on wholesale prices, we use posted Pemex wholesale terminal prices. Before May 2021, Pemex posted daily prices at 78 different wholesale terminals (PEMEX, 2021a). We obtained the daily terminal price list for the remainder of 2021 and 2022 using a public data request. We match each station to a wholesale terminal using the pre-2017 assignment of stations to terminals. For new stations, or for stations that were not assigned to a specific terminal, we match stations to terminals using (i) the modal terminal for the other stations in the same municipality, or if that is unavailable then (ii) the closest terminal measured by driving time to the station. This procedure assigns a daily wholesale price to each station and product in our dataset.

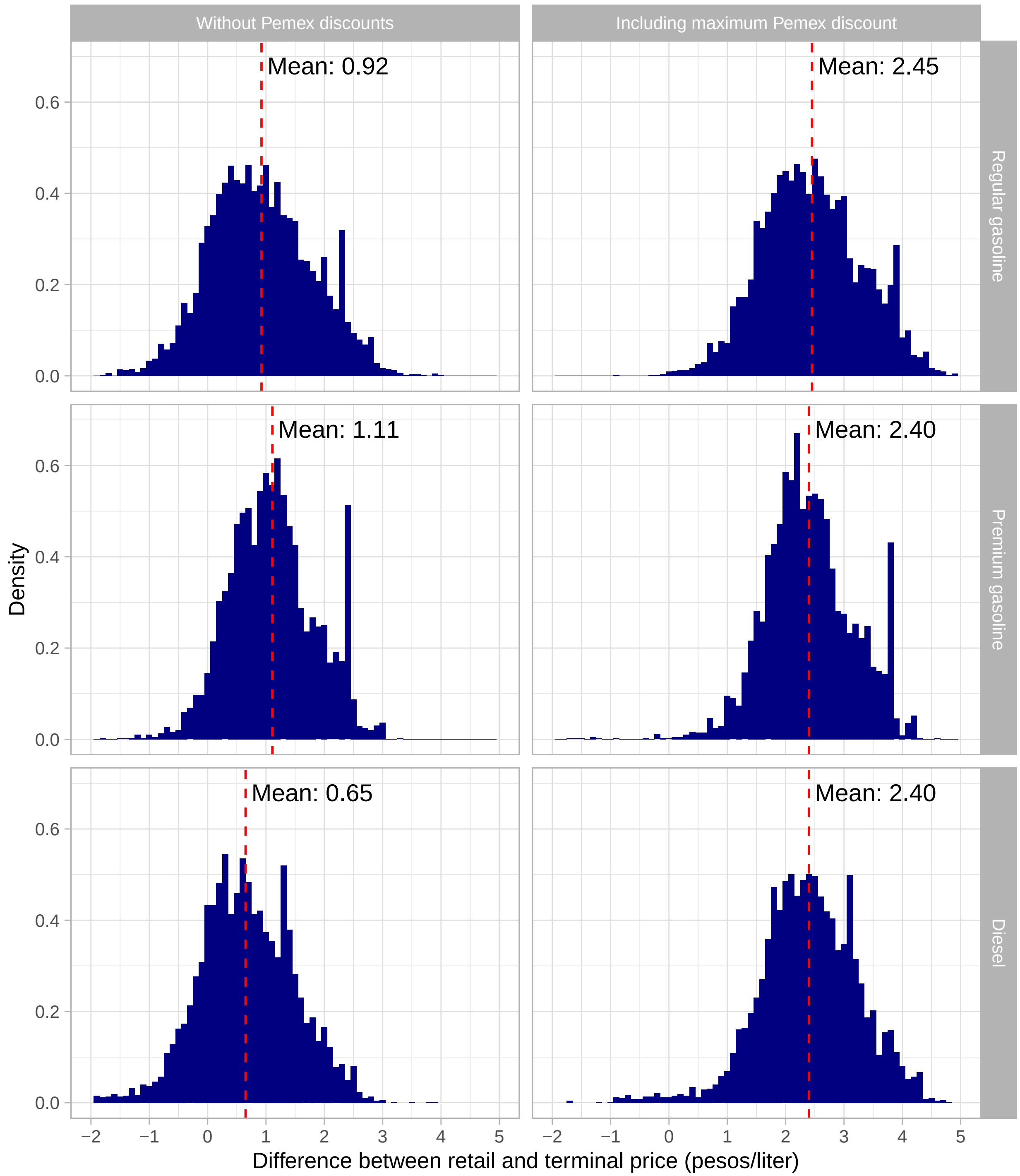
In Mexico, the difference between the retail price and the posted terminal price may not accurately reflect the profit margins of gas stations. Several large firms, most notably international majors such as ExxonMobil, import gasoline from the United States by rail, truck, or boat. The relevant wholesale cost for these stations is the U.S. refinery price plus transportation costs. To retain its wholesale market share, Pemex has responded to this import competition by providing large discounts to high-volume customers who sign long-term contracts. These discounts have led to the creation of wholesaling intermediaries that aggregate demand from many stations to obtain the highest Pemex discount, known as a "Level 9" discount (Meana, 2020). The discounts vary by region and month.

Figure B1 shows the effect of the Pemex discounts on the potential profitability of gasoline stations. The left panels show the distribution of the spreads between the retail and posted terminal prices in October 2021. The right panels show the distribution of the spreads, including the highest Pemex discount available in each region in October 2021. Excluding the discounts, the mean spread for regular gasoline was 0.92 pesos per liter (4.5 percent of the mean retail price of 20.32 pesos per liter), but the spread increased to a mean of 2.45 pesos per liter (12.0 percent of the mean retail price) after including the highest available discount in each region. The discounts are slightly lower for premium gasoline and slightly higher for diesel. Because we do not observe the wholesale price paid by a station, and the discounts potentially have a large effect on station profitability, we use the retail price as our outcome variable in Section 5.

Appendix Figure B2 shows the upward trend in retail and wholesale prices for the three products during our sample period. Appendix Figure B3 provides additional descriptive evidence on how retail spreads (before discounts) have varied over time and across markets with different numbers of competitors. Appendix Table B1 shows the annual mean retail price spreads, in pesos per liter and as a percentage of the retail price, separately for incumbents and entrants.

