The Effect of Government Advertising Policies on the Market Power of Cigarette Firms *

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I. Introduction

Among industries in the United States, the cigarette industry has had a rather unique history of government interventions ranging from antitrust suits to government health warnings and restrictions on advertising due to the addictive nature of nicotine coupled with the deleterious effects of smoking upon health. Early in the 20th century, the government initiated antitrust litigation following more than 20 years of monopolization. James B. Duke had established the country's largest cigarette manufacturing firm in the 1880s through aggressive investment and advertising and used this position to establish the American Tobacco Company in 1890, a merger of the five largest cigarette manufacturers at the time, which controlled 90 percent of the domestic market. In 1911, as a result of a Supreme Court decision that American Tobacco had monopolized the market in violation of the Sherman Antitrust Act, the company was divided into four: American Tobacco, Liggett & Myers, P. Lorillard, and R.J. Reynolds.[1]

In 1931, early in the Great Depression, and in spite of falling tobacco leaf prices, the industry successfully raised prices. This in turn led to entry into the market for premium cigarettes by new firms that charged 10 cents a pack, two-thirds the price of the market leaders' brands. In response to this entry, American led price cuts that were followed by the other major manufacturers with the ultimate result of driving many of the new entrants from the market. However, several new entrants remained, notably Philip Morris & Company and Brown and Williamson, a U.S. subsidiary of the British American Tobacco Company; now six firms dominated the market for cigarettes. The aggressive price cutting that drove new entrants from the market led to new antitrust action against the largest three manufacturers (American, Liggett & Myers, and Reynolds) resulting in a verdict of monopolization against the Big Three in 1941, a verdict upheld by the Supreme Court in 1946 (Jaffe, 2001, p. 66; Scherer and Ross, 1990, p. 340). In this case, no structural remedies were imposed; the firms were merely required to pay fines and to discontinue coordination and communication. The case was especially noteworthy because, while there was no direct evidence of price fixing, the Supreme Court made it clear in its decision that circumstantial evidence, in this case parallel pricing, could be so flagrantly inconsistent with economic circumstances that it would support a finding against alleged conspirators. Nevertheless, and perhaps because the fines at the time were rather modest, cigarette companies continued to coordinate their prices,

[1] For histories of the U.S. cigarette market, see Jaffe (2001) and Fritscher and Hoefler (1996).

changing them at the same time and by the same amount until the introduction of generic cigarettes in the mid-1980s and repackaging of cigarettes into packs of 20 or 25.[2]

All of this might suggest that cigarette manufacturers could have been colluding into the mid-1980s, setting cigarette prices in such a way as to maximize cartel profits. On the other hand, once prices are set firms may perceive them as fixed, or relatively so, over output. Then marginal revenue is perceived as constant, or nearly so, and equal or nearly equal to price; so the firm may seek to increase production to set this perceived marginal revenue equal to marginal cost in a manner similar to a competitive firm, which sets constant marginal revenue equal to marginal cost. This is, of course, the incentive for cheating in a cartel. The desire to increase sales may, in fact, explain the high levels of advertising among cigarette firms.[3]

Prior research suggests that cigarette manufacturers do not maximize profits as a perfect cartel. Sullivan (1985) rejects the hypothesis of a perfect cartel, and states that there is "at least a moderate amount of competition" in the market (p. 593). Ashenfelter and Sullivan (1987) find likewise. Sumner (1981) rejects the hypothesis of perfect competition, but finds firm-level demand functions that are "not flat, but close to it" (p. 1019) indicating weak market power. In fact, Jaffe (2001, p. 67) suggests that a cigarette monopolist would set prices at approximately twice the level of observed prices. All of this suggests that the cigarette market is moderately to very competitive, which in turn suggests that the incentive to cheat, alluded to previously, is strong.

In this paper, we investigate market power among cigarette manufacturers over the period 1952 through 1984 to estimate the level of market power during the heyday of uniform pricing.[4] Attempts at numerical estimates are lacking in the previous literature. We apply an approach suggested by Bresnahan

[2] From 1940 through 1985, the U.S. Department of Agriculture's Economic Research Service reports changes in the prices of cigarettes pinpointed to months of various years. These reports show that in general all major manufacturers coordinated changes in their prices closely, with changes being separated in time by sometimes considerable periods of price stability. The one exception was the period between August through September of 1982 when manufacturers raised prices by different amounts; but the prices were brought back into line in January of 1983 (U.S. Department of Agriculture at http://usda.mannlib.cornell.edu/data-sets/specialty/94012/).

