Vertical Relationships and Competition in Retail Gasoline Markets

Empirical Evidence from Contract Changes in Southern California

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Abstract

This study examines how much, if any, of the differences in retail gasoline prices between markets is attributable to differences in the composition of vertical contract types at gasoline stations in each market. The purchase of the independent retail gasoline chain, Thrifty, by ARCO provides a unique opportunity to examine the effects of changes in different vertical contract types on local retail prices. This event caused sharp changes in the market share of i) fully vertically integrated stations, and ii) independent stations; differentially affecting local markets in the Los Angeles and San Diego Metropolitan areas. Using unique and detailed station-level data, this study examines how these sharp changes affected local retail prices. The detailed data and the research design based on the Thrifty station conversions allow for credible estimation of the effects of the market share of independent retailers and vertically integrated retailers on local market prices, controlling for any omitted factors at the station level, and the city level over time. Results for the Los Angeles and San Diego metropolitan areas indicate that a decrease in the market share of independent stations has a significant positive impact on local retail price. However, a change in the market share of refiner owned and operated branded stations does not have a significant impact on local market price. These results have important implications as policy makers consider the regulation of vertical contracts as a means to increase competition in gasoline markets. The research design and detailed data also allow for inference on the underlying nature of retail gasoline competition.

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I. Introduction

Over the past five years, West Coast cities have consistently experienced substantially higher retail gasoline prices than other regions of the country. For example, for the first week of August 1999, the price of reformulated gasoline in California was 39.6 cents higher than the average price in Gulf Coast States (about ten cents of this difference can be attributed to higher taxes in California)[1]. In addition gasoline prices vary greatly between West Coast cities. Residents in San Diego have paid a consistent five to fifteen cents more per gallon, on average, than Los Angeles residents. These recent price phenomena have sparked intense political debate over the causes of persistent price disparities. Much of the debate is centered around the effect of vertical contracts between refiners and retail stations on retail competition and price levels.[2]

Industry trade organizations, politicians, and consumer groups have noted corresponding increases in the number of fully vertically integrated gasoline stations in cities experiencing higher citywide average prices. Because of this correlation, some form of divorcement legislation or ordinance has been considered in most West Coast cities, as well as at the state level in California and Arizona. Divorcement legislation prohibits or restricts the number of stations that a refiner can own and operate directly. Proponents of divorcement argue that a larger market share of vertically integrated stations lessens competition between refiners and increases their market power since the refiner directly sets the retail price at this type of station. The fully vertically integrated station is usually referred to as a company-operated (company-op) station. Divorcement would require the refiner to convert these stations to lessee-dealer stations or open-dealer stations, where a dealer sets the retail price but is required to pay the refiner's wholesale price, under the assumption that this would result in a lower, more “competitive” retail price.

Another argument that has received much less attention claims that recent decreases in the number of independent, unbranded retailers have decreased retail competition, since these stations typically compete on price with little non-price product differentiation. Independent stations are completely independent from the refiner in that the gasoline dealer owns the station, and sells "unbranded" gasoline. The fact that the gasoline is unbranded allows the dealer to purchase the lowest price wholesale gasoline available. They are not under contract to sell any

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[1] Source: Energy Information Administration, and California Energy Commission.
[2] In the past 6 months, the Midwest and East Coast have also experienced high gasoline prices and significant retail price differences between neighboring cities. As a result, the regulation of refiner's contracts with their retail stations

particular brand of gasoline or purchase from any given refiner, but cannot post a refiner's brand name on their station. The unbranded station therefore competes with other stations by offering the lowest price gasoline. When these stations are replaced by branded stations (or exit the market), price competition in the market may be softened, resulting in a higher equilibrium price.

This analysis uses an event that caused sharp changes in the market shares of independents and company-ops to determine their effects on local retail prices. The “long-term lease” of approximately 260 independent Thrifty gasoline stations by Atlantic Richfield Company (ARCO) provides an opportunity to test both the divorcement hypothesis and the effect of independent retailers on local prices. The independent Thrifty stations were converted to ARCO stations with various vertical contracts. These station conversions provide a “quasi-experiment” for testing the effects of a change in a station's contract type on a nearby competitor's price. The Thrifty stations were distributed across Southern California. Thus, the station conversions differentially affected local markets within the Los Angeles and San Diego metropolitan areas.

These discrete and differential changes in the market share of company-ops and independents allow for a pre-post comparison between affected and unaffected markets. This analysis compares the price changes at stations located in markets affected by the conversion of an independent Thrifty to an ARCO station, with price changes at stations in unaffected markets in order to determine the effects of independent competitors on retail prices. Of the stations in affected markets, the analysis compares price changes in markets with a new company-op ARCO versus price changes in those with a new dealer-run ARCO, to test the divorcement hypothesis that an increase in the market share of company-ops leads to higher prices.

To implement this approach, the analysis uses a new, unique and highly detailed data set of station-level prices and characteristics for retail gasoline stations in the greater Los Angeles and San Diego metropolitan areas. The discrete nature of the Thrifty station conversions, coupled with the detailed station-specific data allow for the inclusion of station-specific fixed effects that control for important determinants of retail prices that confound cross-sectional analyses. In addition, the fact that many local markets within each metropolitan area were unaffected by the conversions allows for the inclusion of city-time effects in the regression analysis - controlling for any potentially unobserved factors that affected retail prices in any of the metropolitan areas in

has become a national issue. State government officials are currently lobbying congress for regulation of these contracts.

any time period. The results indicate that stations competing with a Thrifty station had a significant increase in price, relative to unaffected stations, after the independent Thrifty was converted to an ARCO station. This increase was independent of the type of contract at the new ARCO station, indicating that the type of contract at the branded station did not affect market price, but the loss of an independent unbranded competitor did.

In addition to providing a credible approach to identifying the effects of independents and company-ops on retail prices, the research design employed in this study provides a unique opportunity to examine different models of retail competition in the gasoline industry. The analysis finds evidence supporting a hedonic value of gasoline brands in a model of price competition with differentiated products. Because the prices of local competitors increased in response to the change of an independent Thrifty to a branded ARCO station, but the value of the products they offered did not, the results imply a welfare loss for consumers in the affected markets.

The paper proceeds in seven sections. The first section gives a brief industry background. The second section describes the existing empirical literature on the relationships between vertical contracts and retail gasoline prices. The third section describes the long-term lease of the Thrifty stations and the research design. The fourth describes the data, and the fifth section presents the results and interpretation. The sixth section examines different models of retail competition, and is followed by a conclusion.

II. Industry Background and the Potential Price Effects of Independents

Gasoline is produced by a refiner and then transported to a main distribution center called a Distribution Rack. There are two types of gasoline: branded and unbranded. Branded gasoline has an additive that is mixed into the gasoline just before it is taken for delivery to a retail station. For example, in order to be called "Chevron" gasoline at the retail station, the gasoline must contain the additive Techron™. A similar requirement holds for Shell, Texaco, Exxon, and most of the other brands available on the market. Under these requirements, a branded retail station must sell the branded gasoline its sign displays.

A. Branded Gasoline Contract Types

If a retail station is a branded station, it can have one of three basic vertical contract types with the branded refiner. The first type is a company operated station (company-op). Divorcement legislation targets this type of station. The refiner owns the station and an employee of the refiner manages the station. The refiner sets the retail price directly and pays the employee a salary. The second type of station is called a lessee dealer. In this case the refiner owns the station and leases it to a residual claimant. The lessee is responsible for setting the retail price, however he or she is under contract to purchase wholesale gasoline directly from the refiner at the wholesale price the refiner sets for a station in that "zone". [3] This wholesale price is called the Dealer Tank-wagon price (DTW).[4] In addition, the refiner also sets volume discounts, the lease rate, and other operation stipulations for the station. At the third type of branded station, a dealer owned station, the retailer owns the station property and signs a contract with a branded refiner to sell its brand of gasoline. The station displays the sign of the brand it is under contract to carry. The retailer can either be supplied directly by the refiner (dealer-owned company-supplied) in which case they pay a DTW, like the lessee dealer does, or the dealer can be supplied by a "jobber". A jobber is an intermediate supplier who purchases gasoline at the distribution rack and pays a wholesale price called the rack price. The rack price is the refiner's posted price for branded gasoline at the distribution rack, and it is the same price for any jobber purchasing at that rack. One jobber often supplies, and possibly owns, many different branded and unbranded stations.

B. Independent Retail Stations

The above three types of stations sell branded gasoline. For example, a typical Shell station could be any of those three types. If a station sells unbranded gasoline, it is an independent gasoline station. Examples of independent retail chains include Rotten Robbie, E-Z Serve, Gas City, and USA. These stations can sell any type of gasoline and can purchase it from any refiner selling unbranded (or branded) gasoline at the rack price.[5] Unlike the branded stations at which the retail price of gasoline is directly set (at company-op stations) or indirectly influenced by the branded refiner through lease terms, wholesale prices and volume discount rates, the independent retailer can shop for the lowest wholesale price from any distribution rack and separately determine the retail margin.

[3] Zone pricing is used extensively in large metropolitan areas. A zone can be as small as one particular station, or as large as a whole city.
[4] DTW includes delivery to the station.
[5] Jobbers can purchase branded gasoline and supply it to independent stations if it is cheaper than the unbranded price (the rack prices are "inverted"), but the independent station cannot post the name of the brand that they are selling. Hence, consumers do not know that they are purchasing branded gasoline.

Independent retailers compete on price, offering no brand differentiation, and few of the amenities (such as car washes or fast-food chains) that are offered by integrated branded retailers. What does economic theory predict would be the effect on local market price when an independent station changes to a major branded station of any vertical contract type? The predicted price effect depends on the assumptions placed on the nature of consumer choice and competition. In a pure vertical differentiation model, where a branded station sells a high quality gasoline and an unbranded station sells a low quality gasoline and taste for quality is uniformly distributed in the population, price competition will intensify when the independent station becomes a branded station, thus lowering the market price for all firms towards marginal cost.[6] However, if becoming a branded station allows the station to increase its price because consumers value that brand's reliability, or because they value the brand in and of itself (brand loyalty), the new branded station may increase its price, and competitors will increase their prices in response. Thus, in a model of price competition with heterogeneous products, the predicted price effect of an independent retailer becoming a branded station, all else equal, depends on the assumptions placed on consumer choice, and thus how the change will affect the station's demand, own and cross price elasticities.

Furthermore, consider a model of consumer search where consumers observe the price at a particular station, and must decide if they will purchase from that station, or search for a lower price. Slade (1986) examines models of competition and collusion using price and quantity data for 13 retail stations competing along a heavily traveled strip in Vancouver. She finds that the 3 independent retailers consistently lead price cuts, while the major branded stations lead price increases (which are not always followed by the independents). By committing to compete primarily on price, the independent retail station may decrease the mean and dispersion of local retail prices. A consumer, viewing the price at one station, will choose to search for a lower price if the expected price savings from searching is greater than the search costs. By committing to a low price, and to lead price cuts, the independent marketer changes frequent consumers' expectations over the distribution of local prices, or increases the fraction of low search-cost "shoppers" in a market. This lowers the highest price that other stations can charge without inducing search.[7] The independent station may therefore decrease the average price and the

[6] For example, see the model of vertical differentiation in The Theory of Industrial Organization by Jean Tirole, page 296.