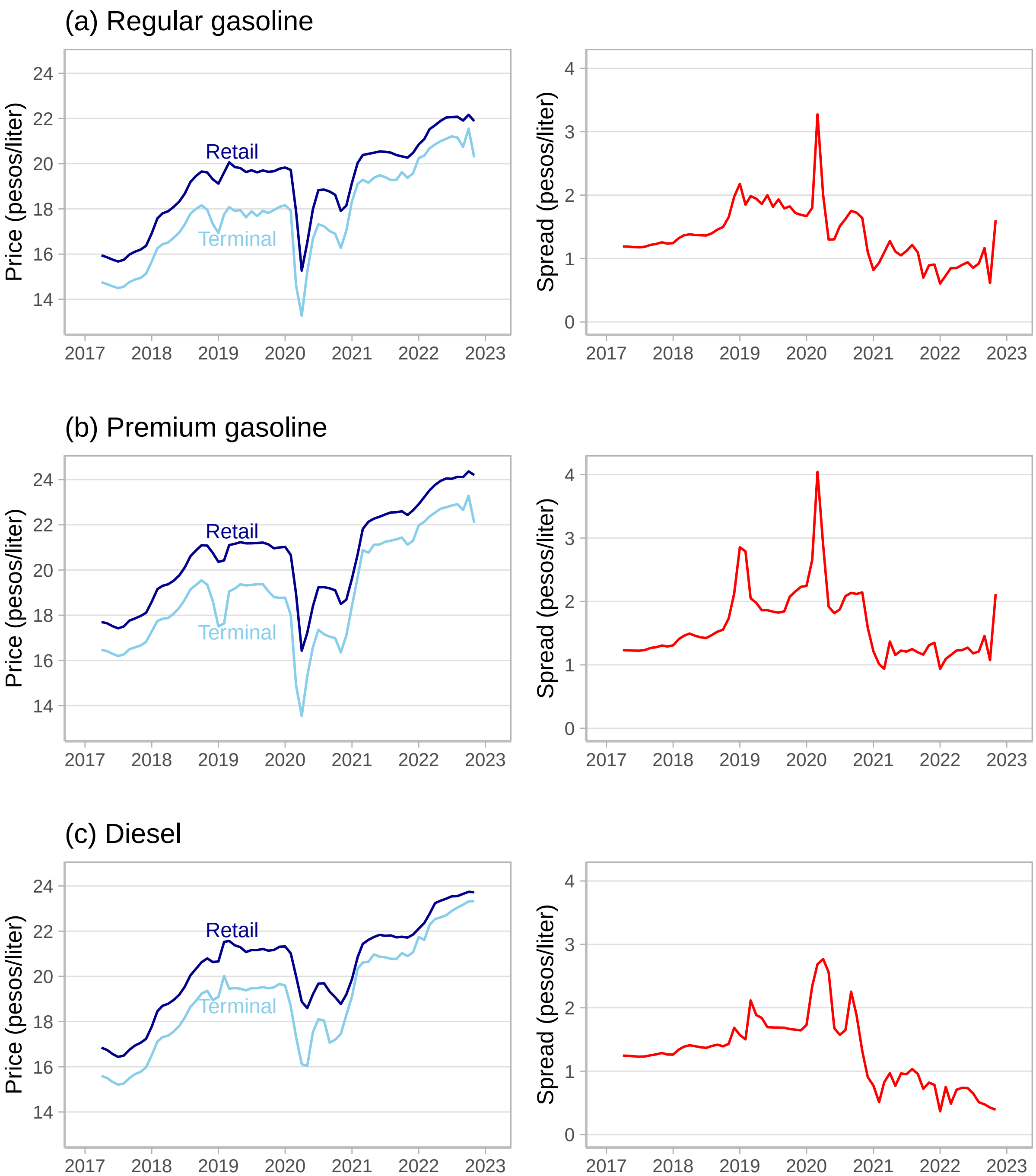
Finally, Table A5 shows our main regression results using the retail spread as the dependent variable instead of the retail price. The estimated coefficients are almost identical to those in Table 2, a result of our fine-grained terminal-by-month-of-sample and day-of-sample fixed effects absorbing nearly all changes in wholesale prices.

Figure B1: Histograms of spreads with and without Pemex discounts, October 2021



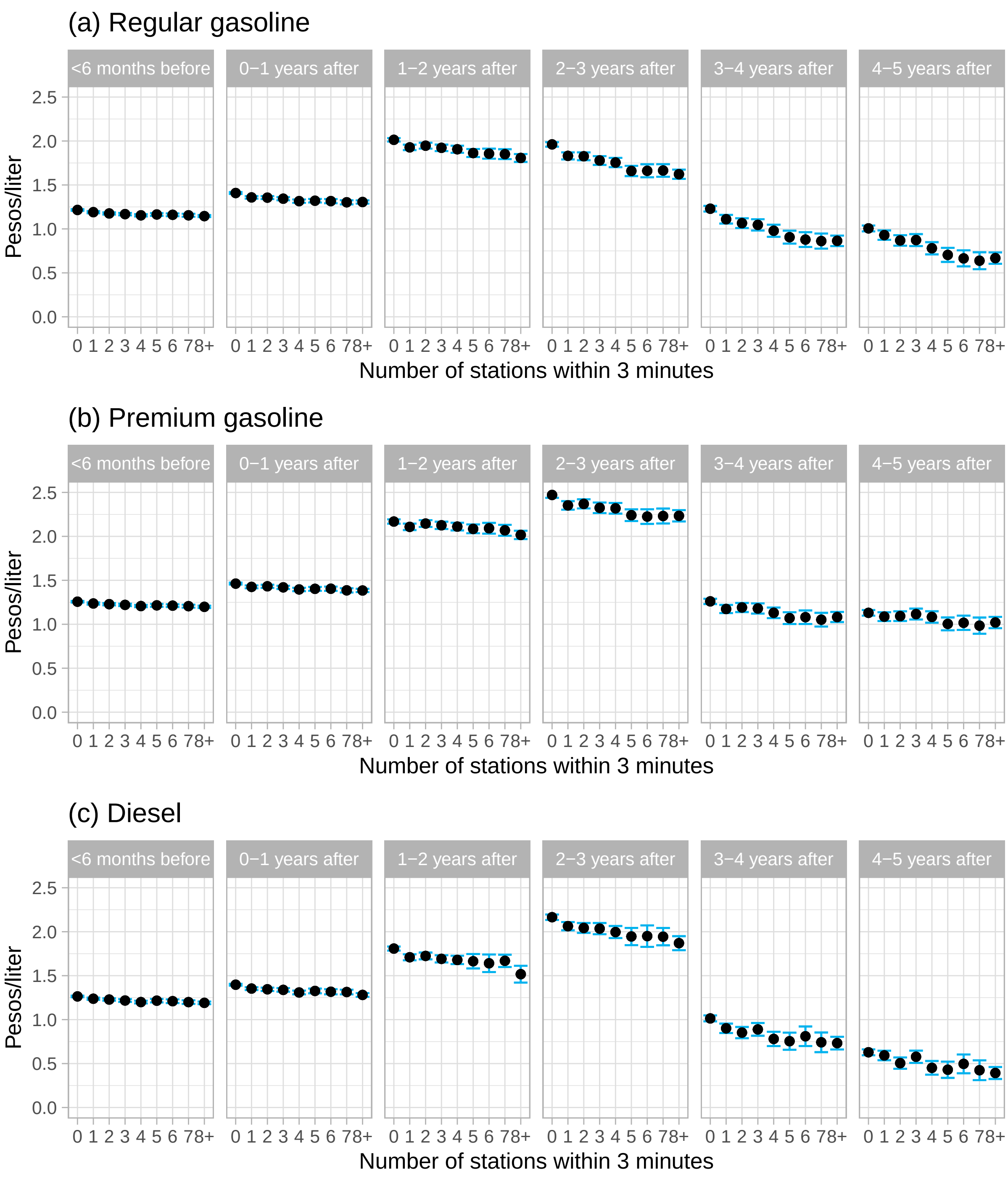
Notes: The left panels show the distribution of the difference between the retail and posted terminal prices between September 16 and October 15, 2021. The right panels show the distribution including the highest available Pemex discount in each region (PEMEX, 2021b). Stations near the U.S. border subject to an alternative tax regime are excluded.

