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Abstract

This paper explores the relationship between the structure of the market for the refining and distribution of gasoline and the wholesale price of unbranded gasoline sold to independent gasoline retailers. Theoretically, the effect of an increase in vertical integration is ambiguous because opposing forces act to increase and decrease wholesale prices. We empirically examine the effects of vertical and horizontal market structures on wholesale prices using both a broad panel and an event analysis. The panel covers twenty-six metropolitan areas from January 1993 through June 1997. The event is a merger of Tosco and Unocal in 1997 that changed the vertical and horizontal structure of thirteen West Coast metropolitan areas. Both data sets show that an increase in the degree of vertical integration is associated with higher wholesale prices.

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1 Introduction

Vertical integration can promote efficient trade and investment by mitigating the contractual hazards that can occur in markets characterized by specific assets and bargaining among firms with market power (Williamson, 1975). However, vertical integration also can create incentives for firms to impose costs on rivals. This is a major thrust of the "post-Chicago" school of competition policy, which emphasizes the potential competitive hazards associated with vertical arrangements. For example, Ordover, Salop, and Saloner (1990) (henceforth OSS) show that a vertically integrated firm has an incentive to charge more for an intermediate good than the profit-maximizing price for an unintegrated upstream firm.[2] The vertically integrated firm profits from the higher price because it increases the marginal cost of the firm's downstream rival and results in higher downstream prices.

The strategic incentive for a vertically integrated firm to raise the price of an intermediate good is the focus of most models in the "raising rival's cost" literature.[3] However, the success of a raising rival's cost strategy depends not only on the vertically integrated firm's incentive to increase downstream prices, but also on equilibrium conditions that determine the firm's ability to raise intermediate good prices and on efficiency gains from a vertically integrated market structure. We develop a model that identifies two opposing effects on intermediate good prices resulting from a vertical merger. A strategic effect arises from the vertically integrated firm's incentive to raise the price of intermediate inputs to its downstream rivals. A confounding substitution effect is a reduction in intermediate product demand that results from the elimination of double marginalization under vertical integration. This substitution effect acts to decrease the price of the intermediate good.[4]

[2] In some situations, vertically integrated firms may profit by refusing to sell an input to downstream rivals at any price. Salinger (1991) examines incentives to foreclose rivals in a model with no product differentiation. In more general models, Hart and Tirole (1990) and Rey and Tirole (1999) show that input foreclosure can be profitable if an upstream monopolist cannot enter into publicly verifyable contracts with downstream firms. The monopolist may not be able to commit itself from flooding the market for the input and lowering its price. Vertical integration can allow the upstream firm to control supply and maximize profits.

[3] See, *e.g.*, Krattenmaker and Salop (1986), Salop and Scheffman (1987), and Riordan and Salop (1995). The first paper we are aware of that analyzes strategic incentives to raise rivals' costs is Williamson (1968).

[4] McAfee (1999) shows that the substitution effect from a vertical merger can lower

In general, the effect of a vertical merger on intermediate good prices (and on the prices of downstream products) is indeterminate.

We adapt the model of a vertical merger to study the effects of vertical and horizontal market structure on intermediate good prices. The model provides a theoretical foundation to explore the empirical relationships between market structure and wholesale gasoline prices that we observe in the data. We consider a market in which two firms merge, one of which is vertically integrated and the other is an unintegrated upstream supplier. The merger has no effect on downstream market structure and has no effect on upstream market structure if the vertically integrated firm was not a wholesale supplier before the merger. Nonetheless, the merger may lead to an increase in wholesale prices if the merged firm sells in the intermediate product market, because the merged firm has a strategic incentive to raise downstream rivals' costs. Similarly, we show that mergers which increase the market share of vertically integrated firms are likely to increase wholesale prices if the substitution effect is small. Our model predicts that wholesale prices are positively related to the level of upstream market concentration, the market share of vertically integrated firms, and the degree of competition in the downstream market between integrated and unintegrated firms.

The impact of vertical integration on consumers and on intermediate firms is ultimately an empirical question, yet little empirical research directly addresses the competitive effects of vertical integration. Several studies examine whether vertically integrated firms achieve lower costs.[5] These studies do not deal with the central issue we address in this paper, namely whether vertical integration affects the prices paid by intermediate firms and by consumers. A few empirical papers address this question. Waterman and Weiss (1996) examine whether vertical integration of cable systems in pay cable networks (such as HBO and Showtime) has an effect on the type and number of pay networks that the cable systems carry and on the prices paid for those networks. The authors find that vertically integrated cable systems are more likely to carry their affiliated networks, but they do not find a statistically significant impact from vertical integration on the prices paid

the equilibrium price for the intermediate good, but his model does not consider strategic incentives to raise intermediate good prices.

[5] For example, Kaserman and Mayo (1991) test for economies of scope in the generation and distribution of electric power. Evans and Heckman (1984) perform a similar study for local and long distance telecommunications.

for network programming by the cable operator or on the prices charged to subscribers. Gertler and Cuellar (2000) explore whether vertical integration between health care providers and insurers has an effect on the prices and delivery of health care services. While these studies suggest that vertical integration can have important competitive effects, the results are confounded by the complex nature of the industries in which they occur. Pay cable networks differ in the quality of the programming that they offer. These quality differences complicate comparisons. Furthermore, vertical integration could have benefits that are difficult to measure, such as accelerating the launch of new networks. Similarly, quality differentials in health care delivery are significant and difficult to quantify.

We empirically test the relationship between vertical structure and wholesale prices using gasoline market data. The gasoline industry is well-suited for this analysis. Gasoline of a particular grade and octane rating is a relatively homogeneous commodity, although there is a small premium for gasoline that has a well-recognized brand. Identification of the price effects from different market structures, particularly for unbranded wholesale gasoline, is not confounded by differences in quality. There is an abundance of gasoline market data and considerable variation in the vertical and horizontal structures of gasoline markets across time and different geographies. During the mid to late 1990's, several mergers, including the mergers of Shell and Texaco, Exxon and Mobil, and Tosco and Unocal, significantly impacted the horizontal and vertical structure of wholesale and retail gasoline markets. In addition, the presence of significant spatial differentiation at the retail (downstream) level of gasoline supply gives rise to market power and incentives for vertically integrated firms to raise their rivals' costs.

Gasoline markets are also interesting candidates to measure the effects of vertical integration because there is a history of allegations of anticompetitive pricing by vertically integrated firms that refine and market gasoline. Unintegrated gasoline retailers (often called independent marketers) have alleged that vertically integrated refiner-marketers have engaged in price squeezes, keeping wholesale prices high and retail prices low, with the intent to monopolize retail gasoline markets and raise prices. Several states have acted on these allegations and limited the ability of refiners to own and control retail gasoline prices, while still permitting refiners to supply wholesale gasoline to franchised retailers. Other allegations focus on regional differentials in wholesale and retail gasoline prices, sometimes contrasting prices in Los

Angeles and San Diego or comparing West Coast prices to prices in the Mid-Continent. Most of these claims focus on the concentration effects of upstream markets on wholesale and retail prices, but to our knowledge, no one has linked these differential pricing patterns to vertical market structures and wholesalers' strategic incentives to raise rivals' costs.

Our empirical analysis follows two tracks. The first is a study of a broad panel of U.S. metropolitan areas from January 1993 through June of 1997 to identify correlations between the average wholesale price and horizontal and vertical market structure. We find that the degree of vertical integration, as well as measures of horizontal market concentration in upstream and downstream markets, are significant components of cross-sectional and intertemporal wholesale price variations. Next we turn to a specific event – the merger of Unocal and Tosco – that affected the vertical and horizontal structure of thirteen West Coast metropolitan areas. Both empirical exercises support the hypothesis that vertical market structure significantly impacts wholesale prices in ways that are consistent with our model's predictions.

2 Raising – or lowering? – rivals' costs

The most studied example of raising rivals cost is the pure vertical merger. The analysis, such as the model in OSS, contrasts an unintegrated market structure with a (partially) vertically integrated structure. Figure 1 shows the typical unintegrated case, with two independent upstream firms and two independent downstream firms. In Figure 2, one of the upstream firms merges with one of the downstream firms. In the OSS model, the merged firm has an incentive to raise the price of the upstream good, because a higher upstream price causes the unintegrated downstream firm to raise its price, which results in higher profits for the integrated firm.

The OSS model makes important assumptions that affect the equilibrium responses to a vertical merger. First, the model assumes that the unintegrated upstream firms in Figure 1 are Nash-Bertrand competitors with constant and equal marginal costs. Therefore, the equilibrium upstream price in the unintegrated market structure is equal to the upstream firms' marginal costs. As a result of this assumption, the vertical merger in Figure 2 does not generate efficiencies by eliminating the double marginalization that occurs when the upstream firms sell at prices that exceed their marginal costs.

A second important assumption in the OSS model is that the vertically integrated firm in Figure 2 can determine the price of the upstream good, for example, by committing to an upstream price. However, OSS do not explain why this commitment is an equilibrium outcome in the upstream market.

We begin by considering a model which provides for equilibrium wholesale prices that exceed marginal costs. Hence the vertical merger will result in efficiency gains through the elimination of double marginalization. This model is consistent with many of the features of the gasoline industry. We make the following assumptions:

(i) There is a homogeneous upstream good produced with zero marginal cost.

In the case of gasoline, the upstream good is wholesale gasoline that is available at a terminal facility. Gasoline terminals serve a large market area. Some terminals serve a single metropolitan area, such as San Diego, Bakersfield, or Sacramento. Large metropolitan areas such as the San Francisco Bay area have more than one terminal. The gasoline supplied at a terminal is a relatively homogeneous product. Independent retailers purchase unbranded gasoline at the rack, which has no brand name product differentiation, and is completely homogeneous within each octane grade. The assumption that the upstream good is produced with zero marginal cost is for convenience. The results extend easily to production with constant marginal costs.

(ii) There are two upstream firms that act as Nash-Cournot competitors

Wholesale gasoline suppliers ship gasoline from their refineries via pipeline to each terminal. These pipelines are often common carrier lines, and firms must schedule periodic shipments in anticipation of demand. Furthermore, supply at each terminal is limited by storage capacity. Unbranded gasoline is a homogeneous product and spatial differentiation at a distribution rack is minimal. Prices tend to adjust to equate demand to the available quantity. Thus the Nash-Cournot model of competition appears to be a reasonable description of competition at the wholesale level.

(iii) One unit of upstream good is required to produce one unit of downstream good

This assumption is appropriate to the gasoline industry. One gallon of retail gasoline requires one gallon of wholesale supply.

(iv) There are two downstream firms that sell differentiated products with zero marginal costs. These firms act as Nash-Bertrand competitors.

Retail gasoline suppliers are spatially differentiated and post prices for their products. Again, the assumption of zero marginal cost is not significant.[6]

We consider two different market structures, corresponding to Figures 1 and 2. In the unintegrated case, the upstream firms and the downstream firms are unrelated. In the vertical integration case, Firm 1 operates in both the upstream and the downstream markets. There is a separate upstream Firm 2 and a separate downstream Firm 2. We model competition as a two-stage game. In the first stage, Firm 1 and the upstream Firm 2 choose quantities of the intermediate good that they sell to the downstream Firm 2. These quantities and the derived demands for the upstream good from the downstream firms determine the equilibrium price of the upstream good. In the second stage, the downstream firms choose retail prices taking each other's prices as given (the Nash-Bertrand assumption) and act as a price-takers with respect to the price of the intermediate good. In the first stage of the game, each firm takes the other's quantity choice as given (the Nash-Cournot assumption). In the partially integrated case, Firm 1 also takes into account that its sales of the intermediate good affect equilibrium retail prices.

