The Market Power-Efficiency Tradeoff, Residual Demand Elasticity Analysis, and the US Air-Piedmont Merger

John Stephen Stockum
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Abstract
Topics in antitrust theory, empirical analysis, and policy are examined, with an application to the USAir-Piedmont merger. The first chapter presents Cournot models to assess the welfare tradeoff between increases in market power and increases in efficiency that may result from a merger. The magnitudes of efficiency gain sufficient to satisfy two alternative welfare standards are derived. To satisfy the first standard, the efficiency gain must be sufficient to offset the deadweight loss created by increased market power. To satisfy the second standard, the efficiency gain must be sufficient to offset the incentive to increase prices resulting from increased market power. In both cases, the critical efficiency gains derived offset the effects of the mergers that are determined endogenously within the model, rather than effects that are predetermined. Results are presented for a range of assumptions about the number of firms, the pre-merger markup of price over marginal cost, and fixed costs.

The second chapter evaluates the method of residual demand elasticity analysis. The relationship between residual demand elasticities and market power is examined. Alternative methods for making inferences of post-merger market power using estimates of pre-merger residual demand elasticities also are examined.

The third chapter estimates and analyzes residual demand elasticities for the USAir-Piedmont merger. Five routes on which the two firms competed prior to the merger are examined. Pre-merger time-series data is used to estimate pre-merger, post-merger, and market residual demand elasticities for each route. The results suggest that a significant degree of market power existed on some routes prior to the merger and that increased market power appears likely to result from the merger on some routes. Other routes exhibit highly elastic residual demand in spite of high levels of market concentration.

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THE MARKET POWER - EFFICIENCY TRADEOFF, 
RESIDUAL DEMAND ELASTICITY ANALYSIS, 
AND THE USAIR - PIEDMONT MERGER

John Stephen Stockum

A Dissertation 
in 
Economics 

Presented to the Faculties of the University of Pennsylvania 
in Partial Fulfillment of the Requirements for the Degree of 
Doctor of Philosophy 

1990
ABSTRACT

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John Stephen Stockum

Supervisor: Dr. Almarin Phillips

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CHAPTER 1

THE MARKET POWER - EFFICIENCY TRADEOFF IN A COURNOT MODEL

Once economies are admitted as a defense, the tools for assessing these effects can be expected progressively to be refined... solemn references to early oratory might finally be displaced in favor of analysis in the continuing dialogue in antitrust enforcement. (Williamson, 1968, p. 34)

I. Introduction

Some mergers may result in increases in both market power and efficiency. Williamson (1968) shows that the deadweight loss due to a given price increase can be offset by a gain of producer surplus due to a relatively small efficiency gain. This paper presents Cournot models to illustrate the tradeoff. Rather than deriving the cost reductions that offset given price increases, as Williamson does, I derive the cost reductions that offset endogenously determined price increases due to a given change in market concentration.

In addition, I distinguish between two alternative standards for the degree of cost reduction that offsets market power increases. A cost reduction meets the "Williamson standard" if it is sufficient to offset the deadweight loss and thus prevent total surplus from falling. However, if this standard is met, a redistribution from consumers to producers still may result. The alternative and more stringent "consumer surplus standard" is based on the fact that prices are a direct function of marginal costs, and thus an efficiency gain in the form of a reduction in marginal costs results in a price reduction. The consumer surplus standard is met if the marginal cost reduction is sufficient to offset the
incentive to increase prices due to increased market power, and thus prevent consumer surplus from falling. Williamson does not address the important effect of efficiency gains on prices.

The Cournot model, in which price is an inverse function of the number of firms, is used in this paper to provide several illustrations of the welfare tradeoff. The results indicate the direction and magnitude of effect of market concentration, cost structure, and markup of price over marginal cost on the determination of the critical values of efficiency gains. The results can be adjusted to reflect conjectural variations other than Cournot conjectures, and such adjustments significantly affect the derived critical values of cost reductions. However, such generalizations of the model appear to remove much of its ability to explain the impact of industry variables on the market power-efficiency tradeoff. Indeed, it is interesting, but not particularly useful, to illustrate that a wide range of efficiency gain may be required by a given welfare criterion depending on the value of the pre-merger and post-merger conjectural variation.

Cournot models, though they do not contain the full range of industry possibilities, provide an interesting simplified illustration of many important aspects of the welfare tradeoff issue. There is no intention to suggest that the Cournot model's assumptions are realistic or that its results are typical. However, it should be noted that the Cournot assumption is not the only determinant of the relationship between price and number of firms; thus the model permits a significant degree of generality.
While chapter 1 uses a Cournot model, the empirical model introduced in chapter 2 and estimated in chapter 3 does not rely on behavioral assumptions such as Cournot. Restrictive assumptions about competitive behavior, while they often are necessary in order to structure theoretical analysis such as that in this chapter, should not be included in empirical models that attempt to measure market performance.

The results in this chapter illustrate the significant difference between the magnitudes of efficiency gains that are required to satisfy the two welfare standards. For example, a particular merger in a five-firm industry requires a 1.5% marginal cost reduction to satisfy the Williamson standard and a 10% marginal cost reduction to satisfy the consumer surplus standard.

The significant difference between the two standards implies that the choice of a standard is an important prerequisite for policymakers' consideration of efficiencies as a mitigating factor. The courts historically have not considered efficiency gains to be a mitigating factor in merger cases and have even considered them to be an aggravating factor because cost advantages may serve to increase the ability to monopolize. Although the 1984 Justice Department Merger Guidelines place increased emphasis on efficiency gains (compare 1982 Guidelines, section 4 and 1984 Guidelines, section 3.5), the Guidelines are ambiguous about what degree of efficiency gains is required. The 1984 Guidelines specifically mention the price-reducing effect of efficiency gains and do not mention the deadweight-loss-offsetting effect. Thus it might appear that the DOJ favors the more stringent consumer surplus standard. Yet
this standard has received little attention in the literature. (A notable exception is Fisher, Johnson, and Lande, 1989.)

In part II, I present a simple Cournot model and derive the marginal cost reductions that meet the Williamson standard. In part III, I derive the cost reductions that meet the Williamson standard for the case where the efficiency gain occurs in the form of a reduction in fixed cost. In part IV, I derive the cost reductions that meet the consumer surplus standard. In part V, I derive the cost reductions for both standards in a model in which firms are not assumed to be of equal size, in order to represent more realistically the asymmetric nature of the pre-merger and post-merger market share distribution.

II. The Model and the Williamson Standard

Consider an industry with n firms producing a homogeneous commodity with no fixed costs and constant marginal cost, denoted $c_n$. The inverse market demand function is characterized by the linear expression $P_n = a - bQ_n$, $a > 0$, $b > 0$, where $Q_n$ is the total industry output. Total (consumer plus producer) surplus in the industry is

\[ W_n = (a - c_n)Q_n - (b/2)Q_n^2 \]

Cournot-Nash equilibrium values are

\[ P_n = \frac{a + nc_n}{n+1} \]

\[ Q_n = nq_n \]

\[ q_n = \frac{a - c_n}{b(n+1)} \]

Substituting (1.3) and (1.4) into (1.1),
(1.5) \[ W_n = \frac{n(n+2)(a-c_n)^2}{(n+1)^2 2b} \]

Now consider a change in the number of firms from \( n+1 \) to \( n \). Rather than imposing a certain degree of cost reduction and analyzing the welfare effects, the proportional difference between \( c_n \) and \( c_{n+1} \) that satisfies alternative welfare standards will be derived. The difference in total surplus between the industry with \( n \) firms and with \( n+1 \) firms is

\[
W_n - W_{n+1} = \frac{n(n+2)(a-c_n)^2}{2b(n+1)^2} - \frac{(n)(n+3)(a-c_{n+1})^2}{2b(n+2)^2}.
\]

To determine the magnitude of cost reduction that satisfies the Williamson welfare standard, i.e. that is sufficient to offset the deadweight loss due to the price increase endogenously determined in the Cournot model, set (1.6) equal to zero and solve for \( c_n \):

\[
(n+3)(n+1)^3 - N = (a-c_n)^2 (a-c_{n+1})^2 \frac{n(n+2)^2}{n+1^2}.
\]

\( N \) is defined for notational simplicity. Normalizing so that \( a=1 \),

\[
(1.8) c_n = 1 + (c_{n+1} - 1)/N.
\]

Equation (1.8) is the derived critical relationship between \( c_n \) and \( c_{n+1} \) that satisfies the Williamson welfare standard. The proportional difference between \( c_n \) and \( c_{n+1} \) implicit in (1.8) is dependent on the initial value of \( c_{n+1} \) assumed. By assuming an initial value for \( c_{n+1} \), we implicitly impose a pre-merger markup. Define the \((n+1)\)-firm markup as

\[
(1.9) L = \frac{P_{n+1} - c_{n+1}}{c_{n+1}}.
\]

Then substitute \( P_{n+1} \) from (1.2) into (1.9) and solve for

\[
(1.10) c_{n+1} = \frac{1}{L(n+2) + 2L+2}.
\]

Substituting (1.10) into (1.8) yields

\[
(1.11) c_n = 1 - \frac{L(n+2) / N}{1 + L(n+2)}.
\]
We are primarily interested in the critical value of the percentage change in costs, i.e. in

\[(1.12) \quad c^* = \frac{c_{n+1} - c_n}{c_{n+1}}.\]

Substituting (1.10) and (1.11) into (1.12) yields

\[(1.13) \quad c^* = L(n+2)/(N-1).\]

So \(c^*\) in (1.13) is the percentage cost reduction that is sufficient to offset the deadweight loss due to a reduction in the number of firms from \(n+1\) to \(n\). Note that \(c^*\) is a function only of the markup and the number of firms. Note also that because markup appears multiplicatively in (1.13), a percentage markup twice as great necessitates a percentage cost reduction twice as great.

Table 1.1 was compiled from equation (1.13) for various combinations of markups and numbers of firms. (The market demand elasticities implicit in these calculations are given in parentheses under each figure; they are arc elasticities calculated between the \(n\)-firm price and the \((n+1)\)-firm price.) So, for example, if a four firm \((n+1=4)\) industry has a markup of 20%, the loss of one firm \((n=3)\) will not result in a welfare loss if average cost is reduced by at least 1.2%.
TABLE 1.1

$c^*$-Percentage Reduction in Marginal Cost that Satisfies the Williamson Standard for a Reduction in the Number of Firms from $n+1$ to $n$

<table>
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<td>(11)</td>
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<td>(3.4)</td>
<td>(2.5)</td>
<td>(1.8)</td>
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<td>2</td>
<td>.005</td>
<td>.011</td>
<td>.022</td>
<td>.032</td>
<td>.054</td>
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<td></td>
<td>(7.7)</td>
<td>(3.9)</td>
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<td>(1.6)</td>
<td>(1.1)</td>
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<td></td>
<td>(5.4)</td>
<td>(2.8)</td>
<td>(1.6)</td>
<td>(1.1)</td>
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</tr>
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<td>.011</td>
<td>.019</td>
</tr>
<tr>
<td></td>
<td>(4.4)</td>
<td>(2.3)</td>
<td>(1.2)</td>
<td>(0.9)</td>
<td>(0.6)</td>
</tr>
<tr>
<td>5</td>
<td>.001</td>
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<td>.008</td>
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<td></td>
<td>(2.6)</td>
<td>(1.9)</td>
<td>(1.0)</td>
<td>(0.8)</td>
<td>(0.5)</td>
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</table>

In this model, the price increase due to a merger is inversely related to the number of firms in the industry. Thus the deadweight loss and the cost reduction called for by the welfare standard also are inversely related to the number of firms.

The inverse relationship between markup and market demand elasticity can be seen in table 1.1; the endogenously determined price increase due to a merger also is inversely related to the market demand elasticity. Thus the deadweight loss and the cost reduction called for by the welfare standard are direct functions of the number of firms.

The small degree of efficiency gain that is sufficient to offset the anticompetitive welfare loss caused by mergers in highly concentrated markets in this model may appear anomalous. This result is not an artifact of the linearity assumptions or the assumption of Cournot
behavior. Rather, this result is largely due to the fact that the efficiency gain modelled accrues to the entire range of output while the deadweight loss accrues only in the range of the output restriction caused by the increase in market power. Thus a very small percentage cost reduction multiplied by a large level of output easily exceeds the deadweight loss triangle within the much smaller range of the output reduction.

It also is apparent, both in table 1.1 and in the following tables, that reductions in the number of competitors do not appear to have a very significant affect on pricing when there are more than about three firms in the industry. If these theoretical results were consistent with marketplace reality, it would appear that antitrust policy should focus on mergers only in industries that are much more highly concentrated than the markets that are referred to as "highly concentrated" in the Justice Department's Merger Guidelines (1984, section 3.11). However, such inferences may not be appropriate. It may be more appropriate to make judgements about the threshold values of the Merger Guidelines from empirical evidence, rather than from numbers that are derived from purely theoretical models. Indeed, certain theoretical models may yield highly monopolistic results at low levels of market concentration that contrast sharply with the Cournot model, and it may not be concluded easily that the assumptions of one model are more realistic than those of the other. Alternatively, it may be the case that two or three competitors are enough to prevent prices from greatly exceeding marginal cost in many industries. But examination of theoretical models is unlikely to strongly support either hypothesis.
III. Fixed Costs

Efficiency gains may arise in the form of fixed cost savings, rather than marginal cost reductions. For example, merging firms may close down a plant and thus save the fixed costs of operating that plant, while marginal production costs remain unchanged. Let $c_n = c$ for all $n$. Given fixed costs, the loss of a firm due to a merger results in each remaining firm expanding its output and thus reducing its average cost. The reduction in average cost will be greater the larger are fixed costs. If fixed costs are large enough, the deadweight loss will be offset by the fixed cost savings. To determine what level of fixed costs is sufficiently large for this to be the case, define $f$ as a firm's fixed costs so that (1.6) becomes

\[ W_n - W_{n+1} = \frac{n(n+2)(a-c)^2}{2b(n+1)^2} - \frac{(n+1)(n+3)(a-c)^2 + f(n+1)}{2b(n+2)^2}. \]

Setting (1.14) = zero, defining $N'$, and solving for $f$,

\[ f = \frac{(a-c)^2}{2b} \frac{(n+1)^3(n+3) - n(n+2)^2}{(n+1)^2(n+2)^2} - \frac{N'(a-c)^2}{2b} \]

so that $f$ in (1.15) is the critical value of fixed cost. In order to derive the percentage change in average cost that is implied by the critical value of fixed cost in (1.15), define $c^{**}$ as the percentage change in average cost:

\[ c^{**} = \frac{c+f/q_{n+1} - (c+f/q_n)}{c + f/q_{n+1}}. \]

Substituting $q$'s from (1.4) and $f$ from (1.15) into (1.16),
(1.17) \[ c^{**} = \frac{N'(1-c)}{N'(1-c)(n+2)+2c} \]

Then substituting \( c \) from (1.10) (i.e. marginal cost as a function of markup and the number of firms; note that markup in this case refers to markup of price over marginal cost, not average cost.) into (1.17),

(1.18) \[ c^{**} = \frac{N'(L^n+2L+1)}{N'(L^n+2L+1)(n+2)+2} \]

Table 1.2 was compiled from equation (1.18). So, for example, if a five firm (\( n+1=5 \)) industry has a markup of 20%, the loss of a firm (\( n=4 \)) will not result in a welfare loss if average cost is reduced by at least 1.2%. Note that the economy is due only to the saving of one firm's fixed cost; marginal costs are held constant in this example.

