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Abstract

The success of market deregulation in low- and middle-income countries depends on the strength of price and non-price competition between firms. In this paper, we study the recently deregulated retail gasoline market in Mexico. During our sample period, nearly 650 new gasoline stations entered the market. We estimate the causal effect of entry on the prices and quality of incumbent firms. We find that the entry of a nearby station decreases markups by nearly 4% for regular gasoline and about 2% for premium gasoline and diesel. We validate these results using the structure of ownership in the market, showing near zero impacts when the incumbent and entrant have the same owner. In addition, we show that the effect of competition on markups attenuates with distance and driving time. We find no evidence that entry affects the quality of existing stations, as measured by online ratings and regulatory inspections.

Keywords: Effects of competition, entry, gasoline stations, Mexico.

JEL: D43, L10, L51, L71, Q41, Q48

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1 Introduction

Price controls for everyday household items are ubiquitous in low- and middle-income countries but are uncommon in advanced economies (Guenette, 2020). The potential effects of these price controls are familiar to anyone who has studied introductory economics. They can lead to shortages, rationing, and the creation of black markets. Less obviously, price controls distort quality and location choices by firms. For example, firms cannot differentiate themselves by providing a higher quality service at a higher price. Moreover, firms have less incentive to enter high-cost, high-demand areas if they cannot charge higher prices. Because of the litany of problems associated with price controls, eliminating them and introducing market competition is a standard prescription for governments.

In an industry with a history of price controls, introducing price competition may not produce immediate benefits. Governments can remove price controls overnight. However, changes in the structure of an industry distorted by decades of regulation might take many years. In the short term, firms have to learn how to set prices and compete with each other on price and non-price dimensions.[1] Consumers have to learn how to obtain information and search for lower prices. Because of the potentially long transition to a new equilibrium, the overall effect of introducing price competition is theoretically ambiguous, and so measuring it is ultimately an empirical question.

This paper studies price and quality competition in the newly deregulated Mexican gasoline market. After being subject to tight control for nearly 80 years, the Mexican government opened up the market in 2017. Stations are now free to set prices. Both international and local oil companies entered the market, opening nearly 650 new stations and acquiring and rebranding many more. As a result, many stations that were once local monopolies now have several nearby competitors. These rapid changes, combined with our high-frequency panel data on entry and prices, allow us to estimate the causal effect of changes in the competitive environment.

To estimate the causal effect of entry on incumbents, we combine three years of daily price data for the universe of gasoline stations in Mexico with the exact location of each station. First, we define a local market around each station using driving times along the road network (three minutes in our base case). We then compare prices of the incumbent

1. In related work, Doraszelski et al. (2018) study a new UK electricity market, and find that when the market first opened there was a period of experimentation during which firms tried different pricing strategies. After three years, firms eventually stabilized on behavior that closely approximates Nash equilibrium. We might expect a similar convergence in behavior in our setting. In a setting with tacit collusion, Byrne and De Roos (2019) show that it takes time for gasoline stations to coordinate their pricing decisions to increase prices.

gasoline stations before and after a competitor enters the market, controlling for station, state-by-month-of-sample, and day-of-sample fixed effects. Assuming that the exact timing of competitor entry is exogenous, we can estimate the causal effect of an increase in competition in both a differences-in-differences and an event study framework.

We find that a negative relationship between prices and the number of competitors gradually emerged after deregulation. We show that this relationship is causal. Entry of a new competitor decreases markups by nearly 4 percent for regular gasoline and about 2 percent for premium gasoline and diesel. We validate these results using the structure of ownership in the market, showing that markups decrease much less when the entrant has the same owner as the incumbent. Event study figures provide strong support for a causal interpretation of our estimates, and additional evidence bolsters this claim. For example, the effect of entry is monotonically decreasing in driving time, and there is no effect of entry more than four minutes away. The effect is largest when entry occurs in markets with few incumbents. Finally, we find the price reductions to be highly persistent after several quarters and not the result of a newness effect.

We use the same framework to study the effect of competition on incumbent quality. Quality in the retail industry is a multi-dimensional concept that is notoriously difficult to measure. As a result, few previous papers have tried to estimate the effect of competition on quality.[2] We use two sources to measure station quality. One is based on an interesting 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 the electronic and mechanical gasoline pump equipment to dispense incomplete liters to customers (Guerrero, 2012; Liu et al., 2018). We use data from multiple inspections over time by the consumer protection agency, using "passing an inspection" as a quality measure. For alternative quality measures based on consumer perceptions, we use user reviews of gasoline stations on an online mapping service, including both the 1-to-5 "star rating" and the text of the review. Using our differences-in-differences and event study methodologies, we fail to find any effect of competition on our quality measures.

Our results have direct policy implications. For Mexican consumers, gasoline market deregulation was the most visible element of the broader energy sector reforms between 2013 and 2018. Gasoline and other refined products are inputs into virtually all goods and services, so all Mexicans are affected by the evolving market structure. Our analysis highlights the essential role of firm entry in increasing the competitiveness of local

2. One exception is Matsa (2011), who estimates the effect on competition on supermarket quality, using product stock-outs as a proxy for quality.

retail markets and reducing prices for the final consumer. The new government of López Obrador, which came to power in 2018, has been skeptical of the energy reforms. While retail gasoline prices remain deregulated at the time of writing, regulatory changes have made it much more difficult to open new gasoline stations, and the entry rate has dramatically declined. Our results imply that this decline in entry has benefited incumbent retailers at the expense of Mexican consumers.

Our paper makes three main contributions to the existing literature. First, we add to the small existing literature on the causal identification of the effect of market competition on prices and quality. Despite the obvious relevance of this question for economics, Nickell (1996) thought that the theoretical reasons for the beneficial effects of competition were "not overwhelming", and that the existing empirical evidence was weak. Since then, many of the best-identified measurements of the causal effect of competition have come from the study of mergers (for example, Dafny et al. (2012) for insurance and Allen et al. (2014) for mortgages), or from competitor entry in supermarket retail at the county level (Matsa, 2011; Atkin et al., 2018). Using a similar empirical strategy to ours, Arcidiacono et al. (2020) study the effects of Walmart entry on prices in existing supermarkets in the United States. Strikingly, they find that Walmart entry does not lead to a decrease in prices of other stores, despite large ex-ante variation in prices, and even though sales decrease at existing stores.[3] In a rare example of a randomized controlled trial in this literature, Busso and Galiani (2019) randomized entry of small stores into local markets in the Dominican Republic and showed that entry led to a decline in prices of between 2 and 6 percent.

