Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California

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Since the late 1990's, 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 10 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 5 to 15 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. Many have drawn a causal inference from this correlation, arguing that a larger market share of vertically integrated stations lessens retail competition since refiners, not residual claimants, directly set the retail price. As a result, many state and local legislatures have considered regulating vertical contracts between refiners and their retail stations in an effort to increase competition and lower gasoline prices.[3]

However, the increases in vertically integrated (company-op) stations in cities experiencing higher citywide average prices have come from a decrease in independent retailers. Integrated refiners have purchased independent retailers, converting the stations to both integrated company-op and franchise stations.[4] The decrease in the number of independent unbranded retailers offers a competing explanation for increased prices. Independent stations typically compete on price with little nonprice product differentiation. These stations are completely independent from the refiner in that the gasoline dealer owns the station, and sells "unbranded" gasoline that can be purchased from any supplier. The unbranded station typically competes with other stations by offering the lowest price gasoline. When these stations are replaced by branded integrated stations (or exit the market), price competition in the market

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[1] Source: Energy Information Administration, and California Energy Commission.

[2] Midwest and East Coast markets 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 has become a national issue.

[3] This type of regulation is typically called Divorcement legislation, and has been considered in most West Coast cities and states. Divorcement legislation prohibits or restricts the number of stations that a refiner can own and operate directly. Divorcement would require refiners to convert their company-op stations to lessee-dealer or open-dealer stations, where the dealer sets the retail price, under the assumption that this would result in a lower, more "competitive" retail price.

[4] 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.

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" and conversion of approximately 260 independent Thrifty gasoline stations to ARCO (Atlantic Richfield Company) stations provides a "quasi-experiment" for testing the effects of removing an independent on a nearby competitor's price. The station conversions differentially affected local markets within the Los Angeles and San Diego metropolitan areas, allowing for a pre-post comparison between affected and unaffected markets.

The independent Thrifty stations were converted to both company-op and dealer-run ARCO stations, allowing for the identification of the effects of independent retailers on local prices, while controlling for the effects of changes in the market share of company-ops. 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 if an increase in the market share of company-ops had any further impact on prices.

To implement this approach, the analysis uses a 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 and city-time effects in the regression analysis—controlling for many potentially confounding unobserved factors. 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 not dependent on whether the new ARCO station was company-operated or not, indicating that local price increases can be attributed to the loss of an independent, unbranded competitor.

In addition to providing a credible approach to identifying the effects of independents on retail prices, the research design is used to examine underlying structure of retail gasoline demand and competition. The empirical results support a model of price competition with differentiated products and consumer brand loyalty.

I. 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.[5]

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). 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 that station.[6] 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 and must buy branded gasoline from that refiner either directly or through an intermediate supplier called a "jobber." A jobber purchases gasoline at the distribution rack and pays a wholesale price called the rack price. The rack price is the same for any jobber purchasing at that rack.

The above three types of stations sell branded gasoline. For example, a typical Shell station

[5] 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.

[6] This wholesale price is called the Dealer Tankwagon price (DTW).

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, RaceTrac, 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.[7] 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 contract terms and wholesale prices, the independent retailer can shop for the lowest wholesale price from any refiner at any distribution rack and separately determine the retail margin.

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 is replaced by a branded station of any vertical contract type? In a model of price competition with differentiated products, the predicted price effect of an independent retailer becoming a branded station, all else equal, depends on the assumptions placed on consumer preferences, and thus how the change will affect the station's demand, own- and cross-price elasticities. The research design based on the purchase and branding of the independent Thrifty stations by ARCO provides an opportunity to estimate the effects of independent retailers on local competitor's prices without requiring, a priori, the structural specification of retail demand and competition.

The effect of independent marketers on retail price levels has not been carefully examined in the empirical 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, and the trade-off between double marginalization and principal-agent problems (Andrea Shepard, 1993; Patrick Rey and Joseph E. Stiglitz, 1995; and Margaret Slade, 1998). The two papers that have mentioned the competitive effects of independent marketers are Slade (1986) and Janet S. Netz and Beck A. Taylor (2002). Slade (1986) estimates price elasticities and conjectural variations using price and quantity data for 13 service stations in Vancouver, BC, during the summer of 1983. She notes that, of the 13 retailers, the independent retailers initiate price cuts, while the major integrated stations lead price restorations. Netz and Taylor (2002) examine spatial differentiation and location patterns for retail stations in Southern California. They find a positive correlation between the local market share of independents and the amount of spatial differentiation between stations. They interpret this result to mean that independents increase price competition more than branded stations do, and therefore, branded stations have an incentive to maximize spatial product differentiation in the presence of independents in order to minimize price competition.

