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THE GAINS FROM MERGER OR COLLUSION IN PRODUCT-DIFFERENTIATED INDUSTRIES*

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I. INTRODUCTION

A MERGER in an industry with differentiated products increases the market power of the merging firms to the extent that their products are close substitutes and that other firms produce only more distant substitutes.[1] Such a merger makes the residual demand curve of each partner steeper, by shifting each in the direction of the industry demand curve.[2] The extent of this increase in market power depends upon the own-elasticity of demand for each merging firm's product, as well as the cross-elasticity of demand for each with all other firms' products. As a result, evaluating the effect of a merger between two firms with $n-2$ other competitors would seem to require the estimation of at least n^2 parameters (all of the price elasticities of demand), a formidable task.

That extremely difficult estimation task is unnecessary, however. The necessary information is contained in the slopes of the two single-firm (residual) demand curves before the merger, and the extent to which the merged firm will face a steeper demand curve. For example, suppose a merger between two U.S. brewing firms, say Pabst and Anheuser–Busch, were proposed. It is not particularly important to determine whether it is competition from Miller or competition from Stroh (or from Heileman, or ...) which puts the most effective brake on Anheuser–Busch's pricing. Only the total effect of these other firms and the particular effect of competition from Pabst are of interest.

This paper proposes econometric procedures for estimating the demand system that merger partners will face, based only on pre-merger data. The key to the procedures is that the effects of all other firms in the industry are summed together. Formally, we start with a model of an n-firm product-differentiated industry. Manipulation of the model removes the prices and quantities of all but two firms. This reduces the dimensionality of the problem to manageable size; rather than an n-firm demand system, we estimate a two-firm residual demand system. In this way the technique extends our econometric method for

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[1] This definition of the increase in market power from a merger ignores possible changes in industry conduct resulting from the change in industry structure. If the merger raises the likelihood of collusion (Stigler [1964]), the definition underestimates the change in market power. If the merger induces entry by new firms or competitive product introductions by existing firms, the definition overestimates the change in market power.

[2] Our definition of the residual demand curve is distinct from, but closely related to, Chamberlin's [1933] *dd'*. We make the distinction precise in Note 6 below.

evaluating single-firm demand elasticities in product-differentiated industries (Baker and Bresnahan [1984]).

Throughout, we do not distinguish a merger between two firms from a bilateral collusive arrangement between them. We use the language "the increase in market power from a merger" but could equally well use the phrase "the gains from a bilateral collusive arrangement between these two firms".

We apply our technique to three U.S. brewing firms: Anheuser–Busch (A–B), Pabst and Coors. Since U.S. brewing is quite concentrated, and since all of these firms are large,[3] a merger between any two of the three would likely be challenged under current U.S. antitrust guidelines. The question of bilateral collusion is therefore more interesting. Our estimates show that neither of the two smaller firms, Pabst and Coors, would have a significant increase in market power from bilateral collusion, although A–B would gain substantially from colluding with either of the other two.

II. TWO FIRMS IN A PRODUCT-DIFFERENTIATED INDUSTRY

This section derives the residual demand curve facing two firms in a product-differentiated industry. The residual demand curve is the relationship between those two firms' prices and quantities, taking the reactions of all other firms into account. This is a natural generalization of the residual demand curve facing a single firm: the relationship between its price and quantity, taking other firms' reactions into account. In product-differentiated industries, it is natural to suppose that there will be a (private) gain to merger, because the merged firm will face a steeper residual demand curve.[4]

A simple location model of product differentiation can illustrate these ideas. Suppose stores are distributed along a road as in Figure 1 (a). The road goes on forever, but we show only the four firms at locations ℓ_1, ℓ_2, ℓ_3 and ℓ_4. Each initially charges the price P_0. Customers need to travel to the stores; their costs per mile are given by the slopes of the delivered-price lines. Customer c_{12} is just indifferent between going to store 1 or 2, but everyone located to the right of c_{12} would rather buy at store 2 than store 1. Suppose that competition in the industry takes the Bertrand (price) form, and that the stores are spaced such that the reaction functions have slope $+\frac{1}{3}$. That is, every store would respond to a price increase by either of its neighbors with a price increase $\frac{1}{3}$ as large.

To define the residual demand curve facing firm 2, suppose that firm 2's costs increased, leading it to increase its price to P_1. After all other stores have reached equilibrium, both of firm 2's neighbors will have increased their prices by slightly over $\frac{1}{3}$ as much.[5] Figure 1 (b) shows that firm 2 will lose customers to both stores 1 and 3. The slope of firm 2's residual demand curve can be

[3] In 1983, Anheuser–Busch had a 32.9 percent national market share (in unit sales), Coors 7.5 percent, and Pabst 7.0 percent.

[4] This presumption is typically false in homogeneous-product industries. See Salant *et al.* [1983].

[5] It is slightly over $\frac{1}{3}$ because store 3's increase leads to an increase by 4, which feeds back to 3, and so on.

