MARKET POWER, VERTICAL INTEGRATION AND THE WHOLESALE PRICE OF GASOLINE[*]

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This paper examines empirically the relationship between vertical integration and wholesale gasoline prices. We use discrete and differential changes in the extent of vertical integration generated by mergers in West Coast gasoline refining and retailing markets to test for incentives to raise rivals' costs. The research design allows us to test for a relationship between vertical integration and wholesale prices, controlling for horizontal market structure, cost shocks and trends. We find evidence consistent with the strategic incentive to raise competitors' input costs. This suggests that vertical integration can have a significant impact on wholesale prices.

I. INTRODUCTION

DURING THE WEEK OF JANUARY 4–8, 1999 the average wholesale price of unbranded regular gasoline was 46.30 cents per gallon in Los Angeles, California. About 110 miles away, in Bakersfield, California, the average price during the same week was about twelve cents higher, and in Houston, Texas, the price was about twelve cents lower.[1] This study examines the determinants of regional price differences at the wholesale level and specifically the consequences of vertical market structure for wholesale prices.

Regional differences in wholesale gasoline prices are often attributed to environmental regulations and market power. Environmental regulations require reformulated gasoline in regions that do not meet federal or state air quality standards, increasing the costs of gasoline production in these areas.[2]

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[1] Source: Wholesale Rack Data from Oil Price Information Service.
[2] For example, California requires the use of reformulated gasoline that meets the emissions specifications of the California Air Resources Board (CARB). During the period covered by this study, these regulations increased the cost of producing gasoline by an estimated 5–8 cents

However, there is substantial wholesale price variation within regions that require the use of reformulated gasoline.[3] This suggests that differences in production costs due to environmental regulations are not the primary cause of large wholesale price differences.

A second factor that may contribute to wholesale price variation is market power at the refinery level. Producers may have the ability to sustain price levels significantly above costs in markets where refining capacity is highly concentrated. However high levels of market concentration at the refinery level are not indicative of the ability to maintain significant wholesale price differentials if third parties could acquire gasoline in low-priced markets and sell the gasoline in markets with high prices.

The degree of vertical integration, measured by the share of retail outlets owned by gasoline refiners, is another dimension of market structure that may influence prices. Gasoline is produced by a refiner and then transported to a wholesale distribution center called a distribution terminal or rack. Independent retail stations purchase unbranded wholesale gasoline from the distribution rack. This wholesale gasoline may be supplied by either vertically integrated refiners (refiners who are integrated into retail gasoline) or unintegrated refiners (refiners who sell wholesale gasoline and do not have a retail component). Vertical integration creates a possible incentive for integrated suppliers to raise wholesale prices to competing retailers as a means to increase profits in downstream markets. In a market where upstream firms have market power and downstream products are strategic complements, an upstream firm may increase its retail profits by increasing wholesale input costs to unintegrated retail rivals.

To test for an effect of vertical market structure on wholesale prices through the incentive to raise rivals' costs, we use detailed data on company-specific wholesale gasoline prices for a panel of markets and a time interval spanning an event that generated variation in the degree of vertical integration into retail markets–the acquisition of Unocal's West Coast refining and marketing assets by Tosco Corporation. This transaction generated discrete and differential changes in Tosco's integration into thirteen West Coast metropolitan areas and provides a credible means to identify the impact of vertical integration on wholesale prices through the incentive to raise rivals' costs.

The discrete nature of the Tosco acquisition coupled with its differential impact on the cities in our data set allow us to control for other factors that might influence wholesale prices, such as intertemporal cost shocks, changes in horizontal market structure, the market share of independent retailers,

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per gallon compared to conventional gasoline that can be sold in many other parts of the country. (California Energy Commission, *http://www.energy.ca.gov/gasoline_q-and-a.html*.)

[3] For example, in the first week of September, 1999, the average wholesale price of unbranded gasoline was 91 cents per gallon in Bakersfield and 72.65 cents in San Diego (Oil Price Information Service). Bakersfield is located about 230 miles north of San Diego. Both markets require reformulated gasoline that meets CARB specifications.

and any potentially confounding city-specific covariates. We find that Tosco increased the wholesale price of gasoline in cities where it faced greater competition with independent retailers following the acquisition. For example, we estimate that the change in vertical market structure resulting from the Tosco-Unocal acquisition led Tosco to increase its wholesale price of unbranded gasoline in Los Angeles by about three cents per gallon. These results are consistent with the strategic incentive to raise competitors' input costs and show that the extent of a wholesaler's vertical integration into downstream markets can significantly influence non-competitive outcomes in markets where upstream firms have market power.

We also analyze a broad panel of data on vertical market structure, horizontal market structure, and wholesale prices for twenty-six metropolitan markets during the merger wave of the mid-1990's. We find evidence in this panel consistent with the incentive to raise rivals' costs identified in the analysis of the Tosco-Unocal acquisition. Specifically, we find that the extent of vertical integration is positively correlated with wholesale prices, controlling for measures of horizontal market structure. In our sample, in markets with few upstream suppliers, wholesale prices are an average of 2.74 cents per gallon higher when the degree of integration of refiners into retail markets is above the median, rather than below it. These correlations are consistent with the effects identified in the Tosco-Unocal acquisition.

The paper proceeds in four sections. In the first section, we discuss the profit maximizing incentives of vertically integrated firms to increase input costs to downstream rivals and outline a set of testable hypotheses. The second section presents the empirical analysis of the effects of vertical integration on wholesale prices using variation generated by the Tosco-Unocal merger. The third section presents further evidence consistent with the Tosco-Unocal results from a broad panel of U.S. metropolitan areas. The final section summarizes our conclusions.

II. THEORETICAL MOTIVATION

There is an extensive body of literature on the theoretical incentives for vertical foreclosure and raising rivals' costs. Williamson [1968], Salop and Scheffman [1987], Ordover, Saloner and Salop [1990], Riordan and Salop [1995], McAfee [1999] and Hendricks and McAfee [2000] are several papers that outline conditions under which a vertically integrated firm may profitably distort downstream competition by raising the price of an intermediate good to its downstream rivals. If downstream firms choose prices that are strategic complements, and if limits to coordination and contracting prevent upstream firms from extracting all of the potential industry profit, then a vertically integrated firm has an incentive to use its upstream price to raise marginal costs for its downstream rivals, because higher marginal costs for rivals lead to higher prices and profits for the vertically integrated firm in the downstream market.