The research design used in this analysis will allow us to credibly identify the causal relationship between the market share of independent retailers and local retail prices. The discrete and differential changes in the market share of independents resulting from the station conversions allow for the inclusion of station-level fixed effects and city-time effects, controlling for any potentially confounding factors at the station-level and the city-level over time that may bias cross-sectional or time-series estimates.

II. 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.[8] The announcement was followed

[7] 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.

[8] 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 rebranded 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.

by a 60-day waiting period, after which ARCO assumed control of and branded the Thrifty stations.[9] Thrifty Oil Company was the largest independent chain of retail gasoline stations in Southern California with approximately 260 stations ranging from San Diego past 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 decrease in independent retailers as well as the increase in company-ops in Los Angeles and San Diego during the 1990's.

After the 60-day waiting period, ARCO branded the Thrifty stations and completed the branding by September 1997. ARCO branded the stations, meaning that they simply changed the station colors and added ARCO gasoline signs to the Thrifties, 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*

Ideally, to test the effects of independent market share and company-op market share on retail prices, the researcher would randomly reassign station ownership and 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 independents and company-ops 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 provided by the Thrifty purchase to dramatically reduce the omitted variables bias problem in estimating the effects of 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.

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. The gasoline stations are grouped into local submarkets of stations in direct competition with each other.[10] Some stations competed with a Thrifty, and some were not located near any Thrifty station. Therefore, the "treatment" effect of a discrete change in whether a competitor is an independent differentially affects stations in the sample. These discrete and differential changes provide for pre-post comparisons across affected and unaffected markets for identifying the effect of independents and company-ops on prices, conditioned on station-level fixed effects and city-time effects.

Because the Thrifty stations were geographically dispersed and their locations and characteristics where predetermined to ARCO's acquisition decision, 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.[11,12] In addition, the Thrifty

All information about the lease was obtained by conversations with ARCO and Thrifty Oil Company officials, and from press releases from ARCO.

[9] 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.

[10] The analysis uses geographic proximity to determine local markets. The markets definition is described in Section IV, subsection B, and in greater detail in Appendix A (available from the author upon request). Results are tested to ensure that they are not driven by market definitions.

[11] In addition to being geographically dispersed, the percent of each brand present in the treatment group (stations that competed with a Thrifty) 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.

[12] The data only include price observations on five of the Thrifty stations, so we use price data on local competitors to estimate the effect of the Thrifty station conversions on local market prices.

stations were simply branded as 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.[13]

We can also use this research design to test if an increase in the market share of company-operated stations has an effect on local prices. However, even though the locations 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 were 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. This potential endogeneity problem is discussed further in Section III.

III. 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 20 percent 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.[14] Table 1 provides summary statistics for the station price samples used in this analysis. The same stations were sampled in all of the four months used in this analysis.

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 one mile along a surface street or freeway. Therefore, a station with a price observation competes with a Thrifty if there is a Thrifty located within one mile. Although many people in Southern California commute, 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.[15]

[13] This assumes that the Thrifties are representative of typical unbranded gasoline stations, which is a reasonable assumption based on station characteristics and retail prices across independent gasoline retailers.

[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. The sample of stations is described as a random sample of stations from the census population. However, independent retailers and minor-brand integrated stations (those with less than 5-percent market share) are significantly undersampled. The representation of the major refiner brands appear to be consistent with a random sample. The major refiners are the primary purchasers of these data reports.

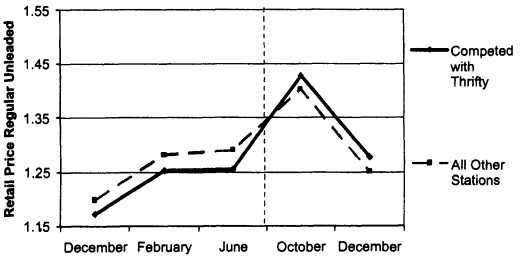
[15] The results from the perturbations in the definition of the local competitive market are printed in an Appendix,