**TABLE 1.2**

\( c^{**} \)=Percentage Reduction in Average Cost that Satisfies the Williamson Standard for a Reduction in the Number of Firms from \( n+1 \) to \( n \): Fixed Cost Case

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<td>1</td>
<td>0.064</td>
<td>0.071</td>
<td>0.083</td>
<td>0.095</td>
<td>0.114</td>
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<tr>
<td>2</td>
<td>0.026</td>
<td>0.030</td>
<td>0.037</td>
<td>0.044</td>
<td>0.056</td>
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<tr>
<td>n</td>
<td>3</td>
<td>0.013</td>
<td>0.016</td>
<td>0.020</td>
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<td>4</td>
<td>0.008</td>
<td>0.009</td>
<td>0.012</td>
<td>0.016</td>
<td>0.021</td>
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<tr>
<td>5</td>
<td>0.005</td>
<td>0.006</td>
<td>0.008</td>
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The marginal cost reductions in Part II reduced the price increase endogenously determined by the reduction in the number of firms. In the fixed cost case, cost savings do not affect pricing. Thus, the deadweight losses are larger in the fixed cost case, and thus the values in table 1.2 are significantly higher than those in table 1.1.
IV. The Consumer Surplus Standard

Marginal cost reductions reduce firms' profit-maximizing prices, as is seen in equation (1.2). In Part II the cost reduction reduces the price increase due to increased market power, thus also reducing the deadweight loss relative to a merger in which there is no change in marginal cost. The price-reducing effect of an efficiency gain may be sufficiently large to offset the price-increasing effect of the increased market power. Then because price does not fall, consumer surplus does not fall, and there is a gain in producer surplus. For both the fixed cost case and the zero fixed cost case, to determine what cost reduction is sufficient to keep the price from rising due to the loss of one firm, simply set $P_{n+1} - P_n$ from (1.2) and solve for $c_n$. The critical value is

$$(1.19) \quad c_n = \frac{(n+1)^2 c_{n+1} - a}{n(n+2)}$$

Substituting (1.10) and (1.19) into (1.12) yields the simple expression

$$(1.20) \quad c^{***} = \frac{L}{n}$$

i.e. the percentage reduction in marginal cost sufficient to offset the price-increasing effect of increased market power from $n+1$ to $n$ firms is simply the markup divided by the number of firms. Table 1.3 was compiled from equation (1.20). So, for example, if a five firm industry ($n+1=5$) has a markup of 20%, the loss of a firm ($n=4$) will not result in a price increase if marginal costs are reduced by 5%. The critical values in table 1.3 are much greater than those in table 1.1. This difference illustrates the importance of the choice of a welfare standard to the magnitude of efficiency required.
TABLE 1.3

c***-Percentage Reduction in Marginal Cost that Satisfies the Consumer Surplus Standard for a Reduction in the Number of Firms from n+1 to n

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V. Firm Asymmetry

The combination of two firms should be expected to result in a firm "larger" than the individual pre-merger firms. Symmetric firm models, such as those used in earlier sections, do not capture the inherently asymmetric characteristics of mergers. In this section, I generalize the model to allow firms to differ from each other. In a symmetric (n+1)-firm homogeneous good model, two pre-merger firms together have 2/(n+1) of the market, while post-merger they have 1/n of the market, the same share as the non-merging firms. A "merger" in a symmetric firm model is not really a merger, but rather is the exit of a firm, resulting in each remaining firm increasing its market share proportionately. In addition to being an unrealistic characterization of the post-merger distribution of market share, symmetric firm models do not result in the firms having incentive to merge in the first place, as Salant, Switzer, and Reynolds (1983) show. DeGraba (1988) resolves the problem by simply having the post-merger firm
maintain both cost functions of the pre-merger firms (this characterization is equivalent to perfect collusion between two firms). Thus the post-merger firm's cost function is the horizontal sum of the two firms' pre-merger cost functions. This method is useful to illustrate the behavioral asymmetry between the pre-merger and post-merger state, but does not permit us to characterize efficiency gains because the industry cost structure does not change due to the merger.

Like DeGraba, Perry and Porter (1985) assume that the post-merger firm maintains the assets (or capital stock) of the two pre-merger firms. However, Perry and Porter assume a cost function in which the increased capital stock results in a cost reduction. A third manner of firm asymmetry exists if the industry has differentiated products and the new firm maintains both "brands" from the merger partners (see Deneckere and Davidson, 1983).

Another possibility is that firm asymmetry arises due to asymmetric strategic behavior such as Stackelberg competition. Daughety (1986) shows that social welfare maximization in a Stackelberg model implies that there exists a significant amount of behavioral asymmetry (i.e. several leaders as well as several followers). Thus even without efficiency gains a merger between two followers that results in their becoming a Stackelberg leader often will increase competition and thus also welfare. In reality a merger may involve cost, demand, and behavioral asymmetries. In this section the previous model will be adapted to account for cost asymmetry.

The assumptions of the previous model are maintained in this example with the exception of the cost function. Cost asymmetry can be characterized in many different functional forms; the cost function used
was chosen for computational simplicity. I assume that there is a factor whose total supply to the industry is fixed; this factor will be referred to as capital. The capital may be distributed among the firms in any way, thus any combination of firm sizes can be modelled. For example in an n-firm industry in which firms have equal shares of capital, each firm has a capital share of $k_i = \frac{1}{n}$. If two of these firms merge, their combined capital share is $k_{ij} = \frac{2}{n}$. This asset is assumed to enter the firms' cost functions in the following way: firm i's total costs are

\begin{equation}
C_i(q_i, k_i) = (c+d/k_i)q_i
\end{equation}

The extent to which a larger stock of the asset results in lower unit costs is dependent on the relationship between $c$ and $d$. If $c$ is large (small) relative to $d$, a merger results in a small (large) efficiency gain. Rather than exogenously setting the relation between these variables and thus also setting the degree of efficiency gain, the critical relation that prevents a welfare loss will be derived. The formulation implies that the efficiency gain is specific to the firms being merged, not industry-wide as in the earlier examples. Thus the model in this section provides a reasonable interpretation of firm-specific efficiency gains as well as more adequately representing the asymmetric nature of mergers and acquisitions. We look first at a merger in which two firms of a symmetric (n+1)-firm industry combine their assets. This model proceeds similarly to the earlier model. The algebra becomes rather copious, however, and thus only the results are presented here. Given the pre-merger markup the critical relationship between $c$ and $d$ that results in a cost reduction sufficient to offset the deadweight
loss is derived. This result is then converted into a percentage reduction in unit costs:

$$c^{****} = \frac{c+d/k - (c+d/2k)}{c+d/k}$$

so that it can be compared to the earlier cases. Thus $c^{****}$ is the percentage by which the merger partners' unit costs exceed their pre-merger costs (and by which they exceed the other firms' costs which remain unchanged after the merger). The results are in table 1.4 and can be interpreted similarly to the results in table 1.1. For example, if two firms from a symmetric three-firm industry with a pre-merger markup of 10% merged, and thus controlled two-thirds of the industry's capital stock, a 2% reduction in the merger partners' unit costs is sufficient to offset the deadweight loss due to the price increase resulting from the merger.

**TABLE 1.4**

$c^{****}$—Percentage Reduction in Average Cost that Satisfies the Williamson Standard for a Merger Which Reduces the Number of Firms from $n+1$ to $n$: Asymmetric Firms Case

<table>
<thead>
<tr>
<th>L</th>
<th>.05</th>
<th>.10</th>
<th>.20</th>
<th>.30</th>
<th>.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.014</td>
<td>.034</td>
<td>.056</td>
<td>.085</td>
<td>.141</td>
</tr>
<tr>
<td>2</td>
<td>.011</td>
<td>.021</td>
<td>.043</td>
<td>.064</td>
<td>.113</td>
</tr>
<tr>
<td>n</td>
<td>.009</td>
<td>.020</td>
<td>.039</td>
<td>.049</td>
<td>.100</td>
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<tr>
<td>4</td>
<td>.007</td>
<td>.015</td>
<td>.028</td>
<td>.044</td>
<td>.073</td>
</tr>
<tr>
<td>5</td>
<td>.006</td>
<td>.013</td>
<td>.025</td>
<td>.037</td>
<td>.053</td>
</tr>
</tbody>
</table>

Next, as in Part IV, the cost reduction sufficient to prevent the post-merger price from exceeding the pre-merger price is derived for the asymmetric-firm model. Surprisingly, the number of firms drops out of the
derivation of the critical value in this case. Not only is the percentage cost reduction sufficient to result in the post-merger price equaling the pre-merger price a function only of the pre-merger markup, but it equals the pre-merger markup, regardless of the number of firms in the industry! The results are presented in table 1.5. For example, if two firms from a symmetric n-firm industry with a pre-merger markup of 10% merged, and thus controlled 2/n of the industry's capital stock, the merger will not result in a price increase if a 10% cost reduction is realized by the merger partners.

Because in the Cournot model the price increase due to a merger is an inverse function of the number of firms in the industry, we should expect that a smaller cost reduction should be necessary to meet the welfare standard the more firms there are in the industry. In fact this is what we observed in the earlier examples. But because in this case the efficiency gain occurs for the merging firms only, the smaller is the combined market share of the merger partners, the larger is the cost reduction that is necessary to offset a given price increase. These two effects offset each other exactly given the assumptions of this example.

The effect of having the efficiency gain accrue only to the merger partners also can be seen in table 1.4. Although c*** is still an inverse function of the number of firms in the industry, its rate of decrease is much slower than in the previous examples. Again this is because the efficiency gain occurs only for the merger partners, thus the smaller is their market share, the greater is the cost reduction that is necessary to offset a given deadweight loss. Also, comparing tables 1.4 and 1.5, we can see that the consumer surplus standard requires a much greater
efficiency gain than the Williamson standard, as we saw in comparing tables 1.1 and 1.2.

TABLE 1.5

| c***-Percentage Reduction in Average Cost that Satisfies the Consumer Surplus Standard for a Merger Which Reduces the Number of Firms from n+1 to n: Asymmetric Firm Case |
|---|---|---|---|---|---|
| L | .05 | .10 | .20 | .30 | .50 |
| 1 | .05 | .10 | .20 | .30 | .50 |
| 2 | .05 | .10 | .20 | .30 | .50 |
| n | .05 | .10 | .20 | .30 | .50 |
| 3 | .05 | .10 | .20 | .30 | .50 |
| 4 | .05 | .10 | .20 | .30 | .50 |
| 5 | .05 | .10 | .20 | .30 | .50 |

The Merger Guidelines (1984, section 3.11) state that if a proposed merger results in an increase of the industry's Herfindahl-Hirschman Index (HHI) of more than 100 and the post-merger HHI substantially exceeds 1800, "only in extraordinary cases" will mitigating factors prevent the Justice Department from challenging it. Recall that the HHI is simply the sum of the squares of the individual firms' market shares. A merger in a symmetric five-firm industry that results in the merger partners controlling 40% of the industry's assets and the three other firms each controlling 20% (although the HHI is calculated in terms of market share, industry assets will be used here as a proxy) results in the HHI rising from 2000 to 2800. However, as we see in table 1.4, a net welfare loss will not result from this merger if there is a 1.5% cost reduction, assuming that the pre-merger markup is 10%. And as we can see in table...
1.5, this same merger will not result in a price increase if there is a 10% cost reduction. Whether or not these circumstances constitute an "extraordinary case" is an empirical question.
CHAPTER 2
RESIDUAL DEMAND ELASTICITY THEORY
AND ANTITRUST POLICY

"It is only because we lack confidence in our ability to measure elasticities, or perhaps because we do not think of adopting so explicitly economic an approach, that we have to define markets instead." (Posner, 1976, p. 125)

I. Introduction

Economic theory suggests that a number of factors affect an industry's competitive performance. According to the Justice Department's Merger Guidelines (1984, sections 3.1-3.4), these factors include market concentration, ease of entry, product homogeneity, information about specific transactions and buyer characteristics, the degree of difference between the products and locations in the market and the next-best substitutes, similarities and differences in the products and locations of merging firms, ability of small or fringe sellers to increase sales, and conduct of firms in the market. With the exception of market concentration measures, antitrust analysts generally offer primarily qualitative descriptions of these variables and their potential effect on competitive performance. No systematic means of measuring these variables or combining them into a quantitative measure of an industry's performance, or estimate of prospective change in performance due to a merger, is generally practiced.

Data and time constraints, due in large part to the structure of the Hart-Scott-Rodino antitrust review process, are the popular rationalizations for the current methodology. Such arguments seem to imply that there is an alternative methodology that could be used if the
constraints were not present; however, no such methodology is generally recognized.

The focus of much of the empirical industrial organization literature is the attempt to explain the relationship between pricing (or profits) and variables accounting for market concentration, entry barriers, and demand. These studies have had limited success at specifying the relationship between structure and performance, in part due to the difficulty of accounting for many of the relevant variables, and in part due to the inherent endogeneity of many of the relevant variables. Further, the specifications of these empirical models generally are not derived from models of industry behavior. Few economists would argue that the coefficients on the market structure variables estimated in these studies should be used to draw inferences about the potential effects of specific mergers.

Baker and Bresnahan (1984, 1985, 1988) have introduced a method for estimating a firm's residual demand elasticity, which is inversely related to market power. Residual demand elasticity estimation attempts to determine the extent to which market power is being exercised by a firm, and the extent to which market power can increase because of a merger between two firms, without completely specifying the relationship between profitability and all of its numerous interrelated determinants. Other studies (e.g., Iwata, 1974, and Lliang, 1987) estimate firms' conjectural variations. Conjectural variations, which can be thought of as an implicit component of residual demand elasticities, exclude the important

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¹For discussions of some of the problems of these empirical studies, see Waterson (1984, ch. 10), Clarke and Davies (1982), and Phillips (1976).
effect of demand elasticity on competitive performance, and the estimation
procedure requires assumptions more restrictive than those required by
residual demand elasticity estimation.

Since Baker and Bresnahan's papers, no further empirical
applications or discussions of the theory of residual demand elasticity
have appeared in the literature (with the exception of Scheffman and
Spiller's application (1987) that is restricted to the subject of market
definition). This paper addresses the theory underlying the analytical
method in greater detail than in Baker and Bresnahan's papers, focusing
on the generality of the assumptions required by the method.