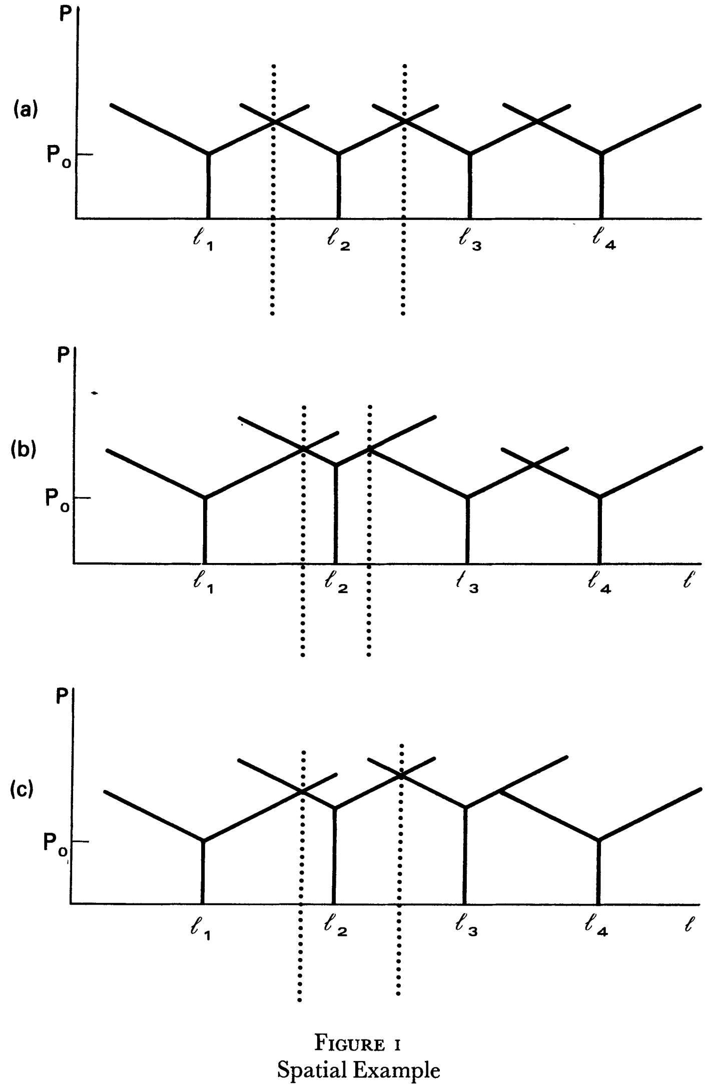

FIGURE 1
Spatial Example

calculated by the amount of sales it loses for a given price increase.[6] As the figure is drawn, the slope of residual demand for firm 3 is identical to that for firm 2, since the firms are symmetric to one another.

Alternatively, stores 2 and 3 might be merged into a single firm. Since its two stores are identical, this firm would set a single price. Figure 1 (c) shows what

[6] The slope of the residual demand curve is different from the slope of Chamberlin's *dd'*. The latter would be defined in our spatial-Bertrand context keeping other firms' prices constant. The residual demand curve lets other firms adjust. It is possible to estimate the slope of *dd'* as well as a residual demand: see, for example, Bresnahan [1981].

would happen if the merged firm raised price. Now, customers switch from store 2 to store 1 *but not to store* 3. Similarly, store 3 loses customers to store 4 but not to store 2. As a result, each store loses only half as many customers as it would have acting independently. The residual demand elasticity for the merged firm is only half that of the pre-merged firms, a considerable increase in market power.

Any real-world product-differentiated industry is likely to be much more complicated than this example. If there are n firms with different products in the industry, one might expect a price increase by any one firm to lead some customers to switch to most or all of the other $n-1$ firms. The situation is unlikely to be symmetric; some particular firms' products will have greater cross-elasticities of demand than others. Further, the assumption of price (Bertrand) competition in our example might be incorrect; firms might exhibit Cournot or other forms of behavior. It therefore seems that calculating the increase in market power due to a real-world merger involves an extremely difficult econometric task. All of the own- and cross-elasticities of demand must be estimated and the nature of competitive interaction must be determined.

Let firms 1 and 2 propose a merger in an industry with $n-2$ other firms. The inverse demand curves for the merger partners may be written

$$(1) \qquad P_1 = h_1(Q_1, Q_2, \underset{\sim}{Q}, Y; \eta_1)$$

$$(2) \qquad P_2 = h_2(Q_1, Q_2, \underset{\sim}{Q}, Y; \eta_2)$$

Here $\underset{\sim}{Q}$ is an $(n-2)$ vector of quantities produced by all other firms, Y denotes a vector of exogenous variables which shift demand, and η_i is a parameter vector. The remaining $(n-2)$ demand curves in this industry may be written compactly as follows:

$$(3) \qquad \underset{\sim}{P} = \underset{\sim}{h}(Q_1, Q_2, \underset{\sim}{Q}, Y; \underset{\sim}{\eta})$$

Note that estimation of (1), (2) and (3) can be very difficult. Denoting the elasticity of h_i with respect to Q_j as η_{ij}, (1), (2) and (3) might be approximated as

$$(1') \qquad p_1 = \eta_{10} + \eta_{11} q_1 + \eta_{21} q_2 + \sum_{j=3}^{\eta} \eta_{j1} q_j + \langle \eta_{1Y}, Y \rangle,$$

$$(2') \qquad p_2 = \eta_{20} + \eta_{12} q_1 + \eta_{22} q_2 + \sum_{j=3}^{\eta} \eta_{j2} q_j + \langle \eta_{2Y}, Y \rangle,$$

$$(3') \qquad p_i = \eta_{i0} + \eta_{1i} q_1 + \eta_{2i} q_2 + \sum_{j=3}^{\eta} \eta_{ji} q_j + \langle \eta_{iY}, Y \rangle, \qquad i = 3, \ldots, n$$

where $q_i = \log(Q_i)$, $p_i = \log(P_i)$ and $\langle \cdot, \cdot \rangle$ is the inner product of two vectors. There are n^2 elasticities of demand η_{ij}, even before considering the exogenous-variable elasticities, η_{iY}. Unless some further structure can be put on (1′), (2′)

and (3′), for example, by grouping firms into market segments, direct estimation will be very difficult if not impossible.[7]