Second, our paper contributes to the existing literature on the effect of competition on gasoline prices. Many of these previous studies use aggregated data at the state-, city-, or district-level (Sen, 2005; Clemenz and Gugler, 2006; Chouinard and Perloff, 2007). For example, using a cross-sectional regression, Clemenz and Gugler (2006) find that Austrian districts with higher station densities have lower average gasoline prices. The challenge with analyses based on more aggregate data is that it becomes difficult to isolate plausibly exogenous variation in market structure. Similar identification challenges arise even with studies that use station-level data (Van Meerbeeck, 2003; Barron et al., 2004; Hosken et al., 2008; Lach and Moraga-González, 2017; Tappata and Yan, 2017). For example, Barron et al. (2004) uses a cross-sectional regression to show that gasoline prices in Phoenix, Tucson, San Diego, and San Francisco are lower for stations with more competitors within

3. Arcidiacono et al. (2020) attribute their null finding to menu costs. One possible reason for the difference between their findings and ours is that menu costs are low for gasoline stations, as there are only three products and often only one price sign.

a 1.5-mile radius. Using our setting of the deregulated Mexican gasoline market, Contreras et al. (2020) show that retail markups are lower and the rate of wholesale cost pass-through is higher in areas with a greater density of gasoline stations. As with the more aggregate studies, these studies emphasizing cross-sectional comparisons are difficult to interpret because the market structure is endogenous and reflects local market demand and other factors.

In contrast to this previous literature, our paper is one of the first studies of gasoline market competition to use variation in market structure over time. Haucap et al. (2016) use the within-day variation created by the limited opening hours of gasoline stations attached to supermarkets and show a negative effect of greater competition on prices. More closely related to our setting, Bernardo (2018) studies the effect of a zoning reform that removed an entry barrier for fueling stations. She shows that prices fell by more than 1 percent for stations in the Barcelona area that experienced an entry of a nearby competitor after this reform.

Our results on the competitive effects of same- or different-owner entry complement the small existing literature on the effects of gasoline station mergers (Hastings and Gilbert, 2005; Simpson and Taylor, 2008; Taylor and Hosken, 2007). In an influential study, Hastings (2004) uses station-level data from San Diego and Los Angeles to show that retail gasoline prices increased significantly in response to an independent gasoline retailer being acquired by a vertically-integrated firm.[4] Whereas these mergers all involved both upstream and downstream operations, interpretation in our setting is particularly straightforward because only downstream operations were affected.

Our final contribution is to the new and growing literature on the industrial organization of retail markets in middle-income countries. As noted above, a distinguishing feature of markets in many middle-income countries is that governments set prices or even directly provide the good or service (Jiménez-Hernández and Seira, 2021). When price regulations are removed, firms and consumers must learn to operate in a competitive market. Another common characteristic of middle-income countries is the presence of a large number of small, informal establishments. In many countries, these small shops are being displaced by the consolidation of national and international chains (Atkin et al., 2018; Talamas, 2021). Our analysis of the retail fuel market in Mexico speaks to both of these issues. Interestingly, these changes in market structure occurred in high-income

4. An alternative approach taken in the literature on gasoline station mergers is to carefully model gasoline demand and then use the model to simulate mergers. Houde (2012) estimates a structural model of demand for gasoline in Quebec City that takes into account the geography of the market and then uses the model to perform an ex-ante simulation of a potential vertical merger.

countries many decades ago. However, fine-scale data on historical prices and entry is typically not available for high-income countries. As a result, the daily station-level data used in our study provides a rare opportunity to observe the evolution of competition in a newly opened market.

The paper proceeds as follows. Section 2 provides background about Mexico's retail petroleum market and the ongoing market reforms. Section 3 introduces our data. Section 4 presents the main results, with evidence on the price and quality effects of entry. Section 5 discusses the implications of our results. Section 6 concludes.

2 Background

Petroleos Mexicanos (Pemex), the government-owned oil company, was founded in 1938 when all private oil companies in Mexico were nationalized. Pemex is vertically integrated, including exploration, refining, transportation, and retail franchising. Between 1938 and 2016, every gasoline station in Mexico carried the Pemex brand and sold Pemex gasoline and diesel at regulated retail prices. By any measure, this is an extremely long time with little change in market structure: almost 80 years with a single brand, no price competition, and limited scope or incentive for product differentiation.

Most Mexican gasoline stations are dealer-owned, dealer-operated franchises. The franchisees own and manage the stations but historically have sold gasoline and diesel purchased exclusively from Pemex at a regulated terminal price. Before 2017, Pemex franchisees received a fixed, guaranteed markup for each liter sold, typically in the range of 5 to 6 percent (Davis et al., 2019). The most commonly sold product is regular unleaded gasoline (known as “Magna”), although most stations also sell premium unleaded gasoline and diesel.

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. We focus in this paper on the effect of price deregulation in the retail sector. While it would be interesting to examine changes in the upstream market, independent companies have so far made limited investments in the infrastructure necessary to store and deliver refined products to gasoline stations. These infrastructure limitations mean that, over our sample period, most gasoline stations in Mexico sold fuels purchased from Pemex.

The energy regulator eliminated price controls for retail gasoline and diesel starting

March 30, 2017. Deregulation was staggered at the state level in four stages, beginning in the north in March 2017 and then continuing south with groups of states deregulated on June 15, 2017 and October 30, 2017. Finally, the last and largest group of states was deregulated on November 30, 2017. Thus by December 2017, stations throughout Mexico could set prices as they wish for gasoline and other refined products. This was a significant change for station owners who had to set prices and gasoline buyers who had to compare prices for the first time.