Define:
p_i = the downstream price for sales by firm $i = 1, 2$.
q_i = the downstream quantity sold by firm $i = 1, 2$.
w = the upstream price
x_i = sales of the upstream good by firm i=1,2.
X= total sales of the upstream good.

2.1 The Unintegrated Case

Downstream Firms: We begin with the second stage of the game, for which the price w of the upstream good is fixed. The downstream firms act as Nash-Bertrand competitors, taking the upstream price w as given. Firm

[6] Although the retail gasoline market has features that are consistent with Nash-Bertrand competition for spatially differentiated products, we cannot rule out other conduct such as history-dependent pricing strategies (see, e.g., Borenstein, Cameron and Gilbert, 1997). However, our results are not strongly dependent on the precise nature of competition at the retail level.

i chooses price p_i to maximize

$$\pi_i^d(p_1, p_2) = (p_i - w)q_i(p_1, p_2). \tag{1}$$

Let $p_i^*(w)$ be the equilibrium downstream prices conditional on the upstream price w. The equilibrium downstream quantities are $q_i(p_1^*(w), p_2^*(w))$. One unit of the downstream good requires one unit of the upstream good. Assuming no storage, X,the total sales of the upstream good, equals $q_1 + q_2$. Thus

$$X = q_1(p_1^*(w), p_2^*(w)) + q_2(p_1^*(w), p_2^*(w))$$

determines the demand for the upstream good, and this can be inverted to give the inverse demand function, $w(X)$.

Upstream Firms The upstream firms are Cournot-Nash competitors. They choose quantities x_i (capacities) to maximize

$$\pi_i^u = w(x_i + x_j)x_i. \tag{2}$$

The Nash-Cournot equilibrium quantities determine a supply of the upstream good, $x_1^* + x_2^* = X^*$, which depends on the derived demand for the upstream good (which in turn depends on the downstream demand functions and the nature of downstream competition). The equilibrium upstream price, w^*, is the price that equates supply and demand for the upstream good:

$$X^* = q_1(p_1^*(w^*), p_2^*(w^*)) + q_2(p_1^*(w^*), p_2^*(w^*)).$$

2.2 Vertical Integration Case

Assume upstream Firm 1 and downstream Firm 1 merge, as indicated in Figure 2. The integrated Firm 1 sells at retail and competes with the upstream Firm 2 for sales of the upstream good to the unintegrated downstream Firm 2. The integrated firm's profit is

$$\pi_1 = p_1 q_1(p_1, p_2) + w(x_1 + x_2)x_1. \tag{3}$$

The unintegrated downstream firm's profit is

$$\pi_2^d = (p_2 - w)q_2(p_1, p_2) \tag{4}$$

and the unintegrated upstream firm's profit is

$$\pi_2^u = w(x_1 + x_2)x_2. \tag{5}$$

As in the unintegrated case, we consider a two-stage game. Firms are Nash-Cournot competitors in the upstream market corresponding to the first stage of the game and they compete as Nash-Bertrand competitors in the second, downstream stage. Competition at the second stage results in equilibrium prices, conditional on the wholesale price, $p_1^{**}(w)$ and $p_2^{**}(w)$. In the first stage, Firm 1 takes into account that its sales of the intermediate good affect equilibrium retail prices in the second stage of the game.

Sales of the intermediate good have to satisfy the identity

$$x_1^{**} + x_2^{**} = X^{**} = q_2(p_1^{**}(w), p_2^{**}(w)).$$

Conditional on w, there is an inverse demand function for the upstream good, $w(X)$, where now $X = q_2(p_1(w), p_2(w))$. Note that the inverse demand for the upstream good in the vertical integration case differs from the inverse demand in the unintegrated case. In the vertical integration case, X measures only sales to the unintegrated downstream Firm 2 - the demand for the wholesale product decreases.

In the first stage of the game, Firm 1's decision problem is to choose x_1, taking x_2 as given, to maximize

$$\pi_1 = p_1 q_1(p_1, p_2) + w x_1 = R(p_1, p_2) + w x_1$$

where p_1 and p_2 depend on w (but not directly on x_1 and x_2) and $w = w(x_1 + x_2)$.

Let $R_1(p_1, p_2) = p_1 q_1(p_1(w), p_2(w))$. The first-order condition for Firm 1 is

$$\frac{d\pi_1}{dx_1} = \left(\frac{\partial R_1}{\partial p_1}\frac{\partial p_1}{\partial w} + \frac{\partial R_1}{\partial p_2}\frac{\partial p_2}{\partial w}\right)\frac{\partial w}{\partial x_1} + \left(w + x_1\frac{\partial w}{\partial x_1}\right) = 0.$$

The second bracketed term is the usual first-order condition for the upstream Nash-Cournot competition. The first term in the first bracket, $\frac{\partial R_1}{\partial p_1}$, is zero because the firms are Nash-Bertrand competitors in the second stage of the game. Thus the first-order condition for Firm 1 is[7]

$$\frac{d\pi_1}{dx_1} = \left(\frac{\partial R_1}{\partial p_2}\frac{\partial p_2}{\partial w}\right)\frac{\partial w}{\partial x_1} + \left(w + x_1\frac{\partial w}{\partial x_1}\right) = 0. \tag{6}$$

[7]This assumes an interior solution and the usual convexity assumptions.

The first order condition for Firm 2 is the same as in the unintegrated case,

$$\frac{d\pi_2}{dx_2} = \left(w + x_2 \frac{\partial w}{\partial x_2} \right) = 0. \tag{7}$$

Solutions to (6) and (7) determine the supply function for the vertical integration case, $x_1^{**} + x_2^{**} = X^{**}$. Equating this to the demand for the upstream good, $q_2 = q_2(p_1^{**}(w), p_2^{**}(w))$, permits calculation of the equilibrium upstream price in the vertical integration case.

The first term on the right-hand-side of (6), $\left(\frac{\partial R_1}{\partial p_2}\frac{\partial p_2}{\partial w}\right)\frac{\partial w}{\partial x_1}$, is the "raising rivals' costs" effect. By supplying less of the upstream good, Firm 1 can raise the equilibrium upstream price. This causes the unintegrated downstream firm to raise its price, which increases Firm 1's profits. We call this the *strategic effect*. Figure 3 illustrates the strategic effect. This figure shows the Nash-Cournot reaction functions for the unintegrated and the integrated market structures. With vertical integration, Firm 1's reaction function shifts to the left, which results in a lower equilibrium upstream quantity and a higher equilibrium upstream price.

There is another effect from vertical integration which acts in the opposite direction on the upstream price. For a given upstream price, w, vertical integration lowers the unintegrated downstream firm's demand for the upstream good. By eliminating double-marginalization, vertical integration results in a lower price, p_1. In addition, the strategic effect identified above increases the input cost to downstream Firm 2, resulting in a higher price, p_2. These two effects lead to a decrease in the derived demand for the upstream good relative to the unintegrated case. McAfee (1999) identified this *substitution effect* and showed that it can result in a lower equilibrium upstream price.

Figure 4 illustrates both the strategic effect and the substitution effect. The strategic effect is a shift of the upstream supply to the left, as Firm 1 restricts output to increase the price of the intermediate good. The substitution effect is a shift of the demand function for the upstream good to the left. These two shifts can result in higher or lower equilibrium prices for the upstream good. We note, however, that the substitution effect would be mitigated to the extent that the unintegrated firms contract efficiently to exchange the intermediate good.

Appendix A solves the system of supply and demand equations for the unintegrated and vertically integrated market structures for the special case

of linear downstream demand (and assuming that market exchange takes place at linear prices). The appendix shows that in the linear case, vertical integration results in a *lower* equilibrium price for the upstream good. The vertical merger lowers rivals' costs!

3 Equilibrium Models of Gasoline Markets

The preceding discussion and the calculations in Appendix A are useful to frame the analysis of price effects from vertically integrated market structures in gasoline supply. However, these examples do not correspond precisely to the market data we examine. In particular, we do not observe a pure vertical merger in our data, corresponding to a movement from the market structure in Figure 1 to the market structure in Figure 2. Instead, we have data on markets that differ in the mix of vertically integrated and non-integrated (independent) refiners and marketers. We also have data on a particular event, corresponding to the sale of upstream refinery assets owned by a vertically integrated refiner-marketer to a refiner with only limited downstream assets. In this section we model the likely differentials in upstream prices corresponding to these different market structures. The model yields predictions about the price effects of vertical and horizontal market structures that can be empirically tested to assess whether the strategic incentive to raise rivals cost is a significant determinant of the intertemporal and cross-sectional variation in wholesale gasoline prices.

3.1 A mix of integrated and non-integrated firms

Assume (as in Appendix A) that demands for retail gasoline are linear in prices, however we scale the size of the market of the integrated firm by a factor M :

$$\begin{aligned} q_1 &= M(\alpha - \beta p_1 + \gamma p_2) \\ q_2 &= \alpha - \beta p_2 + \gamma p_1. \end{aligned}$$

The scale factor $0 < M < \infty$ allows us to explore variations in the size of the vertically integrated sector of the market relative to the size of the market that is supplied by independent retailers. Let $\theta = \frac{\gamma}{\beta}$. The parameter θ is proportional to the ratio of the cross-elasticity to the own-elasticity of

demand for the two products,

$$\theta = -\frac{p_i}{p_j}\frac{\epsilon_{ij}}{\epsilon_{ii}}$$

where $\epsilon_{ij} = \partial \ln q_i / \partial \ln q_j$.

We maintain the sequential nature of the game as discussed above. The upstream firms play Nash-Cournot in the first stage, followed by Nash-Bertrand competition in the second stage of the game, conditional on the upstream price w. To make the model closer to reality, we assume that the independent retail segment is perfectly competitive. Therefore, in the second stage of the game, Firm 1 chooses p_1 to maximize

$$\pi_1 = p_1 q_1(p_1, p_2) + w x_1,$$

with $p_2 = w$, $q_1 = M(\alpha - \beta p_1 + \gamma p_2)$, and taking w and x_1 as given. The equilibrium downstream prices are

$$p_1 = \frac{1}{2}\left(\frac{\alpha}{\beta} + \theta w\right) \tag{8}$$

$$p_2 = w. \tag{9}$$

Sales of the upstream good must equal q_2, the demand for the upstream good. Thus

$$X = q_2(p_1, p_2) = \alpha(1 + \frac{1}{2}\theta) - \beta(1 - \frac{1}{2}\theta^2)w. \tag{10}$$

and

$$w(X) = \frac{1}{\beta(1 - \frac{1}{2}\theta^2)}\left[\alpha(1 + \frac{1}{2}\theta) - X\right]. \tag{11}$$

In the first stage of the game, Firm 1 chooses x_1 to maximize

$$\pi_1 = p_1 q_1(p_1, p_2) + w x_1$$

(taking into account that w, p_1, and p_2 depend on x_1) and the upstream Firm 2 chooses x_2 to maximize

$$\pi_2^u = w(x_1 + x_2)x_2.$$

The first-order conditions are

$$\begin{aligned} \frac{\partial(p_1 q_1)}{\partial w}\frac{\partial w}{\partial x_1} + w + x_1\frac{\partial w}{\partial x_1} &= 0 \\ w + x_2\frac{\partial w}{\partial x_1} &= 0. \end{aligned}$$

Thus the reaction function at the first stage of the game are (for $x_1 > 0$ and $x_2 > 0$)

$$\begin{aligned} x_1 &= \frac{1}{2}\alpha(1 + \frac{1}{2}\theta) - \frac{1}{2}x_2 - \frac{1}{2}M\beta\theta p_1(w), \\ x_2 &= \frac{1}{2}\alpha(1 + \frac{1}{2}\theta) - \frac{1}{2}x_1. \end{aligned}$$

Note the strategic effect, $-\frac{1}{2}M\beta\theta p_1(w)$, in Firm 1's reaction function. If the strategic effect is sufficiently large, Firm 1's optimal upstream supply is zero. For $x_1 > 0$, the total upstream supply is

$$X = \frac{2}{3}\alpha(1 + \frac{1}{2}\theta) - \frac{1}{3}M\beta\theta p_1(w). \tag{12}$$

Equating upstream supply to the upstream demand given by (10), substituting (8) for $p_1(w)$ and solving for the equilibrium upstream price gives

$$w = \frac{\alpha}{3\beta}\left[\frac{1 + \frac{1}{2}\theta(1 + M)}{1 - \frac{1}{2}\theta^2(1 + \frac{M}{3})}\right]. \tag{13}$$

Returning to the assumption that $x_1 > 0$, if $x_1 = 0$, then $x_2 = \frac{1}{2}\alpha(1 + \frac{1}{2}\theta) = X = q_2(p_1, p_2)$. This implies

$$w_{\max} = \frac{\alpha}{2\beta}\left[\frac{1 + \frac{1}{2}\theta}{1 - \frac{1}{2}\theta^2}\right]. \tag{14}$$

Thus the upstream price is the lesser of (13) and $w_{\max}$.