[3] Jaffe points out, "[c]igarettes are one of the most heavily advertised … products in the United States. In 1997, the majors spent … approximately 27 percent of wholesale revenues [on advertising;] an astounding expenditure for a product [without] complicated performance characteristics or design changes."

[4] We define market power as a supplier's ability to maintain price above marginal cost. See, for example, Tirole (1990, pp. 66-67).

(1982), but which is based upon a firm-level model.[5,6] There are two additional changes that we make to the Bresnahan model. First, we employ a dynamic model in the sense that the firms take into consideration habit persistence and/or brand loyalty of consumers in a strategic fashion.[7] Second, we augment the approach by adding a separate advertising equation that takes the form of optimal advertising in a dynamic oligopoly model. The advertising equation helps to identify several of the parameters, thereby increasing the degrees of freedom. In addition, the advertising equation constrains the parameters in a fashion that allows us to interpret several of our results at the firm level, despite the fact that the demand and price equations conform to what we might see in an aggregated market model.

II. Estimating Market Power

Bresnahan (1982) considers the problem of estimating market power from demand and supply-side equations. These equations could take any functional form, but we illustrate the approach using a simple model similar to Bresnahan's original. Let the firm's demand function be

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 I + \varepsilon_d \tag{1}$$

where Q is quantity, P is own price, I is income, and ε_d is an error term. Given this demand function, and assuming for the moment that the firm is a monopolist, the marginal revenue function facing the monopolist is

$$MR = P + \left(\partial Q / \partial P\right)^{-1} Q = P + \left(1/\alpha_1\right) Q \,. \tag{2}$$

Alternatively, to capture all market structure forms, we can write

$$MR = P + \lambda\left(\partial Q / \partial P\right)^{-1} Q = P + \lambda\left(1/\alpha_1\right) Q \tag{3}$$

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[5] Hyde and Perloff (1995) apply various methods to simulated data using various approaches to the determination of market power. They find the Bresnahan approach to be "the only practical approach" that does not require an assumption of constant returns to scale and the only approach that is able to estimate market power. Boyer (1996) questions the assumption that market power will remain the same over time. While this is a valid criticism, such estimates can at least approximate an average over time; moreover, our model will allow the market power parameter to change with government intervention.

[6] Gallet (1999) employs a market-level model of cigarettes suggested by Bresnahan's approach, but does not estimate the level of market power. His index of market power is a sum of a constant and other terms. This constant to added to another constant in his price equation and the sum of the two constants are then estimated as a single coefficient; thus he is unable to identify all the parameters that comprise the market power index

[7] Our approach differs from Steen and Salvanes (1999), which does not employ an underlying dynamic model of firm decision making. Steen and Salvanes' model has the firm pricing in the original Bresnahan fashion; the dynamics referred to in the title of their paper is an error correction framework applied to the regression equations rather than to dynamics in the underlying model of the firms

where we refer to equation (3) as perceived marginal revenue. The profit maximizing firm will set perceived marginal revenue equal to marginal cost, so we have the first-order condition

$$MR = P + \lambda(1/\alpha_1)Q = MC \quad (4)$$

where $\lambda = 1$ if and only if the industry is a perfect cartel,[8]

$\lambda = 0$ if and only if the industry is competitive,

and $\lambda \in (0,1)$ otherwise.

We can employ $\lambda \in [0,1]$ in equations (3) and (4) as an index of market power. To see this, note the following. First, $\lambda = 1$ is the upper bound of the closed interval [0, 1], so the marginal revenue function is given by equation (2) and the firm is acting as a collusive firm in a perfectly coordinated cartel where the firm under consideration is allocated the demand function specified in equation (1). Second, at the lower bound of the closed interval, $\lambda = 0$ so *MR* = *P* = *MC*; thus the firm perceives price to be its marginal revenue and sets marginal cost equal to price as would a perfectly competitive firm. Third, as λ increases from 0, the divergence between marginal revenue and marginal cost increases, so the firm has greater market power by definition.