One rationale for the energy reforms was that the density of gasoline stations in Mexico is low by international standards (COFECE, 2018). Historically, Pemex had granted exclusive territories to some of its franchisees. There is also a history of state and municipal governments creating regulations that made it more difficult for new stations to enter. In addition, the fixed markup rules meant that there often was not enough incentive for new stations to enter the most needed locations. Entry has the potential to generate both more geographical coverage—decreasing the distance between consumers and stations—and increase competition.

Although some hoped that deregulation would increase entry, this has not happened so far. Figure 1 shows the number of new gasoline station entrants in Mexico by year from 2008 to 2019. Before deregulation, there were about 400 new stations per year. Since deregulation, there have been about 300 new stations per year. This lack of increased entry means that deregulation has not resulted in a sharp rise in station density. We discuss some of the reasons for the decline in entry rates in Section 5.

Our objective in the paper is to measure the effect of entry on markups and station quality. It would also be interesting to examine entry decisions and evaluate the energy reforms more broadly, but we defer those questions for future work. Fortunately for our purposes, even though the entry rate has been less than expected, there are still nearly 650 new stations that began operating during our sample period. As we explain in detail below, this entry is the variation we use to identify our empirical model.

3 Data

3.1 Gasoline Station Panel

The core dataset in our analysis is a daily panel of all gasoline stations in Mexico over the period 2017 to 2019.[5] We observe a variety of station characteristics, including the name, address, geographic coordinates, number of pump modules (i.e., sets of fuel pumps), and type of re ned products sold. Much of this information comes from the station permits, which are required for operation (CRE, 2021a, 2021c). We exclude stations that are located in one of 40 municipalities within 45 kilometers of the U.S. border and subject to an alternative tax and subsidy program (SHCP, 2018).[6]

Table 1, panel (A) describes station characteristics. At the time of deregulation, 11,646 stations were operating in Mexico. We refer to these stations throughout as “incumbents”. Between deregulation and November 2019, 646 new stations entered. We refer to these stations throughout as “entrants”. Entrants are new stations opened in locations where there was previously no station. [7] This de nition excludes stations that changed ownership or were rebranded. As illustrated in the table, entrants tended to be slightly smaller on average, as measured by pump modules, and more likely to be in a metropolitan area (CONAPO, 2018). Virtually all stations of both types offer regular gasoline, and most stations offer premium gasoline and diesel.

Our identi cation strategy is based on station entry, so we took care to determine the date each station opened as accurately as possible. Although we observe the date each station was initially permitted, this is a poor proxy for station opening because there is often a considerable lag between when the permit is issued and when a station begins to operate. Instead, we use as the opening date the rst day that the station reports prices to the regulator. We corroborated this information using historical images from an online mapping service and inspection data from the Mexican consumer protection agency (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

5. We use 24 months of daily price data after the nal stage of deregulation in November 2017. We limit ourselves to two years of data to avoid the disruptions in international oil prices and local gasoline demand created by the COVID-19 pandemic in 2020. In addition, our ownership information is a cross-section as of early 2019 (Section 3.3), and so our data on the owners of incumbents and entrants is noisier after that date.

6. Appendix Table A1 shows each step in the construction of our gasoline station panel.

7. To illustrate the geographical pattern of entry, the maps in Appendix Figure A1 show where stations entered in the metropolitan areas of Mexico City and Guadalajara.

permit expires or is revoked, which occurred for 38 stations during our sample period.

Our identi cation strategy also hinges on having accurate geographic information. Our data provide the geographic coordinates (i.e., latitude and longitude) for each station. We con rmed by hand the geographic coordinates of all entrants using an online mapping service and corrected these where necessary.

3.2 Driving Time

A key feature of our analysis is that we de ne local markets using driving time. We match each station to the road network and count the number of competitors within a given drive-time radius around every station. Most previous studies instead de ne markets using straight-line distance, but this is not an accurate measure of proximity when stations are on opposite sides of a divided highway or otherwise inaccessible from one another. This section describes our approach in more detail and provides an illustrative example. Later in the paper, we compare results using both methods.

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 travel times between any two locations.

Figure 2 provides an illustrative example. We focus on one particular gasoline station in Baja California. This station is labeled A on the map. The gure 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. In this example, the two market de nitions are quite different.

Using a market de nition 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 de nition 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 radius 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 de nition, but not when using straight-line distance.

3.3 Number of Stations Within Three Minutes

Our primary measure of competition is the number of stations within a driving time of three minutes. Because the choice of three minutes is arbitrary, we also report results for a range of different driving time bins. We tend to find no evidence of competitive effects from stations located farther away than three minutes. Table 1 reports that incumbents have an average of 3.2 nearby stations within three minutes, whereas entrants have an average of 2.8 stations within three minutes.

We use station opening dates and the location of stations to construct this measure of competition at the station-by-month level. As we explain in detail later, our estimates are identified using changes in the number of nearby stations. Although these changes reflect both entry and exit, there are 20 times as many entries as exits, so the coefficient estimates mostly reflect what happens when a new station enters.

In some specifications, we take advantage of the pattern of station ownership to provide an additional test. Many stations in Mexico are owned by firms that own multiple stations. Confidential data provided to us from CRE allows us to observe the ownership group for each station in Mexico as of early 2019. 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. The construction of this variable is exactly the same as the construction of the more generic measure but includes only stations with the same owner. This variable thus 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 Markups

We are interested in how competition changes the way stations set prices. Our primary outcome variable is the log of the retail markup, where we define the retail markup as the difference between the retail and wholesale prices. We examine markups for regular gasoline, premium gasoline, and diesel.

Our data on retail prices come from the Mexican regulator (CRE, 2021b). Since January 2017, stations have been required to report all price changes to the regulator within one hour of the change being made (CRE, 2018). Before March 2019, all price changes were posted on the CRE website with the exact date and time of the change. After March 2019, prices have been updated only once per day 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.

Although the law unambiguously requires reporting any price changes, enforcement is imperfect. In our data, 3% of stations never report a single price change throughout our sample period. In addition, some stations have periods during which they fail to update prices, in some cases for several months. At the other extreme, there are many stations that report price changes almost every day. To reduce measurement error, we keep price observations only when they fall within 30 days of a reported price change. These observations are the most likely to be accurate. In practice, this exclusion drops 12% of all station-product-date observations.[8] To be clear, this limitation of the data does not affect our measures of market competition; stations are counted among nearby stations even when price data are not available for them.