Next we specify the behavior of the $(n-2)$ non-merging firms. It can be cooperative or non-cooperative, and if non-cooperative it can be Cournot, Bertrand, or some other oligopoly equilibrium. Each firm will satisfy a first-order condition equating marginal cost with *perceived* marginal revenue. For the non-merging firms, perceived marginal revenue, which differs across oligopoly solution concepts, is written as follows:

$$(4) \qquad \underset{\sim}{MR} = \underset{\sim}{P} + \underset{\sim}{g}(Q_1, Q_2, \underset{\sim}{Q}, Y; \underset{\sim}{\eta})\underset{\sim}{Q}$$

In equation (4), $\underset{\sim}{g}$ is a vector of slopes of the demand curves $\underset{\sim}{h}$ perceived by each of the $(n-2)$ non-merging firms.

Although (4) is written as if quantity were the choice variable of the oligopolists, appropriate choice of $g(\cdot)$ can make (4) correspond to any behavioral rule, including equilibria in which firms choose prices.

The vector of marginal costs for the $(n-2)$ non-merging firms depends on output $\underset{\sim}{Q}$, factor prices W, and parameters $\underset{\sim}{\beta}$.

$$(5) \qquad \underset{\sim}{MC} = \underset{\sim}{MC}(\underset{\sim}{Q}, W, \underset{\sim}{\beta})$$

Thus the first-order conditions describing the behavior of the non-merging firms take the following form[8]

$$(6) \qquad \underset{\sim}{MC}(\underset{\sim}{Q}, W; \underset{\sim}{\beta}) = \underset{\sim}{P} + \underset{\sim}{g}(Q_1, Q_2, \underset{\sim}{Q}, Y; \underset{\sim}{\eta})\underset{\sim}{Q}$$

Solving the $2(n-2)$ equations in the vector relations (6) and (3) for the vector $\underset{\sim}{Q}$, we derive

$$(7) \qquad \underset{\sim}{Q} = \underset{\sim}{E}(Q_1, Q_2, Y, W; \underset{\sim}{\eta}, \underset{\sim}{\beta})$$

A different equation $\underset{\sim}{E}_j$ corresponds to each of the $(n-2)$ outputs of non-merging firms. We denote the elasticities of $\underset{\sim}{E}_j$ with respect to Q_i $(i = 1, 2)$ as ε_{ji}; this is the elasticity of firm j's reaction function (to firm i).

Equation (7) defines a partial reduced form for the $(n-2)$ non-merging firm outputs; it defines equilibrium $\underset{\sim}{Q}$, given Q_1 and Q_2. Substituting equation (7) into demand curves (1) and (2) for the merger partners, we derive *partial residual demand curves* for those two firms:

$$(8) \qquad P_1 = h_1(Q_1, Q_2, \underset{\sim}{E}(Q_1, Q_2, Y, W; \underset{\sim}{\eta}, \beta); Y; \eta_1)$$
$$= r_1(Q_1, Q_2, Y, W; \eta_1, \underset{\sim}{\eta}, \underset{\sim}{\beta})$$

$$(9) \qquad P_2 = r_2(Q_1, Q_2, Y, W; \eta_2, \underset{\sim}{\eta}, \underset{\sim}{\beta})$$

[7] For methods which use such further structure, see Bresnahan [1980], Cowling and Cubbin [1972], and Joskow [1983], all applied to the Automobile industry.

[8] Note that (6) are supply relations, functions of both $\underset{\sim}{P}$ and $\underset{\sim}{Q}$. They are the analog of the supply function $P = MC(Q)$ in the theory of perfect competition.

We estimate equations (8) and (9), the partial residual demand system applicable to firms 1 and 2. They are *residual* demand curves because the actions of firms 3 to n have been taken into account. They are *partial* residual demand curves because, for each firm, the potential merger partner's action remains to be specified. Note that this approach includes as a special case the possibility of perfect competition. If P_1 and P_2 are completely explained by Y and W, so that Q_1 and Q_2 have coefficients of zero in (8) and (9), then firms 1 and 2 have no power over price, even acting jointly.

In our empirical work, we approximate (8) and (9) with log–log functional forms

$$p_1 = \eta_{10} + \eta_{11}^{PR} q_1 + \eta_{21}^{PR} q_2 + \Gamma_1 y + \Delta_1 w + v_1 \tag{10}$$

$$p_2 = \eta_{20} + \eta_{12}^{PR} q_1 + \eta_{22}^{PR} q_2 + \Gamma_2 y + \Delta_2 w + v_2 \tag{11}$$

The interpretation of the parameters η^{PR} may be obtained by logarithmically differentiating (8) and (9). This yields

$$\eta_{11}^{PR} = \eta_{11} + \sum_{j=3} \eta_{j1}\varepsilon_{j1} \tag{12}$$

$$\eta_{21}^{PR} = \eta_{21} + \sum_{j=3} \eta_{j2}\varepsilon_{j2} \tag{13}$$

$$\eta_{12}^{PR} = \eta_{12} + \sum_{j=3} \eta_{j1}\varepsilon_{j1} \tag{14}$$

$$\eta_{22}^{PR} = \eta_{22} + \sum_{j=3} \eta_{j2}\varepsilon_{j2} \tag{15}$$

Thus the partial residual demand elasticities η_{ij}^{PR} depend both on the structural demand elasticities η_{ij} and on the reaction function elasticities ε_{ij}. By estimating only the parameters η_{ij}^{PR}, we obtain only a subset of the information about the industry. For example in (12), we cannot separate the effects of firms 3 through n; only the total effect enters the equation.