Allowing inputs to vary, we will specify the short-run marginal cost function, as in Bresnahan, as

$$MC = \beta_0 + \beta_1 W + \beta_2 R + \beta_3 Q \quad (5)$$

where *W* and *R* are costs of inputs. However, it is not possible to identify the degree of market power in the industry with this model. This is because the firm sets *MR* = *MC* so that, equating equation (4) to equation (5) and rearranging terms, the supply relation can be written as

$$P = \beta_0 + \beta_1 W + \beta_2 R + \left[\beta_3 - \lambda(1/\alpha_1)\right]Q + \varepsilon_s \quad (6)$$

where ε_s is an error term. While equation (6) is identified, λ, the market power coefficient, is not because the locus that equates *Q* to *P* could be tracing out points where the quantity and marginal revenue functions intersect or, in the case of perfect competition, points where the quantity and supply functions intersect. This is because parallel shifts in the demand function are associated with parallel shifts of the marginal revenue function.

Bresnahan's solution is to introduce nonparallel shifts in demand. Consider a demand-side exogenous variable, say *Z*, that interacts with *P* so that the demand function can be written

$$Q = \alpha_0 + \alpha_1 P + \alpha_2 I + \alpha_3 PZ + \alpha_4 Z + \varepsilon_d \quad (1')$$

If we respecify equation (1') as

$$Q = B_0 + B_1 P + \varepsilon_d$$

[8] Alternatively, $\lambda = 1$ is a perfect monopolist if it is the only supplier in the market.

where $B_0 = \alpha_0 + \alpha_2 I + \alpha_4 Z$ and $B_1 = \alpha_1 + \alpha_3 Z$, we see that changes in *Z* cause a change in the intercept of the demand curve $(\partial B_0/\partial Z = \alpha_4)$ as well as a change in the slope $(\partial B_1/\partial Z = \alpha_3)$. The latter can be visualized as a rotation of the demand curve, which is the key to identifying market power.

Given the demand function (1'), perceived marginal revenue is

$$MR = P + \left[\lambda/\left(\alpha_1 + \alpha_3 Z\right)\right]Q . \tag{4'}$$

Setting *MR* = *MC* (given by equation (5)) and rearranging terms yields the supply relationship

$$\begin{aligned} P &= \beta_0 + \beta_1 W + \beta_2 R + \left\{\beta_3 - \left[\lambda/\left(\alpha_1 + \alpha_3 Z\right)\right]\right\}Q + \varepsilon_s \\ &= \beta_0 + \beta_1 W + \beta_2 R + \beta_3 Q - \left[\lambda/\left(\alpha_1 + \alpha_3 Z\right)\right]Q + \varepsilon_s . \end{aligned} \tag{6'}$$

We can estimate α_1 and α_3 simultaneously through the demand function (1') and the price function (6') by imposing cross-equation restrictions. Also, due to the nonparallel shifts in the demand function, we can identify and estimate λ.

III. Optimal Pricing and Advertising in a Dynamic Oligopoly Model

Consider an oligopoly in which $n > 1$ firms set price and advertising to influence the demand for their product, which follows a brand loyalty/habit persistence (BL/HP) pattern. The BL/HP model suggests a dynamic problem. We use discrete-time methods in order to guide us in the empirical application; instantaneous changes with respect to time in a continuous-time model tend to confound the relevant periods vis-à-vis the firm's planning for future objectives.[9]

To see this, recall that the typical BL/HP time path of consumption is

$$\Delta Q_{i,t} = Q_{i,t} - Q_{i,t-1} = \mu\left[Q^*_{i,t}\left(P_{i,t}, \mathbf{P}_{\mathbf{r},t}, A_{i,t}, \mathbf{A}_{\mathbf{r},t}\right) - Q_{i,t-1}\right], \tag{7}$$

from time $t - 1$ to time *t* while a model that accords with discrete-time optimal control theory takes the firm's planning into consideration would specify a change from time *t* to time $t + 1$, as

$$\Delta Q_{i,t} = Q_{i,t+1} - Q_{i,t} = \mu\left[Q^*_{i,t+1}\left(P_{i,t+1}, \mathbf{P}_{\mathbf{r},t+1}, A_{i,t+1}, \mathbf{A}_{\mathbf{r},t+1}\right) - Q_{i,t}\right], \tag{7'}$$

where $Q_{i,s}$ is the quantity that the firm *i* sells in period $s = t - 1, t, t + 1$; $Q^*_{i,s}$ is the desired consumption of firm *i*'s brands based on variables in period *s*; $P_{i,s}$ is the price of the good sold by firm *i* (presumably the wholesale price); $\mathbf{P}_{\mathbf{r},s}$ is a vector of the price of rivals' goods; $A_{i,s}$ and $\mathbf{A}_{\mathbf{r},s}$ are the advertising