[7] For example, Stahl (1989) presents a consumer search model where a fraction of the consumers have positive search costs, and the rest have zero search costs. This model generates a Nash equilibrium price distribution as a function of the fraction of consumers with zero search costs, and the search cost of those with positive search costs. He shows that

dispersion of local prices towards the competitive Nash-Bertrand outcome for differentiated products by increasing search intensity.

The purchase and rebranding of the independent Thrifty stations by ARCO provides an opportunity to estimate the effects of independent retailers on local competitor's prices without requiring the structural specification of retail demand and competition. In the end, the research design will also be used to make inferences on the underlying structure of retail competition.

III. Empirical Literature

The effect of independent marketers on retail price levels has not been considered in the literature. The main focus has been on the choice of contract type between the refiner and the branded station: the choice between company operation or lessee dealership for the stations that a refiner owns. If the retail price is set by a residual claimant with market power, as the case may be for dealer-run stations, the dealer may set a super-competitive mark-up over the refiner's wholesale price of gasoline. A company-operated station does not have this second margin, therefore the company-op contract may lead to lower prices since it avoids the double marginalization problem. Borenstein, Cameron, and Gilbert (1997) find evidence that average retail gasoline prices respond asymmetrically to changes in wholesale prices. This finding could be interpreted as evidence that some retailers have a degree of market power, causing city-average prices to fall slowly with decreases in wholesale prices. Borenstein and Shepard (1996), and Slade (1992) also find empirical evidence of market power at the retail level.

Because of this potential for retail market power, many studies of contracts between gasoline stations and refiners have focused on the trade-off between double marginalization and monitoring cost, and hence the refiner's choice between company operation and lessee dealership at the stations it owns. Shepard (1993) applies a principal-agent analysis to examine the refiner’s choice of vertical contractual form observed at a cross-section of retail gasoline stations in Massachusetts. She finds evidence that stations with amenities such as service bays, that would require higher monitoring costs by the principal, tend to be dealer-run, and those with small

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as the percent of consumers with zero search costs approaches one, or as the search cost of those with positive search costs approaches zero, the distribution of prices approaches the Nash-Bertrand outcome. This may imply that independents would have a greatest effect in markets with repeat customers (such as local neighborhoods) where there monitoring costs, stations that mainly sell gasoline and convenience store products, tend to be company operated.

Rey and Stiglitz (1995) show that in differentiated product markets, wholesalers may also have strategic motives for vertical separation, especially when they can use quantity incentives and franchise fees (both available in the lessee-dealer contract) to extract retail profits. The vertical separation can decrease the wholesaler's perceived demand elasticity, resulting in higher retail prices, and producer's profits when a two-part tariff can be used to extract retail profits. In their model, it is the lessee-dealer contract, and not company-operation, that is chosen by the wholesaler to decrease retail price competition. Using retail contract data for gasoline stations in Vancouver, Slade (1998) finds some evidence supporting strategic motives for vertical separation. Both the double marginalization and the strategic-motives models imply that, *ceteris paribus*, dealer-run stations will have higher prices than company-ops when retailers have market power.

Barron and Umbeck (1984) used data on retail gasoline prices from a refiner survey in Maryland to test the double marginalization hypothesis by analyzing the effects of Maryland's 1979 divorcement legislation. They used station level price data for 99 stations from a refiner survey with at least one observation before and after the implementation of divorcement legislation. They found that the price of regular self-serve gasoline at stations that were converted from company operated stations to lessee dealers increased by 1.4 cents after the divorcement took place. Their study provides evidence for the double marginalization hypothesis, and hence against divorcement legislation. However, the study does not control for station-specific fixed effects or time effects – important determinants of retail gasoline prices that may confound results if not included.

There is a second body of literature that attempts to analyze the effects of divorcement legislation for policy proposals or regulation. Most use city average prices to determine if divorcement legislation would increase or decrease prices. For example, Vita (1999) uses monthly statewide average gasoline prices to examine if states with divorcement legislation have higher or lower prices than states without it. [8] The time period considered does not allow for a before and after

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is a larger fraction of consumer's who can incorporate the independent's price-cutting commitment in their search decision.

[8] Hawaii, Connecticut, Delaware, Maryland, Nevada, Virginia, and District of Columbia have all had divorcement for the sample period considered. The legislation in Nevada was passed in 1984 in response to high sustained retail prices

comparison, since the states with divorcement had the legislation in place throughout the sample. Based on the state-average retail prices, he finds that divorcement legislation is associated with a 2.7 cent higher prices. This is interpreted as evidence that divorcement legislation causes higher retail gasoline prices. This correlation may not be causal, since historically, high gasoline prices have caused the proposal and passage of divorcement legislation. We would expect to see divorcement legislation in states with higher average prices.

In fact, it is precisely higher average prices coinciding with increases in the market share of company-ops that has spurred the recent round of divorcement proposals in West Coast cities. Pro-divorcement groups note that the cities that have experienced the most dramatic increases in average prices have also experienced increases in the market share of company-ops. These examples center on Los Angeles, San Diego, Phoenix and Tucson. While it is true that the number of company-op stations in these cities has increased, the correlation between this and the increase in average prices may not be causal. Nearly all of the increase in company-op stations in the West Coast over the past five years came from the purchase of two independent chains by integrated refiners: 1) Thrifty by ARCO, which affected Southern California, and 2) Circle K by Tosco, which mainly affected Phoenix and Tucson.[9] Therefore, at the citywide level of aggregation, the increase in company-ops and the decrease in independents are perfectly correlated. It is therefore unclear which, if either, of these two factors has had a positive impact on retail prices.

The Thrifty case study coupled with detailed station-level data, allow us to separate the two effects: the impact of company-ops and the impact of independents on retail prices. Since the Thrifty stations were converted to ARCO stations with various degrees of vertical integration, some local markets within each metropolitan area had a decrease in independents as a result of the Thrifty conversions, and some markets were unaffected. Of those affected by the conversions, some had a resulting increase in the market share of company-ops, and some did not. The micro-data not only allow us to separate these local markets to identify the impact of company-ops and independents on price, but they also illustrate that city-averages mask a considerable amount of

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following an expansion in the market of company-op gasoline stations. The legislation ranges from prohibiting company-ops to capping their market share, to simply requiring a minimum distance between a company-op and a dealer-run station.

[9] Because the Circle K purchase differed in key ways from the Thrifty purchase, it is being examined in a separate study. Tosco owns the Unocal refining and marketing assets on the West Coast, including refineries, retail stations, and the Union 76 brand.

retail price variation. By using station-level data, this variation can be exploited to control for other potentially confounding factors that affect retail prices within each metropolitan area.

IV. A Research Design Based on the Thrifty Purchase

A. Details of the Thrifty Purchase

In March of 1997, ARCO announced the "long-term" lease of the majority of the independent Thrifty gasoline stations in Southern California.[10] The announcement was followed by a sixty-day waiting period, after which ARCO assumed control of and rebranded the Thrifty stations.[11] Thrifty Oil Company was the largest independent chain of retail gasoline stations in Southern California with approximately 260 stations ranging from San Diego to Santa Barbara. The next largest independent retail chain – USA - has only 32 stations in Los Angeles. Thrifty stations were located all over the Los Angeles and San Diego basins. Almost all stations were included in the long-term lease by ARCO and this event accounts for practically all of the changes in the percentage of company-op stations in Los Angeles and San Diego as well as the decrease in independent retailers during the 1990's.

After the sixty-day waiting period, ARCO re-branded the Thrifty stations and completed the re-branding by September 1997. ARCO rebranded the stations, meaning that they simply changed the signs and colors displayed at the Thrifty stations, but no remodeling or station expansion was done during the period considered in this study. Some of the Thrifty stations were converted to lessee-dealer ARCO stations, some were converted to dealer-owned company-supplied or jobber-supplied stations, and some were converted to company-ops. Approximately two thirds of the stations became company-operated ARCO stations, and the remainder were dealer-run.

B. Research Design

Because of the wide geographic dispersion of the Thrifty stations, local markets in Los Angeles and San Diego were differentially affected by the station conversions. This geographic variation can be exploited using detailed station-level data, thus providing a unique opportunity to test the

[10] The specific details of the long-term lease were not disclosed. ARCO officials state that the stations were not purchased because the lease agreement was a more affordable option. The stations were re-branded and are operated like any other ARCO station. A few stations were not included in the lease because they were substandard and needed renovation and underground storage tank replacement. All information about the lease was obtained by conversations with ARCO and Thrifty Oil Company officials, and from press releases from ARCO.
[11] Thrifty Oil Company was a privately held company. The owner was 75, and decided to retire and sell the company's retail assets to ARCO. ARCO saw this as a good opportunity to expand market share. This is the official reason for the agreement given in all press releases and by officials from either company.

Figure I: Map of Thrifty Stations in Los Angeles Metropolitan Area. Squares with flags denote a Thrifty Station

effects of independent and company-op market share on local retail prices. This study uses these discrete changes in stations' vertical relationships to test if markets experiencing changes in market shares of independents also experienced price increases relative to other markets, and if markets experiencing changes in the market share of company-ops experienced price increases relative to other markets. The research design and data also allow for the inclusion of station-level fixed effects and city-time effects, to controlling for many potentially omitted variables that may be correlated with prices.

Ideally, to test the effects of independent market share and company-op market share on retail prices, the researcher would randomly re-assign vertical contracts at a sample of stations. The resulting change in local prices would then be observed, and causal relationships identified. Random assignment ensures that the differential changes in the market share of company-ops and independents are orthogonal to all other factors that determine retail prices.

Since the random assignment of station contract and ownership types is not possible, one solution is to use sharp discrete changes in contract types provided by the Thrifty purchase to dramatically reduce the omitted variables bias problem in estimating the effects of company-op and independent market share on retail prices. The data are a panel of station-specific prices available for the months of February, June, October, and December of 1997 in the greater Los Angeles and San Diego metropolitan areas. Thus there are observations before and after the station conversion period. The gasoline stations are grouped into local sub-markets of stations in direct competition with each other.[12] Some stations competed with a Thrifty, and some were not located near any Thrifty station. Therefore, the "treatment" effect of a discrete change in a *competitor's* contract type differentially affects the stations in the sample. These discrete and differential changes allow for pre-post comparisons across affected and unaffected markets to estimate the effect of independents and company-ops on prices, conditioned on station-level fixed effects and city-time effects. This research design dramatically reduces the dimension of potentially omitted factors that may be correlated with both prices and the parameters of interest.

The Thrifty purchase provides a credible approximation to random assignment of a change in the market share of independents since the chain included approximately 260 stations that were geographically scattered over the greater Los Angeles and San Diego basins. Their locations and

[12] The analysis uses geographic proximity to determine local markets. The markets definition is described in section V.B., and in greater detail in Appendix A. Results are tested to ensure that they are not driven by market definitions.

characteristics where predetermined to ARCO's acquisition decision. For this reason, it is reasonable to treat the loss of an independent Thrifty as exogenous to a *local competitor station's* pricing decision, conditioned on station-specific fixed effects and city-time effects. The "quasi-experimental" research design examines how an individual station's price is affected by a change in a *competitor's* contract type. A change in a *competitor's* contract type, in this case, is not in a station's choice set, and is therefore treated as exogenous to the individual station's pricing decision, conditioned on fixed effects and time effects.[13] In addition, the Thrifty stations were simply rebranded by ARCO and placed under new contracts, without remodeling, expansion, or other facility improvements. These facts allow for credible estimation of the effect on a station's own price of a change in the market share of independent competitors.

