The cigarette industry before and after the Tobacco Resolution

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¹ I am very grateful to Professor Matthew Weinberg for his data and comments.
I. Introduction

June 20th, 1997 marked a milestone in the history of the U.S. tobacco industry when the largest cigarette companies, most state attorneys general, and trial lawyers came to an agreement of the Tobacco Resolution. The resolution arose in response to a mushroom in tobacco relevant litigation of three major categories, that is, individual personal injury cases, class action personal injury, and health care cost recovery. The rapidly growing number of cases was partly due to the diffusion of stolen documents from Brown & Williamson with hidden information about the health effects of smoking in 1995, the potential payoff to plaintiffs’ lawyers from filing suits, and the seemingly reasonable cause of ending youth smoking. Therefore, the companies faced a high degree of risk of going bankrupt.

Under the Resolution, specific taxes were increased by 35 cents per pack immediately and by 62 cents after five years with adjustments for inflation. It is projected that over 25 years, additional $358 billion would be collected for the government budget (Bulow and Klemperer, 1998). The cigarette companies also had to pay $10 billion in lump sum damages, and to conform to significant marketing restrictions. In return, the Resolution banned class action suits and all punitive damage suits based on the companies’ past actions. Hence, the resolution was claimed to benefit just the government, defendants, and lawyers who could ask for huge fees based on hundreds of billions in “damages” at the expense of consumers.

The U.S. tobacco industry in 1997 was characterized by a tight oligopoly dominated by four companies with 98.6 percent of the market. Table 1 shows the sales and profits of the five leading companies. The fact that the biggest one, Philip Morris, accounted for
Table 1. Sales and Profits by Firm

<table>
<thead>
<tr>
<th>Companies</th>
<th>Unit Sales (billions of cigarettes)</th>
<th>Market Share (percent)</th>
<th>Operating Revenues ($ million)</th>
<th>Operating Profit ($ million)</th>
<th>Profits as Percent of Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philip Morris</td>
<td>235</td>
<td>49.2</td>
<td>10,663</td>
<td>4,824</td>
<td>45</td>
</tr>
<tr>
<td>RJR</td>
<td>117</td>
<td>24.5</td>
<td>4,895</td>
<td>1,510</td>
<td>31</td>
</tr>
<tr>
<td>Brown &amp; Williamson</td>
<td>77</td>
<td>16.2</td>
<td>3,114</td>
<td>801</td>
<td>26</td>
</tr>
<tr>
<td>Lorillard</td>
<td>42</td>
<td>8.7</td>
<td>1,915</td>
<td>777</td>
<td>41</td>
</tr>
<tr>
<td>Liggett</td>
<td>6.5</td>
<td>1.3</td>
<td>235</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Industry</td>
<td>478</td>
<td>100</td>
<td>20,822</td>
<td>7,932</td>
<td>38</td>
</tr>
</tbody>
</table>


nearly half the market while the fourth-ranked Lorillard had around 9 per cent indicates that there were economies of scale, though not too large for major firms. However, these firms enjoyed enormous profitability. Their profits were mostly from the premium brands on which they earned remarkably high markups (Table 2). The strong position of Lorillard in this attractive segment helped explain why it was almost as profitable as Philip Morris.

Although the industry is highly profitable, full cooperation among the companies would raise prices further as the demand elasticity was traditionally estimated to be about -0.4. With the Resolution in 1997, the present cigarette companies were tempted to

Table 2. Product Mix and Profitability by Firm

<table>
<thead>
<tr>
<th>Firm</th>
<th>Percentage of Sales in Premium Segment</th>
<th>Revenue per Pack</th>
<th>Costs per Pack</th>
<th>Profits per Pack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philip Morris</td>
<td>86</td>
<td>$0.91</td>
<td>$0.50</td>
<td>$0.41</td>
</tr>
<tr>
<td>RJR</td>
<td>63</td>
<td>$0.84</td>
<td>$0.58</td>
<td>$0.26</td>
</tr>
<tr>
<td>Brown &amp; Williamson</td>
<td>43</td>
<td>$0.81</td>
<td>$0.60</td>
<td>$0.21</td>
</tr>
<tr>
<td>Lorillard</td>
<td>94</td>
<td>$0.92</td>
<td>$0.55</td>
<td>$0.37</td>
</tr>
<tr>
<td>Liggett</td>
<td>25</td>
<td>$0.73</td>
<td>$0.67</td>
<td>$0.06</td>
</tr>
<tr>
<td>Industry</td>
<td>73</td>
<td>$0.87</td>
<td>$0.54</td>
<td>$0.33</td>
</tr>
</tbody>
</table>

negotiate collusive price increases in order to settle lawsuits. This anti-trust behavior is very likely since these firms were provided not only legal protection but also high barriers to large-scale entry to the industry because of advertising restrictions imposed by the Resolution while most smokers exhibit strong brand loyalty\textsuperscript{2}.