[9] There are many references that discuss continuous-time dynamic optimization, but few that discuss discrete-time models. A very compete discussion is found Chapter 5 of Benavie (1972). Also, see Chapter 2 of Chow (1997).

messages of the firm and its rivals; and μ is the adjustment coefficient. Then the firms will plan in time t for prices and advertising strategies beginning in time $t + 1$.

In the model developed in this section, we use the consumption adjustment equation (7) rather than (7') with the firms planning their next period price and advertising in period $t - 1$. This permits us to simplify notation by specifying variables of the firms' problem in the current period rather than in the subsequent period (for instance, $P_{i,t}$ rather than $P_{i,t+1}$) and to derive the regression equations directly from the theoretical model with time subscripts corresponding to common usage. Future variables (e.g. $P_{i,t+1}$) will still appear in the optimal price and advertising equations due to the necessary conditions, which specify a current and future shadow price where the latter is a function of subsequent period variables. To reconcile the problem of the firm to the use of equation (7) rather than (7'), we suppose that the firm maximizes the long-run profit $J_i = \sum_{t=-1}^{\infty}(1+\rho_i)^{-(t+1)}\Pi_{i,t}$ where the initial period is $t = -1$ and ρ_i is a long-term discount rate of the firm. The firm considers $\Pi_{i,-1} = 0$, and $\Pi_{i,0} > 0$ is discounted one period.[10] This suggests that the firm disregards the profit for time $t-1$ because it is planning ahead, but this is not a problem: it reconciles the two possibilities that 1) the firm is a *de novo* entrant into the market or 2) the firm has existed in the market in earlier periods as follows. First, if a firm is initially entering a market, it costlessly plans prices and advertising in the period before entering, and the profit and production and advertising expenditures in the planning period is zero, since the firm has not yet produced. Second, if a firm has been in the market for some time, the profit for time $t-1$ was taken into account previously.

The problem of the *i*th firm is to choose the time path of price and advertising to maximize

$$J_i = \sum_{t=-1}^{\infty}(1+\rho_i)^{-(t+1)}\left[P_{i,t}Q_{i,t} - C_{i,t}\left(Q_{i,t}\right) - M_{i,t}A_{i,t}\right] \tag{8}$$

subject to condition (7) and the initial condition

$$Q_{i,-1} = Q_i^0 \geq 0 \tag{9}$$

where $C_{i,t}\left(Q_{i,t}\right)$ is the manufacturing cost function, $M_{i,t}$ is the cost of advertising messages, and $A_{i,t}$ is the number of advertising messages.[11]

The Hamiltonian associated with this problem is

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[10] Thus the Hamiltonian accounts for the planning stage by discounting the initial nonzero profit for one period, whereas the usual Hamiltonian does not discount the initial period profit.

[11] We suppose that all firms pay the same for advertising messages. This is implied by the results in Jung and Seldon (1995).

$$H_i = (1+\rho_i)^{-(t+1)}\left[P_{i,t}Q_{i,t} - C_{i,t}(Q_{i,t}) - M_{i,t}A_{i,t}\right]$$

$$+(1+\rho_i)^{-1}\psi_{i,t}\left[\mu Q^*_{i,t}(P_{i,t}, \mathbf{P}_{\mathbf{r},t}, A_{i,t}, \mathbf{A}_{\mathbf{r},t}) - \mu Q_{i,t-1}\right]$$

where $\psi_{i,t}$ is the usual shadow price.[12] The associated necessary conditions for optimization are

$$\partial H_i/\partial P_{i,t} = (1+\rho_i)^{-(t+1)} Q_{i,t} + (1+\rho)^{-1}\psi_{i,t}\mu\left(dQ^*_{i,t}/dP_{i,t}\right) = 0$$

$$\Rightarrow (1+\rho_i)^{-t} Q_{i,t} + \psi_{i,t}\mu\left(dQ^*_{i,t}/dP_{i,t}\right) = 0 \qquad (10)$$