Figure B2: Prices and spreads



Notes: This figure shows monthly average retail and wholesale ("terminal") prices (left figures), as well as implied retail price spreads (right figures), for the three refined products.

Figure B3: Correlations between the number of competitors and spreads



Notes: This figure plots mean price spreads (the difference between the retail and terminal prices, before discounts) and 95 percent confidence intervals by the number of stations within three minutes. The time periods are defined relative to November 2017. For this figure, but not other analyses in the paper, we restrict the sample to a balanced panel of stations in states that deregulated in November 2017.

Table B1: Descriptive statistics for retail price spreads

(a) Average retail price spread (pesos/liter)

	Incumbents			Entrants		
Year	Regular	Premium	Diesel	Regular	Premium	Diesel
2017	0.76	0.99	1.30	1.25	1.28	1.27
2018	1.23	1.38	1.39	1.40	1.51	1.37
2019	1.54	1.84	1.62	1.66	1.95	1.60
2020	1.46	2.09	1.94	1.50	2.17	1.84
2021	0.77	0.95	0.77	0.80	0.98	0.70
2022	0.65	1.00	0.51	0.67	1.05	0.43

(b) Average retail price spread, as a percentage of retail price

	Incumbents			Entrants		
Year	Regular	Premium	Diesel	Regular	Premium	Diesel
2017	4.83	5.62	7.62	7.69	7.14	7.43
2018	6.70	6.93	7.14	7.44	7.44	6.90
2019	7.94	8.87	7.68	8.55	9.36	7.56
2020	8.16	11.18	9.91	8.37	11.60	9.47
2021	3.83	4.37	3.62	4.00	4.53	3.29
2022	3.04	4.24	2.20	3.10	4.46	1.86

Notes: This table reports the annual mean retail price spread, in pesos per liter (B1a) and as a percentage of the retail price (B1b). The retail price spread is the difference between the retail and terminal prices. Stations are characterized as incumbents if they were operating at the end of November 2017 and entrants if they began operations during our sample period from December 2017 to November 2022.

Appendix C Validation of fuel price data

This appendix describes our procedure for validating the price data used in our analysis. As discussed in Section 3.4, our data comes from the prices that all stations are legally required to report to the regulator. To check these reports, we collected the prices that were publicly displayed on price signs in front of the stations, as observed in periodic photos taken by an online mapping service. For a 10 percent random sample of the stations that experienced entry, we compared the price sign information to the prices reported by the station to the regulator.

Our price check sample comprised 220 stations. For each station, we examined all available photos in the online mapping service during our five-year sample period. Table C2 shows that about 11 percent of stations lacked imagery during this time. Among the stations with at least one photo, there was an average of 3.5 photos over the sample period.

We recorded each photo's month and year (exact dates were unavailable) and the displayed prices for regular gasoline, premium gasoline, and diesel. These prices were then checked against the station's daily reported prices for that month. We classified price observations as exact matches if all prices matched on any day, partial matches if all but one product's price matched, and non-matches otherwise. Figure C1 illustrates this procedure.

Table C1 shows the year-by-year classification of price sign observations. Of the 656 price signs in our data, 95 percent match exactly the gasoline and diesel prices reported to the regulator. Nearly 4 percent show partial matches, with one incorrect fuel price out of three products. Just over 1 percent (9 signs) do not match reported prices. Exact matches increase slightly in the latter part of the sample, despite the declining frequency of reported price changes (Figure A1). This suggests the lower number of price changes stems from altered pricing behavior rather than reduced reporting compliance.

Table C2 summarizes price check results at a station level. We classify each of the 220 sample stations into one of five categories. For 11 percent, no images exist during the 2018–2022 sample period. Nearly 4 percent have images, but show closed stations or illegible price signs. Of 188 stations with at least one price sign observation, 88 percent (75 percent of all sampled stations) exhibit exact price matches for all signs. Only 2 of the 188 stations have no exact matches between displayed and reported prices.

The right three columns of Table C2 summarize the mean number of price changes per week, split by station classification. For each station, we calculated the mean number of changes to the regular gasoline price over the five-year sample period (or its operational period, if shorter). The table shows the minimum, mean, and maximum of these station-level means for each category. For the stations with exact price matches, the number of weekly price changes ranges from 0.23 to 3.22, averaging 1.32. This suggests that the station in Figure C1, changing its regular gasoline price five times in the month, is fairly typical of Mexican gasoline stations. Stations with no matched prices or illegible signs report fewer price changes.

These results provide independent confirmation that the large majority of the gasoline stations experiencing entry in our analysis comply with price reporting regulations. The match rate between displayed and reported prices is extremely high. This high compliance likely stems from stations valuing the provision of accurate prices to consumers via price search applications that reproduce the regulator's public price reports.

Figure C1: Matching of station price signs to price data

PEMEX ID	Date	Regular	Premium	Diesel
ES 13879	2021-03-01	20.55	21.55	21.85
ES 13879	2021-03-02	20.55	21.55	21.85
ES 13879	2021-03-03	20.55	21.55	21.85
ES 13879	2021-03-04	20.55	21.55	21.85
ES 13879	2021-03-05	20.55	21.55	21.85
ES 13879	2021-03-06	20.63	21.79	21.98
ES 13879	2021-03-07	20.63	21.79	21.98
ES 13879	2021-03-08	20.63	21.79	21.98
ES 13879	2021-03-09	20.63	21.79	21.98
ES 13879	2021-03-10	20.63	21.79	21.98
ES 13879	2021-03-11	20.63	21.79	21.98
ES 13879	2021-03-12	20.74	21.89	22.06
ES 13879	2021-03-13	20.74	21.89	22.06
ES 13879	2021-03-14	20.74	21.89	22.06
ES 13879	2021-03-15	20.74	21.89	22.06
ES 13879	2021-03-16	20.74	21.89	22.06
ES 13879	2021-03-17	20.74	21.89	22.11
ES 13879	2021-03-18	20.79	21.99	22.19
ES 13879	2021-03-19	20.79	21.99	22.19
ES 13879	2021-03-20	20.79	21.99	22.19
ES 13879	2021-03-21	20.79	21.99	22.19
ES 13879	2021-03-22	20.79	21.99	22.19
ES 13879	2021-03-23	20.79	21.99	22.19
ES 13879	2021-03-24	20.79	21.99	22.19
ES 13879	2021-03-25	20.84	22.09	22.24
ES 13879	2021-03-26	20.84	22.09	22.24
ES 13879	2021-03-27	20.84	22.09	22.24
ES 13879	2021-03-28	20.84	22.09	22.24
ES 13879	2021-03-29	20.84	22.09	22.24
ES 13879	2021-03-30	20.84	22.09	22.24
ES 13879	2021-03-31	20.84	22.09	22.24