While the location and characteristics of the Thrifty stations were predetermined to the ARCO purchase, ARCO chose which stations to convert to company-ops and which to convert to dealers. The discrete timing and differential assignment of these changes significantly reduces the potential omitted variables problem present in cross-sectional or time series analysis of the effects of company-op market share on retail prices. However, because the contract decisions where made by a profit maximizing firm, there is a potential for confounding omitted factors that are correlated with both *prices* and the *location* and *timing* of the company-op contract assignment. For example, suppose that ARCO chose company-op contracts for stations in markets with relatively low price elasticity, *and* ARCO pursued a pricing policy of greater price discrimination at these particular stations after their conversion. Then this pricing policy *change* is correlated with the location and timing of the company-op contract assignment, and may inhibit the identification of the general effect of company-ops on retail prices. A probit estimation of the determinants of company-op assignment is presented in the results section. The estimation does not find evidence that factors affecting local market price elasticity are correlated with the company-op decision. It does, however, find evidence that the decisions were based on legal considerations with existing ARCO dealer stations.

If it is the case that the increase in company-op stations lowers competition and increases market price, then the stations that compete with a Thrifty that was converted to a company-op ARCO should have a larger price increase than those stations that compete with a Thrifty that was converted to a dealer operated ARCO, all else equal. The data analysis presented in this study

[13] The percent of each brand present in the treatment group (stations that competed with a Thrify) approximately reflects the percent of each brand in the station population, adding evidence that the Thrifty chain was fairly evenly

will show that this is not the case. The analysis lends strong empirical evidence supporting the hypotheses that independent retailers have a significant negative impact on competitor's prices, and that when they exit the market, local retail prices increase. This price increase is independent of the resulting contract at the branded station – indicating that an increase in the market share of company-op stations is not correlated with an increase in market price as the divorcement hypothesis would contend.

V. The data

A. Description and Summary Statistics

The first data set used in the analysis is an annual census of retail gasoline outlets in the Los Angeles and San Diego metropolitan areas. The census gives detailed information on the outlet characteristics including: type of convenience store, size of convenience store, number of pumps, service bay, size of service bay, fast food chain, car wash, and location, among others. It also has the ownership and delivery type for each station, which determines if the station contract is company-op, lessee-dealer, dealer-owned-company-supplied, dealer-owned-jobber-supplied, or independent. The second data set contains volumes and prices by grade and service for a sample of the stations in the census report. The volumes were read from each gasoline station's pump meters. The prices are the prices posted at the end of the volume collection period for the months of February, June, October, and December in 1997. The sample size varies by city from 20-25%. The stations in the sample were chosen to reflect the market share of station types in the market. If Chevron stations comprise 15% of the total census of stations, then 15% of the sample are also Chevron stations that were chosen at random out of the population of Chevron stations.[14]

This data set makes it possible to separate the effects of changes in the number of company-op stations and the number of independents on local retail prices. Station-level detail allows for a comparison between local markets that were affected by the Thrifty purchase and those that were not affected. For those that were affected, we can also compare the price changes in the markets where the new ARCO station became a company-op with those in which it became a dealer-run station. These comparisons would not be possible with aggregated data.

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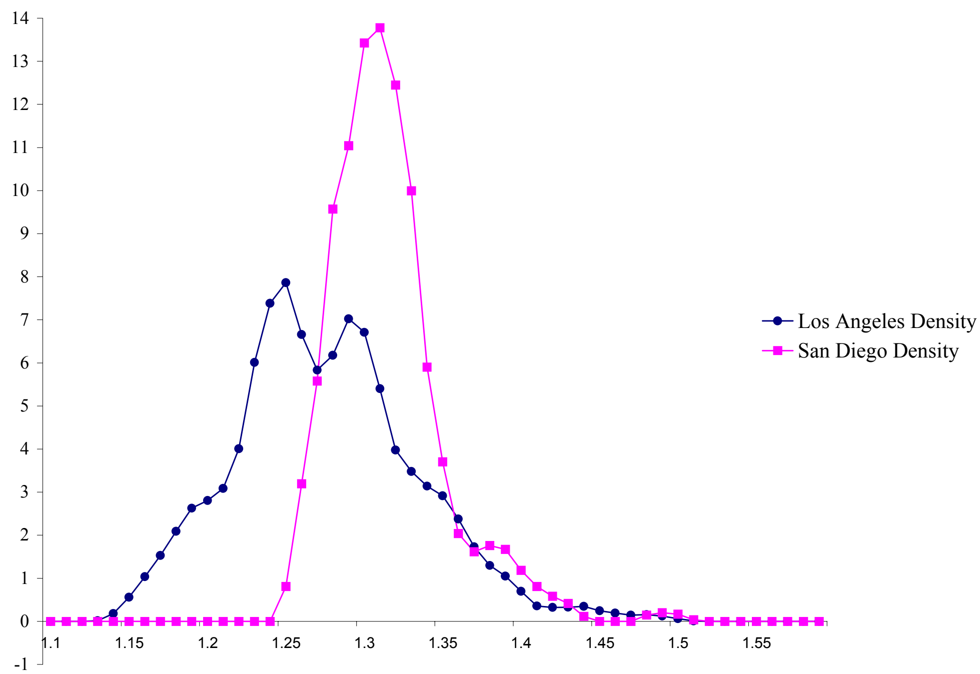
distributed among different brand competitors.

[14] Data were collected by Whitney Leigh Corporation. The volume and price data were read directly from posted prices and pump meters at the stations, and are therefore more reliable than volumes and prices obtained through other methods such as telephone or manager surveys.

In addition, the station-level data highlight the fact that there is as much price variation at the station level as there is in the average prices across metropolitan areas. If the goal is to determine the causes of average price differences between cities, it is important to first determine what causes persistent price differences between stations within each city. Figure 1 presents kernel density estimates for the February 1997 observation in Los Angeles and San Diego.

Figure 1: Kernel Density Estimates for Retail Price of Regular Unleaded Gasoline in February 1997 Observations for Los Angeles and San Diego



* Epanechnikov kernel function was used. Bandwidth was set at the minimum of the optimal bandwidths for Los Angeles and San Diego, where the optimal bandwidth is $h = 0.9m/n^{1/5}$, m=(σ_x, *interquartile range*$_x$/1.349)

The average retail price in Los Angeles for self-serve regular unleaded gasoline was \$1.273 in Los Angeles and \$1.320. This difference in average prices from this data is consistent with the citywide averages used in industry studies. Figure 1 illustrates that the spreads of the price distributions within each metropolitan area are larger than the difference in the average prices across metropolitan areas. The variation within metropolitan area is as significant as the variation across metropolitan areas. The literature in Industrial Organization suggests that retail stations are geographically differentiated products, and hold some degree of market power (Borenstein and Shepard (1996), and Slade (1992)), creating many local sub-markets within each metropolitan area, and potentially creating large price variation within each metropolitan area.

Figure 1 also indicates that the lower tail of prices in Los Angeles drives the difference in average price between Los Angeles and San Diego. This lower tail may be caused by many factors. For example, there are slightly more independent retailers in Los Angeles than in San Diego. However, Los Angeles also has a greater percentage of low-income neighborhoods, or longer average commute times, or a higher retail station density. These factors could all lead to a larger tail of lower priced retail outlets. This emphasizes the benefits of using the conversions of Thrifty stations to ARCO stations to determine the effect of independents on local retail price. Due to the geographic dispersion and the discrete timing of the changes, it is possible estimate the effects of independent competitors on prices while controlling for station-specific fixed effects, such as local commute patterns and retail station density. The fixed-effects absorb any unobserved station-level factors correlated with both independent competitors and the local retail price level.

With station level data we can use a variance components decomposition to examine the amount of total price variation that occurs within a city over time. This variation would be lost when using aggregated data. The variance components model assigns a random effect to each of the categories in the table below. Since the Los Angeles and San Diego metropolitan areas cover such a large geography, the data were further grouped by sub-city within the two metropolitan areas. The sub-city classification groups the sample stations in their local cities, such as Chula Vista (in the San Diego metropolitan area) or Pomona (in the Los Angeles metropolitan area). There are 56 sub-city regions in this analysis.

The variance components estimates show that there is as much variation at the station level over time as there is at the city and time levels. Sub-city does not contribute much to the variation in prices. City is important because of cost differences between Los Angeles and San Diego. All of the refiners are located in Los Angeles, and there is one pipeline used to transport product for distribution in San Diego. Each refiner can make approximately one shipment per week. Because of this, transportation cost to stations in San Diego area are higher than to those in Los Angeles, and prices in San Diego will experience differential trends in prices when there are supply shocks to refineries in Los Angeles. Hence City and City-time are important determinants of retail prices. Within each city, local markets are smaller than the Sub-city level, hence Sub-city classifications account for little of the total price variation. This highlights the benefits of using station level data instead of aggregated data in analyzing the effects of changes in retail market composition on prices. The importance of station level data will become evident again in the final fixed-effects estimation and in the examination of the underlying models of retail competition presented in Section VIII.

Table III: Variance Components Estimation

Component	Variance Component Estimate	Percent of Total Variance
Month	0.00308	0.26506
City	0.00334	0.287435
Sub-City	0.00032	0.027539
City*Month	0.00104	0.089501
Sub-City*Month	0.00036	0.030981
Station-time (residual)	0.00348	0.299484

B. Retail Market Definition

The retail market definition used in the regression analysis presented below is the following: A station with a price observation competes with any station within 1 mile along a surface street or freeway. Therefore, a station with a price observation competes with a Thrifty there is a Thrifty located within one mile. The detailed address information provided by the census data allows for a realistic geographic definition of sub-markets. Although it is true that people in Southern California commute a lot, making it harder to tell which stations compete with each other (stations near your house may compete with stations near your work), this definition attempts to capture the stations that compete most intensely for customers in their area. In order to confirm that the results were not driven by geographic definitions, the regressions were run using perturbations of these definitions, and the results were robust to these changes. The perturbations increased or decreased the scope of the definitions by half a mile. The signs and significance of explanatory variables remained the same, although the magnitudes varied slightly by a statistically insignificant amount.

The above market definition includes factors considered by dealers and refiners to be main determinants of competition. According to dealers, refiners, and trade groups, stations in Los Angeles and San Diego compete most intensely with any station within 1 mile.[15] This definition is further reinforced by the fact that stations of the same brand are usually located more than a mile apart. In addition, many contracts between dealers and refiners stipulate that the refiner will

[15] This information came from various conversations with regional managers, dealer trade organization representatives, and from conversations with various dealers at retail stations.

not brand another station within one mile of that dealer's location. By graphing the stations using mapping software, it is possible to examine each station's nearest competitors. A more detailed description of competition groups and geographic definition is presented in Appendix A. The regressions presented in Appendix A also highlight the problems introduced by geographic aggregation in estimating the parameters of interest.

VI. Results

A. Graphical Analysis

Even though it is possible to control for every recorded station characteristic, it is impossible to control for many factors that are unobservable to the economist but may affect the local demand and competition that a station faces. The "quasi-experiment" based on the Thrifty station conversions provides a credible research design for identifying the effects of i) the market share of independents, and ii) the market share of company operated stations on local retail prices. Graphs I.a and I.b provide a rough estimate of the impact of independent retailers on competitors' prices.