where $dQ^*_{i,t}/dP_{i,t} = \left(\partial Q^*_{i,t}/\partial P_{i,t}\right) + \left(\partial Q^*_{i,t}/\partial \mathbf{P}_{\mathbf{r},t}\right)\left(\partial \mathbf{P}_{\mathbf{r},t}/\partial P_{i,t}\right)$; (11)

$$\partial H_i/\partial A_{i,t} = -(1+\rho_i)^{-(t+1)} M_{i,t} + (1+\rho)^{-1}\psi_{i,t}\mu\left(dQ^*_{i,t}/dA_{i,t}\right) = 0$$

$$\Rightarrow -(1+\rho_i)^{-t} M_{i,t} + \psi_{i,t}\mu\left(dQ^*_{i,t}/dA_{i,t}\right) = 0 \qquad (12)$$

where $dQ^*_{i,t}/dA_{i,t} = \left(\partial Q^*_{i,t}/\partial A_{i,t}\right) + \left(\partial Q^*_{i,t}/\partial \mathbf{A}_{\mathbf{r},t}\right)\left(\partial \mathbf{A}_{\mathbf{r},t}/\partial A_{i,t}\right)$; (13)

and $\left(\partial H_i/\partial Q_{i,t}\right) = (1+\rho_i)^{-(t+1)}\left[P_{i,t} - \left(\partial C_{i,t}/\partial Q_{i,t}\right)\right] - (1+\rho)^{-1}\psi_{i,t}\mu$

$$= -(1+\rho_i)^{-1}\Delta\psi_{i,t} = (1+\rho_i)^{-1}\left(-\psi_{i,t+1} + \psi_{i,t}\right)$$

$$\Rightarrow (1+\rho_i)^{-t}\left[P_{i,t} - \left(\partial C_{i,t}/\partial Q_{i,t}\right)\right] - \psi_{i,t}\mu = -\Delta\psi_{i,t} = -\psi_{i,t+1} + \psi_{i,t} \qquad (14)$$

for $t = 0, 1, 2, \ldots, \infty$ with $\lim_{t\to\infty} = 0$. Equation (14) can be rearranged to derive

$$(1+\rho_i)^{-t}\left[P_{i,t} - \left(\partial C_{i,t}/\partial Q_{i,t}\right)\right] = -\psi_{i,t+1} + (1+\mu)\psi_{i,t}. \qquad (15)$$

From equation (10) we find that

$$\psi_{i,s} = -\left[\mu(1+\rho_i)^s\right]^{-1} Q_{i,s}\left(dQ^*_{i,s}/dP_{i,s}\right)^{-1} = \frac{-Q_{i,s}}{\mu(1+\rho_i)^s\left(dQ^*_{i,s}/dP_{i,s}\right)} \qquad (16)$$

for $s = t, t+1$. Substituting this into equation (15) yields

$$(1+\rho_i)^{-t}\left[P_{i,t} - \left(\partial C_{i,t}/\partial Q_{i,t}\right)\right] = \frac{Q_{i,t+1}}{\mu(1+\rho_i)^{t+1}\left(dQ^*_{i,t+1}/dP_{i,t+1}\right)} - \frac{(1+\mu)Q_{i,t}}{\mu(1+\rho_i)^t\left(dQ^*_{i,t}/dP_{i,t}\right)}$$

$$\Rightarrow P_{i,t} - \left(\partial C_{i,t}/\partial Q_{i,t}\right) = \frac{Q_{i,t+1}}{\mu(1+\rho_i)\left(dQ^*_{i,t+1}/dP_{i,t+1}\right)} - \frac{(1+\mu)Q_{i,t}}{\mu\left(dQ^*_{i,t}/dP_{i,t}\right)}$$

[12] We discount the term with the shadow price for one period to adjust for our departure from the usual dynamic model. In the typical model, this value would not be discounted. Alternatively, one can think of it being discounted in the typical model by $(1+\rho_i)^0 = 1$.

or $$P_{i,t} - \left[\frac{Q_{i,t+1}}{\mu\left(1+\rho_i\right)\left(dQ^*_{i,t+1} \big/ dP_{i,t+1}\right)} - \frac{\left(1+\mu\right)Q_{i,t}}{\mu\left(dQ^*_{i,t} \big/ dP_{i,t}\right)} \right] = \partial C_{i,t} \big/ \partial Q_{i,t} .$$