Notes: This figure illustrates our price sign matching procedure for validating the reported price data. Left: A gasoline station price sign photo from March 2021. Right: The station's prices reported to the regulator in March 2021. The highlighted rows indicate days when the reported prices match the displayed price sign. This example demonstrates an exact price match.

Table C1: Classification of price observations in the price check sample

% of total	2018	2019	2020	2021	2022	Total
Exact price match	93.0	93.6	96.0	95.2	96.3	95.0
Partial price match	1.8	4.8	4.0	3.6	3.2	3.7
No price match	5.3	1.6	0.0	1.2	0.5	1.4
Number of observations	57	188	25	168	218	656

Notes: Columns summarize the price sign matching results by year. The final row gives the price sign observations per year. The first three rows show the percentages of exact, partial, and non-matches to the prices that the station reported to the regulator.

Table C2: Classification of stations in the price check sample

			Mean price changes per week		
Station category	Number	% of total	Minimum	Mean	Maximum
No station images for 2018–2022	24	10.9	0.31	1.23	2.33
Illegible or missing price sign	8	3.6	0.15	1.00	1.46
All prices match exactly	165	75.0	0.23	1.32	3.22
At least one exact match	21	9.5	0.07	1.34	2.60
No matched prices	2	0.9	0.06	0.50	0.94
Number of sampled stations	220	100.0	0.06	1.29	3.22

Notes: Each of the 220 sample stations is classified into one of five categories. We calculated each station's mean number of weekly changes in regular gasoline price over the five-year period. The last three columns show the minimum, mean, and maximum of these station-level means per category.

Appendix D Price results split by urban and rural areas

In this appendix, we show our main price results split by urban and rural incumbents. We expect heterogeneous effects of competition for these two types of stations. In urban areas, we expect to see smaller price effects of entry in our markets defined by driving time. This is because stations that are a short drive time apart might not be on the same commuting routes and so drivers might be less willing to drive out of their way to substitute between them. This will be even more likely in urban areas with substantial traffic congestion (which, for reasons of data availability, we do not consider in the definition of our driving time markets). Conversely, there might be stronger competition between stations in rural areas, which are typically stations located along highways connecting towns and cities. Drivers can substitute between stations along a single highway without any cost of driving out of their way.

We split our sample into urban and rural stations using the Global Urban Areas dataset (Meta Data For Good, 2023). This is a vectorized dataset of polygons showing areas of urban concentration created from high-resolution satellite land use data. Stations are classified as urban if they are located inside an urban area polygon. We found that the satellite land-use data provided a more accurate classification of urban areas than maps using administrative or statistical boundaries. 71 percent of the stations in our data are in urban areas and 29 percent are in rural areas. Plotting the locations of the rural-classified stations shows that most of these are located along highways.

Table D1 replicates our analysis in Table 2 for urban stations only. The magnitude of the effect of competition on price is smaller than in our main results. In urban areas, one additional station within three minutes reduces the regular gasoline price by 0.047 pesos/liter, compared to an effect of 0.069 pesos/liter in the overall sample. Similarly, the effect of an additional station on diesel prices is 0.028 pesos/liter in urban areas, compared to 0.045 pesos/liter in the overall sample. Although their magnitudes are smaller, all price coefficients remain statistically significant at the 0.5 percent level. Interestingly, the point estimates for the effect of same-owner stations on prices are larger than in Table 2. As shown by the p-values for the sum of coefficients, an additional nearby station with the same owner as the incumbent has no statistically significant effect on incumbent prices for any fuel type in urban areas.

Table D2 reports the price results for the rural stations. The magnitude of the results for regular gasoline is about twice as large as in urban areas. One additional station within three minutes in rural areas reduces the price of regular gasoline for incumbents by 0.096

pesos/liter, or 8.3 percent of the regular retail price spread. The difference between urban and rural areas is even greater for diesel. In rural areas, one additional station within three minutes reduces incumbent diesel prices by 0.092 pesos/liter, or 7.2 percent of the diesel retail price spread. This larger effect for diesel in rural areas is consistent with greater competition between gas stations along highways to attract and retain sales to trucks and buses on intercity routes. The competition effects on price have larger standard errors than in urban areas, with the coefficients for regular gasoline and diesel significant at the 5 percent level and the coefficient for premium gasoline not statistically significantly different from zero. For all three fuel types, the entry of a nearby station with the same owner as the incumbent has a positive but not statistically significant effect on price, although there are very few observations of such entry in rural areas.

Table D1: The effect of competition on prices for urban stations

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.047***	-0.049***	-0.041***	-0.043***	-0.028**	-0.029***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.030		0.067***		0.046*
		(0.017)		(0.021)		(0.019)
Sum of coefficients		-0.018		0.024		0.016
p-value for sum of coefficients		0.332		0.253		0.436
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	13,930,577	13,930,577	12,831,566	12,831,566	8,537,322	8,537,322
Dep. variable mean	19.17	19.17	20.64	20.64	20.63	20.63
Number of stations:						
Total	8,943	8,943	8,674	8,674	5,872	5,872
Entrants	737	737	734	734	580	580
Experienced entry	1,972	1,972	1,934	1,934	1,334	1,334
Experienced same-owner entry	376	376	365	365	199	199

Notes: This table reports regression estimates using the same specification as in Table 2. The sample includes only incumbents located in urban areas, where these are defined based on Meta Data For Good (2023). See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table D2: The effect of competition on prices for rural stations

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.096*	-0.100*	-0.052	-0.057	-0.092*	-0.097*
	(0.040)	(0.040)	(0.042)	(0.043)	(0.038)	(0.039)
Same-owner stations within 3 min.		0.149		0.155*		0.168*
		(0.103)		(0.072)		(0.073)
Sum of coefficients		0.049		0.098		0.071
p-value for sum of coefficients		0.637		0.175		0.332
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	5,222,818	5,222,818	4,231,755	4,231,755	4,872,511	4,872,511
Dep. variable mean	19.46	19.46	20.77	20.77	20.75	20.75
Number of stations:						
Total	3,669	3,669	3,103	3,103	3,559	3,559
Entrants	315	315	301	301	287	287
Experienced entry	158	158	145	145	153	153
Experienced same-owner entry	16	16	15	15	16	16

Notes: This table reports regression estimates using the same specification as in Table 2. The sample includes only incumbents not located in urban areas, where these are defined based on Meta Data For Good (2023). See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Appendix E Sensitivity of price results to alternative samples

In this Appendix, we show the robustness of our price results (Table 2) to alternative sample criteria.