In contrast, the empirical literature that tests for the effects of vertical market structure on firm conduct is sparse, and what little is available on this subject is confounded by product heterogeneity. Examples are Waterman and Weiss [1996] and Chipty [2001], who examine the effects of ownership on carriage of cable channels, and Cuellar and Gertler [2002] who consider the effects of physician ownership on the cost of medical care. Slade [1998] examines the effect of vertical structure on the intensity of competition in gasoline and focuses particularly on the delegation of pricing authority to dealers that is profit-maximizing for specific market characteristics. Delgado and Waterson [2003] relate consumer prices to the extent of vertical integration between tire dealers and manufacturers in the retail tire industry.

The gasoline industry provides a suitable environment for testing the extent to which upstream firms employ cost-raising strategies. It has the advantage that the product is homogeneous within a particular grade, there is substantial variation in industry structure, wholesale price data are abundant, and retail products are strategic complements (see *e.g.* Slade [1986]). In addition, merger activity during the 1990's generated substantial discrete and differential variation in market structure, providing a credible research design for identifying the effects of cost-raising strategies on wholesale prices.

The focus of this analysis is on the strategic interaction between vertically integrated refiner-retailers and independent gasoline retailers. Vertically integrated stations include stations that are owned and operated by the refiner and also stations that are owned by the refiner but leased by a residual claimant (called lessee-dealers). For these stations, the refiner can either set the retail price directly or significantly influence the retail price through contractual incentives, including station-specific wholesale prices. Dealer-owned jobber-supplied stations that are contractually bound to sell one refiner's brand of gasoline are not included in the definition of vertically integrated retailers, because the refiner cannot price discriminate at these stations and cannot charge a rental rate. This limits the refiner's ability to extract rents from these retailers. In addition, although the retailer at a dealer-owned and jobber-supplied station is under contract with a refiner to sell that refiner's brand of gasoline, the retailer can switch refiner/suppliers in the long run if it is economically profitable to do so. The lessee-dealer station cannot do this. Hence branded, dealer-owned, jobber-supplied stations do not fall into either the vertically integrated or independent category for the purpose of our analysis.[4]

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[4] This assumption is consistent with the results in Hastings [2004a], which show no significant difference in the pricing behavior between a refiner's directly-operated stations and those operated by dealers (lessee-dealers). In addition, Hastings [2004b] shows from detailed station-specific wholesale price data that the refiner sets a station-specific wholesale price based on the station's demand elasticity, which allows the refiner to extract most of the downstream economic rents. Hence the refiner's incentive to raise rival retailers' costs is similar for stations owned and operated by the refiner and for leased stations.

Independent stations purchase generic wholesale gasoline from refiners who post prices for wholesale gasoline for purchase at the distribution terminal. We include in the category of independent retailers those stations that have no affiliation with a refiner. They are owned by the retailer and supplied by independent firms called jobbers. These stations are not bound to purchase gasoline from any one refiner, but in general can purchase wholesale generic gasoline from any supplier at the distribution rack. For these unbranded, dealer-owned, jobber-supplied stations the refiner sells wholesale gasoline at the distribution terminal at a constant per-unit price, and thus has no direct control over the retail price that the station charges.

All else equal, economic incentives to raise rivals' costs suggest that wholesale gasoline prices should be higher when:

(i). *Integrated stations are in close proximity to independent retailers.*

The logic of the incentive of an integrated firm to raise downstream rivals' costs is that a higher wholesale price for rivals leads to higher retail prices for the integrated firm when the downstream products sold by the integrated firm and its rivals are strategic complements. The assumption that products are strategic complements is appropriate for gasoline retailing, which involves price competition between suppliers of differentiated products. However, the magnitude of the strategic effect depends on the fraction of sales lost by rivals that is captured by the integrated firm. Rival retailers lose sales because a higher wholesale price causes rivals to increase their retail prices. This benefits the integrated firm only if the cross-elasticity of demand between integrated and independent stations is large, so that the integrated firm captures a significant fraction of these lost sales. This will be the case if many of the integrated firm's retail stations are located close to rival stations that purchase wholesale gasoline from the integrated refiner-retailer.

Since retail gasoline is an geographically differentiated product, the fraction of sales lost by an independent retailer that are captured by an integrated refiner-retailer when the independent retailer raises its price is high when the stations are close to each other and low if they are distant from each other. When the stations are geographically isolated, an integrated refiner-retailer would have little incentive to raise wholesale prices to non-integrated stations for the strategic purpose of raising rivals' costs. In this case, increases in a rival's retail price would have little or no positive effect on the downstream profits of the integrated firm and may disadvantage the refiner by reducing sales to wholesale purchasers.

(ii). *Integrated retailers account for a large fraction of a refiner's total sales.*

A high wholesale price benefits an integrated retailer that is in close proximity to independent stations that purchase wholesale gasoline from the

integrated firm, for the reasons described above. However, a high wholesale price also reduces refiners' sales to independent retailers. The extent to which the integrated firm has an incentive to raise wholesale prices in order to distort downstream competition depends on the size of the independent retailer channel. If a refiner sells a large fraction of its gasoline through independent retailers, it will have little incentive to set a wholesale price that differs from the profit-maximizing price for this channel of distribution. The profit-maximizing price for the independent retailer channel depends on the independent retailer's own-elasticity of demand and the marginal costs of wholesale and retail gasoline. The incentives for an integrated refiner-retailer to raise the price of wholesale gasoline above this level are relatively large when integrated retailers account for a large share of total sales, and when integrated retailers are in close proximity to independent retailers that purchase gasoline at wholesale from the integrated firms. In this case the strategic incentive to raise rivals' costs is large and the benefits to the integrated refiner-retailer from a high wholesale price are not offset by large lost sales to independent retailers.

(iii).   *There is significant market power at the upstream, refinery level.*

Assuming that an upstream firm has an incentive to raise its rivals' costs, its ability to do so depends on the presence of market power at the upstream level. If a large number of refiners compete at the wholesale level, competition at that level should be the main determinant of wholesale prices and we would not expect wholesale prices to depend significantly on the structure of downstream retail gasoline markets. Market power at the wholesale level is necessary for a link between vertical integration and wholesale prices. It is not sufficient, because the other conditions described above must be present for an integrated refiner-retailer to have significant incentives to raise rivals' costs.