TABLE 1—SUMMARY STATISTICS OF RETAIL PRICE SAMPLE

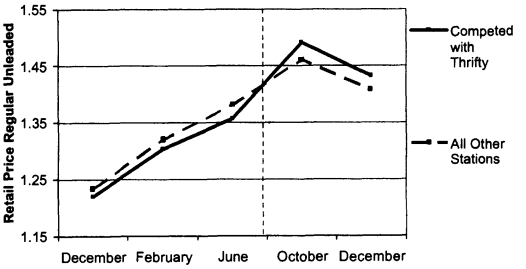
Panel A		
Percent of stations in sample	Los Angeles	San Diego
ARCO	19.41	13.21
Chevron	17.84	17.61
Mobil	15.88	13.21
Shell	14.12	17.61
Texaco	8.43	12.58
Unocal	12.55	11.95
Minor brands	5.25	8.18
Independents	6.52	5.66
Number of observations	$N = 510$	$N = 159$

Panel B		
Average price (Standard deviation)	Los Angeles	San Diego
February, 1997	1.273	1.320
	(0.060)	(0.035)
June, 1997	1.285	1.375
	(0.068)	(0.049)
October, 1997	1.405	1.468
	(0.070)	(0.056)
December, 1997	1.266	1.414
	(0.073)	(0.0610)

Notes: Number of stations in retail price sample: 669. Number of stations that competed with a Thrifty: 99. Number of stations that competed with a Thrifty that became a company-op ARCO: 64.



(a) LOS ANGELES



(b) SAN DIEGO

FIGURE 1. TREATMENT AND CONTROL GRAPHS FOR LOS ANGELES AND SAN DIEGO

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 one mile.[16] 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 not brand another station within one mile of that dealer's location.

available from the author upon request. 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.

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

IV. Results

A. *Graphical Analysis*

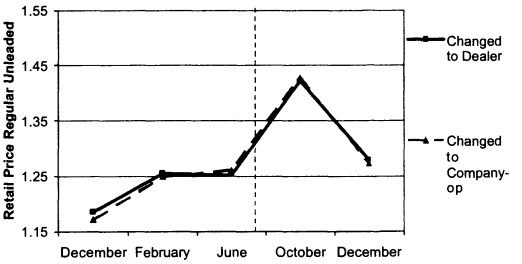
Figure 1(a) and (b) provide a rough estimate of the impact of independent retailers on competitors' prices. These two plots present the average price level in each time period for stations that were affected by a Thrifty conversion, and thus lost an independent competitor, versus the average price level at stations that were unaffected by the conversions. These panels 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 panel, the preconversion trends of the two averages are identical. The preconversion and postconversion 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.[17] Based on this graphical analysis, the stations that competed with an independent Thrifty had roughly a 2- to 3-cent lower average price than other stations before the conversion. After the conversions, these stations had about a 2- to 3-cent higher average price than other stations. These graphs provide preliminary evidence that presence of an independent competitor is associated with a 4- to 6-cent lower local market price.

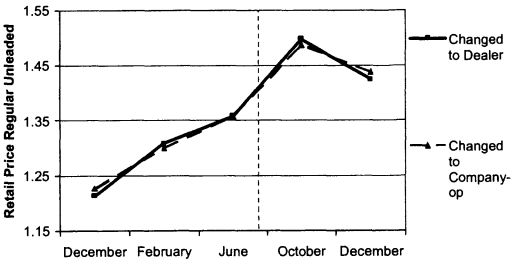
If the stations in the treatment group (stations that competed with a Thrifty) are divided into two groups: (i) stations that now compete with a company-op station, and (ii) those that now compete with a dealer, a similar graphical analysis can be performed. This provides a rough estimate of the impact of an increase in company-ops on local market prices. Figure 2(a) and (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 panels show no apparent difference in the price behavior between stations in markets with an increase in the share of company-op ARCO's and those with an increase in the share of dealer-run ARCO's.

Notice that, within each metropolitan area, the preconversion and postconversion levels and trends are very similar between the two groups. 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 panels imply that an increase in company-ops does not have a significant effect on local retail prices. The four panels together lend preliminary support to the hypothesis that local price increases can be attributed to the loss of independent competitors.

[17] 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 figure. In the regression, they have the appropriate timing. These panels show the majority of the affected stations—those that were converted between the June and October price and volume observations.



(a) LOS ANGELES



(b) SAN DIEGO

FIGURE 2. CHANGE TO COMPANY-OP VS. CHANGE TO DEALER-RUN

B. *Fixed-Effects Estimation*

The research design allows for inclusion of station-level fixed effects as well as city-time effects. The fixed-effect estimator is the only consistent estimator when the expected value of the station-specific error component, conditioned on observables, differs across stations. This is true if the locations of independent stations are correlated with an unobservable local market characteristic that also influences price. This correlation leads to heterogeneity bias in the estimate of the effects of independents in a cross-section regression or random-effects error component specification.