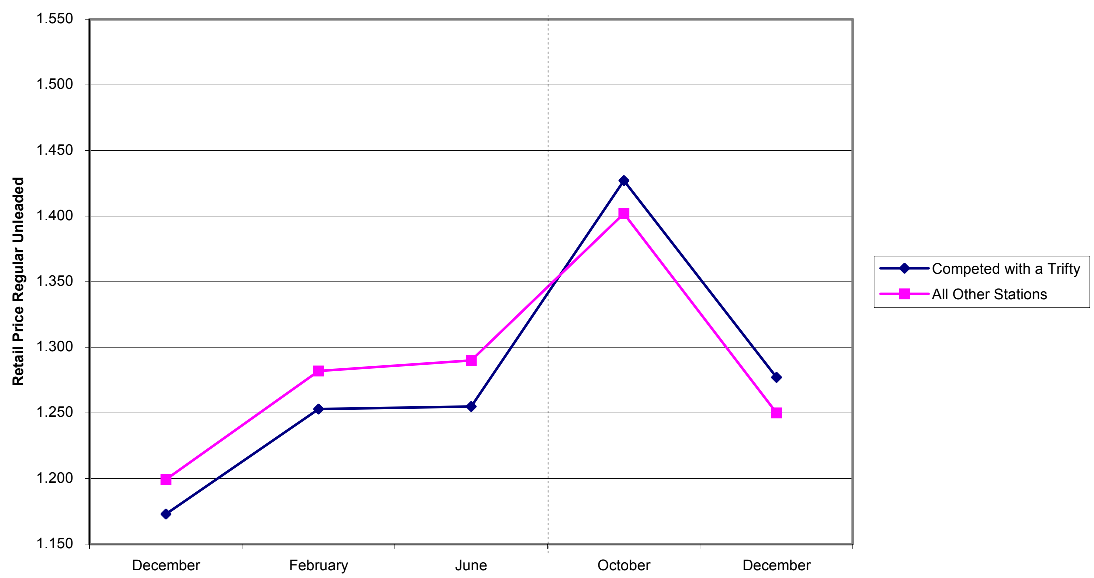
These two plots present the average price level in each time period for stations that were affected by a Thrifty conversion, and thus lost an independent competitor, versus the average price level at stations that were unaffected by the conversions. These figures illustrate that before the long-term lease took effect, the stations that were competing with a Thrifty station (the treatment group) had lower prices than the market averages for stations that never competed with a Thrifty in any time period (the control group). This relationship is the same in both Los Angeles and San Diego, even though the two metropolitan areas experienced differential trends in prices over this period. Within each graph, the pre-conversion trends of the two averages are identical. The pre-conversion and post conversion price difference between the two groups is also similar across metropolitan areas.

After the conversion period, the stations in the treatment group had a higher price than the average price of stations in the control group.[16] Based on this graphical analysis, the stations that competed with an independent Thrifty had roughly a two to three cent lower average price than

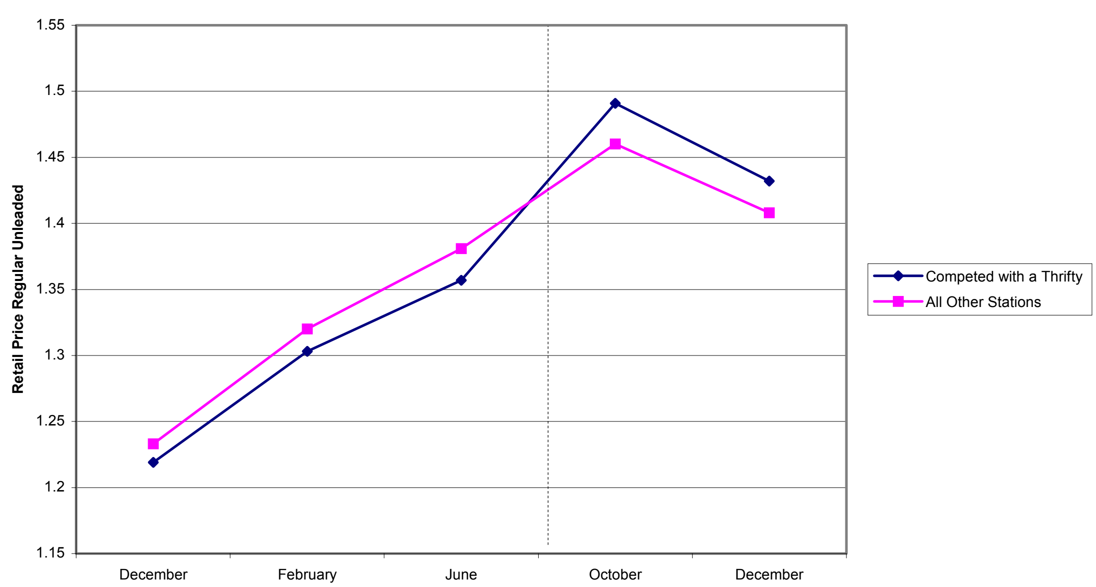
[16] Almost all of the stations were rebranded after the June observation and by about the end of August. A few of the Thrifty stations in the sample were changed to ARCO stations before June. These stations are not included in this graph. In the regression, they have the appropriate timing. These graphs show the majority of the affected stations – those that were converted between the June and October price and volume observations.

other stations before the conversion. After the conversions, these stations had about a two to three cent higher average price than other stations, indicating a price increase of four to six cents resulting from the conversion of an independent Thrifty station to an integrated ARCO, independent of the subsequent contract type. These graphs provide preliminary evidence that presence of an independent competitor is associated with a four to six cent lower local market price.

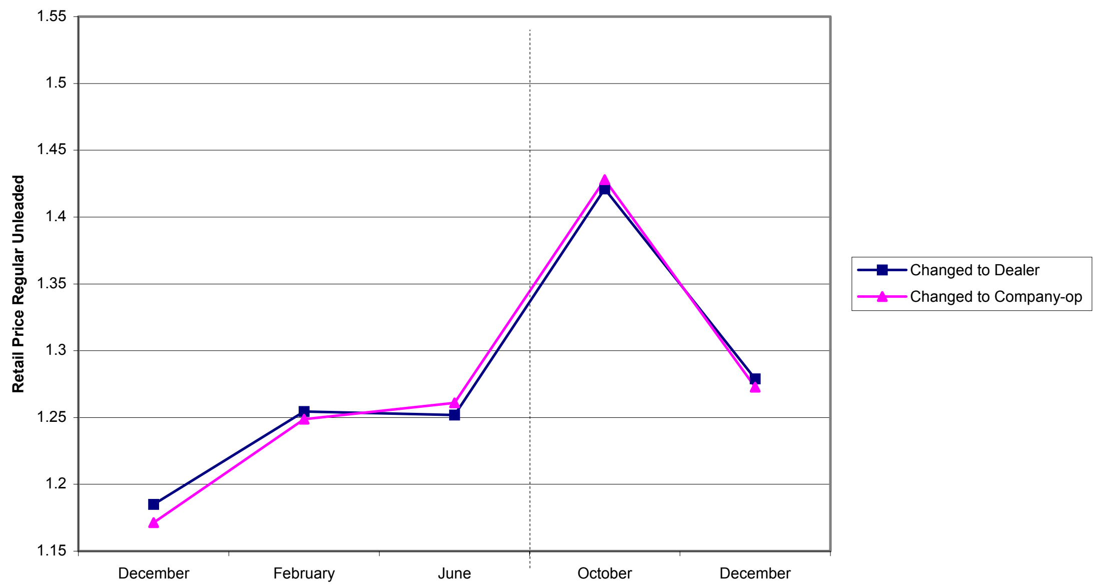
Graph I.a: Los Angeles Treatment and Control Graph



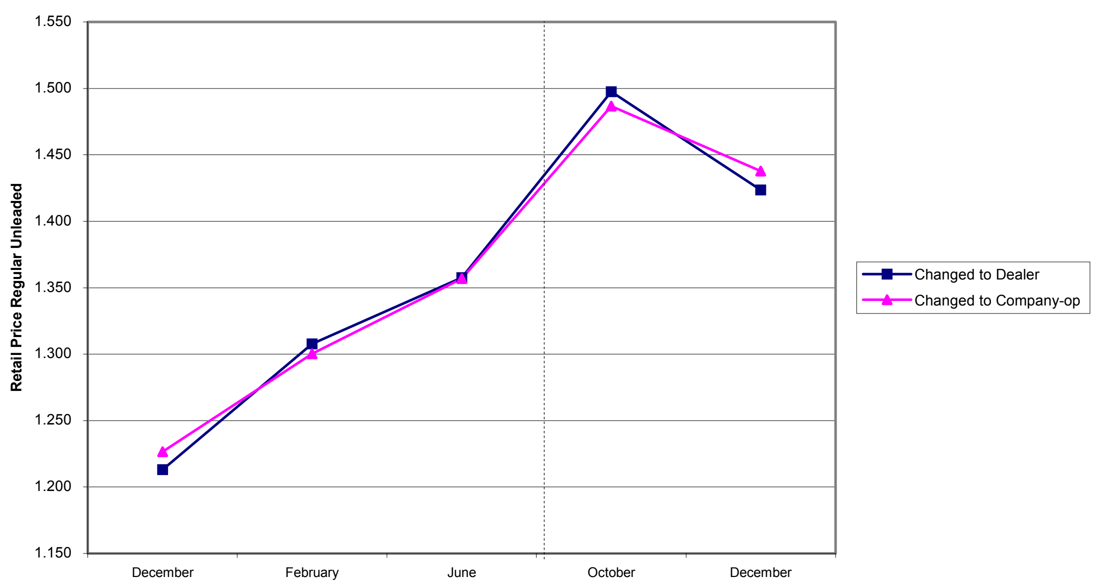
Graph I.b: San Diego Treatment and Control Graph



Graph II.a: Los Angeles Change to Company-op vs. Change to Dealer-run



Graph II.b: San Diego Change to Company-op vs. Change to Dealer-run



If the stations in the treatment group (stations that competed with a Thrifty) are divided into two groups: i) stations that now compete with a company-op station, and ii) those that now compete with dealer, a similar graphical analysis can be performed. This provides a rough estimate of the impact of an increase in company-ops on local market prices. Graphs II.a and II.b summarize the price effect of a Thrifty becoming a company-op ARCO verses a dealer run ARCO that the fixed-effects regression analysis estimates. The graphs show no apparent difference in the price behavior between stations that compete with a new company-op ARCO and those that compete with a new ARCO dealer.

Notice that, within each metropolitan area, the pre-buyout and post-buyout levels and trends are very similar between the two groups. One group does not appear to display a persistently different pattern than the other. This is consistent with "exogeneity" of the contract assignment to other station-level factors that may be correlated with price. Since there is no clear trend in relative prices between the two groups in either metropolitan area, these two graphs imply that an increase in company-ops does not have a significant effect on local retail prices. The four graphs together lend preliminary support to the hypothesis that the presence of independent competitors, and not the presence of company-ops, has an impact on local competitor's prices.