Section II presents the model. Section III.A discusses the
relationship between demand elasticity and the Lerner index, and derives
a generalized version of the relationship. Section III.B discusses the
relationship between the Lerner index and market power, and evaluates
several apparent discrepancies in the relationship. Section IV.A
describes Baker and Bresnahan's approach to estimating post-merger
residual demand elasticities using pre-merger residual demand
elasticities, and generalizes the assumptions necessary for using their
method. Section IV.B offers an alternative methodology for making
inferences about post-merger market power. Section IV.C discusses the
endogeneity of firms' choices of product characteristics and the
implications of this endogeneity for interpretation of the results.
Section V describes how residual demand elasticities can be used to derive
the magnitude of efficiency gain that is sufficient to offset the welfare
effects of an estimated increase in market power.
II. The Model

In a generalized model, the issue of whether to specify price as a function of quantity, or quantity as a function of price, should be a matter of notation rather than a matter of behavioral assumptions. In this paper, price is stated as a function of quantity, and it should become clear that the formulation does not necessarily imply specific competitive behavior, such as Cournot. Firm j's inverse demand function may be written as

\[ P_j = P_j(Q_j, Q_0, Y) \]

where \( Q_0 \) is a vector of the outputs of the other firms in the industry and \( Y \) is a vector of exogenous demand variables. The first-order condition for firm j's profit maximization is

\[ P_j(Q_j, Q_0, Y) + Q_j \frac{dP_j}{dQ_j} = \frac{dC_j(Q_j, W, W_j)}{dQ_j} \]

where \( dC_j(Q_j, W, W_j)/dQ_j \) is marginal cost, \( W \) is a vector of exogenous industry-wide factor prices, and \( W_j \) is the vector of firm j's firm-specific factor prices. \( Q_0 \) is defined implicitly in the system of \((n-1)\) first-order conditions for firms \( j=2,\ldots,n \) as

\[ Q_0 = Q_0(Q_1, Y, W, W_0) \]

Equation (2.3) is the vector of reaction functions of firms 2 through n to firm 1's output. Substituting (2.3) into (2.1) for firm 1 yields

\[ P_1 = P_1(Q_1, Y, W, W_0) \]

Equation (2.4) is firm 1's residual demand function, implicit in which is the behavior of firms 2,\ldots,n. The endogeneity of \( Q_1 \) in this specification necessitates a simultaneous-equations estimation technique. Ordinary least squares estimators are not consistent estimators of the structural coefficients, because the residual demand equation is a single
unidentified equation from a simultaneous system. Rather than fully specifying the simultaneous system of supply and demand functions, a limited-information approach such as two-stage least squares can be used. To identify the parameters of the firm-specific residual demand function with two-stage least squares, data is required on variables that enter firm 1's supply function but are not correlated with the error term in its demand equation. These instruments are regressed on $Q_1$ in the first-stage regression, and the second-stage estimates the residual demand function where the fitted values of $Q_1$ from the first-stage regression are substituted for $Q_1$.

Factor prices that appear in firm 1's supply function appear to be an obvious choice for instruments in this specification. However, because many of firm 1's factor prices also may be factor prices for its competitors, such industry-wide factor prices ($W$) appear in firm 1's residual demand function (see equation 2.4) as well as in its supply function. Firm-specific cost variables $W_1$ that are not included in equation (2.4) are needed for use as instruments. In order for the instruments to identify the residual demand equation, significant variability of $W_1$ that is independent of the variability of $W$ and $W_0$ is required. This requirement is an obstacle preventing the applicability of this method in many markets, because in many markets either costs are highly correlated across firms, or data are not available on the cost components which might not be highly correlated across firms.²

²For example, as Froeb and Werden (1990, p. 14) note, Scheffman and Spiller (1987) used regional fuel prices as cost shifters, but these variables likely would be highly correlated across their sample.
Note that \( \frac{dP_1}{dQ_1} \) from firm 1's first-order condition can be expressed as

\[
(2.5) \quad \frac{dP_1}{dQ_1} = \frac{\delta P_1}{\delta Q_1} + \frac{\delta P_1}{\delta Q_0} \delta Q_0 .
\]

Converting (2.5) to an elasticity measure,

\[
(2.6) \quad \frac{dP_1}{dQ_1} \frac{Q_1}{P_1} = \frac{\delta P_1}{\delta Q_1} \frac{Q_1}{P_1} + \frac{\delta P_1}{\delta Q_0} \frac{Q_0}{P_1} \frac{\delta Q_0}{\delta Q_1} \frac{Q_0}{Q_1} .
\]

which will be denoted

\[
(2.7) \quad e_1 = e_{11} + \sum_{j=2}^{n} e_{1j} r_{j1} ,
\]

where \( e_1 \) is firm 1's inverse residual demand elasticity, \( e_{11} \) is firm 1's inverse own-demand elasticity, \( e_{1j} \) is the inverse cross-demand elasticity between firm 1's price and firm j's output, and \( r_{j1} \) is the elasticity of firm j's reaction function with respect to firm 1's output. (Reaction function elasticities are sometimes referred to as conjectural variation elasticities.) Conjectural variations, not recoverable from the estimation process described, are discussed here only to clarify their role as an implicit characterization of competitive interaction which can be thought of as a component of residual demand elasticity.

Some game theorists contend that the dynamic process of oligopolistic interaction cannot be represented adequately in a static framework (for example, see Friedman, 1983, pp. 106-7). Reaction functions appear to be ambiguous in a single-period model, such as the one above. However, a single-period observation of the prices and quantities determined by a dynamic process must include an implicit characterization of the reaction functions in the dynamic game being played. The conjectural variations implicit in the reaction functions can be
considered to be endogenously determined by the information structure of the industry, the ease of entry, and other factors.

Note that different oligopoly theories can be described in terms of different values of $r_{ji}$. Cournot competition exists between firms $i$ and $j$ if $r_{ji} = 0$, because Cournot competitors assume that their competitors will not respond to their changes in their output. Perfect collusion exists if $r_{ji} = 1$, because responding to competitors' output changes proportionally effectively internalizes monopoly behavior. Bertrand competition exists if $r_{ji} = -1$, because attempted output restrictions are met by equal and opposite output expansions. Intermediate degrees of competition exist for values of $r_{ji}$ between $-1$ and $1$.

The residual demand function can be estimated in loglinear form, so that the coefficients on quantities will be elasticities. Denoting $x_j = \ln X_j$,

\[
(2.4') \quad p_1 = \sigma_0 + \sigma_1 q_1 + \Gamma_1'y + \Omega_1'w + \nu_1,
\]

where $\sigma_1$ estimates $e_1$.

"Residual demand," as referred to herein, should be distinguished from a functional form in which $q_2, \ldots, q_n$ are explicitly specified. If $q_2, \ldots, q_n$ were explicitly specified in the demand equation, the coefficient on $q_1$ would be an own-demand elasticity, $e_{11}$, rather than residual demand elasticity, $e_1$. The residual demand elasticity is a total derivative, while the own elasticity is a partial derivative. While we find in the next section that the residual demand elasticity is the relevant variable for our analysis of competition, much of economic analysis focuses on the own elasticity. For example, Chamberlin (1962, p. 75) refers to the demand curve as "rigidly defined by the fixity of all products and of all
other prices." Expected consumer responses, but not competitor responses, are implicit in this specification of the demand function. However, the actual demand function facing a firm, and thus the marginal revenue that a firm considers in determining its profit-maximizing price and output, must incorporate expectations of both competitor and consumer responses.

III. Demand Elasticity, Lerner Indices, and Market Power

A. The Relationship Between Demand Elasticities and the Lerner Index

It is well known that the Lerner index, \((p-mc)/p\), is an inverse function of demand elasticity. The applicability of the relationship has been perceived to be limited because it usually is derived in the context of models with restrictive assumptions. The assumptions underlying the relationship often are not explicitly acknowledged or adequately explained. In addition, the relationship is derived for various forms of demand elasticities: market elasticity, firm elasticity, residual elasticity, own elasticity, etc. In this section, the relationship will be derived in a generalized form. Restrictive assumptions such as homogeneous products and Cournot behavior are not required. The derivation and discussion will clarify the necessary underlying assumptions, which will be shown to be less restrictive than recognized in many articles, including those of Baker and Bresnahan.

From firm 1's first-order condition, equation (2.2), we can derive

\[
(2.8) \quad \frac{dP_1}{dQ_1} = \frac{P_1 - c_1}{P_1},
\]

where \(c_1 = dC_1(Q_1, W, W_1)/dQ_1\). In the notation introduced in equation (2.7), equation (2.8) can be expressed as

26
\( e_1 = -\left( e_{11} + \sum_{j=2}^{n} e_{1j} r_{j1} \right) \frac{E_1 - c_1}{P_1} \)

i.e. the negative inverse residual demand elasticity of a firm is equal to its Lerner index. The relationship is general in that it does not rely on any assumptions about competitive behavior, \(^3\) functional form of demand or costs, effects of potential entry, number of firms, the degree of product heterogeneity, or market definition. Although the notation specifies \( n \) firms, it will not be necessary to solve \( \Sigma e_{1j} r_{j1} \) for each individual competitor; i.e. it is only their aggregate implicit effect on \( e_1 \) that is of interest. Thus the \( n \) firms should be thought of as all competitors producing any good which consumers consider to be substitutes for firm 1's good and any firms perceived by firm 1 as being potential competitors. As will be discussed below, firm 1 is assumed to be optimizing subject to its expectations of other players' (consumers, competitors, and potential entrants) behavior, but that behavior is not specified, and thus other players' optimizing behavior and industry equilibrium are not necessary for the relationship to hold.

This relationship is derived in many different contexts in many papers. Because the relationship is usually derived in the context of a

\(^3\)Note that the above derivation does not assume Cournot behavior, because \( dP_j/dQ_j \) is a total derivative, not a partial derivative. Defining quantity as a function of price and differentiating with respect to price yields the identical result:

\[
(2.1') \quad Q_j = Q_j(P_j, P_0, Y)
\]

\[
(2.2') \quad Q_j + P_j \frac{dQ_j}{dP_j} = \frac{dC_j}{dQ_j} \frac{dQ_j}{dP_j}
\]

If the residual demand function is monotonic in \((P_j, Q_j)\)-space, then \( dP_j(\cdot)/dQ_j \cdot 1/dQ_j(\cdot)/dP_j \). Dividing \((2.2')\) by \( dQ_j/dP_j \) yields equation \((2.2)\), and thus also equation \((2.8)\).

Baker and Bresnahan (1984, pp. 12-14; 1988, pp. 289-90) list several sets of assumptions that are sufficient for the relationship to hold. These assumptions are dominant firm behavior, Stackelberg behavior, perfect competition, the "limit case of product differentiation" (i.e. monopoly), and consistent conjectures equilibrium. The most general of these assumptions is that of consistent conjectures equilibrium; however, even this assumption is unnecessarily restrictive. Neither equilibrium nor consistent conjectures are necessary for the relationship to hold.

Note that the relationship is derived, not from industry equilibrium conditions, but from firm 1's profit-maximizing first-order condition. The relationship thus requires only that firm 1 is maximizing its profits given its expectation about competitor and consumer responses, but does not place any constraints on competitor and consumer behavior, not even profit-maximizing by firm 1's competitors or industry equilibrium.

A type of "rational expectations" assumption about competitor and consumer responses does underlie the relationship, but the necessary assumption is less restrictive than Bresnahan's consistent conjectures assumption. Because firm 1 maximizes profits with respect to its
expectation of consumer and competitor behavior, the demand elasticity in its first-order condition is an expected value, and thus equation (2.9) could be written as

\[ (2.9') \quad -E_1(e_1) = -E_1(e_{11} + \sum_{j=2}^{n} e_{1j}r_{j1}) = \frac{p_1 - c_1}{p_1} \]

i.e. firm 1's Lerner index equals firm 1's expectation of its residual demand elasticity, where \( E_1 \) is firm 1's expectation operator. Baker and Bresnahan (1988), consistent with Bresnahan's (1981) model, assume that firms know the parameter values \( e_{1j}, j=1, \ldots, n \), and express equation (2.9) (see their equation 11) as

\[ (2.9'') \quad -(e_{11} + \sum_{j=2}^{n} e_{1j}E_1(r_{j1})) = \frac{p_1 - c_1}{p_1} \]

In other words, \(-e_1 = -E_1(e_1) = (p_1 - c_1)/p_1\) only if firm 1 correctly perceives each of its competitors' conjectural variations (i.e. \( E_1(r_{j1}) = r_{j1}, j=2, \ldots, n \)). Note that \( E_1(\Sigma r_{j1}) = \Sigma r_{j1} \) does not satisfy Baker and Bresnahan's consistent conjecture assumption. Knowledge of each individual firm's \( r_{j1} \) is needed, because each \( r_{j1} \) interacts with each \( e_{1j} \) separately.

Thus, in addition to the unnecessary assumption that the industry be in equilibrium, Baker and Bresnahan's consistent conjectures assumption requires that firm 1 knows the \( n \) parameters \( e_{1j}, j=1, \ldots, n \), and has rational expectations about each of the \((n-1)\) parameters \( r_{j1}, j=2, \ldots, n \). However, it probably is very difficult for firms to make informed inferences about partial derivatives based on the data that is observable to the firm. Firm 1 changes its price, and observes a change in its
output. Firm 1 likely has very limited information about the extent to which its output change is influenced by each of the \((2n-1)\) partial derivatives. Rather, market behavior enables firm 1 to observe its residual demand elasticity, \(e_1\). If firm 1 has no information about any of the \((2n-1)\) partial derivatives, but has rational expectations about \(e_1\), i.e. \(E_1(e_1) = e_1\), then the residual demand elasticity predicts the Lerner index without bias.\(^4\) Thus \(E_1(e_1) = e_1\), and profit-maximizing behavior on the part of firm 1, are sufficient to support the inverse relationship between firm 1's residual demand elasticity and its Lerner index.

Rational expectations about demand elasticity do not necessitate rational expectations about competitor behavior, either as an aggregate or for individual competitors. One might argue that rational expectations about competitor behavior may lead to perfect collusion, because price-cutting could be easily detected and punished. But firms' observations of their residual demand elasticities contain a noisy signal of their competitors' behavior, confounded by the effects of own-elasticities, cross-elasticities, and exogenous parameters. The degree to which a firm's behavior is hidden in the noisy signal received by its competitors may significantly affect firms' conjectural variations and thus the degree to which supra-competitive pricing can be maintained.

Next, an apparent indeterminacy in the demand elasticity-Lerner index relationship will be refuted. The inverse relationship between market power and a firm's demand elasticity may appear to conflict with

\(^4\)Past observations of \(e_1\) may provide imperfect information about its current value. Firm 1, of course, can incorporate information in addition to observations of past values of \(e_1\), in estimating the current \(e_1\). No source of bias in firm 1's estimation of \(e_1\) is apparent.
the fact that on certain demand functions (such as linear), there is a direct relationship between price and demand elasticity. Thus it may appear to be ambiguous whether a firm facing elastic demand is in a competitive industry or has significant market power and has raised its price into the elastic range of its demand curve. The apparent ambiguity is due to a confusion between the relationship between price and demand elasticity, and the relationship between profit-maximizing price and demand elasticity.

Although a price increase in some cases may leave a firm at a more elastic point on its demand curve, a price increase that results in a move to a more elastic point on a given residual demand function will reduce a firm's profits. A firm will choose the price that maximizes its profits on a given residual demand function, and (assuming no change in marginal cost), will raise that price only if its residual demand becomes more inelastic. Because firm 1's profit maximization implies $-e_1=(P_1-c_1)/P_1-L_1$ (from equation 2.9), regardless of the functional form of demand,

\[
de_1 = -\frac{dL_1}{dP_1} \leq 0.
\]

(2.10) \[
\frac{dL_1}{dP_1} \leq 0.
\]

This relationship may appear ambiguous in part because of a confusion between market and firm-specific demand elasticity. Consider a merger that increases firms' market power, i.e. reduces the firms' demand elasticities and thus enables them to raise price. The market demand curve (i.e. the demand curve facing a hypothetical monopolist) does not shift due to a change in competition among the firms in that market. The post-merger price is higher than the pre-merger price on the same market demand function, and thus the market demand elasticity may be higher post-merger. Accordingly, the merger results in firm demand...
elasticity falling and market demand elasticity rising. This somewhat counterintuitive result has resulted in some confusion about the relationship between demand elasticity and market power. But the inverse relationship between the Lerner index and a firm's demand elasticity is not made indeterminate by the fact that demand curves may have a direct relationship between price and demand elasticity.

Of course, estimations of demand elasticities appear throughout the literature. However, the specifications of the models generally are not residual demand functions, and thus yield demand elasticities from which market power inferences should not be made. If, for example, rather than specifying a residual demand function, \( P_1 = P_1(Q_1, Y, W) \), we more fully specify the demand function as \( P_1 = P_1(Q_1, Q_2, ..., Q_n, Y, W) \), the coefficient on \( Q_1 \) will have an ambiguous relationship with firm 1's Lerner index. In addition, the inclusion of structural variables such as entry barriers and market concentration implies that the coefficient on \( Q_1 \) will have an ambiguous relationship with firm 1's Lerner index.