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 citywide 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.

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[18]
c_{it} = indicator for if a competitor becomes a company operated station
ε_{it} = error term.

Table 2 presents results from the fixed-effects analysis. 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.[19]

TABLE 2—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)
Adjusted R^2	0.3772	0.3953	0.7181
F-test for no fixed effects:			
Numerator DF: 668			
Denominator DF: 1,999			
F-value: 3.262			Prob. > F: 0.000
Hausman test for random effects:			Prob. > M: 0.000
Hausman's M value: 622.296			

Note: Standard errors are in parentheses.

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 marketwide 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

[18] 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. This is because there were no other changes in market structure, aside from the Thrifty station conversions, in the station-time markets considered in this analysis. 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 produce 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.

[19] Hausman's m value is $m = q' \text{Var}(q)^{-1} q$, where $q = \beta_{FE} - \beta_{RE}$ and $\text{Var}(q) = \text{Var}(\beta_{FE}) - \text{Var}(\beta_{RE})$. 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.

marketwide increase in prices in Figure 1. Column (3) includes the city-time dummies, and the coefficient on Independent is approximately the same as was implied by Figure 1. 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.[20] 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, 5 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.

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.

However, as stated in Section III, because ARCO assigned the new contract type, there is a potential for endogeneity bias at the *station*time* level. To further address the potential endogeneity, 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 significant determinants of the dealer-run contract choice were (i) there was another ARCO dealer within a mile, and (ii) the existing Thrifty dealer accepted credit cards.[21] The fitted value for Company-op from a probit of Company-op on the timing of purchase interacted with an indicator if there was an ARCO dealer already present within a mile was used as an instrument for Company-op. The point estimate for Company-op does not change significantly in the instrumental variables regression; however, the instrument is weak, leading to large standard errors and a weak test for endogeneity.[22]

In summary, the results indicate that the presence of independent retailers leads to lower local retail prices. When these independent retailers are replaced with branded retailers, either company operated or dealer operated, local prices increase.

V. Testing Potential Causes for Price Increase

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. This research design can be used to distinguish between the possible underlying market mechanisms that lead to the estimated price effects of independent competitors.

Gasoline stations are differentiated along many dimensions: brand, location, and amenities such as car washes, number of pumps, etc. The Thrifty station conversions essentially change the identity of a competitor along a single dimension, holding all other characteristics constant. This event allows us to examine how profit-maximizing competitors react if we were to take a product and change its location in the "brand characteristics" space, all else equal. We can use the reactions of competitors to this change to better understand underlying model of consumer preferences, demand, and competition in retail gasoline.

In a differentiated products market, when a

[20] This estimate is the same if the coefficient on Independent is estimated by city. In other words, the coefficient on Independent for treatment stations in San Diego is statistically the same as the coefficient on Independent for treatment stations in Los Angeles.

[21] Dealer contracts generally stipulate that the refiner will not brand another station within a mile of an existing dealer. If there was an existing ARCO dealer within a mile of the Thrifty, ARCO would have an incentive to make this a dealer franchise instead of a company-op, in order to lessen potential protests from the existing dealer.

[22] In addition, when the residuals from the first-stage regression are included in the original fixed-effects regression, the coefficient is near zero and statistically insignificant. The results from the probit and instrumental variables estimations are in an Appendix available from the author upon request.

competitor's identity changes, prices can go up or down. The result depends on consumer preferences and substitution patterns.[23] For example, suppose that all consumers have a preference for quality over brands. Each brand is associated with a quality of gasoline, and the taste parameters over gasoline brands are independently and identically distributed. When an unbranded station is replaced with a branded station, the station has now become a closer substitute to other branded stations. Competition will intensity, causing prices to fall.

Alternatively, prices could rise if preferences are characterized by heterogeneous consumer types with correlated preferences over gasoline brands and prices. An example of this preference structure is brand loyalty. Suppose that there are heterogeneous consumer types—a segment of consumers for each brand who value that particular brand over all other gasoline brands, and a segment of consumers who believe that gasoline is a homogeneous product. Then under price competition, each firm's optimal price is increasing in the share of its brand-loyal customers, and its competitor's share of brand-loyal customers, and decreasing in the share of non-brand-loyal consumers.[24]

With these preferences, when an independent station is replaced by a branded station, equilibrium prices will increase. In addition, when an independent station is replaced with a branded station, price will increase most at stations that were close competitors to the independent (stations with low share of brand-loyal customers), and least at stations that were further substitutes to the independent (those with a high share of brand-loyal consumers).