B. Random Effects Estimation

A first attempt at estimating the effect of changes in a competitor's contract type on another station's price is a pooled regression analysis, assuming a linear relationship between stations' prices and a vector of covariates. This model can be written as:

$$p_{it} = \alpha + \beta w_{it} + \phi c_{it} + \theta z_{it} + \varepsilon_{it}$$

where p_{it} is station i's price for self-serve regular unleaded gasoline at time t, c_{it} is the market share of company-op competitors in station i's market at time t, z_{it} is the market share of independent competitors, and w_{it} is the vector of all other determinants of station i's prices.

In principle, if all of the determinants of a station's price decision were observable and measurable, then the relationship between contract type on retail prices could be identified. In reality, many of these determinants are not observable to the researcher, and their omission may bias the estimation results. A standard least-squares analysis will lead to inconsistent estimates of the impact of independents and company-ops on retail prices if the researcher cannot control for all factors that affect prices and vary with independent and company-op market shares.

The results from the pooled regression with station-specific random effects are discussed below. The random effects estimates are presented as a comparison for the final robust fixed effects results. These results emphasize the importance of the research design using station level fixed effects and city time effects.

The pooled regression in Table IV is specified as:

$$p_{it} = \alpha + \delta\gamma \cdot t + \beta x_{it} + \phi c_{it} + \theta z_{it} + u_i + \varepsilon_{it}$$

where: α = constant

γ = city dummy

t = time dummy

x_{it} = vector of observable station characteristics

c_{it} = indicator for if a competitor becomes a company operated station

z_{it} = indicator if the station competes with an independent Thrifty station[17]

$u_i \sim N(0, \sigma_u^2)$, $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$

Table IV presents the regression results for the Random-effects model. Company Operated is an indicator for when a competitor becomes a company owned and operated station. This variable changes when a competitor Thrifty station becomes a company-op ARCO station. Independent indicates if the station competes with an independent station. This variable decreases discretely when a Thrifty is changed to a branded ARCO station of any vertical contract type. The various columns in the table show the changes in the parameters of interest as the regression models consecutively control for station-level characteristics and city-time effects. The estimates in the final column will be compared to the Fixed Effects estimates presented in Table V.

Column 1 of Table IV on the following page shows the unadjusted correlation between Company Operated and retail prices. This is the estimate of the price effect of increases in company-ops that is used to support divorcement legislation. The coefficient is large and significant. However it is clear from the fourth column that the coefficients on Company Operated in the first three columns are attributing the price effect of the contemporaneous citywide prices increase to Company Operated. The same is true for the coefficient on Independent in column 2.

[17] This regression was also run with c_{it} = number of company-ops station i competes with and z_{it} = number of independents station i competes with. In this case, c_{it} and z_{it} are integers that stay constant over the entire period of observation, except for the stations that compete with a Thrifty. In this case z_{it} changes from 1 to zero when the Thrifty becomes an ARCO, and c_{it} increases by 1 if that new ARCO was a company-op. The estimates using these variable definitions show more bias in comparison to the fixed-effects estimates than those that use only the changes from the Thrifty station conversions. If the number of independents a station competes with is used, the coefficient on Independent in Column 4 is -0.0037 with a robust standard error of 0.0025. The coefficient is no longer significant. Note that the value for Independent stays constant over the sample period for all stations that do not compete with a Thrifty. Hence there is great potential for heterogeneity bias. It is only the discrete changes from the Thrifty station conversions that generate inter-temporal and cross-sectional variation in the number of independents a station competes with. This variation allows the price effects of independents to be identified separately from the price effects of other time-invariant factors. Please see footnote 20 for the fixed-effects results.

Table IV: Pooled Regression: Estimated Effects of Company Operated and Independent stations on Retail Price of Regular Unleaded Gasoline (Robust standard errors in parentheses)

Variable	(1)	(2)	(3)	(4)
Intercept	1.3302* (0.0022)	1.3302* (0.0022)	1.4025* (0.0353)	1.2916* (0.0279)
Company Operated	0.0581* (0.0084)	0.0516* (0.0083)	0.0515* (0.0097)	0.0123 (0.0076)
Independent	-	-0.0519* (0.0072)	-0.0549* (0.0055)	-0.0289* (0.0046)
Self-Serve Nozzles	-	-	-0.0002 (0.0003)	-0.0001 (0.0002)
Ave. Quantity Food	-	-	-0.0001 (0.0001)	-0.00015* (0.00006)
Snack Shop	-	-	-0.0074 (0.0052)	0.0020 (0.0042)
Car Wash	-	-	0.0077 (0.0067)	0.0068 (0.0054)
Fast Food Chain	-	-	0.0299* (0.0140)	0.0141 (0.0120)
Service Bay	-	-	-0.0025 (0.0051)	0.0028 (0.0040)
Credit Card	-	-	0.0077 (0.0058)	-0.0015 (0.0043)
Oil Change	-	-	-0.0087 (0.0128)	0.0157 (0.0111)
Number of Stations within a mile	-	-	0.0062 (0.0010)	-0.0022* (0.0008)
Distance to Nearest Competitor (in yards)	-	-	-0.0000001 (0.000002)	-0.0000004 (0.000003)
Per Capita Income In Census Tract	-	-	-0.0000009* (0.0000004)	-0.00000073* (0.00000034)
Percentage White Population In Census Tract	-	-	0.1149* (0.0149)	0.0511* (0.0119)
Percentage of Workers using Public Transportation	-	-	-0.0355 (0.05136)	-0.0395 (0.0384)
Average Travel Time to Work	-	-	-0.0022* (0.0004)	-0.0002 (0.0004)
LA*June	-	-	-	0.0065* (0.0029)
LA*October	-	-	-	0.1223 (0.0039)*
LA*December	-	-	-	-0.0167 (0.0041)
SD*February	-	-	-	0.0433* (0.0044)
SD*June	-	-	-	0.0985* (0.0050)
SD*October	-	-	-	0.1855* (0.0055)
SD*December	-	-	-	0.1310* (0.0060)
Adj. R-Square Sample Size: 2676	0.017	0.037	0.087	0.537

* Indicates at least a 5% significance level.

Since the timing of the company-op increases and independent decreases coincide with the market-wide price increases shown in Graphs 1.a and 1.b, both variables are large and significant when city-time effects are excluded from the regression. The coefficient on Company Operated is not longer significant in column 4.

Columns 3 and 4 sequentially control for observable station-level characteristics and demographics that may be correlated with retail prices, and for city-time effects. Of the station characteristics, the presence of a Fast Food Chain (such as McDonald's or Subway) is associated with a three cent higher price than other stations, and is significant in column 3.[18] However, the coefficient becomes insignificant in column 4 when the city-time effects are included. In column 4, the coefficient on the Average Quantity of Food sold is significant at the two percent level. The coefficient implies that as the average monthly dollar value of food products sold increases by $100,000, the price at the station decreases by 1 cent. Since the sample average is approximately $18.6 (measured in thousands), the magnitude of the coefficient implies that only stations with the highest volume food sales have slightly lower prices.

The only other station characteristic that is significant is the Number of stations within a mile. The coefficient implies that a station with 6 competitors within a mile would have one cent lower price than a station with one competitor within a mile, all else equal. The sample mean for this variable is 3.6, with a standard deviation of 2.1. Hence, price could vary by one cent a gallon for stations within one standard deviation of the mean number of competitors within a mile, all else equal. The researcher might think, *a priori*, that the other included station characteristics should have a significant effect on a station's retail price level. The fact that they do not suggests that there are confounding, unobservable station-specific factors that are not controlled for. These factors inhibit the pooled regression model from estimating the true contributions of each of these variables to a retail station's price.

Each station was mapped into a census tract, linking demographic data at the census tract level to the individual stations. Demographic variables that may influence price elasticity are included in columns 3 and 4. Of the demographic variables in column 4, both per capita income level and the percentage of the population that is white are significant determinants of retail prices, once city-time effects are controlled for. The coefficient in column 4 on Percent White Population indicates

[18] This may be due to the fact that the station can charge more since consumers only have to make one stop to purchase a meal and gasoline, so consumers are willing to pay more to avoid another stop.

that an increase of 0.10, or ten percent, in the percent of white residents in a census tract is associated with a 0.5 cent increase in station price. This implies that a station in a census tract with 70% whites would have a 1 cent higher price than the same station in a census tract with 50% whites. Per capita income levels are surprisingly negatively correlated with station prices. Since income is in thousands, an increase in income of $100,000 would be associated with a price decrease of 7.3 cents. Hence, an increase in income of about $13,700 would be correlated with a decrease in station price of 1 cent. It is not clear why income should be negatively correlated with price. The correlation coefficient between Income and Percent White is 0.588, however neither variable changes sign or significance when the other is excluded from the regression. It may be the case that there are other factors that are correlated with both income and low prices that are not observable to the researcher. These factors may account for the negative coefficient on income.

It is important to note that the station characteristics and demographic variables explain very little of the total variation in prices. The fit of the regression in column 3 is quite poor, with an adjusted R-squared of only 0.087. The inclusion of station fixed effects will significantly increase the amount of station-level price variation explained, suggesting that there are many important station-specific variables that are unobservable to the researcher, but are still significant determinants of retail prices.

The City-time dummies are all significant. Recalling the differential time effects across cities in Graphs I.a and I.b, it is not surprising that controlling for city-time effects considerably increases the amount of price variation explained by the regression model. Notice that the coefficient on Company-op becomes insignificant once these city-time effects are included. The discrete timing and differential changes in Company-op and Independent across markets allows for city-time effects that control for any citywide shocks to prices in any time period that confound the regression results if not included. Controlling for city-time effects takes out the market-wide trends in Graphs I.a and I.b, thus separating the effects of company-op and independent from the coinciding market-wide price trends.

C. Fixed-effects Estimation

The parameter estimates in Table III are inconsistent if the Random-effects specification is incorrect. This specification assumes that the expected value of the station-specific error term, conditioned on observable station characteristics, is the same across all stations. If the locations of independent stations are correlated with an unobservable local market characteristic that also influences price, this assumption is violated, and the Random-effects estimator is inconsistent. For example, independent stations may choose to locate on local streets rather than directly off of freeways because the station property is less expensive. This unobservable factor affects both local market price and the presence of an independent. This correlation leads to heterogeneity bias in the Random-effects estimate on Independent. The Fixed-effect estimator is the only consistent estimator when the expected value of the station-specific components, conditioned on observables, differs across stations.

With the fixed-effects specification, the effects on price of any station or local market characteristics that are time invariant cannot be determined independently from the fixed effect. Hence city-wide effects cannot be estimated, nor can the effects on price of location, store size, number of pumps, or service amenities, be determined separately from the fixed effect. However, since there were large discrete changes in a key variable - a competitor's ownership and contract type - during the observation period, we can obtain consistent estimates of the price effects for the variables most relevant to current policy decisions. It is precisely the discrete nature of the conversions of the independent retail stations and their broad geographical distribution that allow for convincing identification of the price effects of independents and company-ops. The station fixed effects and city-time effects absorb any potentially confounding factors at the city, city-time, time and station levels.