III.   EMPIRICAL ANALYSIS OF THE TOSCO-UNOCAL ACQUISITION

Our goal is to test empirically for the effects of vertical market structure on wholesale prices through incentives to raise input costs to rival retailers. Our approach focuses on a specific transaction to identify credibly the effect of vertical integration and competition with independent retailers on wholesale prices. The transaction is Tosco Corporation's 1997 acquisition of Unocal's West Coast refining and marketing assets, which discretely and differentially affected Tosco's integration into a large number of markets. The acquisition allows us to control for omitted variables, such as cost trends and shocks, which might bias estimation results otherwise. We find that, controlling for market structure at the refinery level, Tosco's wholesale price of gasoline to independent retailers increased in proportion to the increase in Tosco's retail

market share resulting from the merger, adjusted to account for the proximity of its stations to independent retailers.

(i). *Description of the Acquisition*

In November of 1996, Tosco and Unocal announced the proposed sale of Unocal's West Coast refining and marketing assets to Tosco. This included all of Unocal's refineries, all of their retail outlets, and the Union 76 logo in all West Coast metropolitan areas, along with Arizona and Nevada. The purchase was completed in April of 1997. Unocal's downstream retailers were almost exclusively integrated. Its downstream market share varied from two per cent to eighteen per cent of the total census of retail stations in the metropolitan areas affected by the transaction. Unocal sold unbranded gasoline at the distribution rack in some metropolitan areas, but in others it did not compete in the unbranded wholesale market. The acquisition increased concentration at the wholesale level and reduced the number of suppliers of unbranded gasoline in those metropolitan areas where Unocal had supplied unbranded gasoline at the distribution rack prior to the acquisition. However, in the metropolitan areas where Unocal did not supply unbranded gasoline at the distribution rack, wholesale concentration remained unchanged. Table I shows the metropolitan areas that were affected by the purchase, with the corresponding changes in downstream shares. Table I also shows whether Unocal sold wholesale gasoline in competition with Tosco before the acquisition in each market.

Before the acquisition of Unocal's West Coast assets, Tosco had a retail market presence in a few of the cities affected by the transaction. Its retail market share varied from zero to approximately forty per cent. In the few cities where Tosco had a significant downstream market share, Unocal typically did not have a significant number of downstream outlets. Consequently, the acquisition had no significant impact on the horizontal structure of gasoline retailing. Tosco's downstream assets included the British Petroleum stations and the BP brand (Tosco had purchased BP's Northwest refining and marketing assets in 1993) and the Circle K convenience store and gasoline station chain, which Tosco had acquired at the end of May, 1996.[5] Tosco had few retail outlets relative to refining capacity in most areas and sold wholesale gasoline to independent marketers

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[5] The BP acquisition affected fewer markets than did the Unocal-Tosco merger. In addition, Tosco did not supply wholesale product in many of the affected markets prior to the merger with BP. Hence, many of these markets do not permit examination of the effects of vertical integration on Tosco's wholesale price. The vertical merger with Circle K provides an interesting opportunity to examine raising rivals' costs in a purely vertical merger; however, the timing coincided with the requirement of California Air Resources Board (CARB) reformulated gasoline. Hence, even though we found a discrete jump in wholesale price in affected markets after the vertical merger, this cannot be independently identified from a city-specific CARB regulation effect.

TABLE I
CHARACTERISTICS OF MARKETS AFFECTED BY TOSCO-UNOCAL MERGER

Distribution Rack	Tosco's Pre-Merger Downstream Market Share	Unocal's Pre-Merger Downstream Market Share	Tosco's Post-Merger Downstream Market Share	Change in Downstream Market Share Contact with Independents	Unocal Competed with Tosco at the Distribution Rack
San Jose	0.00	0.15	0.15	5.56	No
San Francisco	0.08	0.07	0.15	3.32	No
Fresno	0.01	0.11	0.12	5.69	Yes
Los Angeles	0.02	0.16	0.18	8.33	Yes
Sacramento	0.06	0.08	0.14	2.77	Yes
San Diego	0.03	0.11	0.14	4.40	Yes
Stockton	0.03	0.07	0.11	3.47	Yes
Santa Barbara*	0.01	0.19	0.20	9.12	NA*
Phoenix	0.29	0.02	0.31	0.00	No
Tucson	0.39	0.06	0.45	0.66	No
Reno	0.00	0.08	0.08	4.20	Yes
Las Vegas	0.06	0.05	0.11	0.51	No
Seattle	0.22	0.02	0.24	0.10	No
Portland	0.13	0.05	0.18	1.11	No

Notes: Downstream Market Share is measured as per cent of total stations in the metropolitan area. Column five gives change in downstream market share times the per cent of stations located within one mile of an independent retailer.

*Table I includes downstream market share changes for Santa Barbara, CA. However, Santa Barbara does not have its own separate distribution rack prices, hence it is not included as a separate metropolitan area in the empirical analysis.

in all of the thirteen metropolitan areas considered in this analysis both before and after the acquisition.

The acquisition of Unocal's downstream assets by Tosco changed the downstream market share for Tosco by varying degrees across West Coast metropolitan areas. Some markets were practically unaffected by the merger, while in others Tosco experienced an increase in downstream market share of up to sixteen per cent. Using detailed retail census data, we construct a variable, which we call 'downstream market contact', that provides an approximation for the degree of competition between Tosco's integrated retail outlets and the independent retailers. This is done by weighting the increase in the downstream market share from the acquisition of Unocal retail outlets by the percentage of the post-acquisition Tosco retail outlets that are geographically located within one mile of an independent retailer.[6] This variable provides a better approximation of Tosco's post-merger incentive to increase wholesale prices than a simple measure of downstream market share, because there is no incentive to raise rivals' costs if stations are so distant from each other that the cross-price elasticity between the Unocal stations and independent stations is zero. If most

[6] See Hastings [2004a] for an analysis and discussion of the extent of geographic competition for retail gasoline stations in Southern California. The definition is made for one driving mile.

Unocal stations had an independent retailer as a close competitor before the acquisition, an increase in downstream market share from the Unocal purchase should have a significant impact on Tosco's wholesale price strategy. On the other hand, if most of the Unocal stations in a metropolitan area were geographically isolated from independent retailers, an increase in downstream market share from the Unocal purchase might not affect Tosco's optimal wholesale price at all. We examined alternative definitions of proximity to ensure that results were not driven by the one-mile specification.