Hence, we can further examine the potential underlying demand structure by dividing the stations in the treatment group into the following categories:

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

These categories are based on the brand's total market share of stations, and the estimated price effect of independents on stations of that brand. ARCO stations in the treatment group are grouped separately, since the Thrifties were converted to ARCO stations, causing a contemporaneous decrease in the number of competitors.[25]

Table 3 presents results from the fixed-effects regression where the treatment group is divided into four groups: the effect of an Independent on stations in High-share, Middle-share, Low-share, and ARCO categories. 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 each brand. For the brands included within each group, the coefficients are similar when they are included separately, but grouping them improves the precision of the estimates by increasing the number of observations in each cell.[26]

Column (1) presents results solely by brand category. An F-test rejects the restricted specification of a single coefficient on Independent in favor of the specification where Independent varies by brand category with a P value of 0.0101. The coefficient on Independent · High-share is significantly lower in absolute value

[23] See Simon P. Anderson et al., 1992.

[24] See Paul Klemperer (1987). Brand loyalty is mathematically equivalent to his model of switching costs.

[25] These brand categories also roughly follow market presence. Chevron, Shell, and Unocal each have 13–16 percent of the stations in each metropolitan area. Low brands have only a handful of stations with less than a 4-percent station market share each. Texaco has a medium market share of about 9 percent. Mobil, however, has a large market share with 14 percent, so its market share is more similar to Chevron, Shell, or Unocal's. It was grouped with Texaco, since the spot estimate on the increase at Mobil stations in response to the Thrifty station exit was the same as the price response at Texaco stations, and larger in value than the price response at Chevron, Shell, or Unocal stations. Market share may serve as an indicator of brand loyalty since a large number of stations would increase the returns to advertising, and may increase the probability that consumers would adopt a brand-specific credit card for their gasoline purchases.

[26] 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.

TABLE 3—FIXED-EFFECTS ESTIMATION, INDEPENDENT COEFFICIENT BY BRAND GROUP

Dependent variable: Retail price for regular unleaded
(Standard errors are in parentheses)

Variable	(1) Parameter estimate	(2) Parameter estimate
Intercept	1.3622	1.3620
	(0.0287)	(0.0287)
Company operated	−0.0018	−0.0008
	(0.0124)	(0.0124)
Independent · High-share brands	−0.0273	−0.0362
	(0.0125)	(0.0156)
Independent · Middle-share brands	−0.0530	−0.0617
	(0.0154)	(0.0179)
Independent · Low-share brands	−0.0700	−0.0741
	(0.0185)	(0.0190)
Independent · ARCO	−0.0731	−0.0741
	(0.0149)	(0.0149)
Independent · *N*-decreased	—	0.0130
		(0.0136)
City-time effects	Yes	Yes
Adjusted R^2	0.7183	0.7187

than the coefficient on Independent · Low-share brands at the 5-percent significance level. However the coefficient on Independent · Low-share is not statistically different from the coefficient on Independent · Middle-share, and the coefficient on Independent · Middle-share is just significantly different at the 10-percent level from the coefficient on Independent · High-share. The patterns lend some further evidence supporting a model of product differentiation with brand loyalty since the spot estimates are consistent with the hypothesis that stations with low market share (and hence a low share of brand-loyal customers) compete more intensely with unbranded stations for nonloyal customers than do stations with high market share and high brand loyalty.[27]

The coefficient on Independent · ARCO is as large as the coefficient on Independent · Low-share. This may be because these stations experienced a decrease in the number of local competitors, or because ARCO has low brand-loyal share of consumers, and is therefore a close substitute to unbranded gasoline. Column (2) further tests if a decrease in the number of competitors affected price increases at the non-ARCO stations in the treatment group. The coefficient on Independent · *N*-decreased tests if a decrease in the number of competitors, *N*, contributed to an additional increase in price after controlling for the station's brand.[28] The coefficients on High, Medium, and Low share in Column (2) are now the effects by brand category of a decrease in the market share of independents for markets with no other local ARCO competitor (markets with no decrease in *N*).[29] The coefficient on Independent · *N*-decreased is the added effect, pooled across all brands, of a decrease in *N* resulting from the merger. The coefficient on Independent · *N*-decreased is not significantly different from zero. In addition, the spot estimates on each brand category do not change significantly across Columns (1) and