The derivation of the equilibrium upstream price generalizes easily to the case in which there are $N \geq 2$ firms that supply wholesale gasoline, one of which is vertically integrated. The corresponding expressions for the more general case are

$$w = \frac{\alpha}{(N+1)\beta}\left[\frac{1 + \frac{1}{2}\theta(1 + M)}{1 - \frac{1}{2}\theta^2(1 + \frac{M}{N+1})}\right] \tag{15}$$

and

$$w_{\max} = \frac{\alpha}{N\beta}\left[\frac{1 + \frac{1}{2}\theta}{1 - \frac{1}{2}\theta^2}\right]. \tag{16}$$

If $N = 1$, the expression for the equilibrium wholesale price depends on the identity of the supplier. If the firm is vertically integrated, the upstream price is given by (15). If the firm is unintegrated, the upstream price is given by (16), and is lower than (15) if $M > 0$. Thus the substitution of an integrated wholesale supplier for an unintegrated wholesale supplier leads to an increase in the wholesale price. We do not focus on retail prices in this analysis. However, it is easily seen that higher wholesale prices lead to higher retail prices in this model.

There is a positive relationship between the factor M and the integrated firm's share of total retail sales, which we derive in Appendix B. In Figure 5, we show the dependence of the upstream price w on the unintegrated marketers' share of retail sales, conditional on the substitution factor θ and the total number of (unintegrated and integrated) wholesale suppliers, N. The plateaus in Figure 5 correspond to $x_1 = 0$; the integrated firm does not supply the wholesale market for these values. Indeed, the data show a number of markets in which integrated firms do not sell gasoline at wholesale. Markets with a larger share of independent retailers have a lower equilibrium upstream price. The explanation is that the strategic effect increases with the vertically integrated market share (decreases with the share of independent retailers). An increase in the independent retailer market share has a bigger impact on the wholesale price when the substitution parameter θ is large because the strategic effect increases with θ. However, these relationships are further complicated by the fact that, in general, we should expect θ to depend on the independent retailers' market share.

These results guide the empirical examination of the effects of market structure on wholesale gasoline prices. Holding the number of upstream suppliers constant, we expect the wholesale price to increase with the market share of the vertically integrated firms. In addition, we expect the wholesale price to be increasing in the cross-price elasticity between integrated and unintegrated downstream firms. These are purely vertical market impacts. The wholesale price should be a decreasing function of N, the number of wholesale suppliers, whether they are integrated or unintegrated. This is a horizontal effect at the wholesale level of the market. We would also expect the wholesale price to increase with the concentration of the vertically

integrated suppliers. This effect can be captured by the factor M,which can be construed to measure the market power of the integrated firm. This effect has both vertical and horizontal elements. It is vertical to the extent that the higher price is driven by the strategic incentive to raise rivals' costs and it is horizontal to the extent that upstream concentration leads to higher wholesale prices.

4 Empirical Analysis

This section empirically examines the effects of vertical integration on the wholesale price of gasoline and tests the predictions of the raising rivals' costs model. The analysis addresses the following questions: Do prices vary with horizontal market structure in upstream markets? Does downstream market structure covary with wholesale prices? Do price patterns suggest a relationship between the degree of vertical integration and the wholesale price that is consistent with the theoretical model in Section 3?

Our approach is twofold. We first analyze a panel of twenty-six U.S. metropolitan areas from January 1993 through June of 1997 to identify correlations between the average wholesale price and horizontal and vertical market structure. The metropolitan are located in West Coast, Rocky Mountain, and Gulf Coast states. We find that the degree of vertical integration, and measures of horizontal market concentration in upstream and downstream markets, are significantly correlated with wholesale prices. Next we turn to a specific event – Tosco Corporation's aquisition of Unocal's West Coast refining and marketing assets – that affected the vertical and horizontal structure of thirteen West Coast metropolitan areas. We use this event to test if the differential changes in downstream market share and the degree of competition with rival independent retailers resulting from the merger were followed by changes in wholesale prices as predicted by our model. Both empirical exercises support the hypothesis that vertical market structure significantly impacts wholesale prices in a manner that is consistent with the theoretical model developed in the previous section.

4.0.1 Data Description: Market Structure and Wholesale Prices

Retail Census data, available annually from Whitney Leigh Corporation for each of the twenty-six metropolitan areas used in this analysis, provide de-

tailed information on the characteristics of every retail gasoline outlet in each metropolitan area. The retail census also includes the ownership and delivery type for each station. This variable determines each staiton's vertical relationship (if any) with the upstream refiner. Hence, the Retail Censuses allow us to examine the degree of vertical integration of each of the upstream refiners selling unbranded gasoline to rival unintegrated retailers in each metropolitan area. We identify stations that are owned by a refiner as vertically integrated stations, whether or not the retail price is set by the refiner or by a residual claimant. This assumption is consistent with the results in Hastings (2000), which show no significant difference in the pricing behavior between a refiner's directly operated stations and those operated by dealers.[8]

Lundberg Wholesale Price Reports provide semi-monthly, average, unbranded wholesale prices for each metropolitan area during the time period considered. Unbranded gasoline is gasoline that is supplied at wholesale at a distribution "rack" (a supply terminal) with no restrictions on its point of sale. 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 detailed information on the average unbranded wholesale price, the companies who are supplying unbranded gasoline at each rack, the downstream market share of each of these companies in each metropolitan area (including if they have no downstream market share at all), as well as the market share of unintegrated retail marketers who purchase unbranded gasoline at the rack and compete with the integrated downstream firms.

Summary Statistics: Table 1 provides summary statistics of the market structure variables of interest. The table shows that there is a great deal of variation within the panel data set. Much of this variation is cross-sectional. However, there is substantial inter-temporal variation within metropolitan areas, largely due to entry, exit and various mergers that occurred in the mid-1990's. For example, the independent retail chain, Stop-N-Go, was purchased by Ultramar Diamond Shamrock, a refiner that was integrated in

[8]This result is also consistent with efficient contracting. The refiner can set a station-specific wholesale price based on the station's demand elasticity, and a station-specific lease rate with a volume discount to extract the retail rents. Hence the refiner's incentives to raise rival retailers' costs is similar for refiner-owned and refiner-supplied stations.

Gulf Coast markets, but not in others. This merger affected markets in Petroleum Administration Defense Districts (PADDs) 3 and 4. Tosco, an unintegrated refiner, purchased Brittish Petroleum's Pacific North West refining and marketing assets. Tosco also purchased Circle K, an unintegrated retailer in a number of Southwest gasoline markets. ARCO, an integrated refiner, purchased Thrifty, an unintegrated retailer in Southern California. These mergers, and other events, caused considerable variation in the horizontal and vertical market structure variables across the city-time units of observation.

Table 2 presents the sample correlation between the market structure variables of interest. The correlation coefficients in Table 2 indicate that horizontal market structure is not highly correlated with vertical market structure. In other words, market structures in the sample are not simply two extreme types: markets with very few unintegrated wholesalers and very high degree of vertical integration, or markets with a very unconcentrated wholesale market and a small degree of vertical integration. For example, in the third quarter of 1995, Albuquerque, New Mexico had a very concentrated upstream market and a very unconcentrated downstream market. The distribution rack had only 3 refiners supplying wholesale product – one vertically integrated with a downstream market share of about fifteen percent, and two unintegrated refiners. However, the independent retail market share was a relatively high twenty-seven percent. In the same quarter, New Orleans, Louisiana had relatively unconcentrated upstream and downstream markets, with ten refiners supplying at the rack, eight of which were unintegrated, and an independent retail market share of about twenty-three percent. Seattle, Washington had concentrated upstream and downstream markets, with one integrated refiner and two unintegrated refiners supplying at the distribution rack, and an independent retail market share of only eight percent. Across all of the markets and time periods summarized in Table 2, the correlation between the market share of independent retailers and the number of unintegrated suppliers is positive, but small. In addition, the correlation between the degree of vertical integration, downstream market share, and the upstream market concentration of both integrated and unintegrated refiners is negative, but also small. Table 2 illustrates that there is sufficient variation to independently identify the wholesale price effects of both horizontal upstream market structure and vertical market structure.

Table 3 presents the data in cell means, which allow us to partition average

prices according to market structure characteristics. In Table 3, 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 market shares of the vertically integrated suppliers. For each variable, high and low are determined by above and below the median value in Table 2. The dependent variable is the average price of unbranded wholesale gasoline in each metropolitan area less the average spot price for crude oil.[9] Although prices are available semi-monthly, they are averaged each quarter for this analysis, because the right-hand-side variables change in discrete jumps, but are fairly constant relative to the wholesale price of gasoline over shorter time periods.

Table 3 shows the average price (wholesale margin over crude oil price) for observations in each cell. For example cell 1, in the top left corner corresponds to city-quarter observations with few integrated wholesale suppliers, a small average downstream market share for the integrated suppliers, few unintegrated wholesale suppliers, and a small market share for independent retailers. Cell 5 (row 1 and column 2) shows the average price for city-quarters with the highest values for all market structures. This cell is for city-quarters with few integrated wholesale suppliers, a large average downstream market share for the integrated suppliers, few unintegrated wholesale 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 most unconcentrated city-quarter markets. This cell has many upstream suppliers of both types, a large market share for independents, and a low average downstream market share for the integrated refiners. This cell has the lowest average price. Moreover, the average price in cell 5 is roughly twice the average price in cell 12.

In addition, conditioned on the other factors, the average price of gasoline in cells with fewer integrated suppliers is higher than cells with many integrated suppliers. Likewise, conditioned on other factors, cells with fewer unintegrated suppliers have higher average prices than cells with many unintegrated suppliers. These two stylized facts in the data are consistent with the traditional price effects of horizontal concentration. As the number of upstream competitors increases, the wholesale price decreases.

[9] The crude price is the spot price at Cushing provided by the Energy Information Administration.