For wholesale prices, we use posted Pemex wholesale terminal prices. Before May 2021, PEMEX posted daily prices at 78 different wholesale terminals (PEMEX, 2021). We match each station to a wholesale terminal using the pre-deregulation assignment of stations to terminals. For new stations, or for stations that were not assigned to a speci c 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.

To limit the effect of outliers on our estimation results, we trim the top and bottom one percent of retail markup observations. Our nal dataset includes 7.5 million station-day observations for regular gasoline, 6.8 million station-day observations for premium gasoline, and 5.5 million station-day observations for diesel. Average markups for incumbents in 2017 were 1.23 pesos per liter for regular gasoline, 1.29 pesos per liter for premium gasoline, and 1.27 pesos per liter for diesel (Table 1).

3.5 Correlation between competition and markups

Before turning to a formal regression framework in Section 4, we present descriptive graphical evidence on the correlation between competition and markups. The motivation

8. Appendix Table A2 shows the construction of our price sample.

for this preliminary investigation is that we expect markups to increase most in those markets that have relatively little competition.

Figure 3 plots markups as a function of the number of competitors within a three-minute driving distance. We show results for each product, with separate panels for before, immediately after, and more than 12 months after deregulation. Our reason for dividing the post-deregulation periods into two parts is that, after decades of price regulation, it may take time for station owners to learn how to price. [9]

Three aspects are evident. First, before deregulation, there was little correlation between markups and the number of competitors. Between January and November 2017, the regulation stipulated a maximum but not a minimum price. In practice, virtually all stations set prices at the cap, and there was minimal variation in markups. [10] Second, during the one year following deregulation, markups increased slightly overall, but there was still little dispersion in markups, and a correlation between markups and competition had just started to emerge. Third, more than 12 months after deregulation, markups increased signi cantly, and the correlation between markups and competition became more pronounced.

This evidence motivates the formal analyses which follow. Although it is hard to draw strong conclusions from these correlations, these results suggest that market structure matters for pricing behavior. In addition, the gure is a reminder that this analysis focuses on a period of intense change in the Mexican market. In the course of just a few months, the market moved from price regulation to price competition, with large year-to-year changes in the overall level of markups. [11]

3.6 Inspections

Our rst measure of station quality is an indicator variable for whether a station passed its inspection by the consumer protection agency. In Mexico, it is common for stations to sell "liters" with less volume than an actual liter. The buyer pays the full price for a liter, but only ends up with, for example, 0.95 liters in their tank. This practice is so common that it

9. For this gure, but not subsequent analyses, we restricted the sample to include only stations in the three-quarters of Mexican states that deregulated in November 2017. This sample restriction ensures that the periods represented in the different panels correspond to the same set of months for all stations. In addition, for this gure, but not subsequent analyses, we restrict the sample to a balanced panel of stations operating for all months throughout our sample period. These restrictions simplify the analysis and reduce compositional biases, but are not necessary later in the paper once we move to a regression framework with station xed effects and other control variables.

10. Knittel and Stango (2003) found an analogous result for the case of nonbinding price ceilings in the credit card market.

11. Appendix Figure A2 shows how average prices and markups have changed over time.

even has a name, "chiquilitros".[12] Stations achieve this by tampering with the mechanical or electronic pump mechanisms. Although this practice is illegal, the monetary and legal sanctions are not large enough to deter this behavior.

PROFECO inspects 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 data on inspections from deregulation until November 2019 using publicly-available station-level records from PROFECO (2021). 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.

Table 1 provides descriptive statistics. More than 9,000 stations were inspected at least once during our sample period. Incumbents and entrants are inspected at similar rates, 6% and 4% per month, respectively.[13] Incumbents pass 79% of inspections, whereas entrants pass 74% of inspections.

3.7 Online Reviews

Our second measure of station quality is online reviews. Users of an online mapping service leave numerical ratings (1 to 5) and short text reviews for stations. In Mexico, nearly all stations are "full-service", not "self-service", and reviews highlight various aspects of service quality, for example, the speed and friendliness of service, the cleanliness of the station, and whether the bathrooms were working.

We scraped reviews for all stations in Mexico between 2017 and 2020. We matched each review to the closest station within a radius of at most 200 meters. We matched about 850,000 reviews, including about 230,000 with text. A limitation with our online review data is that we do not observe the exact date each review was written. The date of newer reviews is described relatively accurately: for example, as being from "3 weeks ago." However, only approximate dates such as "two years ago" are provided for older reviews.

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

13. Appendix Table A3 shows that an increase in the number of nearby competitors slightly increases the probability of inspection. One additional competitor within three minutes increases the probability of inspection in a month by 0.7 percentage points, or about 10 percent of the mean probability.

We use the approximate date information to assign a calendar year to each review, and we do not try to use within-year comparisons when analyzing the review data.[14]

We used natural language processing to measure sentiment for the reviews that include text. First, we filtered out common words that add no substantive meaning to the text, such as conjunctions, prepositions, and articles. Second, we determined the 2,300 most common consecutive word pairs, referred to as bigrams. Third, we manually classified these 2,300 bigrams as positive, negative, or neutral. "Good service" and "bad service" are examples of positive and negative bigrams. Fourth, we created indicator variables for the presence of at least one positive or negative bigram.[15]

Table 1 provides summary statistics. More than 9,500 stations were reviewed at least once during our sample period. The average rating is 3.9 for incumbents and 4.1 for entrants. Thus entrants tend to have slightly higher ratings on average. In terms of the text sentiment, incumbents and entrants are similar. For incumbents, 75 percent of reviews with text included at least one positive bigram, compared to 80 percent for entrants. Negative bigrams are less common. For incumbents, 15 percent of reviews had at least one negative bigram, compared to 11 percent for entrants.

4 Empirical Analysis

In this section, we use a regression framework to measure the causal effects of competition, exploiting the exact timing of entry as in Arcidiacono et al. (2020).