[27] In addition, this specification of consumer preferences fits other facts in the data that are not discussed in detail here. For example, Chevron and Shell stations both have a brand that people value. If people have identical preferences across these two brands, we would expect that, all else equal, Chevron and Shell stations near each other would compete fairly intensely. However, they do not. They both charge high prices. This fact fits a model with heterogeneous consumer preferences such as brand loyalty. The research design with the Thrifty station conversions allows us to test this model, holding all other station characteristics constant.

[28] The treatment group can be divided into two groups: those that experienced a decrease in the number of local competitors, and those that did not experience a decrease. Approximately one-third of the stations in the treatment group fall into the first category. These stations were either ARCO stations themselves, or had an ARCO competitor (without a price observation) within a mile. 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 nearby, 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 a decrease in the number of competitors, 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 a decrease in the number of competitors.

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

(2)—the standard errors only increase since there are fewer observations in each cell.[30]

These results support the hypothesis that independent competitors decrease prices through increased price competition. When they are replaced with branded competitors, in a market with consumer brand loyalty, prices competition will be softened, and equilibrium prices will increase. Prices increase more at stations whose brand is less differentiated from other types of gasoline, and prices increase less at stations whose brand is more differentiated from other types of gasoline. Therefore, the identity of the competitors, and not just the number of competitors, is an important determinant of market concentration and firm conduct in retail gasoline.

VI. 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 independent stations and company-op stations on retail prices. The research design based on the conversions of independent Thrifty stations to ARCO stations coupled with detailed station-level data allow for credible estimation of these effects. The analysis shows that the presence of independent retailers acts to decrease local retail prices. This effect is separately identified from any potentially confounding covariates at the station level, or the city level over time. The analysis does not find evidence that increases in the market share of company-op stations leads to higher prices. These results have important implications for legislation aimed at lowering retail gasoline prices through the regulation of refiner-retailer contracts.

[30] The specification with brand share interacted with *N*-decreased was also run. This makes seven categories within the treatment group. There was no significant difference within each brand category between markets with a decrease in the number of competitors and markets where the number of competitors remained the same. The standard errors were very large, since the number of observations in each category was very small. The specification in Column (2) yields the same results while minimizing the number of categories needed to control for any change in the number of competitors.

The research design and detailed data also allowed for inference on the underlying structure of price competition in retail gasoline. The Thrifty station conversions provided a discrete change in the brand identity of a competitor, holding all other market characteristics constant, allowing for inference on the underlying model of consumer demand. The empirical results are not consistent with a demand structure where consumers' idiosyncratic preferences for branded gasoline that are independently and identically distributed across brands and across consumers does not fit the empirical results identified in this analysis. The empirical results are consistent with a model of differentiated products with consumer brand loyalty. This model predicts that, when independents are replaced by branded integrated stations, price competition in the market is softened, resulting in higher local market prices.

REFERENCES

Anderson, Simon P.; de Palma, André and Thisse, Jacques-François. *Discrete choice theory of product differentiation.* Cambridge, MA: MIT Press, 1992.

Klemperer, Paul. "The Competitiveness of Markets with Switching Costs." *RAND Journal of Economics,* Spring 1987, *18*(1), pp. 138–50.

Netz, Janet S. and Taylor, Beck A. "Maximum or Minimum Differentiation? Location Patterns of Retail Outlets." *Review of Economics and Statistics,* February 2002, *84*(1), pp. 162–75.

Rey, Patrick and Stiglitz, Joseph E. "The Role of Exclusive Territories in Producers' Competition." *RAND Journal of Economics,* Autumn 1995, *26*(3), pp. 431–51.

Shepard, Andrea. "Contractual Form, Retail Price, and Asset Characteristics." *RAND Journal of Economics,* Spring 1993, *24*(1), pp. 58–77.

Slade, Margaret E. "Conjectures, Firm Characteristics, and Market Structure: An Empirical Assessment." *International Journal of Industrial Organization,* December 1986, *4*(4), pp. 347–69.

_____. "Strategic Motives from Vertical Separation: Evidence from Retail Gasoline Markets." *Journal of Law, Economics, and Organization,* April 1998, *14*(1), pp. 84–113.