Notice that the two downstream market structure variables also have a systematic relationship with the cell means in Table 3. Conditioned on the other factors, markets with large shares of independent retailers have lower wholesale prices than markets with small shares of independent retailers. Furthermore, the wholesale price is higher in markets where the wholesale suppliers have a greater average downstream market share, conditioned on the other factors. This difference is most pronounced in markets structures for which the integrated wholesale firms have the greatest incentive and ability to raise downstream rivals costs. Comparing cells 1 and 5 (row 1, column 1 and 2 respectively), we see that in markets where there are a few downstream rivals, and where there are few upstream suppliers either integrated or unintegrated, the difference between the average price in cells where upstream firms have a large average downstream market share and those where they have a small one is large and significant. The difference in the cell averages is 2.74 cents per gallon, and is statistically significant at the seven percent level with an F value of 3.24. These cell mean patterns are generally consistent with the theoretical model.

Notice that moving from cell 1 to cell 3 (column 1, row 1 and row 3 respectively), which corresponds to adding more unintegrated suppliers in a market where there are few independents and few integrated suppliers with a large average downstream market share, decreases the average price by 2.21 cents, which is significant at the ten percent level. These cell comparisons suggest that a move to a small average downstream market share for the integrated supplier holding other factors constant, (the movement from cell 5 to cell 1), has a similar effect on the cell mean as increasing the number of unintegrated suppliers (the movement from cell 1 to cell 3). These values suggest that the degree of vertical integration is an important determinant of wholesale prices – perhaps as important as horizontal upstream concentration.

A movement from a cell in Table 3 with few independent marketers to one with many independent marketers yields a lower cell mean, except when moving from cell 5 to cell 6, or from cell 15 to cell 16. Focusing on cells 5 and 6, where there are few upstream suppliers and the integrated suppliers have a large market share, the theory suggests that the incentive of integrated firms to raise the wholesale price decreases with the independent retail market share and increases with θ. However, there is no change in the cell mean between cells 5 and 6. This may be due to the fact that the independent retail market share and the cross-elasticity parameter θ are almost certainly

related, with θ an increasing function of the independent retail market share. Since retail gasoline stations are geographically differentiated products, as the number of independent retailers increases, their average distance to an integrated retail station may decrease, leading to an increase in the cross-elasticity parameter θ for geographically differentiated products. Thus these two effects may be confounding in some cell means, but we will be able to separate them in the detailed analysis of the Tosco-Unocal merger in the next section.

Table 4 presents a regression correlation between the continuous values of the market structure variables and the wholesale prices. The regression correlation reflects the relationships evident in the cell mean presentation, where the regressors' values were divided into discrete categories. Upstream concentration is positively correlated with price, the market share of independents is negatively correlated with price, and the average market share of the vertically integrated suppliers covaries positively with wholesale price.

4.1 Detailed Panel Regression:

The preceding section offers important insights into wholesale price variation and its relationship to vertical and horizontal market structure. The cell means suggest that the strategic incentive for vertically integrated firms to raise rivals wholesale costs may be a significant determinant of cross-sectional and intertemporal price variation. The merger of Tosco and Unocal allows a more precise identification of the relationship between the degree of downstream integration and wholesale prices - the "vertical component" in horizontal mergers. The merger caused discrete changes in Tosco's downstream market share in thirteen West Coast metropolitan areas. We exploit this variation to test if these changes in downstream market structure were followed by changes in Tosco's wholesale gasoline price as predicted by our model, controlling for costs and other important market structure variables. Moreover, in this analysis we are able to measure the geographic proximity of the integrated stations to rival independents, giving a measure of the cross-price elasticity between the integrated and unintegrated downstream firms.

4.1.1 Details of the Merger:

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 on the West Coast, and all of their retail outlets, including the Union 76 logo, in all West Coast metropolitan areas including those in Arizona and Nevada. The purchase was completed in April of 1997, when Tosco officially took control of the Unocal assets and their operation. Unocal's downstream retailers were almost exclusively integrated. Their downstream market share varied from two percent to eighteen percent of the total census of retail stations in the metropolitan areas considered. In some metropolitan areas, Unocal sold some amount of unbranded gasoline at the distribution rack, but in others they did not compete in the unbranded wholesale market. Table 5 shows the markets that were affected by the purchase, with the corresponding changes in downstream market share and upstream concentration.

Before the acquisition of Unocal's West Coast downstream assets, Tosco had some downstream market presence in a few of the cities considered. Their retail market share varied from zero to approximately forty percent. In the few cities where Tosco had a significant downstream market share, Unocal typically did not have a significant number of downstream outlets. In this respect, the assets of Tosco and Unocal were complementary in each metropolitan area (the acquisition was primarily vertical), hence the merger may not have raised traditional antitrust concerns over increases in horizontal concentration in upstream or downstream markets. Tosco's downstream assets included the British Petroleum stations and the BP brand (Tosco purchased BP's Northwest refining and marketing assets in 1993) and the Circle K convenience store and gasoline station chain, which they acquired at the end of May, 1996.[10] BP stations were mostly in the Pacific Northwest metropolitan areas (Seattle and Portland in our data), with a small market

[10] 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 markets do not provide a before and after comparison on Tosco's wholesale price. The vertical merger with Circle K provides an interesting oportunity to look at rasing rival's cost in a purely vertical merger, however the timing coincided with the requirement of California Air Resorces 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.

share in San Francisco, and Circle K stations were located mostly in Arizona, with a few stations in Nevada and Southern California. Tosco had a few retail outlets relative to refining capacity in most areas, and sold wholesale gasoline to independent marketers in all of the thirteen metropolitan areas that are considered in this empirical analysis.

The acquisition of Unocal's downstream assets by Tosco changed the downstream market share for Tosco by varying degrees across the 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 percent. We empirically test if the discrete changes in the degrees of vertical integration were followed by changes in Tosco's prices for unbranded wholesale gasoline, commensurate with the predictions of our model. In particular, we use the variation in the degree of vertical integration resulting from the merger to test if Tosco's wholesale price is increasing in its downstream market share and increasing in its degree of competition with independent retailers, controlling for variation in costs and horizontal market structure variables.

4.1.2 Data:

For this empirical analysis we use the Retail Census data described in the previous section, coupled with detailed wholesale price data from Oil Price Information Service. The retail census data reported in Table 6 provide a measure of the change in Tosco's downstream market share that resulted in each metropolitan area as result of the acquisition of Unocal's retail outlets. The detailed wholesale rack price data from Oil Price Information Service provide weekly average wholesale gasoline prices by supplier and metropolitan area. The price data are for the period of July 1996 through December of 1998, providing weekly observations on Tosco's price for unbranded gasoline at each distribution rack for about one year before, and a year and a half after the event of interest.

Using these data, we construct two main variables to identify the effects of raising rivals cost incentives on Tosco's unbranded wholesale price of gasoline. The first is the dependent variable: the price of wholesale gasoline. Because our focus is on strategic price effects, we difference wholesale prices to account for factors such as input costs and inventories. Specifically, we subtract the price of wholesale gasoline in Phoenix from the wholesale price

time series in each metropolitan area. We choose Tosco's wholesale price of gasoline in Phoenix as an approximation of cost variables because Phoenix experienced no change in upstream or downstream market structure during the time period considered and, in particular, was not impacted by the Unocal acquisition.[11] 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.[12]

In this section we also construct a variable, which we call "downstream market contact", that provides a better approximation than retail share alone for the competition that exists in downstream markets. The theory described in Section 3 shows that the strategic incentive to raise rivals' costs depends on the demand parameter θ as well as on the market share of independent (that is, rival) retailers. The theory predicts that the equilibrium wholesale price increases with θ and decreases with the market share of independent retailers. Thus, in addition to downstream market share as an explanatory variable, the empirical analysis should attempt to estimate the magnitude of the parameter θ. Retail gasoline outlets are geographically differentiated.[13] In markets where the market share of independent retailers is very small, the interaction between independent and vertically integrated retailers, as parameterized by the factor θ in the theoretical analysis, is also likely to be small because, on average, independent retailers are distant from vertically integrated retailers. Alternatively, if most Unocal stations had an independent retailer as a close competitor before the acquisition, a small increase in downstream market share from the Unocal purchase could have a significant impact on Tosco's wholesale price strategy. This high degree of interaction is more likely when the market share of independents is large. Using Retail Census data, we construct a variable that measures the increase in downstream market competition with independents resulting from the Unocal purchase. This is done by weighting the increase in the downstream market share due

[11] Only 3.5 percent of the stations in Phoenix are Independent marketers. So even though Tosco's market share increased by 2 percent, its downstream contact with independent retailers did not increase at all as a result of the Unocal aqcuisition.

[12] We used crude oil prices to adjust for cost factors in the broad panel analysis discussed in the previous section because no city market had an unchanged market structure over the entire period covered in the broad panel. The regression results presented in Table 6 do not change significantly if add the price in Phoenix as a regressor instead of subtracting it from the left hand side. The coefficent on the Price in Phoenix is 0.953.

[13] See Slade (1986, 1992), Borenstein, Cameron, and Gilbert (1997), and Hastings (2000).

to the acquisition of Unocal retail outlets by the percent of those outlets that are geographically located within one mile of an independent retailer. Creating this variable for Tosco's retail outlets both before and after the merger allows us to test if Tosco's wholesale price is positively impacted by this measure of downstream market competition with independents, as predicted by our model.

4.1.3 Empirical Specification and Results:

We estimate the following regression to estimate variation in Tosco's differenced wholesale price as a function of downstream market share, downstream contact with independent retailers, upstream concentration, and the market share of independent retailers. The variation in Tosco's downstream assets resulting from the merger allow us to separately identify the price effects from these factors and other city-level fixed effects that covary with prices.

The regression is specified as follows:

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

Where:
p_{it} = Tosco's weekly average price of unbranded wholesale gasoline in city i less the price in Phoenix in week t
α_i = city-specific fixed effect
d_{it} = downstream market contact with rival independents in city i in week t
u_{it} = the number of refiners selling unbranded gasoline in city i in week t
r_{it} = the percent of rival 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 some intertemporal variation in this regressor. Some was due to the post-merger exit of Unocal from the markets where it supplied unbranded gasoline. Other variation comes from periodic entry or exit by refiners at each rack. In 1998, after Shell and Texaco merged, Texaco ceased selling unbranded gasoline in many markets where the combined firms had a significant downstream market share. This provides further variation in the number of upstream competitors over our sample period.

The error component is given an autoregressive structure to capture the dynamic effect of gasoline prices. A Dickey-Fuller test for a unit root rejected the hypothesisof a unit root in the wholesale price time series for each city included in the regression. In addition, the specification of an autoregressive error structure is not rejected in favor capturing the dynamic effect with a lagged price value on the right-hand side. The error structure is also given a city-specific component. A Hausman test does not reject the hypothesis that the city-specific error component is uncorrelated with the regressors, hence we cannot reject the random effects model in favor of a fixed-effects specification.[14]

Table 6 present regression results. The first specification includes city-specific fixed-effects and the downstream market contact variable, which measures θ in the theoretical model. The variation in downstream market contact resulting from the merger allows us to separately identify 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. The spot estimate implies that for every one percent increase in the percent of stations in direct competition with a rival independent retailer, the weekly average unbranded gasoline price rises by 0.44 cents per gallon. Consistent with our model, an increase in downstream market contact with rival independent firms increases the strategic incentive to raise rival's costs. The estimates imply that in Los Angeles, for example, where the acquisition of Unocal's retail assets increased the number of integrated stations that compete with rival independents and hence increased Tosco's incentive to raise rival's costs, the estimated price increase is 3.7 cents per gallon.