4.1 Empirical Strategy

We estimate the following equation using least squares:

$$\ln(M_{id}) = \beta_1 \text{Num. Stations}_{id} + \beta_2 \text{Num. Stations Same Owner}_{id} + \alpha_i + \gamma_{sm} + \phi_d + \epsilon_{id} \quad (1)$$

The dependent variable $\ln(M_{id})$ is the markup in logs for station i on day d. We estimate separate regressions for regular gasoline, premium gasoline, and diesel. The independent variable of interest is $\text{Num. Stations}_{id}$, the number of stations within a three-

14. Appendix Table A4 shows that an increase in competition does not change the number of user reviews received by a station. One additional competitor reduces the number of reviews by 0.8 per year (not statistically significant), compared to a mean of 22.4 reviews per year.

15. Appendix Figure A3 provides a list of the most common bigrams and a visualization of the most common word combinations.

minute drive faced by station i on day d. In addition, some specifications will also include $\text{Num. Station Same Owner}_{id}$, the number of stations with the same owner.

Regressions include a variety of fixed effects. Station fixed effects, a_i, control for time-invariant differences between stations like the size of the station, location characteristics, and whether a station has a store and restrooms. State-by-month-of-sample fixed effects, g_{sm}, control for state-level changes over time in markups, for example, driven by state-level trends in demand for refined products. Finally, day-of-sample fixed effects, f_d, control for national-level changes in markups, for example, due to predictable changes in demand during holidays and weekends.

By including state-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. Contreras et al. (2020) examine these price dynamics in the Mexican market, finding that retail prices adjust quickly after a wholesale price increase but more slowly after a wholesale price decrease.

Thus, the coefficient of interest b_1 is identified using within-station variation in the number of competitors. Controlling for state-by-month and day-of-sample fixed effects, the regression describes how markups change as entrants begin operation nearby or, less commonly, as existing stations cease operations. As we explained earlier, nearly 650 stations entered the Mexican market during this period, providing the variation in $\text{Num. Stations}_{id}$ we need to identify the coefficient of interest.

4.2 Regression Evidence

Table 2 reports coefficient estimates. Odd-numbered columns describe regressions with only the single measure of market competition, $\text{Num. Stations}_{id}$. We find that one additional competitor reduces markups by 3.8 percent for gasoline, 1.6 percent for premium, and 2.2 percent for diesel. The table also reports standard errors clustered at the municipality level to account for serial and spatial correlation. All three point estimates are statistically significant at the 5 percent level.

Even-numbered columns describe regressions that control for the number of nearby stations with the same owner. Those columns report coefficient estimates for both variables as well as the sum. As expected, the coefficient estimates corresponding to $\text{Num. Station Same Owner}_{id}$

are positive, and the sums are near zero, consistent with same-owner stations not having the same competitive impact as stations with independent owners. When a new, independently owned station enters nearby, this reduces markups. However, when a station with the same owner enters, it has a near-zero impact on markups. This pattern is reassuring because it conforms with our expectations about the effect of competition on markups and suggests that differential trends or time-varying omitted variables do not drive the results.

4.3 Alternative Specifications

Figure 4 plots competition effects separately for ten alternative measures of driving time. We first calculate ten different measures of $\text{Num. Stations}_{id}$, in each case using a different driving time bin, for example, less than one minute, one to two minutes, and so on. We then estimate a single regression with all ten variables and plot the coefficient estimates and 95 percent confidence intervals. This regression includes the same fixed effects as in the odd-numbered columns in Table 2.

The results indicate a clear pattern in which the effect of competition decays with driving distance. Within one minute, a new competitor reduces retail gasoline markups by more than 5 percent. Effects are smaller but still statistically significant between 1 and 2 minutes and between 2 and 3 minutes. However, past 3 minutes, the effect of an additional competitor is close to zero and not statistically significant. These results corroborate our findings and provide further reassurance that the main estimates are not driven, for example, by differential neighborhood-level trends. The pattern also provides empirical support for our baseline choice of a three-minute driving time.

In the appendix, we perform two related robustness analyses. Appendix Figure A4 plots results from a regression identical to Figure 4, but using straight-line distance rather than driving distance. The results tend to be less precisely estimated, but the overall pattern is similar to Figure 4, with effects concentrated within a straight-line distance of 1.5 kilometers and near-zero effects farther away. Appendix Figure A5 plots results separately by the number of competitors prior to deregulation. We might have expected a non-linear relationship between competition and markups with, for example, a larger effect when a market goes from zero competitors to one competitor, compared to four to five. The point estimates in the figure generally correspond to this expected pattern, but the confidence intervals are wide, making it difficult to draw strong conclusions.

Finally, there have been many recent papers about potential biases in two-way fixed effects (TWFE) models with heterogeneous treatment effects and differential timing

(Goodman-Bacon, 2021; Chaisemartin and D'Haultfœuille, 2020). Most results and solutions in this literature focus on the staggered introduction of binary treatments (Callaway and Sant'Anna, 2021). In the case of equation(1), our "treatment" is a count variable that increases or decreases as competitors enter or exit. Proposed estimators for non-binary treatments recover an "instantaneous" treatment effect using observations immediately before and after the change (Chaisemartin and D'Haultfœuille, 2020). This restriction is problematic in our setting with high-frequency data and uncertainty about the exact entry timing.

Instead, we follow the suggestion of Wooldridge (2021) for estimating a meaningful average treatment effect by adding flexibility to our base TWFE model. [16] Table A5 reports the results for two sets of more flexible regressions. First, we identify the quarter (or quarters) in which incumbents experienced entry, create indicator variables for each of the ten quarters in which entry occurred, then interact these entry cohort indicators with a linear time trend. This specification allows for a different evolution of markups for the stations that did not experience entry and each cohort of stations that did experience entry. In the second flexible specification, we add a separate linear time trend for the 1,469 municipalities in our data, allowing each municipality to follow a different trend. Our results are robust to these more flexible specifications.

4.4 Event Study Evidence

Figure 5 plots coefficient estimates and 95 percent confidence intervals corresponding to standard event study regressions. We include plots for regular gasoline, premium gasoline, and diesel. The x-axis is time in quarters before and after the entry of a competitor, normalized so that the quarter prior to entry is equal to zero.