Calculation of post-merger market power from the partial residual demand curve is straightforward. Suppose that the merged firm will decrease Q_1 and Q_2 in the same proportion to exploit its increased market power.[9] Then a decrease of both Q_1 and Q_2 of one percent will raise P_1 by $\eta_{11}^{PR} + \eta_{21}^{PR}$ and will raise P_2 by $\eta_{22}^{PR} + \eta_{12}^{PR}$.

Pre-merger (current) market power depends on the residual demand curve facing each of firms 1 and 2 acting alone. Since the formal derivation closely follows that of the partial residual demand curve, we present it in Appendix I and just give the main ideas here. The residual demand curve facing firm 1 will take the form

$$P_1 = R_1(Q_1, Y, W, \underset{\sim}{\eta}_1, \underset{\sim}{\eta}, \underset{\sim}{\beta}) \tag{16}$$

[9] The merged firm may not find it optimal to decrease Q_1 and Q_2 in the same proportion to exploit its market power. See Orr and MacAvoy [1964] for analysis of when proportional-quantity rules are jointly profit maximizing for two firms.

This is exactly the same as (8), except firm 2 has been "equilibrated out" along with firms 3 to n. The elasticity of P_1 with respect to Q_1 defined by (16) is η_1^R, the residual demand elasticity for firm 1.

Suppose instead of solving the $2(n-2)$ equations (3) and (4) for $Q_3, \ldots, Q_n$, we expanded them by one demand curve (2) and a first-order condition for firm 2. Then we would have $2(n-1)$ equations for $Q_2, \ldots, Q_n$. We solve for the $(n-1)$ outputs as functions of Q_1:

$$(17) \qquad \begin{pmatrix} Q_2 \\ \vdots \\ Q_n \end{pmatrix} = \hat{E}(Q_1, Y, W; \underset{\sim}{\eta}, \underset{\sim}{\beta})$$

where (17) differs from (7) because Q_2 is on the left, not right. Let the elasticity of Q_i with respect to Q_1 in (16) be ξ_{i1}. Note that there is no obvious relationship between the *partial* residual demand elasticity η_{11}^{PR} and the residual demand elasticity η_1^R, since they are defined by different conceptual experiments. In the partial residual demand system, firm 2's output is held fixed along with firm 1's. In the residual demand curve, firm 2's output is solved out along with all of the other $n-2$ firms.

$\hat{E}(\cdot)$ is the vector of outputs of all firms except firm 1. The elasticity of firm 1's residual demand curve is

$$(18) \qquad \eta_1^R = \eta_{11} + \eta_{21}\xi_{21} + \sum_{j=3} \eta_{j1}\xi_{j1}$$

We could similarly define a residual demand curve for firm 2. It would have elasticity

$$(19) \qquad \eta_2^R = \eta_{22} + \eta_{12}\xi_{12} + \sum_{j=3} \eta_{j2}\xi_{j2}$$

To summarize, the difference between the residual demand curve facing a single firm and the partial residual demand curve facing two firms is this: the price discipline that each of the two firms exerts on the other is isolated. When we estimate the residual demand curve for firm 1, the slope depends (in part) on how firm 1's customers defect to firm 2. When we estimate the partial residual demand curve, we can perform the conceptual experiment of raising both firms' prices together.[10]

Calculation of the exact, quantitative increase in market power as a result of the merger rests on the assumption that the elasticity of demand does not change along the demand curve. Estimates based on pre-merger historical data cannot reveal the elasticity of demand at the hypothetical post-merger point. What they can do is measure the extent to which the merger will change

[10] In a product differentiated industry, residual demand elasticities correspond directly to a firm's markup of price over marginal cost. For an explanation, and a discussion of other circumstances in which the markup is related to residual demand elasticities, see Baker and Bresnahan [1984, section B].

price-quantity incentives. If the demand curve grows steeper as a result of the merger, we can be sure that the merged firm will have an incentive to raise price from the pre-merger level. But we cannot be sure how far; if for some (unlikely) reason the demand curve rapidly flattens at quantities slightly below those observed in the market, the merger will have little effect.

III. THREE BREWERS

In this section, we empirically investigate the extent to which existing competition from other firms' products limits market power in the U.S. brewing industry. Three hypothetical mergers are considered: between Anheuser–Busch (A–B), the largest firm in the national market, and Pabst, another important producer of "premium" beer; between A–B and Coors, the largest firm in the Western states; and between Pabst and Coors.[11] After a discussion of the structure of the industry,[12] we estimate residual demand curves for each of the three firms, and partial residual demand curves for each of the three pairs of firms.

The brewing industry is highly concentrated. In 1983, the last year of our sample, the two-firm (A–B and Miller) concentration ratio was over 50 percent. Four more firms (Pabst, Coors, Heileman and Schlitz) had market shares between seven and thirteen percent. There is also considerable evidence of product differentiation. An FTC study[13] shows substantial long-term trends in the relative prices of different kinds of beer ("popular", "premium", etc.) indicating they must be imperfect substitutes in demand. Similarly, the correlations over time among the prices charged by our three firms suggest they are selling distinct products. Table I reports correlation coefficients for the log of the real price of each firm's primary brand in mid-summer in Northern California, over the period 1962–83.