In the fixed-effects specification in Table 7, 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

[14]Hausman's m value is $m = q'Var(q)^{-1}q$, where $q = b_{FE} - b_{RE}$ and $Var(q) = Var(b_{FE}) - Var(b_{RE})$. The null hypothesis is that $E(a_i|X_i) = 0$ 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 assumes that the distribution of the city-specific error component, conditioned on the regressors, is the same across all cities. Fixed-effects estimates the mean of this component and does not require it to be zero. If $E(a_i|X_i) \neq 0$ the Random-effects estimator is inconsistent.

upstream competitors is significant in the random-effects specification presented in the second column, which assumes that the conditional mean of the city-specific error component is the same across all cities. The coefficient is negative, and would indicate that one less upstream competitor would lead to a 0.403 cent increase in average wholesale price. This parameter estimate agrees with theory, and represents the traditional horizontal component to a merger. Metropolitan areas where there was an increase in market the downstream contact with rival independents, and where there was an increase in concentration resulting from the merger, 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 to precisely identify it separately from the fixed-effect. The coefficient on the market share of independent retail marketers is not statistically significant in either error component specification.

The results in Table 6 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 captures both the effects of the Tosco acquisition and any pre-merger varaition across metropolitan areas. We can focus on the acquisition's effect by examining how changes in city-average prices before and after the acquisition vary with the increase in downstream contact with independent retailers. If, indeed, the price changes are related to downstream market contact, the estimated coefficient should be the same as the coefficient presented in Table 6.

Figure 6 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. These estimated price increases are then plotted against the increase in downstream market contact with independent retailers. Table 7 presents the slope coefficient for the OLS regression of the estimated price change on the change in downstream contact with independents. The coefficient on Downstream Market Contact is 0.3634 and is significant at the one-percent level. This coefficient is the same as the one in Column 2 of Table 6. Hence, the results again suggest that an integrated refiner's unbranded wholesale price is an increasing function of the degree of competition with independent retailers, as predicted

by our Raising Rivals' Cost model.

Table 8 presents results where the downstream market contact variable is replaced with the vertically integrated downstream market share. The regression results indicate a positive relationship between downstream market share and the unbranded wholesale price. The coefficient implies that for every 1 percent increase in downstream market share, Tosco's price rises by 0.198 cents per gallon. For San Jose, this implies a 2.94 cent a gallon increase in the price of unbranded gasoline resulting from the acquisition of Unocal's retail outlets.

5 Conclusion

The impact of vertical market structure on wholesale (and retail) prices is in general difficult to predict. There are theoretical reasons why firms with market power that operate at both the wholesale and retail levels of a market would have an incentive to raise the wholesale price (or refuse to supply at wholesale) in order to disadvantage their downstream competitors. However, these strategic incentives can be offset by changes in the demand for the upstream good that accompany changes in vertical market structure. The balance of these two effects depends on factual circumstances in each market. Indeed, we find that a purely vertical merger (a frequently cited example of raising rivals' costs) can lead to a reduction in wholesale prices. Moreover, changes in vertical market structure can have complicated impacts on other variables, such as the cross-elasticity between independent and vertically integrated firms, which affect the incentives for vertically integrated firms to raise their rivals' costs. Thus investigation of the impacts of vertical market structures requires a careful empirical analysis that is guided by theoretical predictions.

We analyze the expected wholesale price effects of different vertical market structures for the case of gasoline markets. Gasoline markets have the attractive feature that the product is homogeneous, and accurate and abundant data are available to estimate structural impacts. We find evidence in a broad panel that vertical integration matters for upstream retail prices and that wholesale prices tend to be higher in markets with large vertically integrated firms. This finding is consistent with the strategic incentive and ability of vertically integrated firms to raise input costs to downstream rivals.

We further test this correlation with a specific event that caused discrete and differential changes in the degree of vertical integration in gasoline markets across West Coast metropolitan areas. The findings from this more detailed analysis are consistent with the correlations presented in the broad panel of U.S. metropolitan areas. We find that the degree of vertical integration has significant and positive impacts on integrated firms' wholesale prices. Moreover, the incentive to raise price is also positively correlated with the geographic proximity of integrated stations to rival independents, indicating that the greater the degree of competition, or cross-price elasticity, between integrated retailers and rival independent retailers, the greater the integrated firm's incentive to raise rivals' wholesale costs.

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Appendix A

As in the main text, we model a two stage game with Nash-Cournot competition in the first (upstream) stage and Nash-Bertrand competition in the second (downstream) stage. We consider two different market structures, corresponding to Figures 1 and 2. In the unintegrated case, the upstream firms and the downstream firms are unrelated. In the vertical integration case, Firm 1 operates in both the upstream and the downstream markets. There is a separate upstream Firm 2 and a separate downstream Firm 2.

Beginning with the downstream retail market, we assume that final demands are linear in prices,

$$\begin{aligned} q_1 &= \alpha - \beta p_1 + \gamma p_2 \\ q_2 &= \alpha - \beta p_2 + \gamma p_1. \end{aligned}$$

with $\beta > 0$ and $\gamma > 0$. For stability (define), we assume $\beta > \gamma$. Define $\theta = \frac{\gamma}{\beta}$: θ measures the ratio of the cross-elasticity to the own-elasticity of demand for the downstream products.

5.1 The Unintegrated Case

Downstream Firms

We begin with the second stage of the game, for which the price w of the upstream good is fixed. The downstream firms act as Nash-Bertrand competitors, taking the upstream price w as given. Firm i chooses price p_i to maximize

$$\pi_i^d(p_1, p_2) = (p_i - w)q_i(p_1, p_2).$$

The reaction functions are

$$p_1 = \frac{\alpha}{2\beta} + \frac{1}{2}w + \frac{1}{2}\theta p_2 \tag{17}$$

$$p_2 = \frac{\alpha}{2\beta} + \frac{1}{2}w + \frac{1}{2}\theta p_1. \tag{18}$$

The equilibrium prices are

$$p_1 = p_2 = \frac{\alpha + \beta w}{2\beta(1 - \frac{1}{2}\theta)} \tag{19}$$

and the equilibrium demands for the products of the downstream firms are

$$q_1 = q_2 = \frac{\alpha - \beta(1-\theta)w}{2(1-\frac{1}{2}\theta)}. \tag{20}$$

Equation (20) defines an inverse demand function for the upstream good. One unit of the downstream good requires one unit of the upstream good. Let X be the total sales of the upstream good (and assume no storage). Then $X = q_1 + q_2$, and using (20) we have the inverse demand for the upstream good:

$$w(X) = \frac{\alpha - (1-\frac{1}{2}\theta)X}{\beta(1-\theta)}. \tag{21}$$

Upstream Firms

The upstream firms are Cournot-Nash competitors. They choose quantities x_i (capacities) to maximize

$$\pi_i^u = w(x_i + x_j)x_i.$$

The reaction functions are

$$\begin{aligned} x_1 &= \frac{\alpha}{2(1-\frac{1}{2}\theta)} - \frac{1}{2}x_2 \\ x_2 &= \frac{\alpha}{2(1-\frac{1}{2}\theta)} - \frac{1}{2}x_1 \end{aligned}$$

and the equilibrium quantities (capacities) are

$$x_1 = x_2 = \frac{\alpha}{3(1-\frac{1}{2}\theta)} \quad \text{and}$$

$$X = x_1 + x_2 = \frac{2\alpha}{3(1-\frac{1}{2}\theta)}. \tag{22}$$

From (22), (19) and the identity $X = q_1(p_1(w), p_2(w)) + q_2(p_1(w), p_2(w))$, we can compute the equilibrium upstream price (where UI stands for the unintegrated case). The demand for the upstream good is

$$q_1 + q_2 = \frac{1}{(1-\frac{1}{2}\theta)}\left[\alpha - \beta(1-\theta)w\right] \tag{23}$$

and the condition that supply equals demand implies

$$w^{UI} = \frac{\alpha}{3\beta(1-\theta)}. \tag{24}$$

The equilibrium downstream prices are

$$p_1^{UI} = p_2^{UI} = \left[\frac{2\alpha}{3\beta}\right]\left[\frac{1-\frac{3}{4}\theta}{(1-\frac{1}{2}\theta)(1-\theta)}\right]. \tag{25}$$

Note that if $\gamma = 0$, corresponding to separate markets, then $q_1 = q_2 = \frac{\alpha}{3}$,the upstream price is $w^{UI} = \frac{\alpha}{3\beta}$, and the equilibrium prices are $p_1^{UI} = p_2^{UI} = \frac{2\alpha}{3\beta}$. Note that the downstream prices exceed the profit-maximizing price, $p^m = \frac{\alpha}{2\beta}$. This is the result of double-marginalization, which is moderated somewhat by Cournot competition upstream. Equilibrium downstream prices are an increasing function of θ for $\theta < 1$. The downstream products are strategic complements with Nash-Bertrand competition, hence prices rise as the cross-elasticity parameter increases.

5.2 Vertical Integration Case

Assume upstream Firm 1 and downstream Firm 1 merge, as indicated in Figure 1. The integrated Firm 1 sells at retail and competes with the upstream Firm 2 for sales of the upstream good to the unintegrated downstream Firm 2. As before, we assume Nash-Cournot competition upstream and Nash-Bertrand competition downstream. Define:

$x_i =$ sales of the upstream good by Firm i to downstream Firm 2.

$w^{VI} =$ price of the upstream good (where VI stands for the vertical integration case).

The integrated firm's profit is

$$\pi_1 = p_1 q_1(p_1, p_2) + w(x_1 + x_2)x_1.$$

The unintegrated downstream firm's profit is

$$\pi_2^d = (p_2 - w)q_2(p_1, p_2)$$

and the unintegrated upstream firm's profit is

$$\pi_2^u = w(x_1 + x_2)x_2.$$

As in the unintegrated case, we consider a two-stage game. Firms are Nash-Cournot competitors in the upstream market corresponding to the first stage of the game and they compete as Nash-Bertrand competitors in the second, downstream stage. In the first stage, Firm 1 takes into account that its sales of the intermediate good affect equilibrium retail prices in the second stage of the game.

The reaction functions in the second stage of the game are

$$\begin{aligned} p_1 &= \frac{\alpha}{2\beta} + \frac{1}{2}\theta p_2, \\ p_2 &= \frac{\alpha}{2\beta} + \frac{1}{2}w + \frac{1}{2}\theta p_1. \end{aligned}$$

Conditional on w, equilibrium retail prices are

$$\begin{aligned} p_1^{VI} &= \left[\frac{1}{(1-\frac{1}{4}\theta^2)}\right]\left[\frac{\alpha}{2\beta}(1+\frac{1}{2}\theta) + \frac{\theta}{4}w\right] \\ p_2^{VI} &= \left[\frac{1}{(1-\frac{1}{4}\theta^2)}\right]\left[\frac{\alpha}{2\beta}(1+\frac{1}{2}\theta) + \frac{1}{2}w\right]. \end{aligned} \tag{26}$$

Sales of the intermediate good have to satisfy the identity

$$x_1 + x_2 = X = q_2(p_1, p_2) = \alpha - \beta p_2 + \gamma p_1.$$

Note that the inverse demand for the upstream good in the partially integrated case differs from the inverse demand in the unintegrated case. In the unintegrated case, both downstream firms have symmetric demands for the upstream good. In the partially integrated case, X measures only sales to the unintegrated downstream Firm 2. Furthermore, the downstream prices are not symmetric because the marginal cost of the integrated firm is zero, but the unintegrated downstream Firm 2 faces a marginal cost of w.