Table E1 shows the effect of excluding stations that are located in one of the 40 municipalities within 45 kilometers of the U.S. border that are subject to an alternative tax and subsidy program (SHCP, 2018). This reduces the sample size by about 1,000 stations. The estimated coefficients are similar to those in Table 2, demonstrating that our main results are not affected by potentially different price and competition dynamics in the border region.

As discussed in Section 3.4, for our main analysis we drop station-price observations more than 31 days after a price change. We also drop outliers, defined as price observations less than $Q1 - 3IQR$ or greater than $Q3 + 3IQR$, where $Q1$ is the first quartile of prices for each product, $Q3$ is the third quartile, and IQR is the interquartile range. Tables E2 to E4 show the effect of changing these sample criteria on the main results in Table 2. Table E2 reduces the width of the IQR fence for detecting outliers from $3IQR$ to $1.5IQR$. Table E3 keeps only price observations from the same day as the price change, reducing the sample size by nearly 80 percent. Table E4 keeps price observations for up to 60 days after each price change. In all cases, the results in these tables are qualitatively similar to those in Table 2, and in most cases, the quantitative values are almost identical too.

Table E1: The effect of competition on prices: sample excluding stations near U.S. border

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.069***	-0.070***	-0.050***	-0.053***	-0.042***	-0.044***
	(0.011)	(0.012)	(0.011)	(0.012)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.031		0.074***		0.056*
		(0.021)		(0.025)		(0.023)
Sum of coefficients		-0.039		0.021		0.012
p-value for sum of coefficients		0.071		0.382		0.614
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	17,682,161	17,682,161	15,888,032	15,888,032	12,696,194	12,696,194
Dep. variable mean	19.52	19.52	20.88	20.88	20.72	20.72
Number of stations:						
Total	11,610	11,610	10,920	10,920	8,880	8,880
Entrants	1,017	1,017	1,005	1,005	841	841
Experienced entry	2,015	2,015	1,976	1,976	1,438	1,438
Experienced same-owner entry	336	336	332	332	188	188

Notes: This table reports regression estimates using the same specification as in Table 2. The sample excludes stations within 50 kilometers of the U.S.–Mexico border that are subject to an alternative tax and subsidy regime. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table E2: The effect of competition on prices: sample using a stricter definition of outliers

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.067***	-0.068***	-0.049***	-0.052***	-0.044***	-0.046***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.022		0.064***		0.044*
		(0.018)		(0.022)		(0.019)
Sum of coefficients		-0.046		0.012		-0.002
p-value for sum of coefficients		0.024		0.578		0.931
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	18,526,673	18,526,673	16,891,672	16,891,672	13,387,880	13,387,880
Dep. variable mean	19.35	19.35	20.72	20.72	20.68	20.68
Number of stations:						
Total	12,607	12,607	11,776	11,776	9,429	9,429
Entrants	1,052	1,052	1,035	1,035	867	867
Experienced entry	2,114	2,114	2,075	2,075	1,486	1,486
Experienced same-owner entry	388	388	378	378	215	215

Notes: This table reports regression estimates using the same specification as in Table 2. The sample excludes price observations that are less than $Q1 - 1.5IQR$ or greater than $Q3 + 1.5IQR$, where $Q1$ is the first quartile of prices, $Q3$ is the third quartile of prices, and IQR is the interquartile range $Q3 - Q1$. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table E3: The effect of competition on prices: sample using only same-day price changes

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.067***	-0.068***	-0.055***	-0.057***	-0.038***	-0.040***
	(0.011)	(0.011)	(0.011)	(0.012)	(0.009)	(0.009)
Same-owner stations within 3 min.		0.032		0.059***		0.036*
		(0.016)		(0.017)		(0.018)
Sum of coefficients		-0.036		0.002		-0.003
p-value for sum of coefficients		0.048		0.907		0.862
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	4,277,670	4,277,670	3,543,340	3,543,340	2,789,988	2,789,988
Dep. variable mean	18.73	18.73	20.05	20.05	20.1	20.1
Number of stations:						
Total	12,604	12,604	11,759	11,759	9,422	9,422
Entrants	1,048	1,048	1,025	1,025	861	861
Experienced entry	2,101	2,101	2,055	2,055	1,470	1,470
Experienced same-owner entry	368	368	356	356	206	206

Notes: This table reports regression estimates using the same specification as in Table 2. The sample only includes prices for the same day of the price change. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table E4: The effect of competition on prices: sample using prices up to 60 days after price change

	Regular gasoline		Premium gasoline		Diesel	
	(1)	(2)	(3)	(4)	(5)	(6)
Stations within 3 min.	-0.069***	-0.070***	-0.050***	-0.053***	-0.045***	-0.046***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Same-owner stations within 3 min.		0.022		0.064***		0.045*
		(0.018)		(0.022)		(0.019)
Sum of coefficients		-0.047		0.010		-0.001
p-value for sum of coefficients		0.020		0.633		0.958
Fixed effects						
Station	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Terminal-by-Month	Y	Y	Y	Y	Y	Y
Observations	19,153,395	19,153,395	17,063,321	17,063,321	13,409,833	13,409,833
Dep. variable mean	19.26	19.26	20.68	20.68	20.68	20.68
Number of stations:						
Total	12,612	12,612	11,777	11,777	9,431	9,431
Entrants	1,052	1,052	1,035	1,035	867	867
Experienced entry	2,130	2,130	2,079	2,079	1,487	1,487
Experienced same-owner entry	392	392	380	380	215	215

Notes: This table reports regression estimates using the same specification as in Table 2. The sample includes prices for up to 60 days after the price change. See also notes to Table 2. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Appendix F Results using imputation estimator

In this appendix, we replicate the main results of the paper using the two-stage imputation estimator proposed by Borusyak et al. (2024) and Gardner (2022). The first stage regresses the outcome variable (either price or quality) on station, terminal-by-month, and (for the price regression) day-of-sample fixed effects. The sample for this regression uses only observations from stations that never, or have not yet, experienced the entry of a competitor. These estimates of the fixed effects are used to calculate the residualized outcome variables for the full sample, including the treated observations, by subtracting the estimated station and time fixed effects from the outcome variable. The second stage regresses the residualized outcomes on a treatment indicator. In the case of an event study, the second stage regresses the residualized outcomes on a set of relative event time indicators.