Data limitations prevent straightforward extension of our techniques to Miller, Heileman or Stroh–Schlitz. Each of these firms has acquired a rival or been acquired. Miller and Heileman have both been closely held within our sample period. Thus firm-specific data on these firms cannot be assembled from published sources.

Given the concentration and the product differentiation present in the industry, it is natural to ask whether there are gains to collusion or merger. If we find that coordinated pricing between two firms would substantially increase their market power, we can draw two conclusions. First, a merger between them would worsen industry conduct, and would therefore worsen performance if it did not yield cost savings. Second, the firms are not now

[11] None of these hypothetical mergers is likely to occur without antitrust challenge. For a history of brewing mergers and their antitrust treatment, see Ornstein [1981].

[12] Elzinga [1982] presents a detailed review of brewing industry history. The demand for beer has been discussed by Greer ([1971], [1981]), Hogarty and Elzinga [1972], Kelton and Kelton [1982], and McConnel [1968]. Product differentiation issues are discussed in Greer [1981].

[13] Keithahn [1978].

Table I
Correlations Among Prices[a]

	$P_{\text{A-B}}$	P_{Coors}	
$P_{\text{A-B}}$	1.0	0.83	0.93
P_{Coors}		1.0	0.61
P_{Pabst}			1.0

[a] Log of real prices. See Appendix II for description of price data.

pursuing completely colluding pricing policies, which follows directly from the nature of our estimates. If a coordinated pricing policy *would* yield a steeper demand curve than the firm *does* face, we can conclude that a completely coordinated pricing policy is not now being used.

Several long-term trends in the brewing industry's environment and structure affect the specification of residual demand curves for our 1962–83 sample period. First is the question of what variables to include in the equation. The derivation of (8) and (9) shows that variables shifting the cost curves of other firms in the industry must be included, as must variables that shift the demand curve for any brand. The second issue is whether the residual demand system is stable over time.

Regarding the question of cost-side variables, w, we first include two indexes of factor prices. One is short-run average variable cost (SRAVC) for the industry, defined to include labor, agricultural inputs, and energy inputs.[14] The other is a price of capital series (PK). A third variable is suggested by the increasing exploitation of scale economies over time (Elzinga [1982]). If marginal costs are falling because of exploitation of scale economies, then it is important to capture this effect econometrically. Our variable is the average plant size (APS) in the industry, defined to be industry-wide capacity divided by the number of operating plants. The fourth variable is suggested not by long-term trends but by the cyclicality of the demand for beer. If firms $3, \ldots, n$ have excess capacity, then their marginal costs are likely to be lower. We capture this with the variable EKTI, defined as $\text{EKTI} = \Sigma_{j=3}^{n} (K_j - Q_j)$, excess capacity of the other $n-2$ firms.

On the demand side, economic and marketing studies suggest the inclusion of several economic demographic variables.[15] We include *per capita* disposable income (PCDI), firm advertising expenditures, the percentage of the drinking-age population under 45 years old, and the percentage of drinking-age women who ever drink beer. Of these, only PCDI ever approaches significance in our regressions. It is therefore the only demand variable reported below. We suspect the insignificance arises because most demographic variables move very slowly.

On the question of structural stability, there are two important considerations. One is the increasing concentration of the industry over our sample

[14] See Appendix II for precise definitions of all variables.
[15] Hatten and Schendal [1977]; Ellison and Uhl [1964].

period. Two-thirds of the firms in the industry in 1962 exited before 1983; over the same period, the five firm concentration ratio rose from 35 percent to 84 percent. Thus we allow for the possibility that residual demand curves are getting steeper over time by interacting both their slopes and intercepts with a variable which increases by one each year, TIME. The second issue of structural change is the introduction of the heavily advertised "LITE" brand beer by Miller.[16] Other firms responded with the introduction of their own "light" beers. We take account of the effect of this structural change on residual demand by introducing a dummy variable LITE that takes in the value of 1 beginning in 1975. This dummy variable is allowed to shift both the residual demand elasticity and the intercept of the residual demand curve.

Our procedure for estimating these residual demand elasticities regresses both P_1 and P_2 on the two quantities Q_1 and Q_2, demand shift variables Y, and industry-wide cost variables W. In double-log form, we estimate:

$$p_1 = \eta_{10} + \eta_{11}^{PR} q_1 + \eta_{21}^{PR} q_2 + \Gamma_1 y + \Delta_1 w + v_1 \tag{20}$$

$$p_2 = \eta_{20} + \eta_{12}^{PR} q_1 + \eta_{22}^{PR} q_2 + \Gamma_2 y + \Delta_2 w + v_2 \tag{21}$$

The primary econometric problem that must be solved to estimate (20) and (21) is the simultaneity of these equations with as yet unspecified supply relations for the two merging firms. The solution to this problem will also prove that equations (20) and (21) are econometrically identified. The supply relations are derived from equating marginal revenue with marginal cost:

$$MC_1(Q_1, W, W_1; \beta_1) = P_1 + Q_1 t_1(Q_1, Q_2, Y, W; \eta_1, \underset{\sim}{\eta}, \underset{\sim}{\beta}) \tag{22}$$

$$MC_2(Q_2, W, W_1; \beta_2) = P_2 + Q_2 t_2(Q_1, Q_2, Y, W; \eta_2, \underset{\sim}{\eta}, \underset{\sim}{\beta}) \tag{23}$$

Equilibrium in the industry at issue is defined by the simultaneous determination of the two partial residual demand curves (8) and (9) with the two supply relations (22) and (23). As is evident, identification of the parameters of the residual demand curve requires the presence of the firm-individuated cost variables W_1 and W_2. We therefore estimate (20) and (21) by employing firm-specific cost variables as instruments for quantities q_1 and q_2.[17] In addition, to conserve degrees of freedom, we impose a cross-equation restriction that the different industry-wide prices W enter proportionately for both firms. Finally we estimate partial residual demand curves jointly for the two merging

[16] Miller acquired the rights to Meister Brau Lite beer in 1972, which had been unsuccessfully marketed as a diet beer for women by a small Chicago brewery. Miller's innovation was in the nationwide marketing of light beer. Light beers, now made by many firms, are lower in alcohol and calories than premium beers. In estimating demand curves from time series data, we implicitly assume that no unobserved changes in product quality or reputation occur. The one exception to this is the obvious change in the relative attractiveness of different brands after the invention of light beer, which we treat by introducing a dummy variable in the residual demand curve of each firm.