In particular, we plot the estimates δ from the following regression,

$$\ln(M_{id}) = \sum_{\tau=-6}^{\tau=6} \delta_\tau 1[\text{Event Time} = \tau] + \alpha_i + \gamma_{sm} + \phi_d + \epsilon_{id} \qquad (2)$$

The dependent variable is the markup in logs, $\ln(M_{id})$. The regression equation includes a vector of indicator variables corresponding to event time. Event time ranges from -6 for six or more quarters before entry to $+6$ for six or more quarters after entry. As in equation

16. Wooldridge (2021) says that "There is nothing inherently wrong with TWFE... The problem with how TWFE is implemented in DiD settings is that it is applied to a restrictive model." He shows that the usual TWFE estimator with added flexibility identifies a meaningful average treatment effect.

1, we include station, state-by-month, and day-of-sample fixed effects in all regressions.

During the quarters leading up to entry, markups tend to be flat. There is no discernible pre-trend for regular or premium gasoline. There is a subtle positive pre-trend for diesel, but the point estimates prior to entry are not statistically different from zero. After entry, markups decrease significantly for all three refined products. With regular gasoline, for example, markups decrease sharply by 4% in the first quarter after entry and remain at that level for the following year. Similar but smaller decreases occur after entry for premium gasoline and diesel. The point estimates after entry are negative and statistically significant for all three refined products. The magnitude of the implied impacts in Figure 5 are similar to the magnitudes in Table 2.

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 decrease in markups tends to align quite well with entry, with significant drops in the first quarter after entry for all three refined products. Finally, the decreased markups are persistent, with negative and statistically significant estimates throughout the six or more quarters after entry.

4.5 Station Quality

Table 3 reports regression estimates for station quality. This analysis of station quality is motivated by the idea that increased competition might lead stations to make investments aimed at improving service. For example, rather than reducing markups, a station owner might try to make service more efficient or otherwise improve the station's reputation. In terms of identification strategy, these analyses follow the analysis of markups in Table 2, with all regressions including station fixed effects and identifying the effect of competition using within-station variation. Overall, we find no evidence that competition has an impact on station quality.

We first examine inspections. In column (1), the unit of observation is an inspection, and the dependent variable is an indicator variable equal to one if the station passed the inspection. This regression includes station-, state-by-month, and day-of-sample fixed effects, just like the markup regressions before. If competition leads stations to stop selling "chiquilitros", this would be observed in these data as an increase in the probability that a station passes the inspection. The point estimate of .004 indicates that one additional competitor within three minutes driving time reduces the probability that a station passes the inspection by 0.4%, all else equal. This estimate is small and not statistically significant, and at the 95% confidence level we can reject a 5 percentage point decrease in the probability that a station passes the inspection. One possible explanation for the small effect is that selling “chiquilitros” is difficult for consumers to detect and is therefore unaffected by consumer-imposed discipline from competition. Without specialized equipment, it is difficult for consumers to know whether they have received 1.0 liters or, for example, 0.95 liters per “liter”. Moreover, it is not easy for consumers to access information about which stations have been caught. Given the low likelihood of detection by consumers, selling complete liters may not be an effective approach to respond to increased competition from entrants.

We next consider online reviews. In column (2), the unit of observation is the review. We have ratings from over 850,000 reviews. As we explained earlier, we do not observe the exact date each review was posted. Accordingly, these regressions control for station and state-by-year fixed effects but not state-by-month or day-of-sample fixed effects. If competition improved quality, we would expect ratings to increase after entry. The point estimate is 0.001. We can reject an increase in ratings of 0.02 points, out of a mean of 3.87, with 95% confidence. Finally, columns (3) and (4) use as the dependent variable the indicator variables for whether the review has at least one positive or at least one negative bigram. Again, we do not find a statistically significant effect of entry. We find a small reduction of 0.9 percentage points in the fraction of reviews with a negative bigram, out of a mean of 14 percentage points. We can reject an increase of 1.6 percentage points in positive bigrams and a decrease of 1.7 percentage points in positive bigrams.

Finally, Appendix Figures A6 and A7 presents event study evidence for all four quality measures. None of the four figures show visual evidence of a change in quality after entry. While there is no clear pre-trend in any of the event study figures, nor is there any apparent shift corresponding to when entry occurred. Thus, overall, there is no evidence that competitor entry affects station quality. Across all of our quality measures, the point estimates are close to zero and estimated with sufficient precision to rule out relatively small effects.

5 Discussion

Our descriptive analysis shows that retail markups of Mexican gasoline stations increased after deregulation, from an average of 1.23 pesos per liter to 1.94 pesos per liter. Markups are lower for stations that face more nearby competitors. Our empirical analysis shows that competition has a causal effect on markups. For regular gasoline, the entry of one nearby station reduces the markups of existing rms by nearly 4 percent.

We found no effect of increased competition on our measures of gasoline station quality. As mentioned earlier, our inspection measure may capture an aspect of quality that is unobserved by consumers and does not respond to competition. Our results for customer ratings are more puzzling because the ratings incorporate, by de nition, the observable characteristics of the station. Although quality takes longer to adjust than prices, especially if capital improvements are required, our empirical methodology allowed suf cient time for these investments to occur. One possible explanation is heterogeneity in how rms respond to increased competition. Some rms may improve their service quality to blunt the effect of price competition, while others cut costs and reduce quality to undercut their new competitors on price. A second possible explanation is that deregulation led to a level effect in quality in which all stations improved their quality to reduce the effect of competition from existing or potential competitors. In our empirical methodology, the effect of any overall improvement in quality is absorbed by the state-by-month xed effects.

We emphasize that our results do not provide evidence for the overall success or failure of deregulation in the retail gasoline sector in Mexico. Higher markups post-deregulation do not necessarily mean that consumers are worse off. On the contrary, consumers may bene t from overall improvements in service quality. Moreover, non-monetary costs may have changed, such as waiting time. For example, our results are consistent with excess demand at some stations before deregulation, leading to stock-outs and long queues. Markups at those stations would have increased the most after deregulation, inducing the entry of nearby competitors and the subsequent decline in markups that we revealed in our empirical analysis.