Our main regression results in Tables 2 and 3 use an integer-valued regressor for the number of nearby competitors. The imputation estimator relies on a binary treatment indicator to define the control sample for the first-stage regression. To adapt our analysis to the alternative methodology, we create a binary treatment variable that is equal to one in all periods after the first entry of an additional competitor in the sample period, and zero otherwise. For the same-entry regressions, the treatment variable is equal to one after the first entry of an additional competitor with the same owner. This definition of the treatment variable corresponds to our "event" definition for the event studies in Figures 4, 5 and A3.

Table F1 provides our main price results using the imputation estimator with the binary treatment variable. Columns 1 to 3 show the effect on the price of the first entry of any new competitor within a three-minute driving time. For all three products, the entry of an additional competitor has a negative and statistically significant effect on price. The magnitude of the price effects in Table F1 (measuring the "effect of first entry") is larger than in Table 2 (measuring the "effect of one additional competitor"). For example, the first new competitor reduces the retail gasoline price by 0.101 pesos per liter (Column 1 of F1, compared to a reduction of 0.069 pesos from one additional competitor (Column 1 of 2). This difference is likely because (a) the post-first-entry coefficient also captures the effect of subsequent entries, and (b) the first competitor's entry has a larger effect than subsequent entries, given the decline in the effect of entry as the number of competitors increases (Figure 7).

Columns 4 to 6 of Table F1 show the effect on price of the first entry of a new station with the same owner within a three-minute driving time. Unlike our main specification in Table 2, a new nearby gas station with the same owner has a positive effect on the price of all three refined products. For regular gasoline, the positive (though not statistically significant) same-owner-entry effect of 0.033 compares to the negative and statistically significant result for one additional same-owner station in Column 2 of Table 2. For premium gasoline and diesel, the positive same-owner effect is statistically and economically significant, compared to the zero effect in Table 2. The same-owner entry effects in Columns 5 and 6 of Table F1 are similar in magnitude—though opposite in sign—to the overall entry effects in Column 2 and 3. These results provide strong evidence that an increase in the number of branches by incumbent firms has a negative effect on competition.

What explains the difference in the results for same-owner entry between Tables 2 and F1? As shown in Figures 6 and 7, there is considerable heterogeneity in our main effect of competition on price, both by distance to the competitor and the extent of existing competition. Suppose new entrants with a different owner are located further away or in areas with fewer existing competitors than new entrants with the same owner. In that case, the coefficient on the "number of same-owner stations" may be smaller in magnitude than the coefficient on the total "number of stations", not completely offsetting the main effect—as seen in Column 2 of Table 2.

Figure F1 shows the effect of entry on the price of incumbent stations using the event study version of the Borusyak et al. (2024) methodology. Entry of a new competitor leads to an immediate drop of about 0.075 pesos per liter for regular gasoline, 0.05 pesos per liter for premium gasoline, and 0.025 pesos per liter for diesel. This effect increases over time for the three products. In the long run, six or more quarters after entry, the price of regular gasoline is about 0.12 pesos per liter lower than the pre-entry levels. There is no evidence of pre-trends before entry. Overall, the results in Figure F1 are consistent with our main event study results in Figure 4—with the main difference being an increase in the magnitude of the estimated effects.

Figure F2 shows the effect of the first entry by an additional station with the same owner as the incumbent. These event study figures confirm the finding in Table F1 of a positive effect of same-owner entry on prices. Even for regular gasoline, there is evidence that an additional station with the same owner reduces competition and raises prices, although the estimated effect declines and is noisier after about a year. Similarly, same-owner entry raises incumbent prices for premium gasoline and diesel, although the diesel results are noisier and two of the point estimates on the quarter indicators are almost identically zero.

Overall, the Figure F2 results provide even stronger evidence than Figure 5 that an increase in the number of stations owned by the same firm not only does not increase competition but may even have anti-competitive effects and lead to higher prices.

Finally, Table F2 and Figure F3 reproduce the quality results from Section 6 using the Borusyak et al. (2024) methodology. The effect of the first entry of a new competitor on the occurrence of customer complaints (Column 1 of Table F2 is larger than the effect of one extra competitor in Table 3: a reduction of 0.012 in the probability of a complaint, a 25 percent reduction compared to the mean probability of 0.045. The corresponding event study figure (the first panel of Figure F3) shows no event of pre-existing trends. There is a gradual reduction in the probability of a complaint over the six quarters after entry. Similar to the previous results, there is a small but statistically insignificant decline in the probability of failing a pump inspection. Results for the bathroom inspections remain noisy due to the small number of repeated observations for stations that experience the entry of a new competitor.

Table F1: The effect of entry on retail prices, using imputation estimator

	All entries			Same-owner entries		
	Regular (1)	Premium (2)	Diesel (3)	Regular (4)	Premium (5)	Diesel (6)
Post-first-entry (0/1)	-0.101***	-0.070***	-0.054***	0.033	0.068*	0.049*
	(0.011)	(0.009)	(0.010)	(0.035)	(0.032)	(0.022)
Observations	19,149,332	17,057,376	13,406,783	19,151,595	17,060,776	13,409,538
Dep. variable mean	19.26	20.68	20.68	19.26	20.68	20.68
Number of stations:						
Total	12,612	11,777	9,431	12,612	11,777	9,431
Entrants	1,052	1,035	867	1,052	1,035	867
Experienced entry	2,130	2,079	1,487	2,130	2,079	1,487
Experienced same-owner entry	392	380	215	392	380	215