For example, Table I indicates that Tosco's acquisition of Unocal's retail assets increased its share of retail stations in Fresno by 11 percentage points. By mapping Unocal and independent stations in Fresno, we discover that 57% of the Unocal stations were located within a mile of an independent retailer.[7] These stations should have relatively high cross-price elasticity with rival independent retailers and, according to the theory outlined earlier, Tosco could increase retail profits at these stations by increasing input costs to the independents. The remaining acquired Unocal stations were geographically isolated from independent retailers, and hence increasing wholesale prices to independents should have a minimal effect on retail profits at these stations. We considered alternative specifications in order to ensure that the results were robust to changes in the proximity measure. Using the current measure, we estimate that for Fresno, Tosco's downstream market contact with independents increased by 5.7 percentage points. By creating this variable for Tosco's retail outlets both before and after the acquisition, we can test if Tosco's wholesale price is positively impacted by this measure of downstream market competition with independents, as predicted by the raising rivals' costs theory.

These discrete and differential increases in downstream market contact should imply proportional increases in the incentive to raise rivals' costs as outlined in Section II. In addition, the merger affected West Coast markets—markets where it is likely that wholesalers have market power—making it possible for a firm to implement a successful cost-raising strategy.[8] The merger decision was an aggregate event with Tosco acquiring Unocal's refining and marketing assets in all West Coast markets at once. Since market structure in individual markets was determined prior to the acquisition decision, and since the acquisition decision was made at the

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[7] Approximately 20 per cent of the stations in the Fresno retail census were independent retailers.

[8] West Coast refining markets are fairly concentrated. Typically, only a few suppliers post prices for unbranded gasoline at any given rack. In addition, *de novo* entry into West Coast markets at the wholesale level is made more difficult by the fact that West Coast markets are geographically isolated, California markets require special CARB formulated gasoline, and California markets are highly vertically integrated. See Hendricks and McAfee [2000] for measures of horizontal and vertical concentration in California gasoline markets.

aggregate market level, we can arguably view the impact on individual markets as exogenous to other factors differentially affecting both their market structure and prices concurrently with the merger decision. Therefore, we empirically test whether the discrete changes in the degree of vertical integration were followed by changes in Tosco's wholesale prices for unbranded gasoline as predicted by the raising rivals' costs theory. In particular, we use the variation in the degree of vertical integration resulting from the acquisition to test whether Tosco's wholesale price were increasing in its downstream market share and degree of competition with independent retailers, controlling for variations in costs and horizontal market structure.

(ii). *Description of the Data*

Retail census data, available annually from Whitney Leigh Corporation, provide detailed characteristics and locations of every retail gasoline station in each metropolitan area. The data include each station's delivery and ownership type. This variable determines the station's relationship (if any) with an upstream refiner and is used to construct measures of vertical integration.[9] The retail census data reported in Table I provide a measure of the change in Tosco's downstream market share in each metropolitan area as a result of the acquisition of Unocal's retail outlets. We define vertically integrated stations as those which the refiner owns and either operates directly or leases to a residual claimant. We treat both of these contractual forms as vertically integrated because, in both cases, the refiner can profit from higher retail prices. This is obviously true in the directly-operated case because the refiner is the retailer. In the lessee-dealer case, the refiner sets station-specific wholesale prices and lease rates, adjusting these instruments to capture positive economic profits from the retailer. Hence, the refiner can profit from a cost-raising strategy that benefits these outlets in much the same way that it can for its directly-operated stations.

Detailed wholesale rack price data from Oil Price Information Service provide weekly average unbranded wholesale gasoline prices by supplier for each distribution rack. The price data are for the period July, 1996, through December, 1998, providing weekly observations on Tosco's average price for unbranded gasoline at each distribution rack for about one year before and a year and a half after the merger.

The conditions outlined in Section II imply that the strategic incentive to raise rivals' costs is an increasing function of the degree of downstream competition as measured by the cross-price elasticity between the vertically integrated and rival retail stations. Because retail gasoline stations are geographically

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[9] We take the contractual relationship between the retailer and the refiner as exogenous in this analysis. For discussions of the determinants of contract choice in gasoline retailing, see Shepard [1990, 1991, 1993], Blass and Carlton [2001], and Slade [1998].

differentiated products, geographic proximity to rival retailers is a good measure of the degree of downstream competition.[10] The detailed Whitney Leigh data make it possible to estimate the change in downstream competition with independent retailers by examining the geographic proximity of Tosco's post-acquisition stations to independent retailers.

In addition, in order to identify the effect of downstream competition with independent retailers on wholesale prices, we need to control for any changes in the cost of producing wholesale gasoline. Failing to control for production costs, which vary over this time period, may inhibit the identification of the key parameters of interest. We use Tosco's wholesale price of gasoline in Phoenix as an approximation of cost variables because Phoenix experienced no change in upstream market structure during the time period considered and the Unocal acquisition had no significant effect on downstream market structure.[11] In addition, terminals in Phoenix receive almost all of their gasoline via common carrier pipeline from refineries in Los Angeles. Therefore, the Phoenix wholesale prices provide a better approximation of the panoply of cost factors that impact wholesale prices in interconnected West Coast markets than do crude oil prices. We use the price in Phoenix to control for costs in two ways. The regressions are run with the wholesale price in Phoenix subtracted from the wholesale price in each metropolitan area (the dependent variable), and also as a regressor on the right-hand side.

(iii).   *Regression Analysis*

We estimate the following regression equation to determine the effect of changes in downstream contact with independent retailers, upstream concentration, and the market share of independent retailers on Tosco's wholesale price (using the price in Phoenix as a control for costs). The changes in downstream competition with independents allow us to identify the strategic incentive to raise rivals' costs separately from measures of upstream concentration, independent retail market share and any city-specific covariates.

The regression is specified as follows:

(1)
$$p_{it} = \mu + \alpha_i + \beta d_{it} + \gamma u_{it} + \delta r_{it} + \varepsilon_{it}$$
$$\varepsilon_{it} = \rho \varepsilon_{i,t-1} + \xi_{it}$$

where:

p_{it} = Tosco's weekly average wholesale price of unbranded gasoline in city i (less the price in Phoenix in week t)

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[10] See Slade [1986a, 1992], Karrenbrock [1991], Borenstein and Shepard [1996, 2002], Borenstein, Cameron, and Gilbert [1997], Blass and Carlton [2001], Hastings [2004a], and Noel [2001] for analyses of spatial competition among gasoline retailers.