[17] In our earlier paper, we showed that even if we lack such instruments, the estimation of single firm residual demand elasticities will be biased in the conservative direction of disproving market power. Baker and Bresnahan [1984].

TABLE II
PARTIAL RESIDUAL DEMAND CURVES FOR A–B AND COORS

Dependent:	P_{ab}	P_{cs}
Independent		
Constant	1.97	3.67
	(1.71)	(0.92)
q_{ab}	−0.466	0.036
	(−1.94)	(5.35)
q_{cs}	0.093	−0.661
	(5.6)	(−1.76)
SRAVC	0.148	0.699
	(0.75)	(1.17)
APS	−0.009	−0.452
	(−1.10)	—
PK	0.057	0.272
	(2.93)	—
EKTI	0.00019	0.00094
	(2.2)	—
LITE	0.610	
	(2.18)	
q_{ab}*LITE	−0.219	
	(−2.88)	
q_{cs}*LITE	0.043	
	—	
TIME		0.0849
		(1.57)
PCDI	0.404	−0.012
	(0.824)	(−0.007)

partners by three-stage least-squares, a procedure which takes advantages of information available from the correlation of errors in those equations.[18]

Substantial experimentation with the specification produced some simplifications. First, advertising and the demographics were never significant. Thus "Y" in (20) and (21) consists only of PCDL. Second, only the slope and intercept of A–B's residual demand equation are changed by the LITE dummy; this change in industry structure appears to have had little effect on the other two firms. Finally, the TIME coefficient appears to enter the intercept of each of the Pabst and Coors equations, but not to affect the slope of any residual demand curve. The following tables report only the estimates for specifications after these simplifications have been imposed.[19]

[18] If we begin with all of the structured equations of the model (1′), (2′), (3′) and (4) linear in the logs with additive error, then (10) and (11) will have additive error, but v_1 and v_2 will be correlated. Thus three-stage least-squares will increase the power of our estimators.

[19] Baker and Bresnahan [1984] reports on the specification tests in considerably greater detail.

Table II reports the partial residual demand curve for A–B and Coors. Most of the coefficients have the expected signs: a decrease in either firm's quantity would raise its own price and lower that of the other firm. If factor prices were higher (SRAVC or PK), the residual (inverse) demand curve would shift up, as one expects. Similarly an increase in APS (and the resulting lowering of industry-wide costs) shifts the residual demand curve down. The coefficient of excess capacity is of the incorrect sign but small. The demand elasticities appear to be substantial: a one-percent quantity decrease by A–B would lower its price by 0.466 percent, and raise Coors price by 0.093 percent—these price effects take into account the reactions of all firms but Coors. A–B's partial residual demand curve is somewhat flatter when the LITE dummy is turned on. Taking into account the competitive responses of all other firms, A–B plus Coors would have only about half as much control over P_{ab} when LITE $= 1$.

The results for the partial residual demand curve for A–B and Pabst (Table III) are similar in some respects. The coefficients again have mostly the ex-

TABLE III
PARTIAL RESIDUAL DEMAND CURVES FOR A–B AND PABST

Dependent:	P_{ab}	P_{pb}
Independent		
Constant	1.50	3.92
	(8.42)	(1.57)
q_{ab}	−0.523	−0.011
	(−3.27)	(0.58)
q_{pb}	0.185	−0.035
	(1.82)	(0.077)
SRAVC	0.133	0.096
	(1.22)	(2.44)
APS	−0.193	−0.139
	(−1.6)	—
PK	0.072	0.028
	(2.40)	—
EKTI	0.0015	0.0012
	(2.68)	—
LITE	0.805	
	(0.81)	
q_{ab}*LITE	−0.67	
	(−4.1)	
q_{pb}*LITE	0.016	
	—	
TIME		−0.01
		(−1.7)
PCDI	0.249	−0.11
	(4.33)	(−0.13)

TABLE IV
PARTIAL RESIDUAL DEMAND CURVES FOR PABST AND COORS

Dependent:	P_{pb}	P_{cs}
Independent		
Constant	3.96	3.34
	(12.6)	(2.20)
q_{cs}	0.16	−0.648
	(0.312)	(−2.61)
q_{pb}	−0.006	−0.028
	(−0.16)	(−1.18)
SRAVC	0.105	0.225
	(1.71)	(1.44)
APS	−0.197	−0.422
	(−1.39)	—
PK	0.042	0.090
	(1.66)	—
EKTI	0.00033	0.00071
	(0.503)	—
TIME	−0.011	0.041
	(−1.42)	(1.39)
PCDI	−0.218	0.991
	(−1.76)	(1.37)

pected sign. A–B's demand curve is again downward-sloping in own-quantity and increasing in Pabst's quantity. The LITE effect is again to substantially flatten A–B's demand curve. The Pabst equation, however, shows very little market power for the firm.