As noted in Section 2, the rate of entry by new stations declined after deregulation. This is the opposite of what some observers had expected, given Mexico's relatively low density of gasoline stations. One potential explanation is that new administrative requirements for opening a station, introduced at the time of deregulation, increased barriers to entry. For example, ASEA (2016) imposed new technical standards for the design, construction, and operation of gasoline stations. PETROIntelligence (2021) describes the permits needed from seven federal agencies for the construction and operation of a single gasoline station.[17]

17. The relevant federal agencies are CRE (the energy regulator), SENER (the energy ministry), ASEA (the hydrocar-

Additional permits from state and municipal authorities are also required. Obtaining the necessary municipal, state, and federal approvals can take from eighteen months up to four years (Arias, 2018). Given these long delays, it has been easier for new entrants to buy and rebrand existing stations instead of building new stations.

These challenges were compounded by the hostile attitude towards the Mexican energy reforms taken by the administration of Lopéz Obrador that came to power in December 2018. The new government saw the energy reform as harmful to the interests of the former Pemex monopoly. At the time of writing, the government has been unable to amend the Mexican constitution to roll back the reforms. Nonetheless, it has implemented numerous regulatory changes to favor Pemex and disadvantage new entrants. 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. While some of these changes are still being debated in the Mexican courts, the overt hostility of the government to private investment in the retail gasoline sector is apparent.

Our results suggest these regulatory changes may have considerable negative effects on Mexican consumers. By interfering with the entry of new competitors, the government blocks an important channel by which prices for final consumers may be reduced. These barriers to entry are even more relevant given continued growth in the vehicle fleet: in the last 10 years, the number of vehicles in Mexico has grown by more than 60%.[18]

6 Conclusion

A history of regulation—especially one as long as 80 years in the case of Mexico—produces many distortions throughout the sector. Regulation distorts the choices that firms make about pricing, location, and product quality. This history does not disappear overnight when the government removes price controls. Firms have to learn how to set prices and compete with each other, and consumers have to learn how to compare prices and make trade-offs between price, location, and other characteristics.

bon safety and environmental protection agency), SCT (the transportation and communications ministry), CONAGUA (the national water commission), SAT (the tax authority), and PROFECO (the consumer protection agency).

18. https://www.inegi.org.mx/temas/vehiculos/ .

Despite these challenges, our empirical results provide clear evidence of burgeoning competition in the newly deregulated Mexican retail gasoline market. Using an event-study framework and related methods, we find that each additional nearby competitor decreases markups for regular gasoline, premium gasoline, and diesel. Moreover, we validate these results with a series of placebo tests and alternative specifications based on ownership structure, driving time, and the number of nearby competitors.

Although the initial evidence is promising, our results also demonstrate that entry, exit, and upgrades take a long time. There continue to be policy barriers that restrict entry, and uncertainty about the government's commitment to market competition. It will take time for firms to find new ways to compete, to differentiate themselves, and for the full effects of deregulation to be realized.

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Table 1:Descriptive statistics

Panel A: station characteristics	Incumbents	Entrants
Total number of stations	11,646	646
Average number of stations within 3 minutes	3.223	2.828
Average number of same-owner stations within 3 minutes	0.395	0.178
Average number of pump modules	4.157	3.727
Fraction of stations in a metropolitan area	0.641	0.683
Fraction of stations on a main road	0.418	0.358
Fraction of stations selling regular gasoline	0.999	1.000
Fraction of stations selling premium gasoline	0.921	0.985
Fraction of stations selling diesel	0.728	0.892

Panel B: average markup by product after deregulation (pesos/liter)	Incumbents			Entrants		
Year	Regular	Premium	Diesel	Regular	Premium	Diesel
2017	1.23	1.29	1.27	1.23	1.28	1.23
2018	1.45	1.53	1.40	1.57	1.66	1.40
2019	1.92	2.11	1.75	1.82	2.07	1.67

Panel C: station quality	Incumbents	Entrants
Inspections		
Total number of stations inspected	8,964	222
Fraction of stations inspected	0.77	0.34
Fraction of passed inspections	0.79	0.72
Probability of inspection in a given month	0.06	0.04
Reviews		
Total number of stations reviewed	9,226	335
Fraction of stations reviewed	0.79	0.52
Mean rating from user reviews (1 to 5)	3.87	4.09
Fraction of reviews with at least one positive bigram	0.75	0.80
Fraction of reviews with at least one negative bigram	0.15	0.11

Notes:This table reports descriptive statistics for station characteristics, average markups, and station quality. Stations are characterized as incumbents if they were operating prior to deregulation in their state, and entrants if they began operations after deregulation. 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 the purposes of this table are calculated using the last month observed in the data. Station quality is measured using both inspections and online reviews. Stations inspected are those that were visited by a PROFECO inspector at least once between deregulation and November 2019. Passed inspections are those inspections that didnot identify any malfunctioning pump or other issue requiring additional action by PROFECO. The probability of inspection in a given month is calculated as the number of months that a station was inspected by PROFECO divided by the number of months that the station is open. Station reviews are obtained from user reviews on an online mapping service. Stations reviewed are those for whom we were able to match at least one review from 2017 to 2020. Reviews with positive and negative bigrams are those that include at least one positive or negative sequential word pair, respectively.