[11] Tosco's retail market share in Phoenix increased by 2 per cent following the merger. However, its downstream contact with independent retailers did not increase at all.

α_{it} = city-specific error component, fixed or random effect specification

d_{it} = downstream market contact with rival independents in city i in week t

u_{it} = number of refiners selling unbranded gasoline in city i in week t

r_{it} = percent of stations that are independent retailers in city i in week t

ε_{it} = autoregressive error component

ξ_{it} = white noise error term

The number of refiners selling unbranded gasoline is a variable that counts suppliers who posted prices at each distribution rack in each time period. There is inter-temporal variation in this variable in many of the metropolitan areas. Some variation is due to the post-acquisition exit of Unocal from markets where it had supplied unbranded gasoline. Other variation comes from periodic entry or exit by refiners at each rack. For example, in 1998, after Shell and Texaco formed the Equilon joint venture, Texaco ceased selling unbranded gasoline in many markets. This provides further variation in the number of upstream competitors over our sample period.

The error component has an autoregressive structure to capture the dynamic effect of gasoline prices. A Dickey-Fuller test rejected the hypothesis of a unit root in the wholesale price time series for each of the cities included in the regression.[12] In addition, the specification of an autoregressive error structure is not rejected in favor of capturing the dynamic effect with a lagged price value on the right-hand side. The error structure also has a city-specific component. A Hausman test rejects the random effects specification in favor of a fixed-effects specification, with a p-value of 0.05.[13]

Table II presents regression results. The first specification includes city-specific fixed effects and the downstream market contact variable. The variation in downstream market contact resulting from the merger allows us to identify separately the price effect of this variable from the city-level fixed effects and the other covariates included in the regression. The regression results indicate that a higher degree of downstream contact with independent retailers is associated with a higher price for unbranded gasoline sold at wholesale.[14] For example, the spot estimate in the fixed-effects specification implies that for every one per cent increase in the

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[12] This test was also performed on the wholesale price separately for each city, and again the test rejected the hypothesis of a unit root.

[13] See Hausman and Taylor [1981].

[14] The same regression specification was run with the geographic definition increased to 1.5 miles and with just the downstream market share variable instead of downstream market contact. The results do not change significantly. This is due to the fact that the percentage of Tosco's post-acquisition stations that are in close proximity to independent retailers is highly positively correlated with Tosco's total per cent of stations post-acquisition. The locations of the integrated and independent stations do not allow us to separately identify the effects of total integrated market share from the cross price elasticity with independent stations. Recall from Section II that both effects, however, operate in the same direction. In addition, recall that there are three categories of stations in our analysis: independent; vertically integrated; and branded, dealer-owned, jobber-supplied stations.

TABLE II
REGRESSION OF EFFECTS OF RAISING RIVALS' COSTS

	Fixed Effects Parameter Estimate	*Random Effects* Parameter Estimate
Intercept	− 2.95 (0.484) [0.000]	− 0.572 (1.365) [0.675]
Downstream Market Contact with Independent Retailers	0.445 (0.089) [0.000]	0.369 (0.080) [0.000]
Number of Wholesale Suppliers	− 0.083 (0.278) [0.766]	− 0.403 (0.203) [0.048]
Market Share of Independent Retailers	0.129 (0.166) [0.437]	0.084 (0.059) [0.156]
Autocorrelation Coefficient	0.824	0.824
Adjusted R-squared:	0.814	0.237
Hausman Test: $\chi^2 = 7.83$ Prob. $> \chi^2 = 0.0497$		
Number of Observations	N = 12	
	T = 128	

Notes: The dependent variable is the weekly average unbranded wholesale rack price for Tosco less the rack price in Phoenix. Standard errors are in parentheses, with p-values in brackets.

percentage of Tosco retail stations in direct competition with an independent retailer, Tosco's weekly average unbranded wholesale gasoline price rises by 0.44 cents per gallon. Consistent with our theory, an increase in downstream market contact with rival independent firms increases the strategic incentive to raise rivals' costs. The estimates imply that in Los Angeles, for example, where the acquisition of Unocal's retail assets increased the share of integrated stations that compete with rival independents by 8.33 percentage points, the estimated price increase is 3.7 cents per gallon.[15]

In the fixed-effects specification in Table II, the coefficients on the number of upstream competitors and the market share of independents are not significantly different from zero. However, the coefficient on the number of upstream competitors is weakly significant in the random-effects specification presented in the second column. This specification assumes that the conditional mean of the city-specific error component is the same across all cities. The coefficient on the number of upstream competitors is negative, and indicates that one less wholesale supplier of unbranded gasoline is

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[15] An internal Tosco document that describes competition in California gasoline markets is consistent with our findings. 'Tosco intends to devote its PADD V [West Coast] supply to our retail system . . . we want to avoid as much as possible spot supply [unbranded] arrangements. If I were a retailer and didn't have a widely recognized brand with a strong PADD V refining system behind it, I'd be worried!' May, 2002, report, 'Gas Prices: How are they Set?' United States Senate, Committee on Governmental Affairs, Permanent Subcommittee on Governmental Affairs.

associated with a 0.403 cent increase in the average wholesale price.[16] Metropolitan areas where the acquisition caused both an increase in the downstream contact with rival independents and an increase in concentration would experience higher wholesale prices from both the vertical and horizontal effects of the merger. When the city-level fixed effects are included, the coefficient on upstream competitors becomes insignificant, probably because there is not sufficient variation in this regressor in some metropolitan areas to separately identify the change in upstream concentration from a fixed effect. The coefficient on the market share of independent retail marketers is not statistically significant in either error component specification.

Table III shows regression results when the wholesale price in Phoenix is included on the right-hand side, rather than subtracted from the dependent variable. The coefficient on Phoenix is 0.952 for the random-effects specification, and 0.945 for the fixed-effects specification. The coefficient on Phoenix and the adjusted R-squared from the regression illustrate that Tosco's wholesale price in Phoenix is a very good approximation for the cost of gasoline in the other metropolitan areas. The coefficient is significantly different from one in both columns, indicating that the implicit restriction in the specification in Table II, that the coefficient on the price in Phoenix is equal to one, is in fact a binding restriction. However, the estimated coefficients on the variables of interest do not change significantly from Table II to Table III.