B. The Relationship Between the Lerner Index and Market Power

The previous subsection establishes that under very general conditions, a firm's Lerner index is equal to its negative inverse residual demand elasticity. In order to make market power inferences from observations of residual demand elasticities, it also is important to understand the relationship between the Lerner index and market power.

The Lerner index, \( (p - mc)/p \), is an index of market power because it directly reflects the allocative inefficiency due to the divergence of price from marginal cost that results from the exercise of market power.
Because market power often is defined as the ability to charge a price greater than marginal cost, in this respect the Lerner index appears to be an accurate index of the degree of market power. However, the Lerner index has been criticized by some authors (e.g., Clarkson and Miller, 1982, p. 60, Landes and Posner, 1981, p. 941). Several actual and perceived problems with Lerner indices, and the implications for applications of residual demand elasticity analysis, are discussed below.

While the Lerner index reflects the "degree" of market power being exercised, this degree is only one dimension of the welfare loss due to the exercise of market power. Two industries with the same Lerner index may have very different degrees of welfare loss due in part to a difference in output levels. The Lerner index is a component of the calculation of welfare loss, but additional information is required. However, for many policy purposes, an estimate of the total welfare loss is not necessary. An estimate of a Lerner index or a change in a Lerner index is sufficient information to make many antitrust enforcement decisions. One application that might appear to require more information about welfare losses than a Lerner index, but does not, is determining the degree of efficiency required to negate an estimated increase in a Lerner index (see section V below).

Second, if marginal costs are an increasing function of output, the current marginal cost is less than the marginal cost that would exist if there were a procompetitive output expansion. In this case, the Lerner index is not the output produced, but rather the difference between the output produced and the output that would be produced if price equalled marginal cost.

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5The relevant output dimension of deadweight welfare loss actually is not the output produced, but rather the difference between the output produced and the output that would be produced if price equalled marginal cost.
index overstates the degree to which prices exceed the level of marginal cost that would exist in the hypothetical perfectly competitive state.\(^6\)

Third, comparing "markups" based on accounting data across industries may show large variations that appear to be attributable to factors other than differences in competitive performance. This may imply that the markups are not appropriately estimated Lerner indices, rather than that there is an inherent problem with Lerner indices as an index of market power. Comparisons of accounting-data-based markups may overlook important industry cost differences in areas such as marketing and research and development, as well as differences in the opportunity costs of some resources (see Clarkson, 1977). This issue is illustrated by apparently high markups in breakfast cereals and pharmaceuticals, industries in which marketing and R&D are relatively high. As discussed in Klein and Lefler (1981) and Shapiro (1983), firms' earnings on investments in such intangible assets is not inconsistent with competitive performance.

A fourth problem arises due to the fact that Lerner indices are inversely related to marginal costs, as well as directly related to anticompetitive behavior. The inverse relationship between \( L \) and \( c \) can be seen by

\[
\frac{cdP - P}{dc} \leq 0, \text{ since } c \leq P \text{ and } \frac{dP}{dc} \leq 1
\]

(Of course \( dL/dc=0 \) in perfect competition, where \( c-P \) and \( dP/dc=1 \)). In other words, efficiency, rather than market power, may be responsible for a high Lerner index (e.g., see Demsetz 1973). Alternative cost structures

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\(^6\)This argument is discussed in Landes and Posner (1981), p. 941.
for an industry could result in the alternative with the higher price being the alternative with the lower Lerner index. However, the argument that a firm’s relatively high Lerner index is due to its relative efficiency implies that the efficiency this firm has achieved is not available to other firms, because otherwise competition would dissipate the profits from the efficiency. In effect, the firm’s exclusive access to the efficiency is a source of market power; however, it is socially beneficial market power relative to the alternative absence of this unique efficiency. To the extent that an individual firm’s efficiency advantage relative to competitors can persist in the long run, this criticism of Lerner indices is valid. Indeed, we should be especially careful not to mislabel firms with differential efficiencies as anticompetitive.

Fifth, the Lerner index reflects the divergence of price from marginal cost, not just due to anticompetitive behavior, but also due to product differentiation. If products are imperfect substitutes, firms’ prices can exceed their marginal costs even if their conjectural variations are perfectly competitive (see equation 2.7). It might be argued that antitrust policy should focus on anticompetitive conduct, rather than on the divergence of price from marginal cost due to other factors such as product differentiation.

However, as can be seen in equation (2.7), the degree of product differentiation, as measured by cross-elasticities of demand, interacts with firms’ conjectural variations to determine competitive performance. If two merging firms have very low cross-elasticities, a change in their conjectural variations from competitive to collusive will have relatively little effect on their Lerner indices. Because antitrust policy
presumably is intended to influence competitive performance, both the degree of substitution and the degree of competitive conjecture are important to the analysis.\textsuperscript{7}

In addition, product differentiation in some instances may not be exogenous, but rather determined as part of the competitive process.\textsuperscript{8} For example, the most profitable point in product characteristic space generally is one that limits the substitutability between a firm's product and its competitors' products (e.g., see Prescott and Visscher, 1977). Firms presumably consider this important factor in their choices of product characteristics. Thus, "competitiveness" cannot be completely separated from substitution among firms' products, even in theory. Of course, industries with structural barriers insulating firms from competition may not be easily distinguished from industries with beneficial product innovations. In the latter case, similar to the differential efficiency case discussed above, we must be careful to avoid punishing innovative leaders by labeling them as anticompetitive. Thus, greater skepticism should be placed on Lerner indices as measures of market power in industries undergoing rapid innovation.

Thus, the interpretation of Lerner indices is subject to ambiguity from a number of sources. For some types of interpretation, some of the sources of ambiguity are relatively inconsequential. For example, in

\textsuperscript{7}The importance of the degree of consumer substitution is recognized in the Merger Guidelines in sections 3.412, "The Degree of Difference Between the Products and Locations in the Market and the Next-Best Substitutes," and 3.413, "Similarities and Differences in the Products and Locations of the Merging Firms." No quantitative method of evaluating the competitive significance of these variables is suggested.

\textsuperscript{8}A further discussion of the implications of the endogeneity of firms' choices of product attributes is in section IV.C below.
comparing Lerner indices across equal-sized geographic markets in the same industry, it often may be safe to assume that certain cost characteristics are the same across markets.

A Lerner index change brought about by a merger, as opposed to the level of the Lerner index, is not subject to most of the sources of ambiguity discussed. Assuming no efficiency gains due to the merger (efficiency gains will be considered in section V), and assuming no shift in exogenous factors, such as market demand, an increase in the Lerner index must result from an increase in market power. For the purpose of antitrust analysis of a merger, it is the change, not the level, of market power that is relevant. Section IV describes how post-merger changes in Lerner indices can be predicted using residual demand elasticities.

IV. Post-Merger Residual Demand Elasticity Inferences

A. The Baker and Bresnahan Method

While inferring the current degree of market power from estimated residual demand elasticities is a useful exercise, it is the change in market power resulting from a merger that is important for the antitrust analysis of mergers. Baker and Bresnahan suggest a method of making such inferences, however their method raises some difficult issues which they do not discuss. This section analyzes their method and finds theoretical support for their assumptions under certain industry conditions. Section B suggests an alternative method for making post-merger inferences. Section C discusses the possible implications of endogenous choice of product characteristics on our ability to make post-merger inferences.
While the ordinary demand curve of a group of consumers is the simple horizontal summation of the consumers' individual demand curves, the residual demand curve that would face a group of firms if they were to merge is not the simple horizontal summation of their residual demand curves. For example, consider a market with impenetrable entry barriers and two competitors. Competitive interaction between the two firms may result in highly elastic residual demand for both firms, and the horizontal sum of their demand curves also may be highly elastic, although they would face relatively inelastic demand if they merged. The difficulty in making inferences about post-merger demand elasticities from pre-merger data is in determining the independent effect on residual demand elasticities due to competitive interaction between the two merging firms, as opposed to the effects of competition from other sources and the effect of consumer demand elasticity.

Suppose that firms 1 and 2 propose to merge. Firm 1's pre-merger inverse demand function may be written as

\[(2.11) \quad P_1 = P_1(Q_1,Q_2,Q,\ldots,Y)\]

where \(Q_\cdot\) is the output of non-merging firms. Firm 1's first-order condition for profit maximization is

\[(2.12) \quad P_1(Q_1,Q_2,Q,\ldots,Y) + Q_1\frac{dP_1}{dQ_1} = dC_1(Q_1,W,W_1) \frac{dQ_1}{dQ_1}\]

\(Q_\cdot\) is defined implicitly in the system of first-order conditions for firms \(j=3,\ldots,n\) as

\[(2.13) \quad Q_\cdot = Q_\cdot(Q_1,Q_2,Y,W) \]

Substituting (2.13) into (2.11) yields

\[(2.14) \quad P_1 = P_1(Q_1,Q_2,Q,\ldots,Y,W) \]

38
Equation (2.14) is firm 1's "partial" residual demand function. Estimation of partial residual demand functions yields partial residual demand elasticities, which will be denoted with a $p$ in their subscripts, as

\begin{equation}
(2.15) \quad e_{11p} = \left. \frac{dp_1}{dq_1} \right|_{dq_2=0} - \delta p_1 + \sum_{j=3}^{n} \delta p_1 \delta q_j \delta q_1 \approx e_{11} + \sum_{j=3}^{n} e_{1j} r_{1j} .
\end{equation}

Note that the difference between (2.7) and (2.15) is that in (2.15) the summation begins at $j=3$. Similarly, $e_{12p}$ can be expressed as

\begin{equation}
(2.16) \quad e_{12p} = \left. \frac{dp_1}{dq_2} \right|_{dq_1=0} - \delta p_1 + \sum_{j=3}^{n} \delta p_1 \delta q_j \delta q_2 \approx e_{12} + \sum_{j=3}^{n} e_{1j} r_{1j} .
\end{equation}

The partial residual demand function can be estimated in loglinear form, so that the coefficients on quantities will be elasticities. Denoting $x_j=\ln x_j$,

\begin{equation}
(2.17) \quad p_1 = \sigma_{10} + \sigma_{11} q_1 + \sigma_{12} q_2 + \Gamma_1' y + \Omega_1' w + v_1 ,
\end{equation}

where $\sigma_{ij}$ estimates $e_{ijp}$.

Baker and Bresnahan's method for making post-merger inferences is based on an assumption that the two firms will adjust their output proportionally post-merger, i.e. that $\delta q_1/\delta q_2=1$. If the proportional post-merger output adjustment assumption is met, a one percent decrease of $Q_1$ and $Q_2$ will raise $P_1$ by $e_{11p}+e_{12p}$. Thus firm 1's estimated post-merger residual demand elasticity is $e_{11p}+e_{12p}$. 

39
The Lerner index-residual demand elasticity relationship derived in section III.A implies that a given increase in an inverse residual demand elasticity will result in that same magnitude of increase in the Lerner index. Firm 1’s post-merger Lerner index should be \(-(e_{11p}+e_{12p})\) and the estimated increase in the Lerner index for firm 1 is \(e_1-e_{11p}-e_{12p}\). The implied percentage price increase is \(\frac{(e_1-e_{11p}-e_{12p})}{(1+e_{11p}+e_{12p})}\). The proportional output adjustment assumption is a convenient mathematical device that enables us to make post-merger market power inferences. The assumption may be reasonable under certain circumstances but does not appear to apply generally. Baker and Bresnahan do not examine the assumption.

The proportional output adjustment assumption, \(\frac{\delta q_1}{\delta q_2} = 1\), can be interpreted as a unitary conjectural variation between the two firms. A unitary conjectural variation is the equilibrium result of collusion or merger in simple oligopoly models (e.g., Cubbin, 1983, Waterson, 1984), and thus may be a reasonable assumption. Indeed, it makes intuitive sense that colluding firms will change their outputs proportionally, because proportional responses imply coordinated behavior. However, as noted by Forbes (1988), collusion implies \(\frac{\delta q_1}{\delta q_2} = 1\) only if there is "symmetry" between the two firms, which is characterized by \(\frac{\delta \pi_1}{\delta P_2} = \frac{\delta \pi_2}{\delta P_1}\), where \(\pi_i\) denotes firm i’s profits. However, Forbes does not address the market characteristics that will yield this symmetry.

At the extreme, if the merging firms’ products are perfect substitutes, and if the two firms face the same constant marginal cost, it is economically irrelevant how they distribute their output between them. If, alternatively, the firms’ products are perfect substitutes and
the firms face the same increasing cost function, the firms will produce the same outputs pre-merger, and will adjust their output proportionally post-merger in order to minimize the cost of producing any given output. Thus in either case, the proportional output adjustment assumption holds.

Product differentiation complicates the issue, however the proportional output adjustment assumption is reasonable in markets with certain forms of product differentiation. Consider a model of one-dimensional product differentiation. If demand is uniformly distributed, and if firms have the same cost functions and are located at uniform intervals, the products of any two firms (not just adjacent firms) will be symmetrically differentiated, in the sense of the Forbes definition above. Symmetric distribution of competitors, though it may seem to be a stringent assumption, is an equilibrium outcome in models of product differentiation when firms choose their product characteristics (e.g., Prescott and Visscher, 1977). Of course, we should expect that, given uniform demand, firms will choose locations that limit the substitutability between their product and their competitors' products. Though this simple one-dimensional product differentiation model is intuitive, its assumptions, such as uniform demand, are not necessarily required for symmetric product differentiation to exist.

Assume that two firms face the same constant marginal cost and the following symmetric linear demand functions:

\begin{align}
(2.18) \quad P_1 &= a + bQ_1 + cQ_2, \\
(2.19) \quad P_2 &= a + bQ_2 + cQ_1.
\end{align}

Solving the model for the pre-merger and post-merger equilibrium outputs of the two firms, we find that the two firms' outputs change
proportionally. Thus equivalent demand elasticities and cross-elasticities yield proportional output adjustments. Proportional output adjustments may occur more generally. However, in more complex models, if we set the proportional output changes of the two firms equal, and solve for the conditions necessary to support the relationship, the conditions do not have intuitive interpretations.  

B. An Alternative Method

An alternative method for making inferences of post-merger demand elasticities from pre-merger data is based on a simple approach that is sometimes used in calculating "market" demand elasticities. The market demand elasticity is the demand elasticity that would face a hypothetical monopolist in a particular product and geographic market. An approach that has been used to calculate market demand elasticities is to simply sum the sales of the firms in the market and calculate the demand elasticity of this quantity with respect to the average market price. Note that this simple method differs from a horizontal summation of the firms' demand curves in that consumer switching among firms within the market definition due to changes in relative prices is internalized, i.e., such switching does not affect the calculated demand elasticity. Internalizing inter-firm switching is the fundamental difference between market demand elasticities and firm-level demand elasticities.