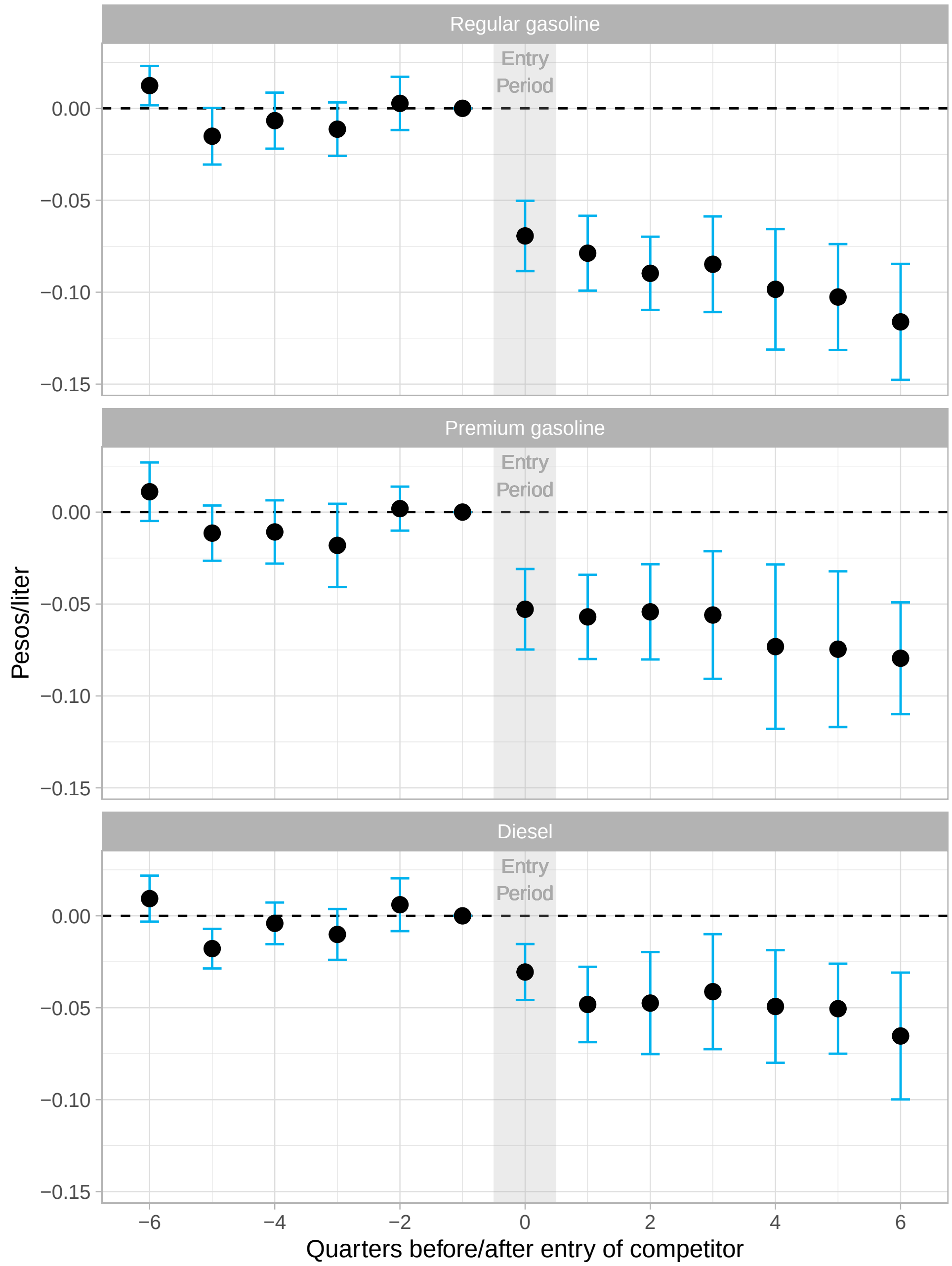
Notes: This table reports coefficient estimates and standard errors from six separate regressions of the retail price (in pesos per liter) on a post-first-entry indicator variable. Estimation uses the two-stage imputation estimator of Borusyak et al. (2024). The post-first-entry variable equals 1 for all periods after the first entry within a three-minute driving time of any new gas station (Columns 1–3) or a gas station with the same owner (Columns 4–6), and 0 otherwise. The first-stage regression includes station, terminal-by-month-of-sample, and day-of-sample fixed effects. See additional notes in Table 2. Bootstrap standard errors are clustered at the municipality level. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Table F2: The effect of entry on retail quality, using imputation estimator

	Customer complaints	Pump inspection	Bathroom inspection
	One or more (1)	Failed (2)	Failed (3)
Post-first-entry (0/1)	-0.012*	-0.013	0.080
	(0.005)	(0.017)	(0.085)
Observations	462,607	40,921	10,793
Dep. variable mean	0.045	0.187	0.170
Number of stations:			
Total	12,684	11,071	4,844
Entrants	565	1,076	487
Experienced entry	1,207	1,382	57

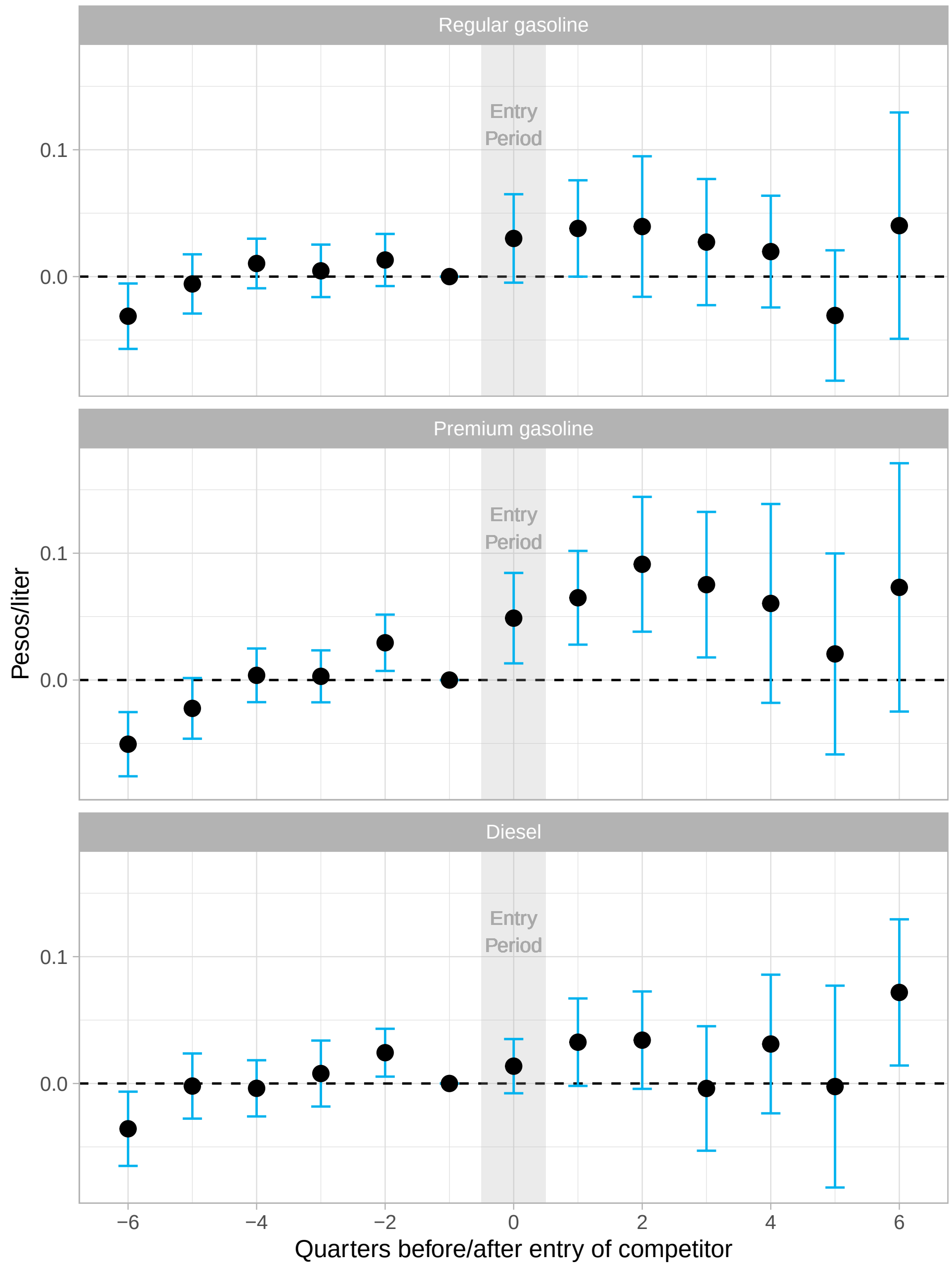
Notes: This table reports coefficient estimates and standard errors from three regressions of our quality variables on a post-first-entry indicator variable. Estimation uses the two-stage imputation estimator of Borusyak et al. (2024). The post-first-entry variable equals 1 for all periods after the first entry within a three-minute driving time of any new gas station, and 0 otherwise. The first-stage regression includes station and terminal-by-month-of-sample fixed effects. See additional notes in Table 3. Bootstrap standard errors are clustered at the municipality level. *Significance codes: ***: 0.005, **: 0.01, *: 0.05*