The results imply that an integrated refiner's price for unbranded wholesale gasoline is an increasing function of its competition with rival independent retailers. The coefficient on the degree of downstream competition with rivals is identified mainly by the inter-temporal and cross-sectional variation generated by Tosco's purchase of Unocal's retail assets. Since this event differentially affected each metropolitan area at one discrete point in time, we can also estimate the event's price effect in each metropolitan area and examine how these changes in average prices vary with the increase in downstream contact with independent retailers. The price increase in each metropolitan area should be an increasing function of the change in downstream contact with independent retailers, and the estimated coefficient should be approximately the same as the coefficient presented in Tables II and III.

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[16] In an alternative specification, we constructed the refiner HHI for markets defined by refinery assets rather than by the number of suppliers at metropolitan area distribution terminals. These refinery markets are the Seattle refinery system, the Northern California refinery system, and the Southern California refinery system. Each refiner's share was calculated as its share of total refining capacity in the system. The HHI was used instead of the number of upstream competitors. The coefficient on HHI was not significant in any specification. Using the HHI instead of the number of upstream competitors did not change the estimate on the downstream market contact variable.

TABLE III
REGRESSION OF EFFECTS OF RAISING RIVALS' COSTS

	Fixed Effects Parameter Estimate	Random Effects Parameter Estimate
Intercept	− 0.041	2.475
	(0.487)	(1.565)
	[0.933]	[0.114]
Tosco's Unbranded Wholesale Price in Phoenix	0.945	0.952
	(0.012)	(0.012)
	[0.000]	[0.000]
Downstream Market Contact with Independent Retailers	0.372	0.296
	(0.090)	(0.082)
	[0.000]	[0.000]
Number of Wholesale Suppliers	− 0.010	− 0.378
	(0.278)	(0.203)
	[0.971]	[0.062]
Market Share of Independent Retailers	0.177	0.094
	(0.166)	(0.059)
	[0.288]	[0.110]
Autocorrelation Coefficient	0.827	0.827
Adjusted R-squared:	0.982	0.926
Hausman Test: $\chi^2 = 16.01$		
Prob. $> \chi^2 = 0.0030$		
Number of Observations	N = 12	
	T = 128	

Notes: The dependent variable is the weekly average unbranded wholesale rack price for Tosco.
Standard errors are in parentheses, with p-values in brackets.

Figure 1 presents a scatter plot of the estimated price increase in each metropolitan area following the Unocal purchase against the increase in downstream competition with rival independent retailers. The fitted values of the price increases in each metropolitan area are plotted against the increase in downstream market contact with independent retailers. The least squares regression line from the scatter plot has a slope coefficient of 0.036 with a standard deviation of 0.111 and a P-value of 0.008. This result is statistically consistent with the coefficient estimates for downstream market contact presented in Tables II and III.

IV.   EMPIRICAL ANALYSIS OF A PANEL OF U.S. METROPOLITAN AREAS

We analyze a panel of twenty-six U.S. metropolitan areas from January, 1993, through June of 1997 to investigate if the effects identified in the Tosco-Unocal acquisition are consistent with the relationship between wholesale prices and market structure more broadly.[17] An expanded version of the retail census data used in Section III provides retail market structure

[17] The metropolitan areas are located in West Coast, Rocky Mountain and Gulf Coast states. Chouinard and Perloff [2001] and Aydemir and Beuhler [2002] perform similar panel studies of gasoline prices and find similar results. However, their analyses use state-level data, and for some variables use data aggregated at multi-state or national levels.

Scatter Plot of Estimated Price Impact as a Function of
Increase in Downstream Competition with Independent Retailers
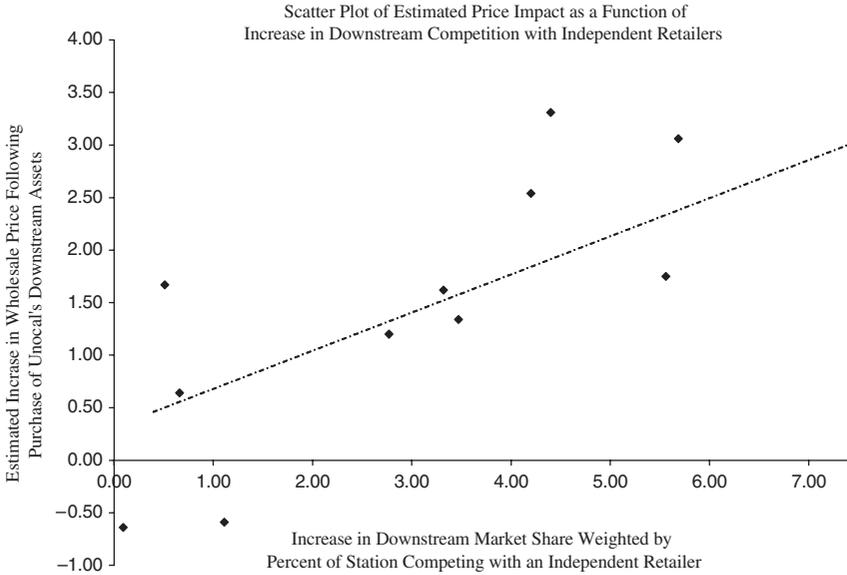
Figure 1
Scatter Plot of Estimated Price Increase in Each Metropolitan Area Following the Tosco-Unocal
Acquisition, Against the Increase in Retail Market Share Weighted by Proximity to Independent
Retailers

and the share of vertically integrated firms for each of the twenty-six metropolitan areas in each year.[18] As described earlier, the retail census includes the ownership and delivery type for each station and identifies each station's vertical relationship (if any) with an upstream refiner, allowing us to examine the degree of vertical integration in each market.

Data on unbranded wholesale prices are from Lundberg Wholesale Price Reports, providing semi-monthly, average, unbranded wholesale prices for each metropolitan area. These average price data are coupled with data from Oil Price Information Service on the names of the companies supplying at each distribution rack during each time period. Thus the compiled data sets provide information on the average unbranded wholesale price, the companies that supply unbranded gasoline at each rack, the retail market share of each company in each metropolitan area, and the market share of independent retailers that purchase unbranded gasoline at the rack.