Station Level Fixed-Effects with City-time dummies:

$$p_{it} = \mu + \alpha_i + \delta\gamma \cdot t + \phi c_{it} + \theta z_{it} + \varepsilon_{it}$$

where: μ = constant

α_i = station-specific deviation from the mean μ

γ = city dummy

t = quarterly dummy

z_{it} = indicator if the station competes with an independent station[19]

c_{it} = indicator for if a competitor becomes a company operated station

ε_{it} = error term

[19] This regression was also run with c_{it} = number of company-ops station i competes with and z_{it} = number of independents station i competes with. In this case, c_{it} and z_{it} are integers that stay constant over the entire period of observation, except for the stations that compete with a Thrifty. For stations that compete with a Thrifty, z_{it} decreases discretely when the Thrifty becomes an ARCO, and c_{it} increases by 1 if that new ARCO was a company-op. These definitions product the same results. This is because i) the Thrifty stations were almost always the only independent station within a mile of the station with the price observation (, z_{it} decreases from 1 to 0), and ii) the number of independents and company-ops does not change over the time period, except for the changes generated by the Thrifty station conversions. Hence, for stations in the control group, the number of independent competitors and company-op competitors remains constant over time. Their price effects are absorbed by the station-level fixed-effect.

An F-test for no fixed effects rejects the hypothesis that there are no station-specific fixed effects. The Hausman test for random effects rejects the random-effects specification in favor of the fixed-effects specification.[20] Note that the Adjusted R-Square in column two of Table V increases by 0.311 over the Adjusted R-Square reported for column three of Table IV, the specification without fixed effects but including observable station characteristics and demographics. This suggest that unobservable characteristics that are absorbed by the fixed – explain three times more of the variation in retail prices than the observable station characteristics do. This fact highlights the importance of station-level fixed effects in decreasing the potential for omitted variables bias in the estimates of the parameters of interest.

Table V: Fixed-Effects Estimation
Dependent Variable: Retail Price for Regular Unleaded

Variable	(1)	(2)	(3)
Intercept	1.3465	1.3465	1.3617
	(0.0421)	(0.0415)	(0.0287)
Company Operated	0.1080	-0.0033	-0.0033
	(0.0107)	(0.0178)	(0.0122)
Independent	-	-0.1013	-0.0500
		(0.0143)	(0.0101)
LA*February	-	-	0.0180
			(0.0065)
LA*June	-	-	0.0243
			(0.0065)
LA*October	-	-	0.1390
			(0.0064)
SD*February	-	-	-0.0851
			(0.0036)
SD*June	-	-	-0.0304
			(0.0036)
SD*October	-	-	0.0545
			(0.0036)
Adj. R-Square	0.3772	0.3953	0.7181
F-Test for No Fixed Effects:			
Numerator DF: 668			
Denominator DF: 1999			
F value: 3.262			Prob.>F: 0.000
Hausman Test for Random Effects:			
Hausman's M Value: 622.296			Prob. >M: 0.000

*Standard errors in parentheses

[20] Hausman's m value is $m=q'Var(q)^{-1}q$, where $q = \beta_{FE} - \beta_{RE}$ and $Var(q) = Var(\beta_{FE}) – Var(\beta_{RE})$. The null hypothesis is that $E(\alpha_i|X_i) = 0$ versus the alternative that it is not equal to zero. Under the null hypothesis, the statistic is distributed chi-squared with K degrees of freedom. If the null is rejected, the random-effects specification is incorrect. Random-effects places an assumption on the conditional distribution of the station-specific error component. Fixed-effects estimates the mean of this component and does not require it to be zero. If $E(\alpha_i|X_i) \neq 0$ the Random-effects estimator is inconsistent.

Column 1 presents the regression results unadjusted for Independents or city-time effects. The coefficient on Company-op is positive and significant since this variable is correlated with the omitted Independent variable, and its timing is correlated with a period of market-wide price increases. Once Independent is included, Company-op becomes insignificant. The coefficient on Independent in column 2 overestimates the effects of independents since the timing of the conversions coincided with the market-wide increase in prices in Graphs 1.a and 1.b. Column 3 includes the city-time dummies, and the coefficient on Independent is approximately the same as was implied by the Graphs 1A and 1B. The coefficient measures the effect of the *presence* of an independent, indicating that prices were 5 cents *lower* at stations competing with a Thrifty before the conversion than they were after the conversion. Hence, the *presence* of an independent competitor is associated with a 5 cent *decrease* in market price, and the *loss* of an independent competitor is associated with a 5 cent *increase* in local retail prices.

The above results indicate that there is a large and significant effect on a station's price if an independent in its competition group changes ownership type. If an independent down the street from a Mobil station, for example, becomes an integrated station of any contract type, the Mobil's price would rise, on average, five cents a gallon. This supports the theory that the loss of independent stations significantly raised retail gasoline prices in affected markets in Los Angeles and San Diego. However, the results also indicate that changing a station to a company-op station does not have a significant positive impact on local competitors' prices. For example, if a Thrifty station became a company-op ARCO station, it would not have a different impact on a competitor's price than if it had become a lessee-dealer ARCO station instead.

As stated in Section IV, the Thrifty stations' locations were predetermined to the ARCO purchase decision, allowing the loss of an independent to be treated as exogenous to the local competitor's pricing decision, conditioned on station fixed-effects and city-time effects. However, ARCO subsequently decided which stations would be company-ops. The research design controls for any potentially omitted factors at the station level and at the city-level over time. However, there is still a potential for omitted variables bias in the estimate on Company-op, since the contract assignment was determined by a profit-maximizing firm. Because of the research design, any confounding omitted factors must be correlated with *prices* and the *location* and *timing* of the company-op contract assignment. For example, if ARCO chose company-ops in high income areas, and also changed the pricing strategy to one of greater price discrimination at these company-op stations after they were converted, then it could be the case that company-ops lower local market prices in general, but the correlation of the change in this sample with this specific change in pricing strategy would bias the estimate upwards.

A Probit model of the choice of contract type at the new ARCO's was run on station characteristics, census tract level demographic data, and local market characteristics. The results are presented in Table VI on the following page. The assignment of a *Dealer Contract* is given a value of one, so the table below shows the influence of each covariate on the probability that a Thrifty station received a Dealer-run contract.

Table VI: Probit Estimation of the Probability of Choosing a Dealer Contract Type

Variable	Parameter Estimate	Standard Error	Chi Square	Probability>Chi
Intercept	-0.2718	1.9811	0.0188	0.0891
Existing Arco Dealer within 1 mile	**0.6579**	**0.2640**	**6.2096**	**0.0127**
HHI	0.5357	0.8227	0.0424	0.5149
Number of Competitors	-0.0040	0.1062	0.0014	0.9699
Percent of Competitors with Dealer contracts	0.1945	0.3213	0.3664	0.5450
Distance to Nearest Competitor	-0.00008	0.0001	0.3830	0.5360
Ave. Quantity Food	0.000009	0.00001	0.6448	0.4220
ATM machine	-0.7505	0.4638	2.618	0.1056
Convenience Store Size	0.2892	0.2280	1.4579	0.2273
Service Bay	-0.4143	0.4201	0.9727	0.3240
Credit Cards Accepted	**0.5498**	**0.2406**	**5.2225**	**0.0223**
No. Self-serve Nozzles	-0.0172	0.0201	0.7321	0.3922
Per Capita Income	0.000004	0.00002	0.0480	0.8266
Percent White	0.7359	0.8167	0.8119	0.3676
Percent of Workers Commuting Alone	-0.1492	2.2951	0.0042	0.9481
Average Commute Time	0.0094	0.0278	0.1151	0.7344
Percent of Workers using Public Transportation	-0.5884	2.9304	0.0403	0.8409
N = 170				
Log Likelihood:				-92.74

Table VI shows that Income, Percent White, and Number of Competitors were insignificant explanatory variables of the assignment of contract type at the new ARCO stations. Even though Percent White was significantly positively correlated with higher prices in the pooled regression analysis in Table IV, it is not a significant determinant of ARCO's contract decisions. Number of

Competitors within a mile was negatively correlated with prices in the pooled regression, however it is also not a significant determinant of contract choice. Several factors that may affect the degree of local market competition were also included. The percent of competitors that are dealers, the refiner concentration (HHI), and the distance to the nearest competitor were all included as regressors. None of these factors were significant determinants of ARCO's contract decision.

Table VI shows that only two variables were significant determinants of contract type: whether the Thrifty station was located within a mile of an existing ARCO dealer-run station, and whether the Thrifty station accepted credit cards. Both of these factors increased the probability that the station was assigned a Dealer contract instead of a Company-op contract. ARCO claimed that they preferred a dealer contract if the station was too close to an existing ARCO dealer. This abated the chances that the existing ARCO dealer would protest the branding of the new station. Dealers are much more likely to protest if they are forced to compete with a station directly operated by their refiner, than with one operated by another dealer. ARCO also claimed that they preferred to assign a dealer contract if a "competitive" and "conscientious" dealer was available. Since Thrifty did not have a policy of accepting credit cards, the decision to accept credit cards was left to the dealer. Since merchants must pay the credit card processing fees, this acceptance of credit cards may indicate the presence of a "competitive" dealer, especially since major branded competitors usually accept credit cards.

The Probit results do not find evidence that the contract assignment decision was based on observable variables that may be correlated with the station's price elasticity of demand. Legal considerations with existing ARCO dealers seemed to be one factor in the contract decision. An instrumental variables regression was run using the predicted value of company-op from a Probit regression of the probability of company-op contract choice on whether the Thrifty station was located within a mile of an existing ARCO dealer-run station as an instrument. The spot estimates from the instrumental variables estimation do not change significantly from the fixed-effects estimates, however the instrument is weak, leading to large standard errors.

The divorcement hypothesis rests on the assumption that retail prices rise significantly with an increase in the number of company operated stations. The results do not find that the increase in the market share of company-op stations has a significant impact on retail prices. However, t it is the loss of independent stations, and not the subsequent contractual form with a branded refiner, that has a significant positive effect on competitor's prices.

VII. Potential Models of Retail Competition

The geographic dispersion and the discrete timing of station conversions, along with station-level micro data, allowed for a credible identification of the impact of independent stations on local retail prices. The data and research design can be used to distinguish between the possible underlying market mechanisms that lead to the estimated price effects of independent competitors. This section briefly discusses three simple models of competition and determines if each models' predictions are consistent with the empirical evidence.

A. Vertical Differentiation

Recall that the Thrifty stations were simply rebranded as ARCO stations. Since the station's characteristics changed only along this one dimension, a possible model of product differentiation is vertical (quality) differentiation. Suppose that two firms sell vertically differentiated products: one sells low quality (unbranded) gasoline and the other sells high quality (branded) gasoline. As a result of the ARCO rebranding of the Thrifty stations, the low quality unbranded station now becomes a higher quality branded station. Suppose that consumers vary uniformly in their taste for quality, and that the bounds on the quality taste parameter are such that the market is covered.[21] In this model, both firms' price-cost margins are proportional to their product quality difference. Therefore, when an unbranded competitor becomes a branded competitor, the quality difference between the two firms decreases, and so do their prices. The products are now *closer* substitutes for each other, since they are closer in quality, hence price competition intensifies, and the equilibrium prices *decrease*. This model is not supported by the empirical results, since the price at the branded competitor station *increases* by an average of 5 cents when an independent competitor becomes a branded station.