In the second stage equilibrium,

$$X = \left[\frac{1}{2(1-\frac{1}{2}\theta)}\right]\left[\alpha - \frac{\beta(1-\frac{1}{2}\theta^2)}{(1+\frac{1}{2}\theta)}w\right]. \tag{27}$$

Hence the inverse demand for the upstream good is

$$w(X) = \left[\frac{1+\frac{1}{2}\theta}{\beta(1-\frac{1}{2}\theta^2)}\right]\left[\alpha - 2\left(1-\frac{1}{2}\theta\right)X\right]. \tag{28}$$

In the first stage of the game, Firm 1's decision problem is to choose x_1, taking x_2 as given, to maximize

$$\pi_1 = p_1 q_1(p_1, p_2) + w x_1 = R(p_1, p_2) + w x_1$$

where p_1 and p_2 depend on w through the equilibrium values given by (26) and $w = w(x_1 + x_2)$ is given by (28).

Let $R_1(p_1, p_2) = p_1 q_1(p_1, p_2)$. The first-order condition for Firm 1 is

$$\frac{d\pi_1}{dx_1} = \left(\frac{\partial R_1}{\partial p_1}\frac{\partial p_1}{\partial w} + \frac{\partial R_1}{\partial p_2}\frac{\partial p_2}{\partial w}\right)\frac{\partial w}{\partial x_1} + \left(w + x_1\frac{\partial w}{\partial x_1}\right) = 0. \tag{29}$$

The second bracketed term is the usual first-order condition for the upstream Nash-Cournot competition. The first term in the first bracket, $\frac{\partial R_1}{\partial p_1}$, is zero because the firms are Nash-Bertrand competitors in the second stage of the game. Thus the first-order condition for Firm 1 is

$$\begin{aligned} \frac{d\pi_1}{dx_1} &= \left(\frac{\partial R_1}{\partial p_2}\frac{\partial p_2}{\partial w}\right)\frac{\partial w}{\partial x_1} + \left(w + x_1\frac{\partial w}{\partial x_1}\right) && (30) \\ &= -\frac{\theta}{(1-\frac{1}{2}\theta^2)}p_1(w) + \left(w + x_1\frac{\partial w}{\partial x_1}\right) = 0. && (31) \end{aligned}$$

The first order condition for Firm 2 is the same as in the unintegrated case,

$$\frac{d\pi_2}{dx_2} = \left(w + x_2\frac{\partial w}{\partial x_2}\right) = 0. \tag{32}$$

Thus, using (28), the reaction functions in the upstream market are

$$x_1 = \frac{\alpha}{4(1-\frac{1}{2}\theta)} - \frac{\beta\theta p_1(w)}{4(1-\frac{1}{4}\theta^2)} - \frac{1}{2}x_2 \tag{33}$$

and

$$x_2 = \frac{\alpha}{4(1-\frac{1}{2}\theta)} - \frac{1}{2}x_1. \tag{34}$$

Total supply in the upstream market is

$$x_1 + x_2 = X = \frac{\alpha}{3(1-\frac{1}{2}\theta)} - \frac{\beta\theta p_1(w)}{6(1-\frac{1}{4}\theta^2)}. \tag{35}$$

Demand for the upstream good is $q_2 = \alpha - \beta(p_2(w) - \theta p_1(w))$, which, using (26) is

$$q_2 = \frac{\alpha}{2(1-\frac{1}{2}\theta)} - \frac{\beta(1-\frac{1}{2}\theta^2)}{2(1-\frac{1}{4}\theta^2)}w. \tag{36}$$

Along with (26), (35) and (36) define the supply and demand functions for the upstream good. It is instructive to compare the equilibrium of supply and demand for the unintegrated and the partially integrated markets. To do this, we normalize the unintegrated supply and demand equations for the fact that the unintegrated wholesale market is twice as large. For the unintegrated case, we have

$$\frac{\alpha}{3(1-\frac{1}{2}\theta)} = \frac{\alpha}{2(1-\frac{1}{2}\theta)} - \frac{\beta(1-\theta)}{2(1-\frac{1}{2}\theta)}w. \tag{37}$$

For the vertical integration case, we have (after some re-arranging

$$\frac{\alpha}{3(1-\frac{1}{2}\theta)} - \frac{\beta\theta p_1(w)}{6(1-\frac{1}{4}\theta^2)} = \frac{\alpha}{2(1-\frac{1}{2}\theta)} - \frac{\beta(1-\theta)}{2(1-\frac{1}{2}\theta)}w - \frac{\beta\theta}{2(1-\frac{1}{4}\theta^2)}w. \tag{38}$$

A comparison of equations (37) and (38) shows that there are two effects that determine whether the upstream price is higher or lower after vertical integration. The first is the *strategic effect* and is reflected in the term $-\frac{\beta\theta p_1(w)}{6(1-\frac{1}{4}\theta^2)}$. The strategic effect reduces the supply of the upstream good. Firm 1 will under-invest in capacity relative to the unintegrated case in the first stage of the game, and by an amount that increases with θ. This is the "raising rivals' cost" effect. Firm 1 underinvests to increase the price of the intermediate good. A higher price of the intermediate good causes the unintegrated downstream firm to increase its retail price, which increases the retail demand for Firm 1 and increases Firm 1's profit. The second effect is the *substitution effect.* Vertical integration reduces the downstream price of good 1 (by eliminating double marginalization). This, in turn, reduces the demand for good 2 because they are substitutes and, *ceteris paribus*, reduces the equilibrium price of the upstream good.. In this case, the reduction in demand for the upstream good relative to the unintegrated case is given by $\frac{\beta\theta}{2(1-\frac{1}{4}\theta)}w$. Thus, whether vertical integration raises or lowers rivals costs depends on the relative magnitudes of these two effects.

In the vertically integrated case, the equilibrium price of the upstream good is

$$w^{VI} = \frac{\alpha}{3\beta}\left[\frac{(1+\frac{1}{2}\theta)(1+\frac{\theta}{2z})}{2z-1-(\frac{1-z}{3z})}\right] \tag{39}$$

where $z \equiv 1 - \frac{1}{4}\theta^2$.

Vertical integration *lowers* the upstream price in this example. In other words, the substitution effect is larger than the strategic effect.[15]. Downstream prices also fall in the vertical integration case relative to the unintegrated case.

[15] Of course these results can change with different assumptions. OSS (1990) assume that the vertically integrated firm can *commit* to an upstream price. Under this assumption, with price competition the unintegrated upstream firm would make all of the sales of the upstream good, but the high price would nonetheless benefit the integrated firm by raising its rival's costs. It is not difficult to show that the vertically-integrated firm's profit-maximizing wholesale price is higher than the price in the unintegrated case if θ is not too large.

Appendix B

The vertically integrated firm's market share is

$$s_1 = \frac{q_1}{q_1 + q_2} = \frac{M(\alpha - \beta(p_1 - \theta p_2)}{M(\alpha - \beta(p_1 - \theta p_2) + \alpha - \beta(p_2 - \theta p_1)}, \tag{40}$$

where

$$p_1 = \frac{1}{2}\left(\frac{\alpha}{\beta} + \theta w\right), \tag{41}$$

$$p_2 = w \tag{42}$$

and

$$w = \frac{\alpha}{(N+1)\beta}\left[\frac{1 + \frac{1}{2}\theta(1+M)}{1 - \frac{1}{2}\theta^2(1 + \frac{1}{N+1}M)}\right] \tag{43}$$

provided $w \leq w^{\max}$. Substitution into the expression for s_1 gives

$$s_1 = \frac{M}{2}\left[\frac{1}{\frac{1}{2}(M+\theta) + \frac{\alpha - \beta w}{\alpha + \beta\theta w}}\right]. \tag{44}$$

Add to references:

Table 1: 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
Percent of Stations* that are Company-operated	0.21	0.12	0.58	0.28	0.19	0.11	0.03
Percent of Stations that are Lessee-Dealer	0.28	0.19	0.68	0.45	0.26	0.11	0.01
Percent of Stations that are Dealer-Company-Supplied	0.11	0.67	0.28	0.14	0.10	0.06	0.00
Percent of Stations that are Dealer-Jobber-Supplied	0.18	0.13	0.46	0.27	0.17	0.06	0.02
Percent 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 of Integrated Suppliers	0.14	0.07	0.47	0.16	0.13	0.09	0.01

*Percent of Stations of each vertical contract type is defined as the number of stations with that contract type 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 integrated stations in the retail census that the refiner owns, divided by the total number of stations in the retail census, for each metropolitan area.

Table 2: Correlation Coefficients for Upstream and Downstream Market Variables for Broad Panel Regression

	Percent Company-Operated	Percent Lessee-Dealer	Percent Dealer Owned - Branded	Percent Independent Retailers	Number of Unintegrated Refiners	Number of Vertically Integrated Refiners	Average Downstream Market share for Integrated Suppliers	Maximum Downstream Market share of Integrated Suppliers
Percent* Company-Operated	1.00	-0.73	0.40	-0.25	0.33	-0.23	0.15	0.10
Percent Lessee-Dealer	-0.73	1.00	-0.80	-0.17	-0.45	0.25	-0.21	0.02
Percent Dealer Owned – Branded	0.40	-0.80	1.00	0.03	0.28	-0.10	0.21	0.01
Percent Independent Retailers	-0.25	-0.17	0.03	1.00	0.24	-0.08	-0.14	-0.28
Number of Unintegrated Refiners	0.33	-0.45	0.28	0.24	1.00	-0.08	-0.09	-0.12
Number of Vertically Integrated Refiners	-0.23	0.25	-0.10	-0.08	-0.08	1.00	-0.22	0.13
Average Downstream Market Share for Integrated Suppliers	0.15	-0.21	0.21	-0.14	-0.09	-0.22	1.00	0.83
Maximum Downstream Market Share of Integrated Suppliers	0.10	0.02	0.01	-0.28	-0.12	0.13	0.83	1.00

Table 3: Cell Means by Combinations of Market Structure Variables
Dependent Variable: Quarterly average price of unbranded wholesale gasoline
by rack less the spot price of crude oil

		Few Integrated Suppliers		Many Integrated Suppliers	
		Small Downstream Market Share	Large Downstream Market Share	Small Downstream Market Share	Large Downstream Market Share
Few Unintegrated Suppliers	Few Independent Retailers	19.75 (1.02)	22.49 (1.13)	20.70 (1.40)	22.22 (1.54)
	Many Independent Retailers	18.33 (2.36)	22.29 (2.36)	17.31 (0.96)	18.65 (2.59)
Many Unintegrated Suppliers	Few Independent Retailers	17.54 (0.86)	19.29 (0.88)	13.10 (1.11)	13.19 (1.09)
	Many Independent Retailers	15.30 (0.71)	16.27 (0.66)	11.61 (1.29)	14.38 (1.40)

Standard errors in parentheses

Table 4: Broad Panel Regression Results
Dependent Variable: Quarterly average unbranded wholesale price by metropolitan area, less the spot price of crude oil
Robust Standard Errors corrected for serial correlation and city-specific heteroskedasticity*

	Parameter Estimate	Robust Standard Error	P-Value
Intercept	22.56	1.118	0.000
Number of Vertically Integrated Suppliers	-1.588	0.244	0.000
Number of Unintegrated Suppliers	-1.006	0.152	0.000
Average Downstream Market share for Integrated Suppliers	12.309	5.613	0.029
Market Share of Independent Retailers	-6.485	3.512	0.066
California Reformulated Gasoline Requirement	5.782	1.055	0.000
Adjusted R-Square	0.287		
Number of Observations	N=26 T=18		

*Newey-West standard errors are reported, 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.