---

9 For example, if we generalize the above model to

\[
(2.18') \quad P_1 = a + bQ_1 + cQ_2 \\
(2.19') \quad P_2 = e + fQ_2 + gQ_1
\]

and allow the two firms to face different marginal costs, \(d\) and \(h\), respectively, set \((Q_1' - Q_1)/Q_1 = (Q_2' - Q_2)/Q_2\), and solve, we get

\[
(g^2 + 2fgc_{121})(hd - ha - ed + ea) + ccr_{21}(2eh - e^2g - h^2g + 2ceh - ce^2 - ch^2) - (c^2 + 2bgr_{12})(hd - ha - ed + ea) + gr_{12}(2adc - a^2c - d^2c + 2gad - ga^2 - gd^2).
\]
This same method could be used to calculate the "market" demand elasticity based on a market definition that includes only the two merging firms, as opposed to the market defined by other means such as that described in the Merger Guidelines. This method internalizes consumers' switching between the two firms' goods, and thus yields an estimate of the post-merger demand elasticity that the merged firm would face.\(^\text{10}\)

Scheffman and Spiller (1987) use residual demand analysis to estimate "market" demand elasticities based on quantities that are the sum of the sales of the firms in the market. They refer to their estimates of demand elasticities as the "potential market power" of the group of firms in the market. They apply the method to a homogeneous good industry, and the method appears reasonable in this context. The demand curve that would face a hypothetical combination of producers of a homogeneous product can be represented in two-space, while product differentiation implies that market demand curves may not be well defined in two dimensions.

However, we should not necessarily dismiss the method in all differentiated product contexts. Symmetry between firms, discussed above with respect to Baker and Bresnahan's method for making post-merger inferences, also should satisfy this approach. If the average of two firms' prices yields the same total sales regardless of the distribution of prices across firms, \textit{i.e.} if there is a unique mapping from average

\(^{10}\)A simple two-period example with two firms illustrates this point. In the first period, \(P_1=10, Q_1=8, P_2=8, Q_2=10\). In the second period, firm 1 increases its price, and firm 1's sales fall, in part because some consumers switch to firm 2: \(P_1=11, Q_1=6, P_2=8, Q_2=11\). Firm 1's demand elasticity is four, and the demand elasticity of the combined firm, calculated using the two firms' average price and total quantity, is one.
price to total quantity, then the market demand elasticity is well defined. This unique mapping need not exist for all possible distributions of prices that constitute a given average price, but only for those combinations of prices that are observed in the sample. Indeed, it may be true that under fairly general conditions the average of two competitors' prices that we observe in equilibrium will yield the same total output sold by the two firms.

Given a homogeneous good or a unique mapping from average price to total quantity, this method will yield a demand elasticity that is on the market demand curve, because the sum of the outputs of a group of producers sold at a given price must be the output that they could sell at the same price if they acted in concert; however, the elasticity may be on a different point on the demand curve than the monopolist's profit-maximizing price. Thus the estimated market demand elasticity may not be the equilibrium demand elasticity for the hypothetical monopolist.

This alternative method of inferring post-merger market power has not been rigorously demonstrated to be superior to Baker and Bresnahan's method, but it has intuitive support and can be estimated with very little marginal effort. Thus the method, at the very least, provides a promising intuitive alternative. In chapter 3, post-merger residual demand elasticities will be estimated using Baker and Bresnahan's method and the alternative method just proposed. In addition, market demand elasticities will be estimated using average price and total market quantity. Because the market demand elasticity is the demand elasticity that would face the hypothetical monopolist, it provides a reference point to determine the
proportion of potential market power in the market that is being exercised by the incumbents and could be exercised by the proposed merger partners.

C. Endogenous Product Differentiation

Implicit in both methods of making post-merger inferences is an assumption that the post-merger firm will maintain the product offerings of both pre-merger firms. This assumption may be more reasonable in some markets than in others, and in those in which it is not reasonable, the post-merger estimates may not fully reflect the welfare effects of the reduction in competition.

Of course, if products are homogeneous, the assumption is not problematic, because customers cannot place a positive value on differences in product characteristics that do not exist. Further, in industries with certain characteristics, we should expect that firms will maintain the product offerings of both firms. Brand-specific reputation, perhaps built up over years of advertising and years of consumers' experience with the product, should lead firms to maintain both sets of product offerings. Indeed, this is what we have seen in numerous consumer-product mergers. For example, although the brewing industry has experienced numerous mergers (many of them in the 1970s), these mergers did not result in dropping the successful brands of the pre-merger firms, even though some efficiency arguably might result from consolidating brands.

However, in other industries we should expect some changes in product offerings in the post-merger state. Many industries offer products that have relatively homogeneous physical characteristics, but are differentiated primarily on the basis of geography and/or time.
Competing retail chains may merge and close or relocate some of their stores. Similarly, two airlines may merge and redistribute the times at which they schedule flights, and perhaps also reduce the number of flights, on routes on which they previously competed.

As many models of product differentiation illustrate, the further is a customer's optimal product choice from the closest available choice (in product-characteristic space, geographic space, or time space), the greater is the "travel" cost that must be incurred. However, redistributing and reducing product characteristics may not have an unambiguous effect on welfare. Both demand and costs may be affected by changes in the products offered by producers. Though additional differentiated products add to consumer welfare, fixed cost per product implies that total surplus does not rise unambiguously as the number of differentiated products increases. As Spence (1976) shows, the equilibrium level of product diversity provided by multiproduct firms may be either greater or less than the social optimum, depending on own- and cross-elasticities of demand and the level of fixed costs. Competition can generate too much product diversity because the fixed cost of an additional product offering may more than offset the incremental consumer benefits, although the firm's incentive to introduce the product may still exist because some consumer surplus is transferred from one firm to another. As Spence shows, the incentive to provide the optimal product mix is dependent on the fraction of net surplus from an incremental product introduction that a firm can capture (p. 410). While Spence does not address how the degree of competition affects this incentive (he uses a monopolistic competition model), clearly the externality described is
internalized as competition falls. Of course the net effect on consumer welfare is unclear.

In addition, a reduction in product offerings may involve other sources of efficiency gains important to a welfare analysis of a merger. For example, an airline merger may result in fewer flights offered per day on a given route, but the airline may be able to use larger, more efficient aircraft and/or fly at a higher rate of capacity than in the pre-merger state (perhaps because competition resulted in both firms offering flights during certain periods in which demand was not sufficient to fill two larger aircraft). Thus, although the method of making post-merger inferences discussed in sections A and B focuses on price effects of horizontal mergers under conditions that are relatively general, other sources of consumer welfare loss and efficiencies are possible; a full welfare analysis of the effects of a merger should include consideration of all such effects. Unfortunately, the magnitudes of many market power and efficiency effects are difficult to estimate.¹¹

V. Efficiency Gains

As discussed in chapter 1, an efficiency gain may be sufficiently large to negate the welfare loss caused by the increased market power created by the merger. "Sufficiently large" might be defined as sufficient to offset the deadweight loss due to the price increase (the Williamson standard) or as sufficient to deter the merger partners from raising price above the pre-merger level (the consumer surplus standard).

Determining the magnitude of efficiency gain that would satisfy the consumer welfare criterion might seem to be a formidable task; but given estimates of residual demand elasticities, the critical level of reduction in marginal cost can be easily derived. From equation (2.9), solve for firm 1's price,

\[ P_1 = \frac{c_1}{1+e_1} \]  

(2.20)

Assuming proportional post-merger changes in \( Q_1 \) and \( Q_2 \) as before, the post-merger price of firm 1 is

\[ P_1' = \frac{c_1'}{1+e_{11p}+e_{22p}} \]  

(2.21)

where prime subscripts denote post-merger values. The merger will result in no loss of consumer surplus if \( P_1'-P_1 \). Thus, setting (2.20) equal to (2.21) and solving for \( c_1' \) yields

\[ c_1' = \frac{c_1(1+e_{11p}+e_{12p})}{(1+e_1)} \]  

(2.22)

Thus \( c_1' \) is the post-merger marginal cost that is sufficiently low to keep firm 1's price from rising due to the additional market power created by the merger. The percentage reduction in marginal cost implied by (2.22) is

\[ \frac{c_1-c_1'}{c_1} \frac{1+e_1}{e_1} = \frac{e_1-e_{11p}-e_{12p}}{1+e_1} \]  

(2.23)

Thus the percentage reduction in marginal cost that would fulfill the consumer surplus standard (i.e. \( P_1'-P_1 \)) can be calculated from the residual demand elasticities without imposing any additional assumptions or requiring any additional data. In chapter 3, section V.D, this method is applied to the USAir-Piedmont merger.
CHAPTER 3

THE USAIR-PIEDMONT MERGER:
AN ESTIMATION OF RESIDUAL DEMAND ELASTICITIES

"... we might have challenged USAir-Piedmont."\(^{12}\)

I. Introduction

While many consider the Department of Transportation's permissive antitrust stance toward airline industry mergers in the 1980s to have resulted in significant reductions in competition, the case against airline mergers has not been strongly supported by empirical studies. More generally, empirical methods have had very limited success at answering many important questions about competition and antitrust policy. The necessity for policymakers to predict changes in competition due to a merger \textit{ex ante} provides a particularly difficult empirical problem. Residual demand elasticity analysis, discussed in detail in chapter 2, is used in this chapter to address the competitive implications of the USAir-Piedmont merger on five routes on which they competed before the merger. Those routes are Baltimore-Tampa, Washington-Norfolk, Boston-Norfolk, Memphis-Nashville, and Baltimore-Orlando. Pre-merger time-series data are used to estimate the pre-merger and post-merger degrees of market power for each of the routes.

Section II is a brief discussion of airline industry competition and policy issues. Section III is a discussion of alternative empirical techniques that can be used to address airline competition. Section IV describes the data and discusses specification issues. Section V

\(^{12}\)Charles Rule, Assistant Attorney General for Antitrust, Department of Justice, quoted in \textit{Air Transport World}, February, 1989, p. 36.
describes the USAir-Piedmont merger and presents the empirical results for the five routes.

II. Airline Industry Competition and Mergers

Recent mergers and increases in fares have raised concern among many about competition in the airline industry. Some economists (e.g., Levine [1987] and Borenstein [1989]) argue that structural characteristics resulting in anticompetitive performance in the industry include a scarcity of landing slots and gates, "fortress" hubs, frequent-flyer programs, airline-owned computer reservation services, and travel agent commission incentives. However, the airline industry sometimes is cited as having structural characteristics conducive to contestability, particularly capital that is highly mobile. Bailey and Panzar (1981, p. 125) argue that "this theory [contestability] is particularly relevant to city-pair airline markets."

Antitrust policy in the industry in the 1980s appears to have followed this latter view. Table 3.1 below lists chronologically the twenty largest airline mergers approved by the Department of Transportation (DOT) between May, 1985, and October, 1987.

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13 Competitive concerns have been expressed by the press, (e.g., Wall Street Journal, July 19, 1989), by airline industry publications (e.g., Air Transport World, December, 1988), and by some economists (e.g., Kahn, 1988).
Table 3.1: Recent DOT-Approved Airline Mergers

<table>
<thead>
<tr>
<th>1985</th>
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<tbody>
<tr>
<td>USAir - Pennsylvania Commuter Airlines</td>
</tr>
<tr>
<td>Midway - Air Florida</td>
</tr>
<tr>
<td>Southwest - Muse</td>
</tr>
<tr>
<td>People Express - Frontier</td>
</tr>
<tr>
<td>United - Pan Am’s Pacific Division</td>
</tr>
</tbody>
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<table>
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<tr>
<th>1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piedmont - Empire</td>
</tr>
<tr>
<td>Horizon - Cascade</td>
</tr>
<tr>
<td>People Express - Britt</td>
</tr>
<tr>
<td>Northwest - Republic</td>
</tr>
<tr>
<td>Presidential - Key</td>
</tr>
<tr>
<td>Texas Air - Eastern</td>
</tr>
<tr>
<td>Alaska Air - Jet America</td>
</tr>
<tr>
<td>TWA - Ozark</td>
</tr>
<tr>
<td>Texas Air - People Express</td>
</tr>
<tr>
<td>Delta - Western</td>
</tr>
<tr>
<td>Alaska Air - Horizon</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>1987</th>
</tr>
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<tbody>
<tr>
<td>USAir - Pacific Southwest</td>
</tr>
<tr>
<td>American - Air California</td>
</tr>
<tr>
<td>USAir - Piedmont</td>
</tr>
<tr>
<td>Braniff - Florida Express</td>
</tr>
</tbody>
</table>

There has been significant disagreement between the two federal agencies responsible for antitrust enforcement in the industry. The Department of Justice (DOJ) played an antitrust advisory role to the DOT until 1989, when antitrust jurisdiction was transferred from DOT to DOJ. Before the transfer of jurisdiction, DOJ recommended opposing three mergers that were ultimately approved by the DOT (Northwest-Republic, TWA-Ozark, and United’s purchase of Pan Am’s Pacific Division).

In the USAir-Piedmont case, the DOJ filed comments suggesting possible anticompetitive problems, but later withdrew from the case without an official recommendation. An industry publication reported, “when asked why Justice did not oppose the USAir-Piedmont merger . . .
Charles Rule told ATW, '[Our arguments on] the three others were rejected.' An administrative law judge recommended disapproval of the USAir-Piedmont deal (US DOT, 1987), but the DOT ultimately approved it.

More recently, the Justice Department challenged Eastern's sale of Philadelphia gate space to USAir and the merger of American and Delta's computer reservation systems. Some interpret these actions as signals that the tide has turned in airline industry antitrust enforcement, and that future airline mergers are unlikely to meet with federal government approval. It appears that in spite of the volume of industry research, there is not strong empirical support either for the past relatively lax antitrust enforcement or for the present apparently stricter enforcement. Because airline data is relatively abundant, the lack of applicable empirical results may be primarily due to limitations in empirical techniques.

III. Empirical Approaches to Analysis of Airline Competition

The airline industry has been the subject of numerous recent structure-performance studies. These cross-section studies regress fares on measures of market concentration, measures of potential competition, dummy variables for slot-constrained airports, dummy variables for hubs, measures of leisure vs. business travel, mileage, load factors, and numerous other variables. Some of these studies (e.g.,

\[\text{Air Transport World, February, 1989, p. 36.}\]

Bailey, Graham, and Kaplan, 1985) characterize their approaches as tests of the contestability hypothesis. The hypothesis of perfect contestability generally is rejected because the coefficients on structural variables are significant and positive. These studies are unanimous in their conclusion that "structure matters."

Morrison and Winston's results (1988) indicate that for routes with three or more carriers, a loss of one competitor increases average fares by about $6 (less than one cent per mile). A reduction from two competitors to one increases fares by $89 (nine cents per mile), indicating a much more pronounced effect on fares of a second competitor than of a third, fourth, etc. (and also indicating potential problems with linearity assumptions in the specification of structural variables in many of these studies).

Some of these studies have introduced an interesting innovation to structure-performance analysis by including measures of potential competition. Measures of the degree of potential competition are relatively straightforward in this industry because the presence of airlines operating out of one or both of the endpoints of a route suggests that they may be best able to respond quickly to attempted anticompetitive behavior on that route. Evidence that the presence of potential competitors affects pricing is suggestive of a degree of contestability, but the contestability is imperfect if the current number of competitors also affects pricing. Morrison and Winston found that each potential entrant (defined as a carrier with operations at both endpoints) reduces average fares by $2.56 (one-fourth of one cent per mile).
Variations on this potential entry specification include the treatment of Hurdle (1988), who considers the differential effects of potential entrants based on ease of entry into alternative types of airports. Hurdle finds that the effect of potential entry on yields differs according to whether or not an entrant can achieve scale economies at a given airport (i.e. whether the airport is small enough to be a natural monopoly) and whether or not incumbents have developed scope economies via hub-and-spoke systems at that airport.