B. Market Concentration

Perhaps this five cent coefficient on Independent from Table V is due to an increase in concentration in the markets affected by the conversion of the Thrifty stations to ARCO stations. An increase in concentration leads to an increase in equilibrium prices in a Nash-Bertrand model

[21] For example, see the model of vertical differentiation in The Theory of Industrial Organization by Jean Tirole, page 296.

of competition with differentiated products. Suppose that a Refiner *r* owns one station in a market, and competes on price with other refiner's stations in the area. The refiner's profit maximizing price for station i is given by the solution to the first order condition:

$$\pi_{ri} = (p_i - c_r)q_i(p_i, p_{-i})$$

$$FOC: \frac{\partial \pi_{ri}}{\partial p_i} = q_i(p_i, p_{-i}) + (p_i - c_r)\frac{\partial q_i}{\partial p_i} = 0 \qquad (1)$$

Let p^* be the solution to the first order condition above. Now suppose that this refiner purchases another station in the same market. The profit maximizing price must now reflect the fact that a decrease in price at one of the refiner's stations will decrease the quantity sold at his other station. The new profit maximizing price solves the following first order condition:

$$\pi_{ri} = (p_i - c_r)q_i(p_i, p_{-i}) + (p_j - c_r)q_j(p_j, p_{-j})$$

$$FOC: \frac{\partial \pi_{ri}}{\partial p_i} = q_i(p_i, p_{-i}) + (p_i - c_r)\frac{\partial q_i}{\partial p_i} + (p_j - c_r)\frac{\partial q_j}{\partial p_i} = 0 \qquad (2)$$

Let p^{**} denote the solution to this first order condition. Notice that the first order condition in (2), evaluated at p^*, is greater that zero. The first two terms are equal to zero at p^* by (1), but the third term is positive for substitute goods.

$$\left.\frac{\partial \pi_{ri}}{\partial p_i}\right|_{p_i*} = 0 + (p_j - c_r)\left.\frac{\partial q_j}{\partial p_i}\right|_{p_i*} > 0 \qquad (3)$$

Since the first order condition must be zero at p^{**}, and it is greater than zero at p^*, it must be the case that $p^{**} > p^*$. Because the refiner now owns more than one station in the market, the profit maximizing prices at his stations increase. If all competitors are competing on prices with differentiated products, the products are strategic complements, and the best response of other firms in the market is to raise prices as well.

It is possible to test if the five cent increase in price is the result of an increase in concentration in markets affected by the Thrifty purchase by ARCO. The stations in the treatment group (those who competed with a Thrifty that was converted to an ARCO of any contract type) can be divided into two groups: those that experienced an increase in local market concentration, and those that did not have an increase in market concentration as a result of the Thrifty puchase by ARCO. Approximately one third of the stations in the treatment group experienced an increase in concentration as a result of the Thrifty purchase. These stations were either ARCO stations themselves, or had an ARCO competitor (without a price observation) less than a mile away.[22] These stations experienced a decrease in independent market share and an increase in brand concentration at the same time.

Dividing the treatment group into two categories: i) stations in markets that experienced an increase in concentration, and ii) stations in markets with no increase in concentration as a result of the Thrifty conversions, we can determine how much of the 5 cent coefficient on Independent in Table V is attributable to a change in concentration.

Table VII: Fixed-Effects Estimation, Independent coefficient by concentration effects
Dependent Variable: Retail Price for Regular Unleaded

Variable	Parameter Estimate	P-Value
Intercept	1.3617	0.0001
	(0.0288)	
Company Operated	-0.0002	0.9851
	(0.0119)	
Independent: Concentration Increased	-0.0468	0.0001
	(0.0105)	
Independent: Concentration Stayed the Same	-0.0454	0.0004
	(0.0127)	
LA*February	0.0181	0.0001
	(0.0037)	
LA*June	0.0244	0.0001
	(0.0036)	
LA*October	0.1390	0.0001
	(0.0036)	
SD*February	-0.0854	0.0001
	0.0066	
SD*June	-0.0295	0.0001
	(0.0065)	
SD*October	0.0542	0.0001
	(0.0064)	
Adj. R-Square		0.7167

*Standard errors in parentheses

[22] Recall that prices are only available for a sample of the stations. Hence an ARCO competitor may be present in the Census of gasoline stations, but not in the sample with price observations. For example, suppose that there are price observations on two Chevron stations. Each one is located within a mile of a Thrifty, so both are in the treatment group. The first Chevron has a Shell station near by, and the second Chevron has an ARCO near by. When the Thrifty was converted to an ARCO, the both stations had a decrease in independent competitors. However, the second Chevron also experienced an increase in market concentration, while the first Chevron did not . Both of the second Chevron's competitors are now ARCO stations. Hence the second Chevron experienced both the loss of an independent competitor, and an increase in market concentration.

Table VII reports that the coefficient on Independent does not significantly differ by resulting market concentration. This result does not support the hypothesis that the 5 cent increase in prices at stations affected by the Thrifty purchase was caused by an increase in market concentration.[23] Therefore, all of the price change is indeed attributable to a decrease in independent market share.

C. Hedonic Brand Value

A third possible explanation for the paper's main empirical result is a model of price competition in a differentiated products market with hedonic values for various brands of gasoline. Suppose that there are two stations that compete on price with differentiated products.

Let each station's demand be linear function of its own price and its competitor's price:

$$q_i = a_i - bp_i + d_i p_j \tag{4}$$

Then firm *i* maximizes profits given by $\pi_i = (p_i - c_i)q_i$, which yields the following reaction functions and optimal prices:

$$R_i(p_j) = \frac{1}{2b}(a_i + d_i p_j + bc_i) \tag{5}$$

$$p_i{*} = \frac{1}{4b^2 - d_i d_j}\left[2b(a_i + bc_i) + d_i(a_j + bc_j)\right] \tag{6}$$

Without loss of generality, assume that firm 1 is the competitor station whose price observation increases by an average of 5 cents when firm 2 changes from an independent unbranded station to a branded station of any contractual form. Then the addition of a brand name gasoline at firm 2 can be modeled an increase in a_2. Both firms' profit maximizing prices are increasing in a_2, so the result of branding the unbranded station will be an increase in market equilibrium prices. In particular, for firm one,

$$\frac{\partial p_1}{\partial a_2} = \frac{d_1}{4b^2 - d_1 d_2} > 0 \tag{7}$$

[23] It may be the case that there was a market-wide increase in prices in Los Angeles and San Diego due to an increase in concentration that affected both the treatment and control groups. The 5cent coefficient is determined independently of any market-wide effect.

This increase in price is supported by the main empirical results in the paper. Further empirical evidence consistent with this model is found by dividing the treatment group into brand categories[24]:

- High brand: Treatment station is a Chevron or Shell station
- Mid-brand: Treatment station is an Exxon, Mobil, Texaco, or Unocal station
- Low brand: Treatment station is a Beacon, Circle K, Citgo, Conoco, or Ultramar station

The brands are grouped in categories, since there are not enough stations in the treatment group for some of the brands to allow for precise estimation of the effects of Independents on stations of that brand. For some brands with larger representation, such as Chevron and Shell, or Texaco and Mobil, their coefficients are similar when included separately, however, grouping them improves the precision of the estimates. In addition, the percent of each brand present in the treatment group approximately reflects the percent of each brand in the station population, adding evidence that the Thrifty chain was fairly evenly distributed among different brand competitors.

Suppose that the degree of substitution between a station and any competitor, d_1, is largest for the low brands and smallest for the high brand. For example, consumers of low brands may be less loyal to those brands than are consumers of high brands. Then when firm 2 brands its gasoline, the resulting increase in the competitor station's price will be largest for low brands and smallest for high brands since:

$$\frac{\partial^2 p_1*}{\partial a_2 \partial d_1} = \frac{4b^2}{4b^2 - d_1 d_2} > 0 \qquad (8)$$

Empirical support for this result is presented in Table VIII below, where the treatment group is divided into four groups: the effect of an Independent on stations in High brand, Middle brand, Low brand, and ARCO categories.

An F test shows that the coefficient on High Brands is significantly lower in absolute value than the coefficient on Low Brands, with an F value of 4.13, which is significant at the 5 percent level. However the coefficient on Low Brands is not statistically different from the coefficient on Middle Brands, nor is the coefficient on Middle Brands significantly different from the coefficient on High Brands. However, the patterns lend some further evidence supporting the

[24] These brand categories also roughly follow market presence. Chevron and Shell each have 15-20% of the stations in each metropolitan area. Low brands have only a handful of stations, and the middle brands have market shares of 5-11%.

hedonic model of brand value since the spot estimate of the effect of an independent station on a competitor's price decreases in absolute value for stations with higher brand status.

It is important to note that, even though consumers have a hedonic value for ARCO's brand in this model, customers purchasing at the competitor stations are strictly worse off. The type of gasoline sold, and all other station amenities, at the competitor stations remained the same, yet their prices increased by an average of 5 cents a gallon when the independent was rebranded as an ARCO. This suggests a welfare loss resulting from the loss of independent stations in Southern California.

Table VIII: Fixed-Effects Estimation, Independent coefficient by Brand Group
Dependent Variable: Retail Price for Regular Unleaded (Standard Errors in Parentheses)

Variable	Parameter Estimate	P-Value
Intercept	1.3622	0.0001
	(0.0287)	
Company Operated	-0.0018	0.8842
	(0.0124)	
Independent: High Brands	-0.0304	0.0168
	(0.0127)	
Independent: Middle Brands	-0.0447	0.0018
	(0.0143)	
Independent: Low Brands	-0.0707	0.0001
	(0.0185)	
Independent: ARCO	-0.0743	0.0001
	(0.0149)	
LA*February	0.0185	0.0001
	(0.0037)	
LA*June	0.0249	0.0001
	(0.0036)	
LA*October	0.1390	0.0001
	(0.0036)	
SD*February	-0.0854	0.0001
	0.0066	
SD*June	-0.0303	0.0001
	(0.0065)	
SD*October	0.0542	0.0001
	(0.0064)	
Adj. R-Square		0.7183

VIII. Conclusions

This study used exogenous shocks to a panel of retail stations in Los Angeles and San Diego to determine and differentiate between the effects of the market share of company-op stations and independent stations on retail prices. The research design based on the conversions of independent Thrifty stations to ARCO stations and unique, detailed station-level data allow for convincing estimation of these effects. The analysis does not find support for Divorcement legislation. An increase in company-op stations in a market does not lead to an increase in the retail price level relative to unaffected markets. However, the loss of an independent station does have a significant positive impact on the retail price. This finding is logical. Independent retailers are the only retailers that can purchase gasoline from the lowest price wholesaler, and they are also the only stations that can completely determine their retail price independently of the upstream refiner. Even though lessee dealers and branded dealers can set the retail price, because the branded refiner can set the wholesale price (specific to the station in the case of the lessee dealer) they effectively set the lowest retail price that the station can charge. In the case of the lessee dealer, the refiner can set the lease rate, a volume discount, and the station-specific dealer tank-wagon price. These may be sufficient tools for retail price setting, as is evidenced in Shepard (1993). The independent station is the only type of station that can purchase gasoline from any refiner and independently set its retail markup, thus increasing competition at the wholesale and retail levels. These results have important implications for legislation aimed at lowering retail gasoline prices through the regulation of refiner-retailer contracts.