[18] These metropolitan areas constitute the metropolitan areas for which Whitney Leigh collected data over the course of the 1990's. It is not a random sample; however, it is the only data set, and the most extensive, available on vertical market structure covering a significantly long and broad panel of metropolitan areas.

TABLE IV
SUMMARY STATISTICS OF MARKET CONCENTRATION AND VERTICAL INTEGRATION
VARIABLES FOR THE ENTIRE PANEL OF DATA

	Mean	Standard Deviation	Maximum	75th Percentile	Median	25th Percentile	Minimum
Per cent of Stations that are Vertically Integrated*	0.49	0.13	0.84	0.58	0.47	0.39	0.27
Per cent of Stations that are Independent Retailers	0.21	0.085	0.44	0.27	0.20	0.16	0.02
Number of Vertically Integrated Wholesalers	2.18	1.05	5.00	3.00	2.00	2.00	0.00
Number of Unintegrated Wholesalers	2.45	1.84	9.00	3.00	2.00	1.00	0.00
Average Downstream Market Share for Integrated Suppliers**	0.10	0.05	0.39	0.12	0.09	0.07	0.01
Maximum Downstream Market Share for Integrated Suppliers	0.14	0.07	0.47	0.16	0.13	0.09	0.01

*Per cent of Stations that are Vertically Integrated is defined as the number of refiner-owned stations in the retail census divided by the total number of stations in the retail census, for each metropolitan area. Branded dealer-owned and jobber-supplied stations are treated as neither vertically integrated nor independent.

**Downstream Market Share for an Integrated Supplier is defined as the number of stations in the retail census that the refiner owns, divided by the total number of stations in the retail census, for each metropolitan area.

IV(i). *Summary Statistics*

Table IV provides summary statistics for the market structure variables of interest. There is cross-sectional variation as well as substantial inter-temporal variation generated by several mergers that occurred in the mid-1990s. The degree of variation in each market structure variable is striking. All measures of vertical as well as horizontal concentration vary greatly across the city-time markets.

Table V presents the sample correlation between the market structure variables of interest. Note that measures of vertical and horizontal market structure variables are not highly collinear. In other words, market structures in the sample are not simply two extreme types: markets with high wholesale market concentration and very high degree of vertical integration, or markets with low wholesale market concentration and a small degree of vertical integration. This variation increases our ability to separate the correlations between wholesale prices and measures of horizontal and vertical market structure.

Table VI presents the fraction of variation in the market structure variables that is attributable to variation at (i) the city level, (ii) the time level, and (iii) the city*time level from a variance components estimation. There is significant variation in vertical market structure at the city*time level due to a wave of mergers that affected vertical market structure differentially across the cities in the panel. These mergers include: (i) Tosco Corporation's

TABLE V
CORRELATION COEFFICIENTS FOR UPSTREAM AND DOWNSTREAM MARKET VARIABLES FOR BROAD PANEL REGRESSION

	Per cent Vertically Integrated Retailers	Per cent Independent Retailers	Number of Unintegrated Refiners	Number of Vertically Integrated Refiners	Average Downstream Market Share for Integrated Suppliers	Maximum Downstream Market Share for Integrated Suppliers
Per cent Vertically Integrated Retailers*	1.00	−0.50	0.33	0.14	−0.15	0.12
Per cent Independent Retailers	−0.50	1.00	0.24	−0.08	−0.14	−0.28
Number of Unintegrated Refiners	0.33	0.24	1.00	−0.08	−0.09	−0.12
Number of Vertically Integrated Refiners	0.14	−0.08	−0.08	1.00	−0.22	0.14
Average Downstream Market Share for Integrated Suppliers**	−0.15	−0.14	−0.09	−0.22	1.00	0.83
Maximum Downstream Market Share of Integrated Suppliers	0.12	−0.28	−0.12	0.14	0.83	1.00

*Per cent of Stations that are Vertically Integrated is defined as the number of company-owned stations in the retail census divided by the total number of stations in the retail census, for each metropolitan area.
**Downstream Market Share for an Integrated Supplier is defined as the number of stations in the retail census that the refiner owns, divided by the total number of stations in the retail census, for each metropolitan area.

	Percent of Variation Attributable to		
Dependent Variable	City	Time	City* Time
Number of Unintegrated Suppliers	0.832	0.014	0.154
Number of Vertically Integrated Suppliers	0.627	0.089	0.284
Percent Independent Retailers	0.602	0.128	0.270
Mean Downstream Market Share of Integrated Suppliers	0.561	0.056	0.383

acquisition of British Petroleum's West Coast refining and marketing assets in December of 1993 and June of 1994; (ii) Diamond-Shamrock's acquisition of the independent retail chain, Stop-N-Go at the end of 1995, which primarily affected Gulf Coast and Rocky Mountain markets; (iii) Tosco Corporation's April, 1996, purchase of the independent retail chain, Circle K, affecting the South West and Rocky Mountain regions; (iv) Tosco's April, 1997, acquisition of Unocal's West Coast refining and marketing assets; and (v) ARCO corporation's April, 1997, purchase of the independent retail chain, Thrifty, in Southern California.

IV(ii).   *Regression Analysis*

Table VII presents the data in cell means, which partition average prices according to different combinations of market structure characteristics. Each cell gives the average wholesale price of unbranded gasoline less the average spot price for crude oil for city-time observations that fall into that cell.[19]

The cell means analysis allows us to examine the rough contribution of each market structure variable to wholesale price variation, holding other market structure variables constant. The data are grouped by combinations of high and low numbers of vertically integrated suppliers, high and low numbers of unintegrated suppliers, high and low market shares of independent retail marketers, and high and low average downstream

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[19] The crude price is the spot price at Cushing, Oklahoma, provided by the Energy Information Administration. The dates for the crude oil prices were matched with the dates for the wholesale price observations. The crude oil price was then subtracted from the wholesale price in each metropolitan area, and those differences were averaged over each quarter in each metropolitan area to create the margins reported in the cell mean analysis. These prices are averaged over each quarter because the regressors change in discrete jumps at the financial quarters of merger completions during each year, but are fairly constant relative to the wholesale price of gasoline over shorter time periods.