Dummy variables for hub airports generally have positive coefficients. This result is consistent with the hypothesis that hubs somehow enable firms to maintain anticompetitive prices. One theory of how hubs may facilitate anticompetitive pricing is that a carrier with numerous flights to and from a hub is in a relatively strong position to use predatory actions toward firms attempting to undercut the hubbing firm’s prices on individual flights to and from the hub (Levine, 1987, p. 445). But a significant source of efficiency from hubbing is that it permits frequent service to routes that are so thinly traveled that they could not support such service otherwise (Levine, 1987, p. 441). Increased load factors on these thin routes result in lower unit costs. But the positive coefficients on hub dummies suggest that the former effect may outweigh the latter.

Borenstein (1989) argues that hubs constitute entry barriers in that they foreclose input markets (e.g., the market for gates at a given airport). He estimates cross-section equations for individual firms rather than aggregating across firms as most of the other studies do. He includes an airline’s share of total enplanements at the endpoints and
finds that the coefficient is significant and positive. This estimated effect of airport share is independent of the effect of route share.

The coefficients on dummies for slot-constrained airports in these studies are significant and positive. Morrison and Winston (1988) use four slot dummies, one for each of the four slot-constrained airports, and the fact that the coefficients differ from one other by as much as a factor of eight suggests that this specification is a significant improvement over other studies' use of only one slot dummy.

One of the numerous innovations of Morrison and Winston's study is that it makes inferences about post-merger market performance for specific mergers, including the USAir-Piedmont merger. The method by which they make post-merger inferences is to apply the structure-performance coefficient estimates to the changes in the explanatory variables that resulted from the merger. Thus, for example, if the number of carriers on a route fell from seven to six because of the merger, the coefficient estimate on number of carriers (-.0062) multiplied by the number of passenger miles flown on that route per year yields an estimate of consumer loss. Using this coefficient, Morrison and Winston estimate that the USAir-Piedmont merger should result in a consumer loss of $81 million per year (1983 dollars).

In addition to the effect of mergers on fares, Morrison and Winston also estimate the effects of mergers on other dimensions of consumer welfare, including transfer time, schedule delay, and frequent-flyer programs. Schedule delay is increased to the extent that reduced

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18Slot-constrained airports generally are defined as the four airports at which the FAA has established slot allocation mechanisms, Washington-National, New York-LaGuardia, New York-Kennedy, and Chicago-O'Hare.
competition results in fewer flights and thus in greater lengths of time between passengers' desired flight time and the closest available flight time. Morrison and Winston first estimate passengers' value of schedule delay time using a multinomial logit model of air traveler choices. Then they use the estimate of the output reduction due to reduced competition to infer the reduction in number of flights. Applying the value of time estimate to the estimated reduction in flights yields the value of consumer loss due to increased schedule delay.

Transfer time can be affected if the merger results in the merged firm's serving a greater range of routes. More routes served by a single carrier implies that some previously interline transfers can now be accomplished intraline, and this generally leads to shorter transfer times because of intraline coordination. Passengers' value of transfer time is estimated to be much higher than their value of schedule delay time, probably because passengers can make more productive use of time spent before the actual flight than time spent between connecting flights. The estimated value of transfer time is applied to the estimated time savings due to increased number of intraline transfers to yield consumer savings.

Frequent-flyer benefits may result from a merger because the increased number of routes served increases the value of the program to members. In their structure-performance model, Morrison and Winston include a frequent-flyer variable, number of frequent-flyer miles awarded on a route times the number of cities served by the airline, and obtain a positive coefficient. They then multiply this coefficient by the increase in the number of cities served that results from the merger to yield the increased value created by the enhanced frequent-flyer program.
In the USAir-Piedmont merger, they estimate a gain to customers of $68 million per year (1983 dollars).

Morrison and Winston estimate several possible effects of airline mergers that other approaches do not address. The net effect of these variables that they estimate for the USAir merger is an annual consumer loss of $12.7 million per year. However, these effects are derived from the coefficient estimates from a structure-performance model that appears to have many of the problems inherent in the other airline studies and more generally in the very nature of structure-performance studies.

Structure-performance studies have been criticized for numerous problems of model specification as well as significant data limitations. The recent airline studies do not appear to be immune from such problems. One potentially important problem with the airline studies is omitted entry variables. Entry impediments (such as gate and slot constraints) and their effect on competitive performance may vary substantially across geographic markets, and the entry variable proxies employed in these studies, such as dummy variables for the few slot-constrained airports, may miss the effects of many conditions of entry. For example, in several cities, airlines' contracts with local airport authorities contain apparently restrictive majority-in-interest clauses preventing the authorities from expanding airport capacity without the consent of incumbents. In addition, congestion at many airports, particularly during the most desirable flight times, may result in scarcity rents that

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18See Air Transport World, December, 1988, p. 60.
drive up fares.\textsuperscript{19} Such constraints and their effects on fares may vary substantially across airports and, absent a thorough study of their characteristics, are not likely to be reasonably proxied in cross-section structure-performance studies.

If market concentration and entry barriers are positively correlated across geographic markets in the industry, omission of relevant entry variables will result in an upward bias on the concentration coefficients, and thus in policy prescriptions biased toward antitrust intervention. The degree of entry barriers and the degree of market concentration may be positively correlated because the supracompetitive profits from achieving a higher market share, and thus the incentive to achieve a higher market share, should be positively related to the degree of entry barriers.

Residual demand elasticity estimation does not necessitate structural variables such as measures of market concentration and entry conditions, and thus it is not subject to many of the sources of specification error that pervade structure-performance studies. Residual demand analysis approaches the (in some respects less ambitious) task of estimating the competitive performance of firms rather than explaining the underlying relationship between structure and performance. The effects of structural variables will be implicit in the estimates, but the estimates do not explain the extent to which individual structural

\textsuperscript{19} A recent FAA report notes that 21 US airports currently are "seriously congested," because aircraft delays exceed 20,000 hours per year. By the turn of the century, 50 airports are expected to be in this category, and these airports handle 80\% of US air traffic. See "FAA Predicts Big Jump in Air Traffic, Portending More Crowds, Few Bargains," \textit{Wall Street Journal}, March 2, 1990, p. B1.
variables are responsible for the estimated performance. By estimating performance on individual routes, residual demand analysis can identify which routes appear to be relatively problematic and thus which routes may deserve policymakers' attention. In addition, partial residual demand cross-elasticities can be estimated to make inferences about increases in market power due to specific mergers on specific routes.

Although it does not raise the same specification problems as structure-performance, residual demand elasticity estimation raises other specification problems, most importantly identification of the firm-specific demand equation. Shifts of firm-specific cost variables are needed to identify firms' demand equations, and we will see that the data set appears to be well suited to this task.

Residual demand elasticity analysis can be performed on both cross-section and time-series data. However, the data limitations that affect cross-section structure-performance analysis also would affect cross-section residual-demand-elasticity analysis. An inability to control for factors that may vary across geographic markets implies that cross-section demand elasticity estimates may be less useful than intra-market estimates. In addition, it is individual markets that must be the focus of analysis for many antitrust applications, such as the review of airline mergers and gate sales.

But one advantage of cross-section analysis is that pre-merger demand elasticity estimates can be compared to post-merger estimates. Such comparisons will be impractical with time-series data because of limitations on the number of observations. In the airline industry,
quarterly data implies that a merger could not be analyzed using time-series data until several years after it was consummated.

However, before-after cross-section comparisons raise other problems. Results may differ substantially depending on the quarters chosen. For example, the quarter or two immediately following a merger may not reflect the complete integration of the companies, and thus the full realization of market power or efficiencies. The multi-year transition toward full integration of USAir and Piedmont illustrates this point. In addition, market power increases may appear large at first, although entry may result and drive prices down. Thus cross-section comparisons may reflect quasi-rents rather than sustainable market power. This point may be illustrated by the number of entrants into Minneapolis-based routes following the Northwest-Republic merger.

Another problem with comparing pre-merger and post-merger residual demand elasticities may at first appear to be an advantage. Post-merger residual demand estimates will incorporate the actual effect of changes in both market power and efficiency, both of which are relevant to the welfare effects of a merger. However, we will not be able to determine the independent effect that the two factors had on the Lerner index. Without holding either costs or market power constant, a change in a Lerner index has ambiguous welfare consequences. Substantial efficiencies may result in increases in the Lerner index when the post-merger price actually falls. Methods for inferring market power changes from pre-merger data such as the two approaches discussed in chapter 2, section IV, while prospective, are able to hold costs constant and thus are not
subject to this source of ambiguity. Efficiencies then can be incorporated into the analysis (chapter 2, section V).

Last, the before-after cross-section approach can address the effects of a merger only ex post, while antitrust agencies often must estimate the effects of a merger ex ante. While it certainly is useful to look back on the actual effects of a merger, antitrust enforcement often requires a forward-looking approach. Thus, intra-market time-series residual demand analysis appears to have substantial advantages relative to both cross-section residual demand analysis and structure-performance analysis.

IV. Description of Data and Discussion of Specification Issues

A. Introduction

Since Baker and Bresnahan's application of residual demand elasticity estimation to the brewing industry (1984, 1985, 1988), no further applications have appeared in the literature (with the exception of Scheffman and Spiller's market definition application (1987)). In large part, this absence of applications is likely due to an absence of appropriate data in many industries. Residual demand analysis requires detailed data on prices, outputs, and firm-specific costs. In the airline industry, regulatory requirements for reporting of cost and revenue data are unusually extensive for an industry that is not price regulated.
Indeed, airline industry data appears likely to be among the best available data for residual demand analysis.20

Until recently, residual demand elasticity estimation using time-series data in the airline industry would have been impossible because of the small number of post-deregulation observations. Revenue data are available only on a quarterly basis, and price regulation was not relaxed until September, 1980.21 The revenue and output data are available beginning with the first quarter of 1981; thus 27 quarterly observations are available before the regulatory approval of the USAir-Piedmont acquisition.

The two firms competed in about 30 city pairs at the time of the merger. But the two firms competed in only nine city pairs throughout the entire sample period. The limited number of observations thus restricts us to these city pairs. The five routes used were chosen because of their relatively stable structural characteristics during the sample period.

20Additional applications of the method may be feasible in many industries, for example in markets for products sold in groceries, partly because of the increased availability and quality of supermarket UPC scanner data (for an example of the use of this data, see Katz and Shapiro, 1984). In some industries, although some of the necessary data may not be publicly-available, firms in the market may have the necessary data. Antitrust agencies may subpoena the necessary data during the course of investigations. It may be possible in some cases to perform the analysis even under stringent Hart-Scott-Rodino time constraints.

21Prices were not completely deregulated until January 1, 1983. However, pricing regulations had been relaxed sufficiently that generally there was substantial unused upward and downward pricing flexibility, and thus pricing was essentially deregulated, by September, 1980 (Bailey, Graham, and Kaplan, 1985, chapter 3). Entry deregulation moved at a faster pace than pricing deregulation, and was essentially fully deregulated by January, 1980 (Bailey, Graham, and Kaplan, 1985, chapter 4).
Most of the data for this analysis was obtained from the databases of Reuters Information Services (formerly IP Sharp Associates), which includes data collected from air carriers by the Department of Transportation. Revenue and output data come from the Origin and Destination Data Base (O&D), the cost data from Form 41, and other data from the Service Segment and T9 data bases. The variables are summarized in the appendix.

Recall from chapter 2, section II that firm 1's residual demand function is

\[ P_1 = P_1(Q_1, Y, W, W_0) \]

where \( Y \) is a vector of exogenous demand variables, \( W \) are industry-wide input costs, and \( W_0 \) are firm-specific costs for the competitors of firm 1. \( W_1 \), input costs that are specific to firm 1 (i.e. not elements of \( W \) or \( W_0 \)), are used in the first-stage regression, \( Q_1 = 0 + \sum b_{11}W_{11} \). The second-stage regression estimates (4), substituting the fitted values of \( Q_1 \) from the first-stage regression for \( Q_1 \). The residual demand function can be estimated in loglinear form, so that the coefficients on quantities will be elasticities. Denoting \( x_j = \ln X_j \),

\[ P_1 = \sigma_0 + \sigma_1 q_1 + \Gamma_1' y + \Omega_1' w + v_1 \]

where \( \sigma_1 \) estimates the residual demand elasticity \( e_1 \). Similarly, the partial residual demand function can be estimated by

\[ P_1 = \sigma_{10} + \sigma_{11} q_1 + \sigma_{12} q_2 + \Gamma_1' y + \Omega_1' w + v_1 \]

where \( \sigma_{ij} \) estimates \( e_{ijp} \).

For each city pair, the demand elasticities from six specifications are estimated: pre-merger for USAir, pre-merger for Piedmont, post-merger...
for USAir (Baker & Bresnahan method), post-merger for Piedmont (B&B method), post-merger for the combined firm (alternative method proposed in chapter 2, section IV), and for a hypothetical monopolist on the route (market demand elasticity, also discussed in chapter 2, section IV). In all the specifications, price is quarterly average revenue, aggregated across coach and coach discount, and aggregated across one-coupon and two-coupon itineraries. In the pre-merger and post-merger (B&B-method) cases, price is calculated for each firm individually. In the alternative-method post-merger specification, price is calculated as a weighted average price of the merging firms. In the market specification, price is a weighted average across all airlines serving the route.

In the pre-merger specification, \( w \) includes an industry average operating expenditures variable (per revenue passenger mile), and/or the same variable for the major incumbents other than firm 1. Also included in \( w \) is a cost of capital measure and a retail gasoline price index.

\( w_{i1} \) in the first stage of the pre-merger specification and in the first stage of the B&B-method post-merger specification are firm 1's expenses per revenue passenger mile for fuel, pilots and copilots, personnel expenses, airframe repair labor, engine repair labor, engine maintenance parts, and airframe maintenance parts for the aircraft it flew on the route. In the alternative-method post-merger results, \( w_{i1} \) includes twelve instruments, the six listed above for both of the merging firms. In the market specification, \( w_{i1} \) includes the six variables calculated as weighted averages of those variables for the incumbent firms.

Demand variables (\( y \)) include income measures for the two endpoints and advertising and promotion expenditures for firm 1. The following
three subsections provide more details about the price and quantity data, cost data, and other variables, including discussions of specification issues.

B. Price and Quantity Data

The O&D data are based on carriers' submissions of computer tape records of 10% of the passenger tickets sold (those with ticket numbers ending with the digit 0). An itinerary is included in the sample for a particular city pair (or "directional segment") A to B if the passenger flew (1) a direct flight from A to B without continuing (or B to A; a round trip itinerary is treated as equivalent to two one-way tickets), (2) from A to B, and then on to C, where point C is closer to A than B is to A (i.e. point B is a "directional break"), or (3) an indirect flight from A to D to C, if the stop at D does not constitute a directional break.

The O&D data are based on actual retail transaction prices, net of discounts, rather than retail list prices, wholesale prices, or advertised prices, as some studies estimating demand elasticities and conjectural variations have used (e.g., Baker and Bresnahan - advertised prices; Lliang - wholesale list prices).

Some observations are eliminated from the sample (by the data vendor, Reuters), because they appear likely to be the result of reporting error. Another adjustment is made to the data to account for firms that report more or less than 10% of their tickets, by correcting the number

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23Observations are eliminated from the sample only if (a) non-numeric fare data is recorded, (b) the itinerary has more than one directional break, or (c) the recorded fare is more than $1,000 and the revenue per passenger mile is more than $2. For example, a Baltimore-Tampa ticket would be eliminated from the sample only if its one-way fare exceeds $1,684 or its round trip fare exceeds $3,368.
of passengers based on another source (Form 41 T1) that collects the universe of tickets to measure output but not revenue or price. Thus if a carrier underreports, this method assumes that the fares of the reported tickets are representative of the fares of the unreported tickets. The observations eliminated from the sample because of apparent reporting error, discussed above, are corrected for similarly.