The results for Pabst and Coors (Table IV) are consistent with what one would expect from the first two tables. Pabst has no market power, even with the cooperation of Coors. The Coors partial residual demand curve is again quite steep.

To use the information in Tables II–IV to evaluate mergers or collusion, we need to estimate the residual demand curves for each of the three firms. This is reported in Table V. The estimates show that Coors, acting alone, has a steep demand curve. Pabst, acting alone, has very little power over price. A–B's market power appears to vary over time, because of the effects of LITE.

Table VI summarizes the coefficients needed to evaluate the gains from a merger or collusion. The first section reports η^R_{11} for each firm, the inverse demand elasticity when all other firms act independently. The second section reports $\eta^{PR}_{11}+\eta^{PR}_{12}$, the inverse demand elasticity if two firms moved their quantities proportionately. Looking first at the A–B/Coors merger, we observe that the A–B demand curve would be steeper after a merger with Coors. In the 1967–74 period the A–B demand elasticity grows slightly as a result of the merger (−0.373 *vs.* −0.313), while it grows substantially after the "LITE"

TABLE V
RESIDUAL DEMAND CURVES FOR ALL THREE BREWERS

Dependent:	P_{ab}	P_{cs}	P_{pb}
Independent			
Constant	2.625 (7.77)	2.85 (3.73)	3.53 (12.00)
q_{ab}	−0.313 (−5.99)		
q_{cs}		−0.633 (1.82)	
q_{pb}			−0.028 (−0.961)
SRAVC	0.094 (1.811)	0.326 (2.33)	0.086 (1.81)
APS	−0.079 (−1.15)	−0.277 —	−0.073 —
PK	0.025 (1.31)	0.082 —	0.024 —
EKTI	0.0023 (0.54)	0.008 —	0.0023 —
LITE	0.629 (0.918)		
q_{ab}*LITE	−0.311 (9.07)		
TIME		0.042 (2.91)	−0.011 (−2.57)
PCDI	0.115 (0.775)	0.537 (1.50)	−0.026 (−0.19)

TABLE VI
GAINS TO MERGER OR COLLUSION

I. RESIDUAL DEMAND ELASTICITIES: η_{11}^{R}		
Coors:	−0.633	(−10.07)
Pabst:	−0.028	(−0.961)
A–B, 1962–74:	−0.313	(−5.99)
A–B, 1975–83:	−0.002	(−0.014)
II. POST-MERGER DEMAND ELASTICITIES: $\eta_{11}^{PR}+\eta_{12}^{PR}$		
Merger of A–B and Coors:		
Coors:	−0.625	(−7.81)
A–B, 1962–74:	−0.373	(−3.45)
A–B, 1975–83:	−0.176	(−2.57)
Merger of A–B and Pabst:		
Pabst:	+0.024	(+0.14)
A–B, 1962–74:	−0.338	(−6.28)
A–B, 1975–83:	−0.151	(−2.14)
Merger of Pabst and Coors:		
Coors:	−0.676	(1.97)
Pabst:	+0.01	(0.103)

dummy is turned on (−0.176 *vs.* −0.002). Hence, as expected, a merger with Coors would substantially increase A–B's market power. The Coors demand curve, by contrast, grows slightly less steep as a result of the merger. We conclude from this insignificant change that Coors' market power would be unaffected by merger with A–B.

The merger of A–B and Pabst would be similar. The Pabst demand curve moves from being small, negative, and insignificantly-sloped, to being small, positive, and insignificantly-sloped. Just as Pabst is a price-taker now, so would the merged A–B/Pabst firm be a price-taker in its Pabst product line. The A–B demand curve, however, again grows steeper by a small amount before the introduction of "LITE" and by a large amount after it.[20] The Pabst/Coors merger does not substantially enhance the market power of either product; though the Coors elasticity grows slightly; this occurs because Pabst and Coors appear to be *complements* in demand.

All three sets of estimates show an increase in the slope of the demand curve only for A–B. We can determine the importance of this increase by a simple calculation. Suppose a merger increased the inverse demand elasticity for Budweiser, A–B's flagship product, by 0.05. This is conservative: except for the merger with Pabst in the pre-1975 period, all of our estimates show a larger increase. An increase of 0.05 means that the price–cost margin for Budweiser would increase by five percent of cost. A conservative estimate A–B marginal cost is $50/barrel. In 1983, A–B sold 42 million barrels of this brand. Thus collusion or a merger with a smaller firm would yield additional monopoly profits of at least $105 million per year.

IV. CONCLUSION

Our estimates show that collusion or a merger between A–B and either Pabst or Coors would lead to a substantial increase in market power for A–B. No merger among any two of the three firms yields any increase in market power for the other two brands.[21] We draw a strong and a weak conclusion about the nature of competition in brewing.

Our strong conclusion is that these three brewers are not colluding in price, even though there is substantial market power in the industry. The evidence for the absence of complete collusion is compelling; a change from the pricing rules firms now use to coordinated pricing would yield very large increases in profits. Market power such as we measure can exist even without collusion in a product-differentiated industry.

[20] The Pabst/A–B merger suggests that our convention of assuming proportional decreases in post-merger quantities may be too conservative. Since the post-merger Pabst demand curve remains flat, but decreases in Pabst sales shift the A–B demand curve out, the merged firm would find it profit-maximizing to decrease Pabst quantity much more sharply than A–B.