Table 5: Characteristics of Markets affected by Tosco-Unocal Merger
Downstream Market Share is measured as percent of total stations in the metropolitan area

Distribution Rack	Tosco's Pre-Merger Downstream Market Share	Unocals's Pre-Merger Downstream Market Share	Tosco's Post-Merger Downstream Market Share	Unocal Competed with Tosco at the Distribution Rack
San Jose	0.00	0.15	0.15	
San Francisco	0.08	0.07	0.15	
Fresno	0.01	0.11	0.12	Yes
Los Angeles	0.02	0.16	0.18	Yes
Sacramento	0.06	0.08	0.14	Yes
San Diego	0.03	0.11	0.14	Yes
Stockton	0.03	0.07	0.11	Yes
Santa Barbara	0.01	0.19	0.20	
Phoenix	0.29	0.02	0.31	
Tucson	0.39	0.06	0.45	
Reno	0.00	0.08	0.08	Yes
LasVegas	0.06	0.05	0.11	
Seattle	0.22	0.02	0.24	
Portland	0.13	0.05	0.18	

Table 6: Regression of Effects of Raising Rival's Costs
Dependent Variable: Weekly average unbranded wholesale rack price for Tosco less the rack price in Phoenix.

	Fixed Effects	Random Effects
	Parameter Estimate	Parameter Estimate
Intercept	-0.512 (0.484) [0.384]	-0.572 (1.365) [0.675]
Downstream Market Contact with Independent Retailers	0.445 (0.087) [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	0.105 (0.164) [0.521]	0.084 (0.059) [0.156]
Autocorrelation Coefficient	0.824	0.824
R-Square		
Within:	0.017	0.176
Between:	0.219	0.395
Number of Observations	N=12 T=129	

Standard Errors in parentheses. P-Values in brackets.

Table 7: Ordinary Least Squares Regression of Scatter Plot in Figure 6

	Parameter Estimate	Standard Deviation	T-Statistic	P-Value
Intercept	0.3055	0.4551	0.6713	0.5172
Downstream Market Contact with Independent Retailers	0.3634	0.1108	3.2786	0.0083
Adjusted R-Square = 0.4699				
N = 12 F = 10.71 Probability > F = 0.008				

Table 8: Fixed Effects Regression of Effects of Raising Rival's Costs
Dependent Variable: Weekly average unbranded wholesale rack price for Tosco less the rack price in Phoenix.

	Parameter Estimate	Standard Deviation	T-Statistic	P-Value
Intercept	-0.671	0.498	-1.35	0.178
Downstream Market Share	0.198	0.039	5.13	0.000
Number of Wholesale Suppliers	-0.071	0.278	-0.26	0.796
Market Share of Independent Retailers	0.105	0.164	0.64	0.521
Autocorrelation Coefficient	0.824			
R-Square Within: Between:	0.018 0.011			
Number of Observations	N=12 T=129			

Table 9: Regression of Effects of Raising Rival's Costs
Dependent Variable: Weekly average unbranded wholesale rack price for Tosco

	Fixed Effects	Random Effects
	Parameter Estimate	Parameter Estimate
Intercept	-0.041 (0.487) [0.933]	2.475 (1.565) [0.114]
Tosco's Unbranded Wholesale Price in Phoenix	0.945 (0.012) [0.000]	0.952 (0.012) [0.000]
Downstream Market Contact with Independent Retailers	0.372 (0.090) [0.000]	0.296 (0.082) [0.000]
Number of Wholesale Suppliers	-0.010 (0.278) [0.971]	-0.378 (0.203) [0.062]
Market Share of Independent Retailers	0.177 (0.166) [0.288]	0.094 (0.059) [0.110]
Autocorrelation Coefficient	0.827	0.827
R-Square		
Within:	0.798	0.943
Between:	0.172	0.397
Number of Observations	N=12 T=129	

Standard Errors in parentheses. P-Values in brackets.