Therefore, it is very interesting to examine whether the tobacco industry has become more collusive after the Resolution in 1997. In other words, are there any significant changes in the market structure of the industry before and after 1997?

There have been several empirical studies on the industry behavior. Sullivan (1985), using parametric statistical techniques, found that the numbers equivalent of firms is not less than two or three. On the other extreme, Ashenfelter and Sullivan (1987) constructed a non-parametric test of the monopoly model in the tobacco industry based on the revealed preference approach. They also observed that the monopoly hypothesis is not a good predictor of the effect of excise tax changes on cigarette prices, sales, and revenues. However, since the non-parametric technique provides simple and illuminating analyses of the traditional questions of producer theory, it is used in this paper. And the tobacco industry seems to have become more collusive after the introduction of the Resolution in 1997.

The paper is structured as follows. Following the Introduction, section II presents the nonparametric tests, which are applied in section III to the data on the cigarette industry. Finally, section IV gives some conclusions on the nonparametric approach to tests of the market structure and on the empirical behavior of the cigarette industry.

\textsuperscript{2} According to A Report of the Surgeon General (1989), some 10 percent of smokers switched their brands annually, but often to other brands of the same cigarette company.
II. Nonparametric Tests

For an industry that is a monopoly with upward sloping total cost function \( C(q) \) and downward sloping demand function \( P(q) \), the chosen level of output is \( q \) if any other level of output, \( q + \Delta q \), is not more profitable:

\[
(q + \Delta q)P(q + \Delta q) - C(q + \Delta q) \leq qP(q) - C(q) \tag{1}
\]
or

\[
\Delta qP(q + \Delta q) + q[P(q + \Delta q) - P(q)] \leq C(q + \Delta q) - C(q) \tag{2}
\]

It is assumed that changes in an excise tax \( t \) are equivalent to changes in marginal cost. The total cost function can be written as \( C(q) = C_0(q) + tq \) where \( C_0 \) increases in \( q \).

Suppose there are two tax rates \( t_0 \) and \( t_1 \), \( t_0 < t_1 \), two corresponding profit maximizing output levels, \( q_0 \) and \( q_1 \), and price levels, \( p_0 = P(q_0) \) and \( p_1 = P(q_1) \). Inequality (2) indicates that when the tax rate is \( t_0 \),

\[
(q_1 - q_0)p_1 + q_0(p_1 - p_0) \leq C_0(q_1) - C_0(q_0) + t_0(q_1 - q_0) \tag{3}
\]

and when the tax rate is \( t_1 \),

\[
(q_0 - q_1)p_0 + q_1(p_0 - p_1) \leq C_0(q_0) - C_0(q_1) + t_1(q_0 - q_1) \tag{4}
\]

Adding (3) and (4) leads to:

\[
(t_0 - t_1)(q_1 - q_0) \geq 0
\]

Since \( t_0 < t_1 \), then \( q_0 \geq q_1 \) (5) and \( p_0 \leq p_1 \) (6). So, an increase in an excise tax must raise the monopoly price and lower the monopoly output.

Since the cost function is assumed to be upward sloping, or \( C_0(q_0) \geq C_0(q_1) \), (3) becomes

\[
(q_1 - q_0)p_1 + q_0(p_1 - p_0) \leq t_0(q_1 - q_0)
\]
or

\[
p_1q_1 - p_0q_0 \leq t_0(q_1 - q_0) \tag{7}
\]

which is the main testable hypothesis of the monopoly model.
If the industry is instead perfectly competitive or firms in that market take the price as exogenously given, then they will select \( q \) such that

\[
(q + \Delta q)P(q + \Delta q) - C(q + \Delta q) \leq qP(q + \Delta q) - C(q)
\]

or

\[
\Delta qP(q + \Delta q) \leq C(q + \Delta q) - C(q)
\] (8)

(8) implies that at other levels of output, \( q + \Delta q \), extra revenue earned is not larger than extra cost.