Table 2: The effect of competition on retail markups

	Regular gasoline		Premium gasoline		Diesel	
			log(markup)			
	(1)	(2)	(3)	(4)	(5)	(6)
Number of stations within 3 minutes	-0.038	-0.038	-0.016	-0.017	-0.022	-0.023
	(0.009)	(0.009)	(0.007)	(0.007)	(0.010)	(0.010)
Number of same-owner stations within 3 minutes		0.009		0.016		0.012
		(0.005)		(0.005)		(0.006)
Sum of coef cients		-0.03		-0.001		-0.011
p-value for sum of coef cients		0.005		0.921		0.298
xed effects						
Station	Y	Y	Y	Y	Y	Y
State-by-Month	Y	Y	Y	Y	Y	Y
Day-of-sample	Y	Y	Y	Y	Y	Y
Observations	7,480,699	7,480,699	6,778,974	6,778,974	5,496,683	5,496,683
R^2	0.788	0.788	0.834	0.834	0.707	0.707
Dep. variable mean	0.444	0.444	0.516	0.516	0.389	0.389
Number of stations	11,162	11,162	10,466	10,466	8,457	8,457
Number of entrants	646	646	646	646	646	646
Number that experienced entry	1,270	1,270	1,245	1,245	908	908

Notes: This table reports coef cient estimates and standard errors from six separate least squares regressions. The sample period begins with deregulation (which varies across states but is in all cases during 2017) and ends in November 2019. Regressions are estimated for three different re ned products, as indicated in the column headings. In all cases, the dependent variable is the retail markups in logs, $\ln(\text{markup}_{id})$, where the unit of observation is station i by day d. The regression speci cation is the following: $\ln(\text{markup}_{id}) = a_i + g_{sm} + f_d + b_1 \text{Num. Stations}_{id} + b_2 \text{Num. Same owner Stations}_{id} + e_{id}$, where a_i are station xed effects, g_{sm} are state-by-month xed effects, and f_d are day-of-sample xed effects. The variable of interest is $\text{Num. Stations}_{id}$, which measures the number of stations within a three-minute driving distance of each station i as of day d. Even-numbered columns additionally include the number of stations owned by the same owner: $\text{Num. Same owner Stations}_{id}$. The table also reports several different measures of the number of observations. Overall, the number of observations in columns 3-6 is smaller because not all stations sell premium gasoline or diesel. The number of entrants is the number of stations that opened within the corresponding time window. Stations that experienced entry are those that experienced at least one additional station within three minutes. Standard errors are clustered at the municipality level. Signi cance codes: ***: 0.005, **: 0.01, *: 0.05

Table 3: The effect of competition on station quality

	PROFECO	User reviews		
	Passed inspection (0/1)	Rating (1 to 5)	Review has a positive bigram (0/1)	Review has a negative bigram (0/1)
	(1)	(2)	(3)	(4)
Number of stations within 3 minutes	-0.004	0.001	0.006	-0.009
	(0.020)	(0.009)	(0.005)	(0.004)
xed effects				
Station	Y	Y	Y	Y
State-by-Month	Y	N	N	N
Day-of-sample	Y	N	N	N
State-by-Year	N	Y	Y	Y
Observations	18,765	852,967	233,778	233,778
R^2	0.669	0.050	0.072	0.075
Dep. variable mean	0.790	3.87	0.753	0.146
Number of stations	9,186	9,561	8,920	8,920
Number of entrants	646	646	646	646
Number that experienced entry	427	1,356	1,164	1,164

Notes: This table reports coef cient estimates and standard errors from four separate least squares regressions. The speci cations used for these regressions are similar to the speci cations used in Table 2 but the sample periods differ due to data availability, explaining why the number of observations differ somewhat from previous tables. In column (1) the unit of observation is an inspection, and the dependent variable is an indicator variable for passed inspections. For inspections, the data begin with deregulation and continue until November 2019. In column (2) the unit of observation is a user-provided online review score (i.e. from 1 to 5 stars). For reviews, data are available from 2017 to 2020, but, the exact date of the review is usually not provided so these regressions include state-by-year xed effects, but not state-by-month or day-of-sample. In columns (3) and (4) the unit of observation is again a user-provided review, but in these columns the sample is restricted to those reviews which include text. In these two columns the dependent variables are indicator variables for reviews including at least one positive, or at least one negative sequential word pair, respectively. For all regressions standard errors are clustered at the municipality level. Signi cance codes: ***: 0.005, **: 0.01, *: 0.05

Figure 1:Number of new entrants by year

Notes: This gure plots the number of new stations by year that enter the market. Station entry is measured using permit data from CRE (2021c). The entry date for each station is the rst date for which price or other data is observed, or (for stations that entered before 2015) the opening date for the station listed on the permit.

Figure 2: Example of alternative market de nitions

Notes: These maps illustrate the market de nition 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 locations of stations. 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 irregular shaped area corresponding to locations within a three-minute driving time.

Figure 3: Correlations between the number of competitors and markups

(a) Regular gasoline

(b) Premium gasoline

(c) Diesel

Notes: This gure plots the markup means and 95 percent con dence intervals for groups of observations based on the number of competitors within three minutes for any given station and day. The time period is grouped in three: 0-6 months before deregulation, 0-12 months after deregulation and 12-24 months after deregulation. For this gure, but not other analyses in the paper, we restrict the sample to a balanced panel of stations in states that deregulated in November 2017. See the text for details.

Figure 4: Effect of one additional competitor on regular gasoline markups, split by driving-time distance to the competitor

Notes: This figure plots coefficient estimates and 95 percent confidence intervals from a single least squares regression. For this exercise the number of stations was calculated for each of ten driving-time bins. The dependent variable is the retail markup for regular gasoline (in logs) and the independent variables of interest are the number of stations within a certain driving time (in minutes), as indicated in the x-axis labels. The regression specification is the following: $\ln(Markup_{id}) = \alpha_i + \gamma_{sm} + \phi_d + \sum_{m=1}^{m=10} \beta_m \mathbb{1}[\text{Number of stations in driving time bin}_m] + \varepsilon_{id}$, it includes station, state-by-month, and day-of-sample fixed effects. The unit of observation is station i by day d, and the sample period covers from deregulation to November 2019. Standard errors are clustered at the municipality level.

Figure 5: Event study for the effect of entry on incumbent markups

(a) Regular gasoline

(b) Premium gasoline

(c) Diesel

Notes: This figure plots event studies of the effect of station entry on the retail markup for local incumbents. As in the text, incumbents are all previously existing stations within a three-minute drive from the entrant. For each refined product we estimate the following event study regression: $\ln(\text{Markup}_{ieqd}) = \alpha_i + \gamma_{sm} + \phi_d + \sum_{\tau=-6}^{\tau=6} \delta_\tau 1[\text{Entry event at quarter} = \tau] + \epsilon_{id}$. The figures plot coefficients and their 95 percent confidence intervals. The excluded category is $\tau = -1$. Standard errors are clustered at the municipality level.

Appendix A Supplementary tables and figures