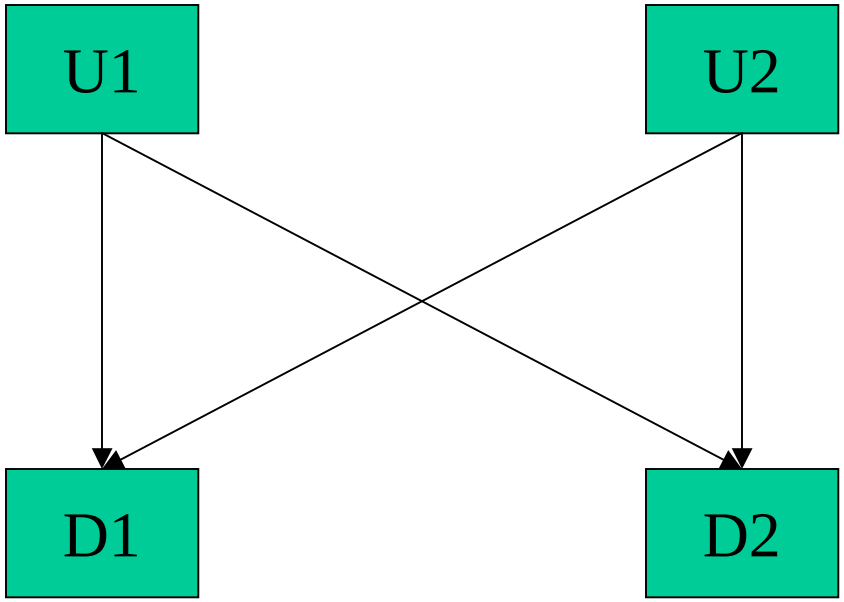

Figure 1. Unintegrated Case

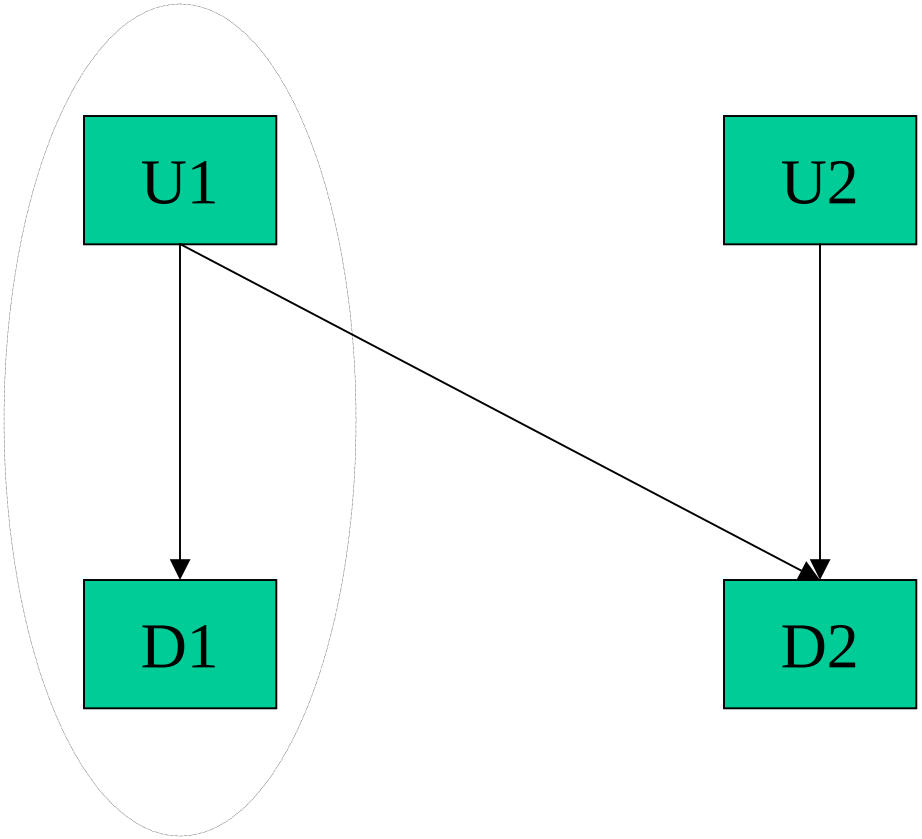

Figure 2. Vertical Integration Case

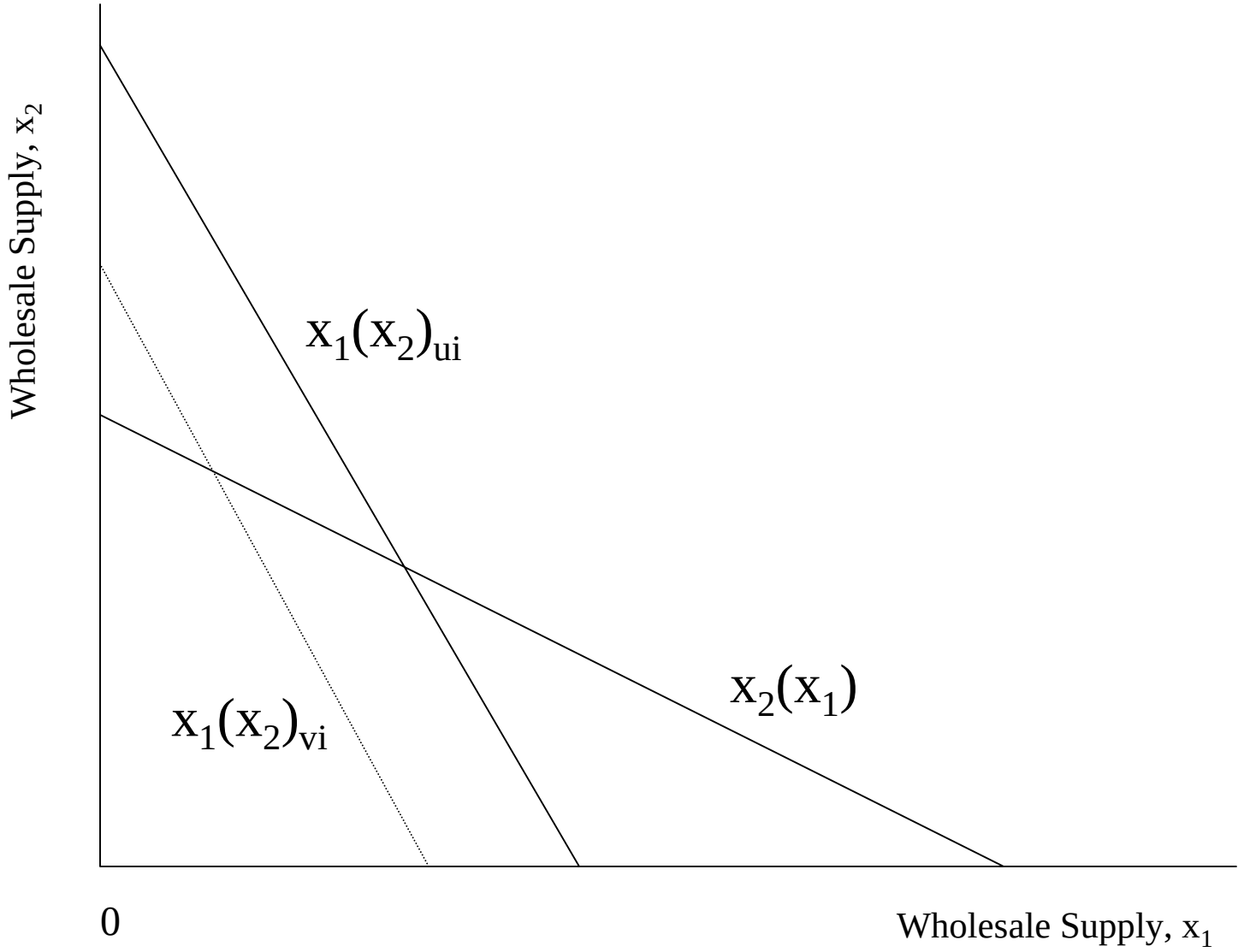

Figure 3. The Strategic Effect

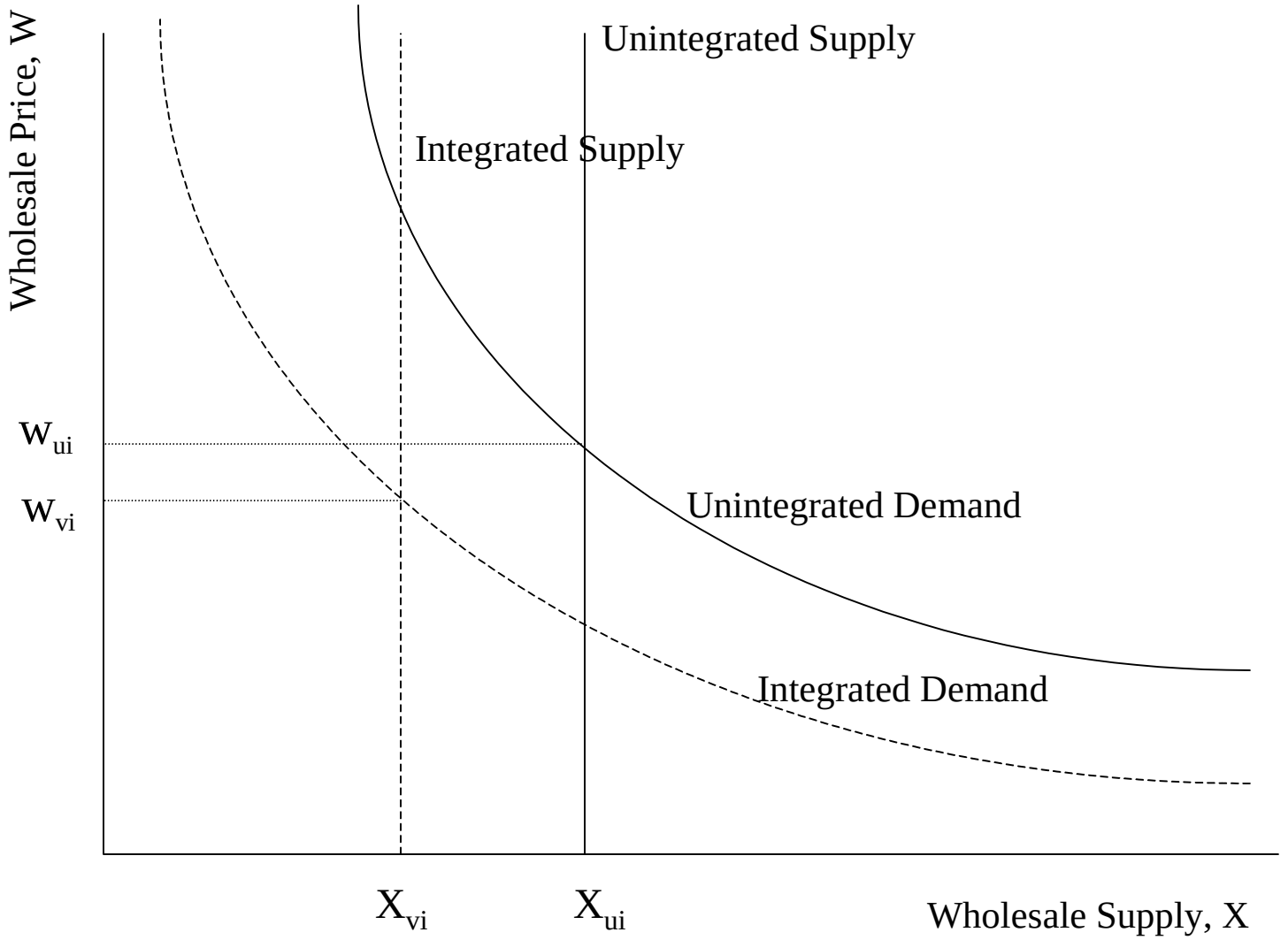

Figure 4. Strategic and Substitution Effects

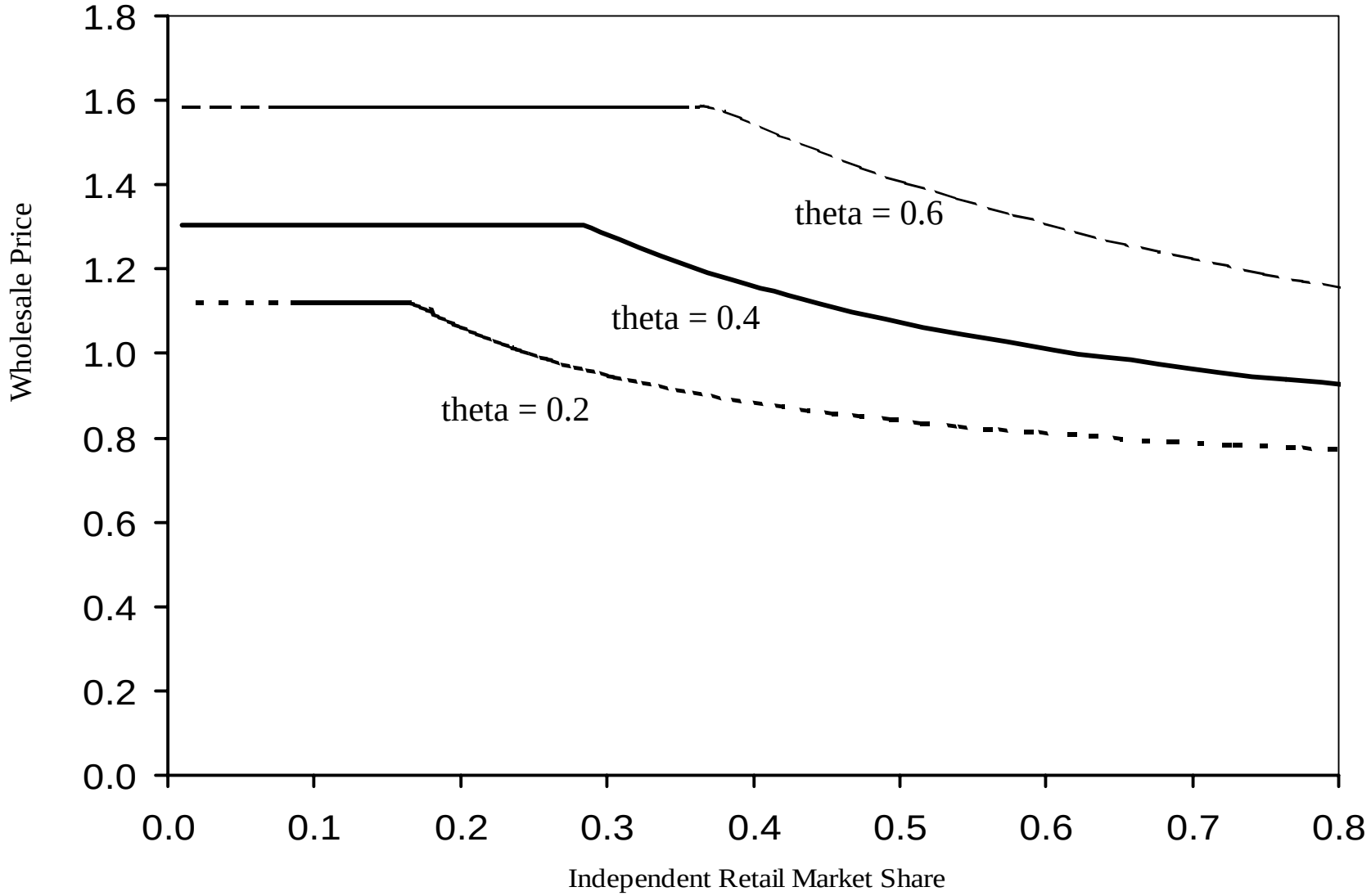

Figure 5. Wholesale Price Versus Independent Retail Market Share

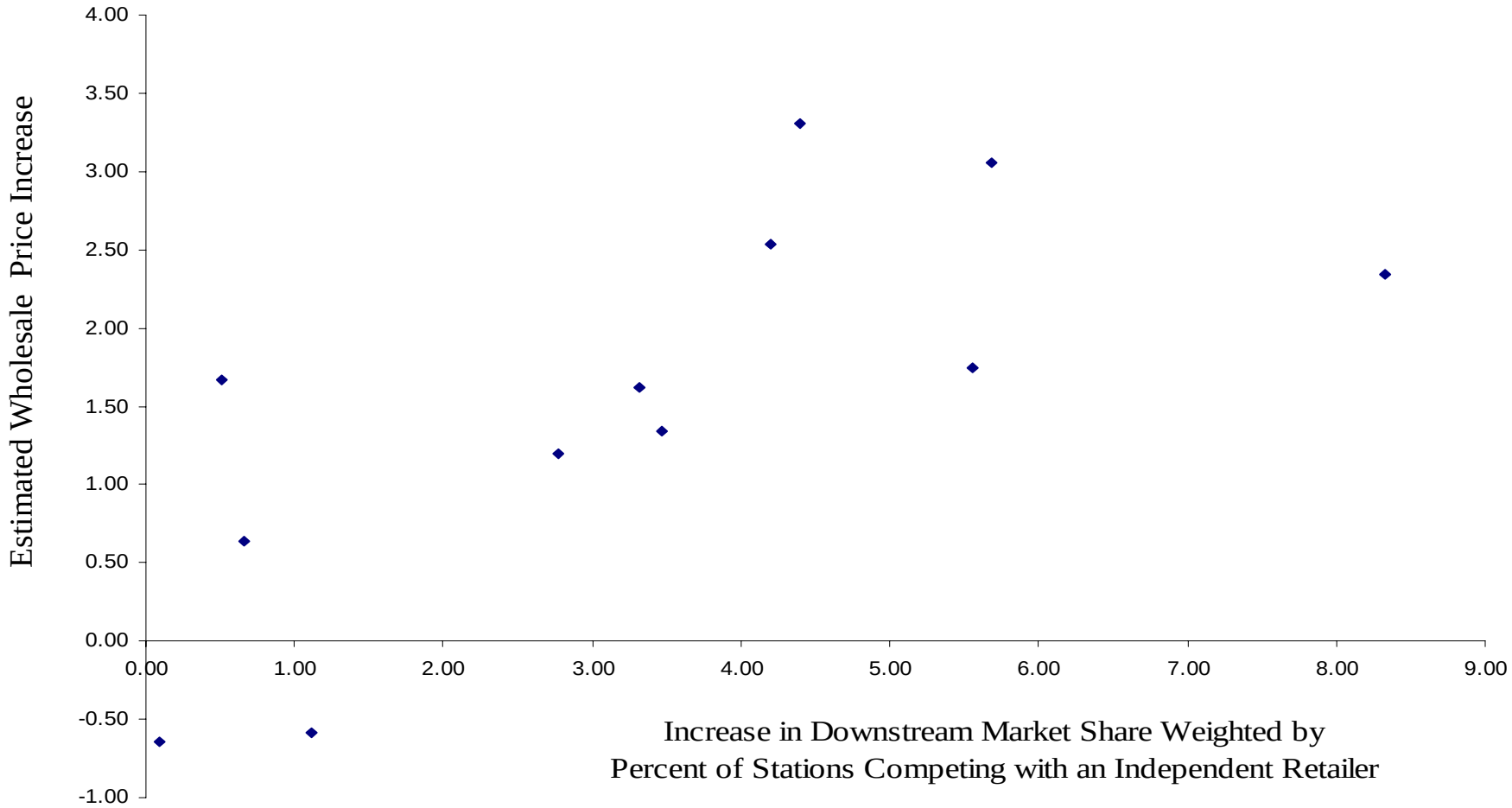

Figure 6. Estimated Wholesale Price Increase in Each Metropolitan Area Versus Increase in Retail Market Share