From this, a dynamic analogue to the Bresnahan optimal-price equation that incorporates an index of market power is

$$P_{i,t} - \lambda \left[\frac{Q_{i,t+1}}{\mu\left(1+\rho_i\right)\left(dQ^*_{i,t+1} \big/ dP_{i,t+1}\right)} - \frac{\left(1+\mu\right)Q_{i,t}}{\mu\left(dQ^*_{i,t} \big/ dP_{i,t}\right)} \right] = MC_{i,t} . \tag{17}$$

Having derived the condition for profit-maximization through prices, we next consider optimal advertising. From equation (12), we find that

$$\psi_{i,s}\mu\left(dQ^*_{i,s} \big/ dA_{i,s}\right) = \left(1+\rho_i\right)^{-s} M_{i,s} \Rightarrow \psi_{i,s} = \frac{M_{i,s}}{\mu\left(1+\rho_i\right)^s \left(dQ^*_{i,s} \big/ dA_{i,s}\right)} . \tag{18}$$

Substituting this into equation (15) and multiplying through by $\left(1+\rho\right)^t$ yields

$$P_{i,t} - \left(\partial C_{i,t} \big/ \partial Q_{i,t}\right) = \frac{-M_{i,t+1}}{\mu\left(1+\rho_i\right)\left(dQ^*_{i,t+1} \big/ dA_{i,t+1}\right)} + \frac{\left(1+\mu\right)M_{i,t}}{\mu\left(dQ^*_{i,t} \big/ dA_{i,t}\right)} \tag{19}$$

Equation (19) can be rearranged to yield the optimal inverse advertising equation.

In equation (11), define $P_{j,r}$ as an element of the $n-1$ dimensional vector $\mathbf{P_r}$. Then $\partial Q_i^* \big/ \partial \mathbf{P_r}$ is an $n-1$ dimensional row vector with element $\partial Q_i^* \big/ \partial P_{j,r}$ and $\partial \mathbf{P_r} \big/ \partial P_i$ is an $n-1$ dimensional column vector with element $\partial P_{j,r} \big/ \partial P_i$. The latter is the conjectural variation in prices. Similarly, $\partial Q_i^* \big/ \partial \mathbf{A_r}$ in equation (13) is a vector with element $\partial Q_i \big/ \partial A_{j,r}$ and $\partial \mathbf{A_r} \big/ \partial A_i$ is a vector with element $\partial A_{j,r} \big/ \partial A_i$.

IV. The Demand and Supply-side Model for Cigarettes

We use a BL/HP model where the representative individual's consumption of a firm's brands adjusts in a manner such that

$$q_{i,t} - q_{i,t-1} = \mu\left(q^*_{i,t} - q_{i,t-1}\right) \tag{20}$$

where $q_{i,t}$ is the individual's quantity demanded for cigarettes in time *t*, $q^*_{i,t}$ is the desired per capita consumption at time *t*, and μ is the adjustment coefficient. Let $P^R_{i,t}$ denote the retail price of firm *i*'s cigarettes at time *t* and $\mathbf{P}^R_{\mathbf{r},t}$ denote the vector of the rivals' retail prices with element $P^R_{j,r,t}$. We assume that $\partial q^*_{i,t} \big/ \partial P^R_{j,r,t} \geq 0$ and $\partial q^*_{i,t} \big/ \partial A_{j,r,t} \leq 0$ for all $j \neq i$. Furthermore, we denote policy interventions that affect the individual's demand at time t by binary variables in a vector $\mathbf{D}_t$. Then the representative individual's desired level of consumption at time t can be specified as

$$q^*_{i,t} = \alpha_0 + \boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \alpha_1 P^R_{i,t} + \alpha_2 \mathbf{i}\mathbf{P}^R_{\mathbf{r},t} + \alpha_3 A_{i,t} + \alpha_4 \mathbf{i}\mathbf{A}_{\mathbf{r},t} + \alpha_5 P^R_{i,t} A_{i,t} + \alpha_6 \left(\mathbf{P}^R_{\mathbf{r},t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t} + \alpha_7 y_{i,t} \quad (21)$$

where $A_{i,t}$ in equation (21) is per capita advertising messages, $\mathbf{i}$ is a five-dimensional unit row vector, $\mathbf{P}^R_{\mathbf{r},t}$ and $\mathbf{A}_{\mathbf{r},t}$ are five-dimensional column vectors,[13] $y_{i,t}$ is the individual's disposable income, and T is the transpose operator. Substituting equation (21) in equation (20) and rearranging terms, we get