From (2) and (8), it can be said that the industry has a monopoly index \( \beta \) if

\[
\Delta qP(q + \Delta q) + \beta q[P(q + \Delta q) - P(q)] \leq C(q + \Delta q) - C(q)
\] (9)

for all \( \Delta q \). The index \( \beta \) ranges from 0, in perfectly competitive industry, to 1, in monopoly industry. The higher \( \beta \) is, the tighter the oligopoly.

In the case of two excise taxes \( t_0 \) and \( t_1 \), if \( q_0 \geq q_1 \) and \( p_0 \leq p_1 \), then (9) implies

\[
\beta \leq \frac{(t_0 - p_1)(q_1 - q_0)}{q_0(p_1 - p_0)}
\] (10)

This inequality provides a nonparametric way to bound the index \( \beta \).

Suppose there are \( n \) firms with increasing cost functions \( C_1(q_1), \ldots, C_n(q_n) \), and with outputs \( q_1, \ldots, q_n \). The first order conditions across the firms imply that

\[
q(t)p'(t) + (p(t) - t)q'(t)n(t) \geq 0
\] (11)

From (11), if \( t_0 < t_1 \), we have

\[
\int_{t_0}^{t_1} [q(t)p'(t) + (p(t) - t)q'(t)n(t)]dt \geq 0
\] (12)

If \( q(t) \) decreases and \( p(t) \) increases in \( t \), then for \( t \) between \( t_0 \) and \( t_1 \), \( q(t_0) \geq q(t) \geq 0 \) and \( 0 \leq p(t_0) - t_1 \leq p(t) - t \), and (12) can become
\[ \int_{t_0}^{t_1} \left[ q_0 p'(t) + (p_0 - t_1)q'(t)n(t) \right] dt \geq 0 \]

There exists a certain \( \tilde{t} \) between \( t_0 \) and \( t_1 \) such that

\[ n(\tilde{t}) \geq \frac{q_0(p_1 - p_0)}{(q_1 - q_0)(p_1 - t_0)} \]

(13)

which gives the lower bound on the numbers equivalents in the industry.

### III. Empirical Results

The data used in this paper consist of the federal and state tax rates, quantity sold, and the average retail price in 51 states from 1970 to 2003. The tax variable is the sum of the federal and state taxes for the state and year in the sample. The tax and price variables are converted to real terms by dividing by the national consumer price index.

In deriving the predictions of the simple monopoly model in (5), (6) and (7), we have assumed that the demand and cost functions applied to both data points considered remained the same. However, the same demand and cost functions might not have prevailed across the states. The predictions tested below are thus only for pairs of points in the same state. In addition, patterns of cigarette consumption have changed a lot over the years though slowly, predictions are restricted to pairs of points at most two years apart.

Panel A in Table 1 shows the all pairs of consecutive years within the same state. The model seems to predict weakly, even worse than in Ashenfelter and Sullivan (1987). Of the 1326 changes before the introduction of the Resolution in 1997, the monopoly predictions in terms of quantity, price and revenue changes separately are true only 33%, 60.6% and 25.6%. But for those changes after 1997, the accuracy of the model improves considerably, except for price changes. It is interesting to find that the expression (7)
which says that the revenue loss due to producing a non-optimal output level is greater than the decreased tax payments associated with that level holds in percentage after 1997 more than double before 1997, i.e. 56.6% compared to 25.6% respectively. And so does the joint prediction in the last column.

However, the first two rows in Panel A show that the evidence in general does not appear to support the monopoly hypothesis in the cigarette industry. It may be attributed