The research design and detailed data also allowed for inference on the underlying structure of retail price competition. Results indicate that independent competitors have a significant negative impact on retail prices. The results are consistent with a hedonic brand value in a differentiated products market where firms compete on price. When independents are replaced by branded integrated stations, competitors respond by increasing prices. This suggests that the loss of independent retailers resulted in a loss to consumer welfare

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Appendix A: Retail Market Definitions

The variance components estimation indicates that there is significant variation in retail gasoline prices within sub-city regions. This implies that competition occurs between stations in smaller geographic regions with in each sub-city. Retail dealers and refiners state that these competition groups have quite narrow geographic definitions. The one mile definition of competition groups was adopted for the main results presented in the paper, and this section explores how these results are affected by changes in this definition, and what this implies for competition in retail markets. A rigorous economic exploration of the determinants of retail gasoline market definitions is the topic of further research.

Dealers state that geographic competition is fairly narrowly defined. Although there is some spill-over, dealers claim that they compete mostly with stations within a mile. "Compete with" in this case means that if the competitor lowers his price, for example, by three cents a gallon, then the dealer will notice a drop in his volume demanded. This definition is further reinforced by the fact that stations of the same brand are located more than a mile apart (see Graph III). Even along the same street, it is fairly common to find stations of the same brand, but they are almost always at least a mile apart. In addition, many contracts between branded dealers and branded refiners stipulate that the refiner will not brand another station within one mile of that dealer's location.[25]

In order to illustrate the relationships between competition intensity and station location, Fullerton is used as a representative sub-city in the Los Angeles metropolitan area. Graph II shows a map of this example. The stations with price observations are labeled on the example map. These comprise roughly 25 percent of the stations in this area. In Fullerton, the Beacon station, and the ARCO and Chevron stations are included in the treatment group, since they are within a mile away from the Thrifty station that was converted to an ARCO station. Applying this definition to the whole sample of stations in Los Angeles and San Diego yields the results presented earlier in the paper.

Suppose that the definitions are broadened by half a mile so that the stations compete with any station within one-and-a-half miles. This definition will now include more stations in the

[25] Barron and Umbeck (1984) ask refiners to list stations that they believe compete with stations in their data sample. The refiners list 3-4 stations as competitors for each station, and the authors use these groups as market definitions. Again, the market is defined narrowly: 3-4 stations usually fall within a mile of eachother. Also, Virginia's divorcement legislation required that a one and a half mile distance between any new company-op station and an existing dealer.

treatment group: stations that competed with an independent station that became a branded station of any contractual type. This now implies that ARCO station at 401 N. Placentia Avenue is in the treatment group. When this geographic definition change is applied to the whole sample of stations in the Los Angeles and San Diego metropolitan areas, the results of the paper are not significantly affected.

Table A.I: Fixed-Effect Estimation with Market Definition at One and a Half Miles
Dependent Variable: Retail Price for Regular Unleaded Gasoline

Variable	Parameter Estimate	T-Statistic	Standard Deviation	P-Value
Intercept	1.3599	47.5736	0.0285	0.0001
Company Operated	0.0023	0.2306	0.0102	0.8176
Independent	-0.0444	5.5611	0.0087	0.0001
LA*February	0.0180	8.5576	0.0036	0.0001
LA*June	0.0243	4.9583	0.0036	0.0001
LA*October	0.1389	39.0635	0.0035	0.0001
SD*February	-0.08512	-13.037	0.0066	0.0001
SD*June	-0.0304	-4.6878	0.0065	0.0001
SD*October	0.0545	8.5576	0.0063	0.0001
Adjusted R-Square				0.7201
F-Test for No Fixed Effects:				
Numerator DF: 668				
Denominator DF: 1999				
F value: 3.2855				Prob. > F: 0.000
Hausman's M Value: 622.2957				Prob. > M: 0.000

Further increasing the scope of competition would expand the bounds of geographic competition to 2 miles along streets and cross streets. In the Fullerton example, the treatment group is unchanged, since there are no stations that are further than 1.5 miles, but closer than 2 miles. Other markets are affected by this change, however. If this definition is applied to the whole sample, then the estimate of the effect of an independent competitor on a station's own price drops to –3.61 cents per gallon, indicating that adding these stations brings the mean change in price of the treatment group closer to that of the control group. This estimate is significantly different that the initial estimate of –5 cents at the 95% confidence level. This indicates that including these station lowers the average treatment effect, however the coefficient on Independent is still relatively large and significantly different than zero. Even if market definitions are increased by 100% of the industry definition, the result is still significant.

Table A.II: Fixed-Effect Estimation with Market Definition Two Miles
Dependent Variable: Retail Price for Regular Unleaded Gasoline

Variable	Parameter Estimate	T-Statistic	Standard Deviation	P-Value
Intercept	1.3787	47.537	0.0290	0.0001
Company Operated	-0.0071	-0.7709	0.0092	0.4408
Independent	-0.0361	-4.4406	0.0081	0.0001
LA*February	0.0194	5.1504	0.0037	0.0001
LA*June	0.0256	6.8631	0.0037	0.0001
LA*October	0.1389	38.886	0.0035	0.0001
SD*February	-0.0827	-12.2679	0.0067	0.0001
SD*June	-0.0288	-4.3585	0.0066	0.0001
SD*October	0.0545	8.5188	0.0064	0.0001
Adjusted R-Square				0.7155
F-Test for No Fixed Effects:				
Numerator DF: 668				
Denominator DF: 1999				
F value: 3.2054				Prob. > F: 0.000
Hausuman's M Value: 629.1963				Prob. > M: 0.000

One more increase can be made before reaching the sub-city level. The final group increases the market definitions out to 3 miles along streets. Industry evidence suggests that stations in such a large geographic range do not compete directly with each other. There are geographically differentiated markets within this range, and therefore the treatment group will include stations that did not directly compete with the affected Thrifty stations. In the Fullerton example, the Shell and station will now be included in the treatment group. Applying this definition to the entire sample lowers the average treatment effect further, however it is still significantly different than zero.

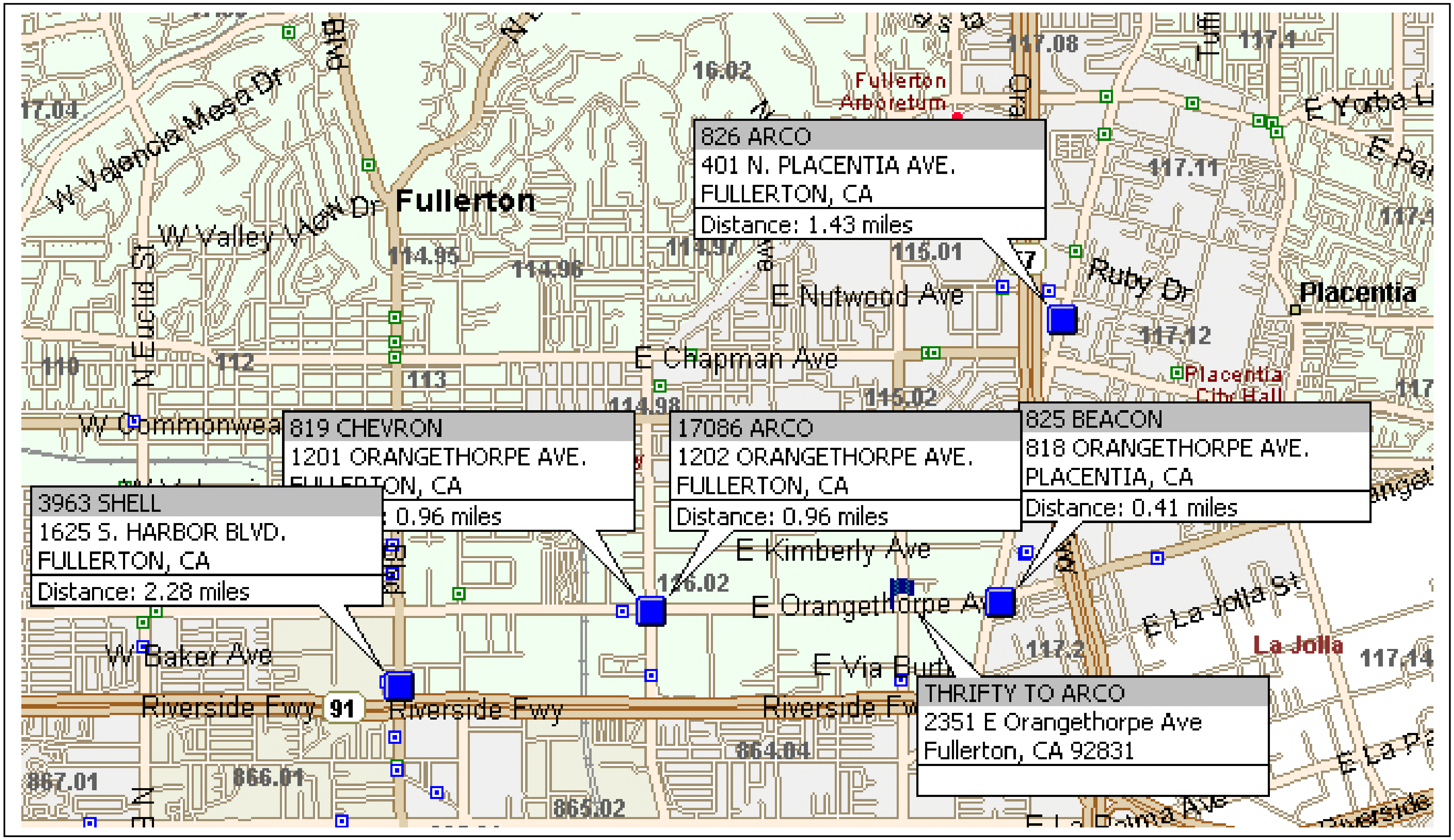
Table A.III: Fixed-Effect Estimation with Market Definition Three Miles
Dependent Variable: Retail Price for Regular Unleaded Gasoline

Variable	Parameter Estimate	T-Statistic	Standard Deviation	P-Value
Intercept	1.3729	47.1558	0.0290	0.0001
Company Operated	-0.0008	-0.1022	0.0092	0.9186
Independent	-0.0220	-2.8844	0.0081	0.0040
LA*February	0.0179	4.7027	0.0037	0.0001
LA*June	0.0244	6.4533	0.0037	0.0001
LA*October	0.1389	38.6995	0.0035	0.0001
SD*February	-0.0851	-12.3840	0.0067	0.0001
SD*June	-0.0309	-4.6131	0.0066	0.0001
SD*October	0.0545	8.4778	0.0064	0.0001
Adjusted R-Square				0.7181
F-Test for No Fixed Effects:				
Numerator DF: 668				
Denominator DF: 1999				
F value: 3.262				Prob. > F: 0.000
Hausman's M Value: 622.2957				Prob. > M: 0.000

Past three miles, the competition groups are equivalent to the sub-city definition used in the variance of components estimation presented earlier, for most sub-cities in the sample. In fact, in the case of Fullerton, the 3 mile definition includes all but one of the price observation stations in the sub-city sample. At the next level, the sub-city level, there is a significant variation that is not being controlled for. There is significant evidence that the first definition is the correct model of local competition, however increasing this definition by 50% does not significantly change the results.

Graph III: Map of Thrifty Stations in Los Angeles Metropolitan Area. Squares with flags denote a Thrifty Station

Graph IV: Sample Thrifty Conversion in Fullerton. The flag denotes a Thrifty station that was converted to an ARCO station. The boxes mark the locations of stations with price observations.



Graph V: Sample of stations in La Habra, California in the Los Angeles Metropolitan Area
Census Data from La Habra shows the distance between stations of the same brand.
1 mile =