[21] This statement presumes that the merger will not increase the probability of collusion on an industry-wide basis. In general, we would expect mergers between larger firms to have a greater effect on the probability of collusion. Thus we think our assessment of A–B's gains to merger is conservative.

Our weak conclusion concerns the competitive role of the producers, such as Coors and Pabst, with market shares in the 5–15 percent range. These firms seem to provide an important brake on the pricing power of the market leader, A–B. This conclusion is weak because data limitations prevent extension of the analysis to other firms. First, we do not know whether our results about Coors and Pabst also apply to the other "second tier" firms; Schlitz, Stroh, and Heileman. We conjecture that we would also find substantial anti-competitive effects of bilateral collusion (or merger) between any of these and A–B. Second, the conclusion is weak because we can say nothing about the role of Miller, the second-largest producer.

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APPENDIX I*

The (inverse) demand function for firm 1, the firm of interest, is

$$P_1 = P^1(Q_1, \hat{Q}, \tilde{Y}, \tilde{\eta}^1) \tag{A.1}$$

Here P_1 and Q_1 are price and quantity for firm 1's product, $\hat{Q}$ is a vector of quantities for other firm's products, $\tilde{Y}$ are exogenous variables entering the demand system, and $\tilde{\eta}^1$ are parameters. Q_i is a typical element of $\hat{Q}$. $\hat{Q}$ includes Q_2, as well as $Q_3, \ldots, Q_n$.

The model also includes (inverse) demand equations for $\hat{Q}$, the vector of quantities of all other relevant products, including 2.

$$P_i = P^i(\hat{Q}, Q_1, Y, \tilde{\eta}^i), \qquad i = 2, \ldots, n \tag{A.2}$$

$\tilde{P}$ is a vector composed of the P_i.

The third element of the model is the supply behavior of all the firms i. Their supply relations are written in the form marginal cost equals marginal revenue:

$$MC^i(Q_i, W, \beta^i) = MR^i(\hat{Q}, Q_1, Y, \tilde{\eta}^i), \qquad i = 2, \ldots, n \tag{A.3}$$

The first step in deriving the single-firm residual demand is to solve the equations (2) and (3) simultaneously for the vectors $\hat{Q}$ and $\hat{P}$.

$$\hat{Q} = \hat{E}(Q_1, Y, W; \tilde{\eta}, \tilde{\beta}) \tag{A.4}$$

The elasticity of Q_i with respect to Q_1 in this partial-reduced form is denoted ξ_{i1}:

$$\xi_{i1} = \frac{\partial \ell n E^i}{\partial \ell n Q_1}$$

* A complete development of this appendix can be found in Baker and Bresnahan [1984].

The residual demand curve facing firm 1 is derived by substituting $\hat{E}(\cdot)$ into (A.1):

$$P_1 = P^1(Q_1, \hat{E}(Q_1, Y, W, \eta, \beta), Y, \eta^1) \quad \text{(A.5)}$$

Substituting out the redundancies, we have:

$$P_1 = R(Q_1, Y, W, \eta, \beta) \quad \text{(A.6)}$$

where the notation $R(\cdot)$ means (inverse) residual demand. The arguments of the residual demand curve are threefold; own quantity, structural demand variables, and other firm's cost variables.

Note that the elasticity of residual demand depends on all the ordinary demand elasticities and on the elasticities of other firms' reactions, ξ_{i1}:

$$\eta_1^R = \eta_{11} + \sum_i \eta_{i1}\xi_{i1} \quad \text{(A.7)}$$

where η_1^R is (inverse) residual demand elasticity, and η_{i1} is the own- or cross- (inverse) demand elasticity in the usual sense.

APPENDIX II

This appendix describes the sources for the variables employed in our study.

Price and Quantity

Nationwide production figures are available from trade publications, such as the yearly *Modern Brewery Age Blue Book* and *Brewers Almanac*. Q in our regressions is annual production of the flagship brand. *Per capita* adjustments were made using the U.S. population over age 18. Prices were transformed into real terms by dividing by GNP deflator. Flagship brand prices are reported in issues of the *Beverage Industry News of Northern California* until 1978. After 1978, newspaper advertisements are used.

Factor Prices (Cost Variables)

Time series on four factors of production were assumed to apply industry-wide: labor, materials, variable capital, and advertising. The price of labor is the average hourly wage of brewing production workers collected by the Bureau of Labor Statistics, reprinted annually in *Brewers Almanac*. The price of variable capital is the user-cost measure from Hazilla and Kopp [1983] for food and beverage industries, and updated by us through the end of the sample period.

Two variants of the materials price series were used. The first uses data on the prices and quantities of a list of specific inputs: malt, corn, rice, hops, cans, bottles, and power. The second divides cost of materials for brewers, as reported in *Brewers Almanac*, by quantity of beer manufactured in barrels. The quantities consumed of all specific inputs are found in *Brewers Almanac*, except power. *MBA Blue Book* reports expenditures on power. The price series for the specific inputs are from *Producer Prices and Prices Indexes*. In real terms, the two materials price series are correlated at 0.99. The advertising price series is computed as an index of media prices; brewing industry weights are from *Leading National Advertisers*.

Demand Variables

Population and income variables are taken from Census and other Commerce Department Sources.

Instruments

Brewer capacity, by plant, is reported in *Beer Marketer's Insights*. This is the basis of both K and APS. The Colorado manufacturing wage rate series is from the *Statistical Abstract of the United States*.

Other Variables

Advertising variables, include each firm's expenditures on advertising, as reported in *Brewers Almanac*. These variables are normalized either by sales, or by the industry price of advertising as described above and a population index.