### Table 3. Tests of the Predictions of the Monopoly Model About Changes in Quantity, Price and Revenue

<table>
<thead>
<tr>
<th>Panel A</th>
<th>Number of cases</th>
<th>Percentage Predictions Correct</th>
<th>Panel B</th>
<th>Number of cases</th>
<th>Percentage Predictions Correct</th>
<th>Panel C</th>
<th>Number of cases</th>
<th>Percentage Predictions Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\Delta q \leq 0^a$</td>
<td>$\Delta p \geq 0^b$</td>
<td>(5)-(6)$^c$</td>
<td>(7)$^d$</td>
<td>(5)-(7)$^e$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before 1997</td>
<td>1326</td>
<td>33.0</td>
<td>60.6</td>
<td>29.8</td>
<td>25.6</td>
<td>8.4</td>
<td>(Real Increases)</td>
<td>Before 1997</td>
</tr>
<tr>
<td>After 1997</td>
<td>357</td>
<td>38.1</td>
<td>45.1</td>
<td>31.9</td>
<td>56.6</td>
<td>19.6</td>
<td>(No Statutory Change)</td>
<td>After 1997</td>
</tr>
<tr>
<td>Before 1997</td>
<td>981</td>
<td>26.5</td>
<td>56.0</td>
<td>22.9</td>
<td>23.1</td>
<td>5.7</td>
<td>(Statutory Changes)</td>
<td>After 1997</td>
</tr>
<tr>
<td>After 1997</td>
<td>400</td>
<td>50.3</td>
<td>71.3</td>
<td>47.5</td>
<td>33.8</td>
<td>16.8</td>
<td>(No Statutory Change)</td>
<td>Before 1997</td>
</tr>
<tr>
<td>Before 1997</td>
<td>926</td>
<td>25.6</td>
<td>56.0</td>
<td>22.1</td>
<td>22.0</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After 1997</td>
<td>220</td>
<td>15.5</td>
<td>15.9</td>
<td>9.1</td>
<td>62.3</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: 

- $^a$ Prediction tested is expression (5): Quantity consumed will decrease when excise taxes increase.
- $^b$ Prediction tested is expression (6): Retail price will increase when excise taxes increase.
- $^c$ Test of the joint prediction that quantity decreases and retail price increases.
- $^d$ Prediction tested is expression (7): Revenue loss will be larger than the decreased tax payments.
- $^e$ Test of the joint prediction that changes in quantity, retail price and revenue will comply with the monopoly model.
- $^f$ Pairs of data observations separated by one year.
- $^g$ Statutory tax rates are constant for both data observations and a statutory increase during the intervening year.
to the possibility of measurement errors. Not all pairs of consecutive years should be considered because a large number of changes in the real tax rates come entirely from changes in the consumer price index which is not really perfect. The predictions are likely to be incorrect for those changes that are very small.

If we are confined to consecutive years with statutory tax changes, shown in the first two rows in Panel B, the predictions are much better for both periods, especially for the post-1997 period, hence widening the gap in the performance of the monopoly model between the two periods. The prediction that the price should rise when the tax rate increases for those years after the Resolution was put in place is correct for 92%.

The predictions exhibited even slightly further improvements for a subgroup where there was an increase in the real tax rates from the earlier year (in the third and fourth rows of Panel A). In contrast, the last two rows of Panel A displays that for consecutive years with decreases in the real tax rates, the performance of the monopoly model is very poor. However, of 981 and 221 real decreases before and after 1997, there are 926 and 220 cases in which there is no change in the statutory rate (in the last two rows of Panel B). As almost all of the real decreases were exclusively due to the continuous rise in the national consumer price index, there are much more violations. Indeed, when attention is restricted to those real increases or statutory changes in consecutive years where measurement errors are likely to be less significant, the monopoly model predicts quite well for the post-1997 period, but not that well for the pre-1997 period.

In order to remove measurement error from the tax data, pairs of points separated by one year are considered. For the subset of these “Skip Year Changes” where in the first year the rate was constant, in the second year the rate was jumped, and in the third year
the rate remained flat again, as shown in the last two rows of Panel C, the correct percentages of the model’s predictions are somewhat lower than those for consecutive years with real increases or statutory changes. This is because any instability in cost or demand functions are allowed to more heavily influence the results in this subset. However, if all skip year changes are examined (in the first two rows of Panel C), then the model predicts marginally better than it does for all consecutive years (in the first two rows of Panel A), but worse in terms of revenue changes.