TABLE VII
CELL MEANS BY COMBINATIONS OF MARKET STRUCTURE VARIABLES

		Few Integrated Suppliers		Many Integrated Suppliers	
		Small Downstream Market Share[1]	Large Downstream Market Share	Small Downstream Market Share	Large Downstream Market Share
Few Unintegrated Suppliers	Few Independent Retailers	19.75 (1.02) N = 32	22.49 (1.13) N = 26	20.70 (1.40) N = 17	22.22 (1.54) N = 14
	Many Independent Retailers[2]	18.33 (2.36) N = 6	22.29 (2.36) N = 6	17.31 (0.96) N = 36	18.65 (2.59) N = 5
Many Unintegrated Suppliers	Few Independent Retailers	17.54 (0.86) N = 45	19.29 (0.88) N = 44	13.10 (1.11) N = 27	13.19 (1.09) N = 28
	Many Independent Retailers	15.30 (0.71) N = 67	16.27 (0.66) N = 78	11.61 (1.29) N = 20	14.38 (1.40) N = 17

Notes: Dependent Variable: Quarterly average price of unbranded wholesale gasoline by rack less the spot price of crude oil. Standard errors in parentheses.
[1] Average downstream market share of vertically integrated suppliers.
[2] Measured by share of all retail outlets.

market shares of the vertically integrated suppliers. For each variable, high and low are determined by above and below the median value in Table IV.[20]

Patterns across cells indicate that the average wholesale price is positively correlated with the extent of vertical integration and horizontal concentration. Cell 5 (row 1 and column 2) shows the average price for city-quarters with the highest concentration values for all market structures. This cell is for city-quarters with few wholesale suppliers, a large average downstream market share for the integrated suppliers, and a small market share for independent retailers. It is also the cell with the highest wholesale price. Cell 12 (row 4 and column 3) is the cell for the least concentrated city-quarter markets. This cell has the lowest average price. Moreover, the average margin (the difference between the wholesale price and the spot price of crude) in cell 5 is roughly twice the average margin in cell 12.

Holding horizontal market structure constant, the two downstream market structure variables (market share of independent retailers and the average downstream market share for vertically integrated wholesalers) display a systematic relationship. Cell means are lower in markets where a larger fraction of retailers are independent retailers, although the differences are not always statistically significant. Cell means are generally higher in markets where the integrated suppliers have a greater average downstream market share, conditioned on the other factors. This difference is

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[20] This selection is arbitrary; however, it allows us to make some interesting comparisons.

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TABLE VIII
BROAD PANEL REGRESSION RESULTS

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	(1) OLS with Robust Standard Errors*	(2) City-Specific Fixed-Effects Regression
Intercept	22.56	21.770
	(1.118)	(3.123)
Number of Vertically Integrated Suppliers	− 1.588	− 0.117
	(0.244)	(0.381)
Number of Unintegrated Suppliers	− 1.006	− 0.429
	(0.152)	(0.334)
Average Downstream Market share for Integrated Suppliers	12.309	17.902
	(5.613)	(7.896)
Market Share for Independent Retailers	− 6.485	− 1.786
	(3.512)	(5.204)
California Reformulated Gasoline Requirement	5.782	6.328
	(1.055)	(0.874)
Adjusted R − Square	0.287	0.460
Number of Observations	N = 26	N = 26
	T = 18	T = 18

Notes: Dependent Variable: Quarterly average unbranded wholesale price by metropolitan area, less the spot price of crude oil.
*Newey-West standard errors are reported in parentheses, correcting for serial correlation and heteroskedasticity. First order autocovariances for the wholesale margin time series were insignificant in each metropolitan area. Second order autocovariances were negative and significant, but small, in a few of the metropolitan area time series. Higher order autocovariances were all insignificant.

pronounced in markets where integrated suppliers have the greatest ability to raise downstream rivals' costs (markets where there is high upstream concentration). Comparing cells 1 and 5 (row 1, column 1 and 2 respectively) and cells 2 and 6 (row 2, column 1 and 2 respectively), we see that in markets where there are few upstream suppliers, the difference between the average price in cells with a large average downstream market share and those with a small one is large and significant. The difference between the prices in cells 1 and 5 is 2.74 cents per gallon, and is statistically significant at the seven per cent level with an F-value of 3.24.

A simple regression analysis is presented in Table VIII, and summarizes the correlations indicated in the cell means. Column 2 includes city-specific fixed effects. In Column 1, upstream concentration is positively correlated with price, for both unintegrated and integrated suppliers. One more supplier of either type is associated with a decrease in the average wholesale price. However these variables become insignificant when city fixed-effects are included. The market share of independents is also negatively correlated with price, but statistically insignificant when city-level fixed effects are included. The average downstream market share of the vertically integrated suppliers is positively correlated with wholesale price, and significant in both regressions. Large, discrete and differential changes in this variable from a series of mergers independently identify it from the city-level fixed effects. The coefficient implies that a one per cent increase in the average

downstream market share of integrated wholesalers is associated with a wholesale price increase of 0.179 cents per gallon.

These results suggest that the effects of cost raising strategies on wholesale prices identified in the Tosco-Unocal acquisition are consistent with correlations between vertical market structure, horizontal market structure and wholesale prices in gasoline markets more broadly.

V. CONCLUSION

We empirically examine the relationship of vertical and horizontal market structure to wholesale prices for unbranded gasoline. Our empirical analysis focuses on the 1997 acquisition by Tosco of Unocal's West Coast refining and retail assets to credibly identify the relationship between vertical market structure and upstream conduct. The acquisition allows us to examine the reaction of Tosco's wholesale prices in thirteen metropolitan areas to differential increases in competition with independent retailers resulting from the merger, while controlling for potentially confounding cost shocks and trends, as well as any city-specific covariates. We find that the degree of competition with independent retailers has significant and positive impacts on the integrated firm's wholesale prices. This result is consistent with raising rivals' costs. Using variation across twenty-six U.S. metropolitan areas and over time generated by a merger wave during the 1990's, we find further evidence that correlations between wholesale prices and vertical market structure more broadly are consistent with the result identified in the analysis using the Tosco-Unocal acquisition.

This empirical analysis demonstrates that mergers in the gasoline industry that increase the extent of vertical integration may lead to an increase in wholesale prices as a consequence of the incentive to raise rivals' costs. The incentive to raise input costs to rivals adds a potentially significant competitive effect that arises from changes in vertical structure. Our analysis suggests that, in the presence of upstream market power, changes in vertical market structure can have significant impacts on upstream firm conduct and equilibrium prices.

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