Total revenue and quantity of tickets are reported for each quarter, carrier, and city pair, for each of eight fare categories (first class, first-class discount, coach, coach discount, other, miscellaneous/unknown, frequent flyer, and mixed-fare class). For the results presented, the data were aggregated across coach and coach discount fare categories. These two categories constitute over 90% of the tickets sold; thus further aggregation produced similar results. Disaggregating further, to coach only or coach discount only, appears to create a relatively arbitrary distinction. Coach and coach discount are not precisely defined and do not appear to be defined consistently across carriers or across time for a given carrier.

As well as being reported separately by fare category, the data are reported separately for one, two, three, and four-or-more "coupons." A one-coupon ticket is not necessarily a nonstop flight, although all nonstop flights are one-coupon tickets. The number of "coupons" corresponds to the number of flight numbers; thus a one-stop flight could be either a one-coupon or two-coupon flight, depending on whether the carrier chooses to give separate flight numbers to the two legs. This is another somewhat arbitrary distinction, although it appears to separate most nonstops from most one-stops. The results are reported for data
aggregated across one coupon and two coupon. Three coupons and four-or-more coupons are very few, and are not included.

Baker and Bresnahan (1984, p. 49) suggest that aggregation of data across products in multiproduct firms may bias results toward elasticity. They argue that aggregation may dampen the fluctuations in the independent variables, thus resulting in their explanatory power being suppressed. Because inverse elasticities are being estimated, a downward bias in the coefficient would result, toward apparently competitive performance. Baker and Bresnahan also note that aggregation will yield an average elasticity and thus may result in overlooking relatively inelastic demand that may exist for some disaggregated product categories. In airlines, perhaps aggregation across coach and coach discount could have this bias if coach passengers have less elastic demand than those passengers who are able to meet the restrictions on the discounted tickets. It might appear that focusing on coach (and thus not including coach discount) might result in more inelastic demand because this group of passengers may be largely those who are not able to meet the restrictions required for discounted seats. Disaggregated estimates of individual fare categories did not yield elasticity estimates that were consistently below or above the reported results (and the regression fit generally was significantly poorer). However, this result may be largely because the fare categories are not defined in an economically meaningful way, rather than that airlines have not successfully price discriminated.
C. Cost Data

As discussed in chapter 2, section II, residual demand estimation requires firm-specific cost data in order to identify firm-level residual demand curves. An abundance of firm-specific cost data is available for the airline industry; accordingly it is not necessary to resort to the use of proxies such as firms' capacity, as in Baker and Bresnahan's brewing industry applications (1985, 1988). The cost data from Form 41 is reported by each firm on a quarterly basis, for numerous categories of costs (see table 3.2 below; other cost variables are also available), separately for each type of aircraft flown (DC9-10, DC9-30, 727-100, 727-200, etc.). The cost data are not specific to the particular city-pair markets being served. But because of the mobility of capital in this industry, much of the cost of operating a given type of aircraft by a given carrier in a given quarter should not be expected to vary dramatically across city pairs.

In order for a firm's residual demand equation to be identified, its costs must shift independently of other firms' costs. Airline costs appear relatively likely to satisfy this criterion, in part because competing carriers often use different aircraft to fly the same routes, and these aircraft have significantly different fuel, crew, and maintenance requirements. For example, on the Baltimore-Tampa route, Piedmont flew DC9-30s almost solely, throughout the sample period, while USAir flew primarily 737s.24 Even when competing airlines use the same

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24 It may appear surprising that two competing carriers would persist in the long run in flying different aircraft on the same city pair, because significantly different degrees of fuel efficiency and passenger capacity would appear to imply that a particular aircraft model should be
type of aircraft, their costs differ due to different compensation of flight crew and maintenance personnel, different number of crew per aircraft, different number of seats per aircraft, and other factors. However, it is not absolute differences across competitors in components of marginal costs, but independent shifting of these variables that is required to identify residual demand functions. Certain cost variables, such as fuel, may be highly correlated across carriers. The following table shows the lack of correlation between the components of USAir's and Piedmont's costs used as instruments, for the aircraft they flew on Baltimore-Tampa during the sample period. This lack of correlation suggests that the use of these variables as instruments in the residual demand estimation should identify firm-level demand.

Table 3.2: Cross-Carrier Cost-Component Correlation Coefficients

| USAir DC9-30 - Piedmont 737-200 (real costs per revenue passenger mile) |
|-----------------------------|-----------------------------|
| fuel                        | .98                         |
| pilots-copilots             | .44                         |
| personnel expenses          | .26                         |
| airframe repair labor       | .16                         |
| engine repair labor         | .01                         |
| engine maintenance parts    | .01                         |
| airframe maintenance parts  | .44                         |

It is not immediately clear which components of airlines' costs should be considered important components of the marginal cost that is optimal on a particular route. One possible explanation is that carriers may base their choice of aircraft models on their efficiency on a certain range of route distances, and one of the carriers tended to fly on longer routes. Scale economies of purchasing and/or maintenance of aircraft may then offset the efficiencies of selecting the optimal aircraft for each individual route.

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24(...continued)
relevant for firms' pricing decisions. The incremental cost of each additional passenger on an already-scheduled flight should be quite low, including only the costs of a small amount of fuel to carry the additional weight of the passenger and baggage, one additional meal or snack, and additional baggage handling and ticketing. But the data are aggregated well beyond the level of the incremental passenger. Observations of price, output, and costs are quarterly. Incumbent carriers may be able to divert aircraft relatively easily across many city pairs over a quarterly time horizon, and thus aircraft operating expenses such as fuel, crew, and equipment maintenance expenses can be considered to be relevant marginal costs.

Estimation of a firm's residual demand elasticity requires that its firm-specific costs be included as instrumental variables in the first stage regression and its competitors' costs as exogenous variables in the second stage. The second-stage cost variables are aggregated into a total expenditure variable that is an aggregate of the component costs discussed above, for each competitor for the aircraft flown by that competitor on that route. Thus for example on Baltimore-Tampa, USAir's residual demand equation includes total operating expenditures per revenue passenger mile for Piedmont's 737-200s, Delta's 727-200s, and Eastern's 727-200s. On routes on which there were not sizable incumbents, an industry aggregate cost variable was constructed to represent potential entrants' costs. Other possible industry cost variables, including indices of landing fees, food expenditures, and advertising expenses did not prove to be significant and are not included in the reported regressions.
In the B&B-method post-merger specifications, the cost variables are the same as in the pre-merger specification. But in the alternative-method post-merger results, both USAir's and Piedmont's costs are included as instruments in the first stage, because the method aggregates prices and quantities across the merger partners. The costs only for the competitors other than the merger partners is included in the second stage of this specification. For the "market" specification, price and quantity are aggregated across all the incumbents, so all airline costs appear as instruments in the first stage only.

As Froeb and Werden illustrate (1990, p. 15), if the variance of the cost shifters constitutes a small proportion of the variance of the firm's marginal cost, and/or if the cost shifters are highly correlated across firms, the variance of the instrumental variables estimator will be high. Table 3.2 illustrates that the latter issue does not appear to raise a problem in this case, but the former problem may be more difficult to detect. If the cost shifters constitute a high proportion of marginal cost, the problem should be unlikely. In this case, the cost shifters constitute about 70% of non-overhead expenses (Bailey, Graham, and Kaplan, 1985, p. 49). However, it could be the case that omitted cost shifters, though they constitute a small percentage of marginal cost, constitute a relatively high percentage of firm-specific variance in marginal cost. Variables such as landing fees, reservation and sales expenses, and the implicit rental value of aircraft and gates are not included. However, these variables appear relatively unlikely to be the source of a high proportion of firm-specific variance in marginal cost. Landing fees should be equivalent for competitors on a given route, reservation and
sales are performed very similarly across the industry, and a relatively
efficient secondary market for aircraft and a market for options to buy
aircraft imply that the implicit rental value of aircraft should not
produce much firm-specific cost variance.

Another cost variable included is the cost of capital, Moody's index
of yields on Baa corporate bonds. In addition, on the two shorter routes,
Memphis-Nashville and Washington-Norfolk, the retail gasoline component
of the Consumer Price Index is included.

D. Other Variables

Other variables in the regressions include income, advertising,
quarterly dummies and a time-trend dummy. The income variable is the
simple sum of personal income in the two metropolitan areas that are the
endpoints of the city pair. The measure is total income, not per capita
income. Constructing the variable this way allows it to account both for
per capita income growth and for population growth. While population and
per capita income may not affect airline demand proportionally,
regressions run with these two variables specified separately did not
significantly affect the results; thus they were combined in this way to
conserve degrees of freedom. Advertising expenditures are included, but
they are reported only nationally for each carrier, and thus are not
specific to the individual markets. Quarterly dummies are included to
control for seasonal variations in demand.

Dummy variables are included in some of the specifications to
account for short-term shocks to the structure of competition on the
individual routes. On Baltimore-Tampa, a dummy is included for the period
preceding Piedmont's introduction of nonstop service on that route in
IQ83. On Baltimore-Orlando, a dummy is included for the three-quarter period in which World Airways entered the route and gained up to a 25% share. Similarly, a dummy is included for Boston-Norfolk for Eastern's five-quarter presence, during which it gained a market share of up to 18%.

Because we are estimating residual demand elasticities for individual city pairs, it may appear that we implicitly assume that city pairs are relevant geographic markets (as defined in the Merger Guidelines, 1984, section 2.3). It also may appear that we implicitly assume that commercial air travel is a relevant product market. While the demand characteristics of city pairs in many instances may be supportive of a relevant city-pair market, supply substitutability may imply that a broader geographic market is more appropriate in many instances. While excluding relevant competition will bias market concentration measures, there is no a priori reason to expect residual demand estimates to be biased, because the effect of any form of competition should be reflected implicitly in the demand elasticities (as discussed in chapter 2, section III).

V. Results

A. General Discussion

Regression coefficients for thirty regressions (six for each of the five routes), t-statistics, and market concentration data are reported in table 3.3. The complete regression results are reported in the appendix. The coefficients are reported as negative inverse residual demand elasticities and thus are proxies for the Lerner index \((L=\frac{1}{e})\), as discussed in chapter 2, section III. Results are reported for pre-merger
specifications for each firm, for post-merger specifications based on the B&B method and the alternative proposed method, and for a market (i.e., hypothetical monopolist) specification.

On the pre-merger results, note that low t-statistics (particularly on Memphis-Nashville) indicate that quantity is not significant in explaining price, thus implying a highly elastic residual demand function. Post-merger results are given for both the Baker and Bresnahan (B&B) method, discussed in chapter 2, section IV.A, and an alternative method proposed in chapter 2, section IV.B. Recall that the B&B method estimates partial residual demand equations for each of the two merging firms and sums the own- and cross-partial residual demand elasticities estimated in each equation to yield an estimate of the post-merger demand elasticity. Thus their method results in separate post-merger results for each firm while the alternative method estimates a single post-merger result for the combined firm. For the B&B-method results, first the sum is reported, then the own- and cross-partial terms that were added to calculate the post-merger result. For example, the post-merger result for USAir on Baltimore-Orlando is .61, the sum of the own-partial (.56) and cross-partial (.05) elasticities. The alternative method estimates the residual demand elasticity for the weighted average price and total quantity of the merging firms.
### TABLE 3.3

**RESIDUAL DEMAND ELASTICITIES AND MARKET CONCENTRATION**

<table>
<thead>
<tr>
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<th>MEMPHIS-</th>
<th>BOSTON-</th>
<th>WASHINGTON-</th>
<th>BALTIMORE-</th>
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<td>NORFOLK</td>
<td>NORFOLK</td>
<td>TAMPA</td>
<td>ORLANDO</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>USAIR</td>
<td>-.05 (.7)</td>
<td>.14 (2.1)</td>
<td>.09 (2.9)</td>
<td>.20 (2.5)</td>
<td>.58 (4.0)</td>
</tr>
<tr>
<td>PIEDMONT</td>
<td>-.09 (.6)</td>
<td>.43 (3.7)</td>
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<td>.41 (2.3)</td>
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|                  |          |         |             |            |            |
| **PREMERGER**    | 3339     | 4859    | 4268        | 2825       | 2963       |
| **INCREASE**     | 182      | 3250    | 3534        | 1826       | 960        |
| **POSTMERGER**   | 3521     | 8109    | 7802        | 4701       | 3923       |

|                  |          |         |             |            |            |
| **MARKET SHARES**|          |         |             |            |            |
| USAIR | US | .07 | US | .25 | US | .57 | US | .30 | US | .20 |
| PIEDMONT | PI | .13 | PI | .65 | PI | .31 | PI | .38 | PI | .24 |
| OTHER  | NW | .40 | EA | .03 | UA | .07 | EA | .19 | EA | .44 |
| AM | .39 | TW | .03 | DL | .11 | DL | .09 |

Market power increases can be inferred by the significance of the cross-partial term in addition to the degree to which the sum of the cross-partial- and the own-elasticities (i.e. the reported post-merger result) exceeds the pre-merger residual demand elasticity. An insignificant cross-partial term indicates that the pricing behavior of the one firm is not affected by the pricing behavior of the other and thus that other factors (e.g., other competitors, the threat of entry, costs, highly elastic consumer demand) are the critical constraints on the firm's pricing.

After the premerger and postmerger results, the "market" or "hypothetical monopolist's" demand elasticity is presented. This is
estimated using the same method as the combined post-merger estimates, the price being the weighted average price, in this case across all competitors on the route, and the quantity being the total number of carriers on the route.

Note that the Herfindahl indices (HHIs) on all the routes are in the Merger Guidelines' "highly concentrated" range (above 1800, post-merger). The HHI increases resulting from the merger also fall in the Guidelines' upper range (above 100). The Guidelines state that "only in extraordinary circumstances" will a merger be considered not likely to lessen competition if both the level and increase in market power are in the upper range (1984, section 3.11). But city-pair routes may not constitute relevant markets as defined in the Merger Guidelines; thus application of Guidelines' thresholds to these figures may be inappropriate. Although these routes all have market concentration in the Guidelines' upper range, a significant degree of variation in market concentration exists across the routes, both with respect to the level (a range of 3500-8100) and the increase (a range of 180-3500) in the HHI brought about by the merger. The concentration figures are averages over the time series, and thus do not necessarily reflect the market concentration that existed at the time of the merger. For example, if a carrier had a thirty percent share during one-third of the sample period then exited, its share appears as ten percent.

The results are reported for regressions run on data aggregated across coach and coach discount fare categories, and across one-coupon and two-coupon flights. These categories are defined, and aggregation across them discussed, in section IV.B above.
In time-series regression analysis, autocorrelation, the correlation of error terms, can arise and affect the efficiency of the estimators, thus biasing standard errors downward. The Durbin-Watson statistics reported in the appendix indicate that autocorrelation does not appear to be a problem in these regressions. The null hypothesis of no autocorrelation cannot be rejected for any of the specifications. For the specifications with the lowest Durbin-Watson statistics, the Cochrane-Orcutt procedure was run and did not generate notably different results. Note that the inclusion of a time-trend variable and the absence of lagged dependent variables mitigate potential autocorrelation problems.

B. Comparisons of Pre-merger, Post-merger, and Market Demand Elasticities

For each route, estimated pre-merger market power is less than or equal to estimated post-merger market power, and estimated post-merger market power is less than the estimated market power of the hypothetical monopolist. Thus it appears that the estimation technique may have successfully distinguished among the three distinct levels of demand elasticities. Neither of the alternative methods of making post-merger inferences distinguishes itself as superior to the other. The "combined" post-merger results appear to be very close to weighted averages of the firm-specific B&B-method post-merger results.