Table 4 shows how the predictions (5)–(7) work according to the size of the tax changes. As implied by Table 3, we just look at a group where there was an increase in the real tax rates. When the magnitude of the tax change increases from under to over 1 cent (in 1977 dollars), nearly all predictions for both periods tend to be more correct. But for the tax change greater than 2 cents, they have the least success, except for price

Table 4. Tests of the Predictions of the Monopoly Model for Skip Year Real Increases, Disaggregation by Size of Tax Change

<table>
<thead>
<tr>
<th>Δt^g</th>
<th>Number of cases</th>
<th>Δq ≤ 0^a</th>
<th>Δp ≥ 0^b</th>
<th>(5)-(6)^c</th>
<th>(7)^d</th>
<th>(5)-(7)^e</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>129</td>
<td>82</td>
<td>34</td>
<td>175</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Before 1997</td>
<td>126</td>
<td>34</td>
<td>175</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Before 1997</td>
<td>126</td>
<td>34</td>
<td>175</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>&gt; 2</td>
<td>Before 1997</td>
<td>175</td>
<td>93</td>
<td>175</td>
<td>93</td>
<td></td>
</tr>
</tbody>
</table>

Notes:  
^a Prediction tested is expression (5): Quantity consumed will decrease when excise taxes increase.  
^b Prediction tested is expression (6): Retail price will increase when excise taxes increase.  
^c Test of the joint prediction that quantity decreases and retail price increases.  
^d Prediction tested is expression (7): Revenue loss will be larger than the decreased tax payments.  
^e Test of the joint prediction that changes in quantity, retail price and revenue will comply with the monopoly model.  
^f Pairs of data observations separated by one year.  
^g Change in tax rate in 1977 cents.
changes. As the cigarette firms raise their prices in response to a high jump in the tax rates, smokers fail to reduce their quantities consumed in more than half cases, thus making these firms in over 90% cases to incur a bigger increase in the tax payments than the gains in revenue received. Though, in all three subgroups, the predictions perform better for the post-1997 period.

Table 5 presents the extent to which other oligopoly models with higher numbers equivalents are consistent with the “Skip Year Changes” data. The expression (13) was derived based on the assumptions that quantity declines and price increases when the tax rate rises. Thus, the test is applied to only pairs of years in which these conditions were true. The data shows that the monopoly model (with 1 firm equivalent) is consistent with more or less half of the data in the two periods. Roughly 90% of the data points can be explained by models with numbers equivalent in excess of 5 for the pre-1997 period and

<table>
<thead>
<tr>
<th>Numbers Equivalent</th>
<th>Percent Consistent With Numbers Equivalent*</th>
<th>Skip Year Changes $\Delta q \leq 0 \ &amp; \Delta p \geq 0$</th>
<th>Before 1997 (203 cases)</th>
<th>After 1997 (151 cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 1</td>
<td>39.4</td>
<td>51.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 2</td>
<td>74.4</td>
<td>88.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 3</td>
<td>83.3</td>
<td>93.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 4</td>
<td>86.7</td>
<td>94.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 5</td>
<td>89.7</td>
<td>95.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 6</td>
<td>92.1</td>
<td>96.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 7</td>
<td>93.1</td>
<td>96.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 8</td>
<td>94.6</td>
<td>97.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 9</td>
<td>95.1</td>
<td>98.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = $\infty$</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * Consistency means that the expression (13):

$$n \geq \frac{q_o(p_t - p_0)}{(q_t - q_o)(p_t - t_o)}$$

holds for the indicated value of $n$ or quantity and price changes are consistent with that value for the numbers equivalent of firms in the market.
2 for the post-1997 period. The small number equivalent for the latter period seems to suggest that a duopoly model be considered instead, which should be proceeded with caution since the two conditions above held in 72.2% of the cases. However, it can be concluded that this simple conjectural variations models should include some amount of competition.

IV. Conclusion

The non-parametric tests imply similar conclusions of Ashenfelter and Sullivan (1987) that the monopoly model generally predicts poorly the effect of excise tax changes on cigarette prices, sales, and revenues. In addition, simple conjectural variations models are consistent with the data only if they embody at least some amount of competition.

The low accuracy of the monopoly hypothesis, nevertheless, can be attributable to measurement error. If attention is confined to those data points (for consecutive or skip year changes) where there are real increases in the tax rates, the data indicate that tax increases indeed act to increase cigarette prices and to decrease cigarette sales, especially for the post-1997 period.

And it seems that the tobacco industry has become more collusive after the introduction of the Resolution in 1997. Their responses to excise tax changes are more likely to follow what the monopoly model predicts than those in the pre-1997 period.
Reference