Figure F1: Event study for the effect of entry on retail prices, using imputation estimator



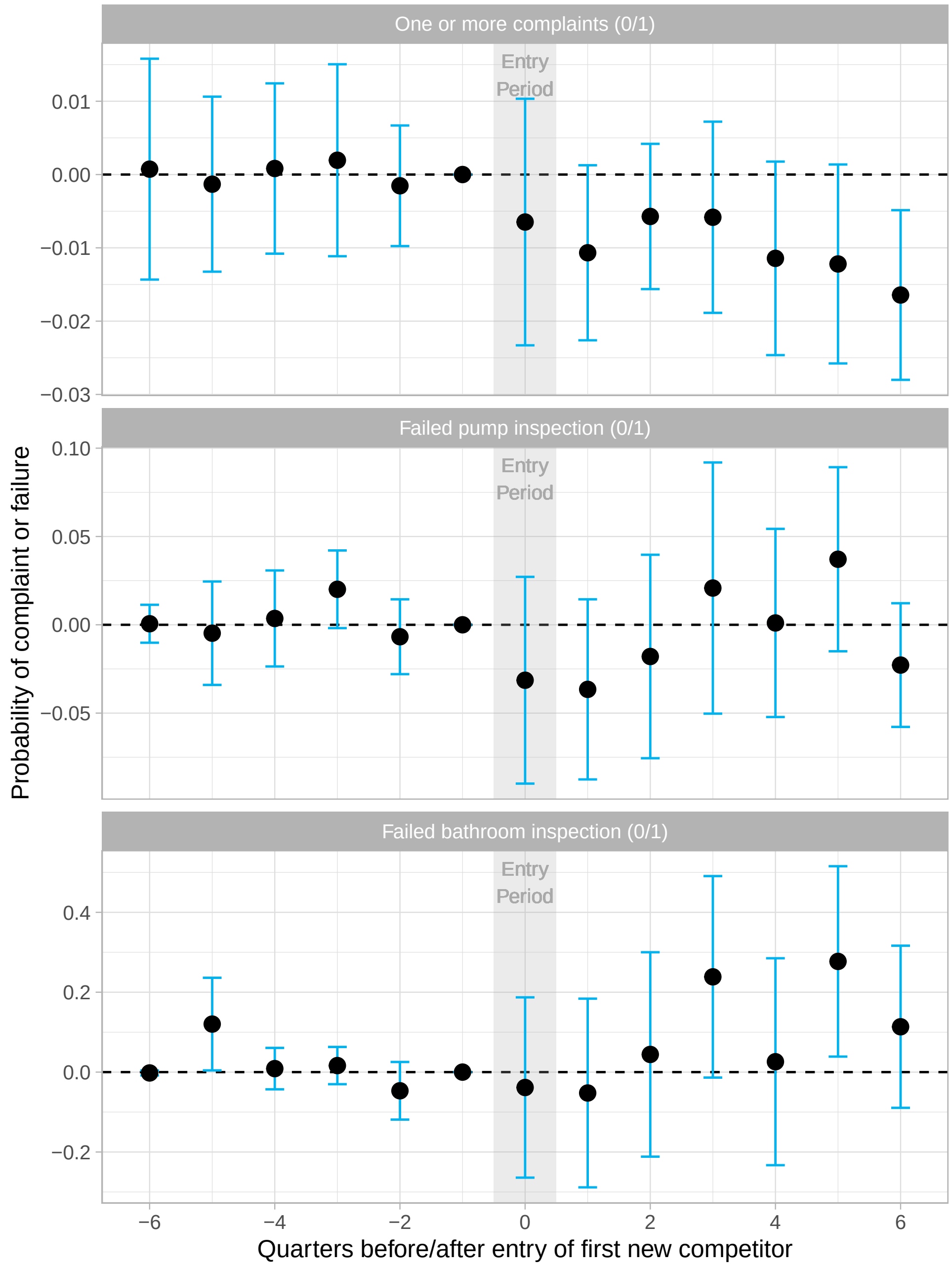
Notes: This figure plots coefficient estimates and 95 percent confidence intervals for the event study version of the two-step imputation estimator (Borusyak et al., 2024). The dependent variable is the retail price in pesos per liter and the event is the first entry of a new station within a three-minute driving time of an existing station. Time is normalized relative to the quarter of entry ($\tau = 0$) and the excluded category is $\tau = -1$. The first-stage regressions include station, terminal-by-month, and day-of-sample fixed effects. Bootstrap standard errors are clustered at the municipality level.

Figure F2: Event study for the effect of same-owner entry on retail prices, using imputation estimator



Notes: This figure plots coefficient estimates and 95 percent confidence intervals for the event study version of the two-step imputation estimator (Borusyak et al., 2024). The dependent variable is the retail price in pesos per liter, and the event is the first entry of a new station with the same owner within a three-minute driving time of an existing station. Time is normalized relative to the quarter of entry ($\tau = 0$), and the excluded category is $\tau = -1$. The first-stage regressions include station, terminal-by-month, and day-of-sample fixed effects. Bootstrap standard errors are clustered at the municipality level.

Figure F3: Event study for the effect of entry on retail quality, using imputation estimator



Notes: This figure plots coefficient estimates and 95 percent confidence intervals for the event study version of the two-step imputation estimator (Borusyak et al., 2024). The dependent variables are the three measures of quality used in Table 3 and the event is the first entry of a new station within a three-minute driving time of an existing station. Time is normalized relative to the quarter of entry ($\tau = 0$), and the excluded category is $\tau = -1$. The first-stage regressions include station and terminal-by-month fixed effects. Bootstrap standard errors are clustered at the municipality level.