The estimates of the market power of the hypothetical monopolist provide an estimate of the maximum degree of market power that could be generated on each route. For example, on Washington-Norfolk, where even a monopolist would be able to price at only 25% above marginal cost, mergers provide much less potential threat to consumer welfare than mergers on routes in which the hypothetical monopolist could price 80% or
more above marginal cost. Because in many industries cost data is not
firm-specific, often only market demand elasticities can be estimated.
In these instances, estimates of market demand elasticity can still
provide useful estimates of the maximum market power that could be
created. However, this suggests that results indicating substantial
market power, such as those of Baker and Bresnahan, could be biased
because a lack of firm-specific data may imply that we are erroneously
estimating market demand elasticity rather than firm-specific residual
demand elasticity.

On the Memphis-Nashville route, the coefficients are negative, but
they are near zero, and their t-statistics are very low, suggesting a flat
residual demand curve. The cross-partial coefficients also are not
significant, suggesting that the merger will not create market power on
this route. This result is not surprising because the market shares of
USAir and Piedmont are low (7% and 13% respectively, although these
figures still place the merger within the Guidelines' upper range) and the
relatively short distance of the route25 implies that air travel may face
significant competition from ground travel.

Boston-Norfolk, on the other hand, exhibits significant market power
for both firms premerger and a relatively strong market power increase due
to the merger, with the estimated post-merger Lerner index approaching
that of the hypothetical monopolist. The highly significant cross-partial
coefficients on this route suggest that the presence of the other carrier

25The driving distances of the routes are Memphis-Nashville - 209
miles, Boston-Norfolk - 581 miles, Washington-Norfolk - 189 miles,
Baltimore-Tampa - 950 miles, Baltimore-Orlando - 892 miles.
was a substantial constraint on USAir's and Piedmont's pricing on this route. The two firms combined market share on the route is 90 percent.

Washington-Norfolk exhibits a small degree of pre-merger market power (6-9% Lerner indices), and the coefficient for USAir is significant while the one for Piedmont is not. The post-merger estimates exceed the pre-merger estimates but only slightly, with very low t-values on the cross-partial coefficients. The results indicating relatively competitive performance in the presence of high market concentration may be due in part to competition from ground travel, the presence of United and TWA with small market shares, and/or the threat of entry. However, we might expect that entry into slot-constrained Washington-National Airport would be relatively difficult, while the Washington-Norfolk results are highly competitive. Apparently, the existing fringe competitors and ground travel competition are sufficient to maintain relatively competitive pricing even in the presence of what may be substantial entry barriers.

On Baltimore-Tampa, both USAir and Piedmont appear to be able to price about 20% above marginal cost, and the merger does not appear to increase their market power significantly, in spite of an HHI increase of over 1800.

On Baltimore-Orlando, USAir appears to have significant market power while Piedmont does not. The coefficients suggest that Piedmont will gain significant market power from the merger but that USAir will not. These results may appear anomalous because one might expect that two competitors with similar market shares (20 and 24%) should have similar degrees of market power (as is the case, for example, on Baltimore-Tampa). As it turns out, the discrepancy may be produced at least in part by the fact
that USAir flew about 93% of its passengers on this route nonstop, while Piedmont flew 68% of its passengers nonstop. Because Piedmont directed many of its passengers through Charlotte on this route, its costs likely were relatively high, and thus it should be expected to command a lower average markup than its rival. Indeed, for flights that were fully booked, the cost to Piedmont of a passenger flying from Baltimore to Orlando through Charlotte includes the opportunity cost due to that passenger’s displacing two alternative passengers, one from Baltimore to Charlotte and another from Charlotte to Orlando. (For a pricing model that incorporates the effects of this form of supply substitution, see Kleit and Maynes, 1990.)

The Boston-Norfolk results exhibit a similar discrepancy in the residual demand elasticities, but in this case it is Piedmont that has the relatively high markup. Just as in the previous case, it turns out that the carrier with the more elastic demand is also the carrier that flew a relatively higher proportion of one-stop flights on the route. Piedmont flew 86% of its flights direct and USAir flew 73% of its flights direct. In addition, on this route Piedmont had a much greater market share than USAir (65% vs. 25%). Piedmont’s higher market share suggests that it likely offered more flights per day on average than USAir. If Piedmont offered several flights per day and USAir were somehow limited to offering only one or two flights per day on this route, Piedmont’s preferable product selection may have enabled it to charge somewhat higher prices than USAir. However, these effects may not explain fully the differences in the coefficients.
These apparent asymmetries between competitors raise some doubt about the degree to which the data conform to the symmetry assumption required by the methods used to calculate post-merger and market demand elasticities (discussed in chapter 2, section IV). At first glance, it may appear that the symmetric competition assumption would be reasonable in the airline industry. Though certainly not homogeneous, two competitors' air travel services from city a to city b in many cases do not appear to be characterized by substantial net advantages for one of the competitors. However, in many cases, one carrier offers a package of services that may be preferred by a significant proportion of customers, such as more departures, preferable departure times, better on-time performance, better in-flight services, and shorter layovers. This carrier may then face more inelastic demand than its competitors. Accordingly, \( \frac{\delta\pi_1}{\delta P_2} - \frac{\delta\pi_2}{\delta P_1} \) may not be satisfied. The direction and magnitude of any bias that may be introduced by this asymmetry is not clear.

C. Comparisons Across the Five Routes

The empirical method estimates only the level of market power; it does not explain the causal factors leading to the existence of market power. The sources of differences in market power often may be readily apparent, for example differing degrees of market concentration. However, in some cases apparent differences in competitive performance may appear to be anomalies, because we often may have limited information about differences in entry conditions and other structural characteristics of markets. It is difficult to assess the extent to which apparent anomalies
result from data and specification problems or from market power sources that are not readily apparent.

Comparisons across markets are subject to less ambiguity in the current case, in which we are comparing across geographic markets within a given product market, than in cases in which comparisons across product markets are attempted, because many structural characteristics should be expected to be similar across the cross-section. However, substantial unobserved differences in structural characteristics still may exist. While many of the costs of airlines will be similar across routes, significant variations in competitive performance across airline routes may result from differences in landing fees, gate and slot allocations, demand characteristics, and other route-, airline-, and airport-specific factors. In addition, in this case there are only five cross-section observations from which to make comparisons. However, the fact that many of the variations in the results across routes appear to result from observed structural differences provides some confirmation of the soundness of the results.

Note that the estimated market demand elasticity on the two shorter routes (Memphis-Nashville and Washington-Norfolk) indicates that a monopolist on these routes would have less ability to raise prices than a monopolist on longer routes, perhaps in large part because of competition from ground travel. In addition, the estimated market power increase is lowest on the two short routes (Memphis-Nashville and Washington-Norfolk) and highest on a longer route with a relatively high increase in market concentration (Boston-Norfolk).
Washington-Norfolk results provide an interesting contrast to the Memphis-Nashville and Boston-Norfolk results. Because the route distance is about the same as that of Memphis-Nashville, the degree of competition from ground travel should be comparable. Yet the market concentration figures are very similar to those on Boston-Norfolk, which exhibited a significant market power increase. Thus it appears that competition from ground travel may prevent anticompetitive pricing on this short route in spite of high market concentration.

The results in Memphis-Nashville and Baltimore-Tampa suggest that the Merger Guidelines’ HHI thresholds may be unreasonably low, because no market power appears to be produced by the merger on either of the two routes, despite market concentration levels and increases that are well into the Guidelines’ upper ranges. Further, since estimated market power on the five routes is not a strictly increasing function of market concentration, the results suggest that strict application of HHI thresholds may be inappropriate even within a given product market, let alone across product markets. Of course, such conclusions are premature given the limited scope of this study, but perhaps further applications will cast further light on the reasonableness of the Guidelines’ thresholds.

D. Route Spinoffs and Efficiency Gains

One possible remedy for airline mergers that are found to be anticompetitive is to require spinoffs of gates and slots in the overlap markets. However, in the deregulated airline industry airlines do not have rights to individual routes, so routes cannot be spun off, only gates and slots can be. Yet the analysis points to possible anticompetitive
problems on specific routes, not at specific airports. In any event, we can simulate a route spinoff by simulating an alternative merger with another incumbent on the route. In policy applications, analysis might find that a number of routes from a given airport raise competitive concerns and that a spinoff of gates from one of the incumbents may provide opportunities for other carriers to compete on the problem routes, although it would not guarantee that the recipients of the gates would compete on those routes. The simulation assumes that we can spin off specific routes, because the simulation is equivalent to the simulation of a merger on that route. The estimated market power effect of the spinoff can then be compared to the estimated effect of the merger.

Incumbents with market shares smaller than the merging firms may be the most obvious candidates for spinoffs. However, in order to simulate a spinoff, the firms must have competed long enough to accumulate enough observations to perform the analysis. Many firms with small market shares may not have competed throughout the sample period, in which case such simulations often may not be possible. In the current application, we estimated a significant market power increase on two routes, and the competitors with smaller market shares than USAir and Piedmont did not compete throughout the sample period. Thus in this case, spinoff simulation is not possible.

Chapter 2, section 5 derives a formula for estimating the critical level of efficiency gain that would prevent the post-merger price from exceeding the pre-merger price:

\[
(3.4) \quad \frac{c_1-c_1^*}{c_1} = \frac{e_1-e_{11p}-e_{12p}}{1+e_1}.
\]
Applying this formula to the Boston-Norfolk route, the critical reduction in marginal cost for USAir is 41% and for Piedmont is 14%. The only other statistically significant market power increase is for Piedmont on Baltimore-Orlando. The critical efficiency gain in this case is 13%. While these figures appear high, efficiencies realized by the merger may have been spread across all overlap routes, including routes with little or no anticompetitive effect, such as Memphis-Nashville. If such is the case, the critical level of efficiency gain would be much lower. For example, if we assume that the estimated competitive effects on the five routes are representative of the routes for which an efficiency gain also will result from the merger, a 7% reduction in marginal cost would be sufficient to prevent an increase in average price. Of course, a much smaller efficiency gain would be sufficient to offset the deadweight loss from the price increases. Further, reductions in fixed costs also may result and would add to total surplus, but would not affect pricing.

VI. Conclusion

Residual demand elasticities were estimated at the pre-merger, post-merger, and market level for five routes on which USAir and Piedmont competed prior to merging in 1987. These results suggest that a significant degree of market power existed on some routes prior to the merger and that increased market power appears likely to result from the merger on some routes. Other routes exhibited highly elastic residual demand in spite of high levels of market concentration. Because of the

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26 This also assumes that each of the routes handle the same number of passengers: \(0.07 = (0.41 + 0.14 + 0.13)/10\).
limited scope of this study, it would be inappropriate to draw conclusions from these results about the net effects of the merger on the numerous routes affected, or on the effects of airline mergers generally. As the results suggest, competitive performance may vary considerably across routes.

The results do suggest that residual demand analysis can provide significant insights about competition that other analytical methods such as structure-performance analysis and the DOJ-Merger-Guidelines approach often may be unable to provide. This point raises the question of the potential usefulness of residual demand analysis for antitrust policy and enforcement. The stringent data requirements and the requirement of independent shifts of firm-specific cost components necessarily imply that the method could be used in only a small minority of cases, and thus could act only as a complement not a substitute for the Merger Guidelines' methodology.

Even if the methodology were more widely applicable, it is unlikely that it could ever replace the Guidelines method. While residual demand estimation synthesizes the relevant factors that affect competition into a single statistic, it is unlikely that enforcement officials would ever rely on such a statistic absent support in the form of descriptions of the observable variables that affect competition in a given market. The Merger Guidelines approach provides such relevant descriptive information about an industry.

The Guidelines approach is standardized, generally applicable, and based in large part on sound economic theory. However, it often is not applicable in a rigorous manner, and thus objective applications of the
method can yield opposite conclusions. For example, the data necessary
to apply rigorously the Guidelines' "5% test" for defining geographic and
product markets often is not available, and thus often more than one
market definition is consistent with available information. Market
congestion figures in these alternative proposed markets can vary
dramatically and thus yield opposing conclusions about the likely
competitive effects of a merger. Similarly there often is substantial
disagreement about the conditions of entry and their implications for
competitive performance in a given industry. In cases such as these where
standard analysis yields ambiguous results, residual demand analysis may
have its greatest potential value.

Further, the benefits of an application of residual demand analysis
may significantly exceed the value of the results in the individual case
for which they are estimated. Applications of the method will add to the
understanding of the method useful in future applications, to the
understanding of competition in the industry useful outside of the
immediate application, and to the understanding of competition issues and
resulting policy implications more generally.

To the extent that residual demand estimates appear inconsistent
with directly observable industry variables, and this inconsistency
persists across a number of applications, the inconsistency may lead us
to question commonly held beliefs about the competitive importance of
those industry variables. Similarly, results may suggest that certain
industry variables be given greater or lesser weight in our analyses than
they commonly have been given in the past. Economic theory does not
provide unambiguous guidance, and the Guidelines do not suggest any rules,
for determining the appropriate weights to be placed on market concentration measures and the numerous other potentially relevant observable market variables in judging the competitive significance of mergers.

Applications of the methodology are not without costs. In cases in which an existing appropriate data set is available at low marginal cost (e.g., the airline industry), it may be worthwhile to apply the method in most cases. However, the costs of generating a data set may be high in some cases, and may outweigh the benefits from a single estimation of residual demand elasticities. The opportunities for applications that are likely to yield net benefits may be increasing due to the increased availability and quality of UPC scanner data. Thus with improvements in data sources, improvements in residual demand elasticity estimation methodology, and a greater understanding of the potential value of the methodology, further applications may be judged to be increasingly productive.
Appendix

Dependent Variable

PRICE - log real average revenue aggregated across coach, coach discount, one coupon and two coupons. For the first four specifications for each route, this variable is firm specific; for the fifth specification ("combined"), this variable is a weighted average for USAir and Piedmont; for the last specification ("market"), this variable is a weighted average for all carriers on the route.

Independent Variables

QUANT - log number of passengers aggregated across coach, coach discount, one coupon and two coupons; for the first four specifications for each route, this variable is firm specific; for the fifth specification ("alt method"), this variable is the sum of the quantities of USAir and Piedmont; for the last specification ("market"), this variable is the sum of the quantities of all carriers on the route.
AVCOST - log real total operating expenditures per revenue passenger mile
INT. RATE - log real cost of capital - Moody's Index of Baa bond yields
INCOME - log real total personal income for the two endpoint metro areas
ADV - log real national advertising and promotion expenses
GASPRICE - log real retail gasoline component of the Consumer Price Index
TIME - quarters 1-27
QTR2-4 - quarterly dummies
DUMPI - dummy variable for first eight quarters preceding Piedmont's introduction of nonstop service on Baltimore-Tampa
DUMWO - dummy variable for three quarters in which World Airways competed on Baltimore-Orlando
DUMEA - dummy for five quarter presence of Eastern Airlines on Boston-Norfolk
DUMTW - dummy for TWA's entry into Washington-Norfolk in the twentieth quarter
DUMUA - dummy for United's entry into Washington-Norfolk in the twenty-third quarter

Instrumental Variables

LRFUR - log real fuel cost per revenue passenger mile (rpm)
LRPCR - log real pilot and copilot salaries per rpm
LRPER - log real personnel expenses per rpm
LRMER - log real engine repair materials per rpm
LRMAR - log real airframe repair materials per rpm
LRLER - log real engine repair labor per rpm
LRLAR - log real airframe repair labor per rpm
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References


Clarkson, K.W., 1977, Intangible Capital and Rates of Return.


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