$$q_{i,t} = \mu\alpha_0 + \mu\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \mu\alpha_1 P^R_{i,t} + \mu\alpha_2 \mathbf{i}\mathbf{P}^R_{\mathbf{r},t} + \mu\alpha_3 A_{i,t} + \mu\alpha_4 \mathbf{i}\mathbf{A}_{\mathbf{r},t} + \mu\alpha_5 P^R_{i,t} A_{i,t}$$
$$+ \mu\alpha_6 \left(\mathbf{P}^R_{\mathbf{r},t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1}.$$

Then the market demand for the ith firm's cigarettes is

$$Q_{i,t} \equiv N_{i,t} q_{i,t} = \Big[\mu\alpha_0 + \mu\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \mu\alpha_1 P^R_{i,t} + \mu\alpha_2 \mathbf{i}\mathbf{P}^R_{\mathbf{r},t} + \mu\alpha_3 A_{i,t} + \mu\alpha_4 \mathbf{i}\mathbf{A}_{\mathbf{r},t}$$
$$+ \mu\alpha_5 P^R_{i,t} A_{i,t} + \mu\alpha_6 \left(\mathbf{P}^R_{\mathbf{r},t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1}\Big] N_{i,t} \quad (22)$$

where $N_{i,t}$ is the number of firm i's customers among the smoking-age population (16 years of age and older), $Q_{i,t}$ is total consumption of the firm's cigarettes in time t, and $y_{i,t}$ is per capita disposable income.

The demand function (22) has retail prices, which equals the sum of wholesale price, taxes and markups. To insert wholesale prices into demand, we separate the retail prices into two components, so

$$P^R_{i,t} = P_{i,t} + E_{i,t} \qquad \text{and} \qquad \mathbf{P}^R_{\mathbf{r},t} = \mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t} \quad (23)$$

where $P_{i,t}$ is the wholesale price of the firm i's cigarettes, $\mathbf{P}_{\mathbf{r},t}$ is a vector of the rivals' prices, $E_{i,t}$ is taxes plus markups on the firm's brands, and $\mathbf{E}_{\mathbf{r},t}$ is a vector of markups of the rivals' brands.[14]

Our data span the period 1955-1985. Over this period, there were four major policy interventions in cigarettes: the 1964 Surgeon General's report, the 1965 Cigarette Labeling and Advertising Act (effective beginning in 1966), the 1968 Fairness Doctrine (effective between 1968-70, allowing one free broadcast antismoking announcement for approximately every three paid cigarette ads), and the 1971 broadcast advertising ban on advertising (which rendered the Fairness Doctrine ineffective). The Cigarette Labeling

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[13] Thus $\alpha_2 \mathbf{i}\mathbf{P}^R_{\mathbf{r},t} = \alpha_2 P^R_{1,r,t} + \alpha_2 P^R_{2,r,t} + \ldots + \alpha_2 P^R_{5,r,t}$ (so the effect of changes in rivals prices are equal) and $\mathbf{i}\mathbf{A}_{\mathbf{r},t}$ can be interpreted as total advertising of the rivals.

[14] The model of the last section did not distinguish between wholesale price and retail price, so the demand of the last section can be interpreted as derived demand to the firm. Nevertheless, the results of the last section fall through precisely into the econometric model.

and Advertising Act reinforced the 1964 Surgeon General's report, so we do not include this Act as a separate policy intervention. Thus we employ the following binary variables: $D_{64} = 1$ for years 1964−1985, $D_{68} = 1$ for years 1968−1971, 0 otherwise; and $D_{71} = 1$ for years 1971−1985, 0 otherwise. The 1964 Surgeon General's report is assumed to shift the demand curve. Similarly, the 1968 Fairness Doctrine, by allowing antismoking commercials, could also shift the demand curve,[15] as could the 1971 advertising ban. Assuming all policy interventions are effective, we specify

$$\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} = \alpha_{D,64} D_{64} + \alpha_{D,68} D_{68} + \alpha_{D,71} D_{71} .$$

Substituting equations (23) into the demand function (22), we get

$$\begin{aligned} Q_{i,t} \equiv N_{i,t} q_{i,t} = \Big[& \mu\alpha_0 + \mu\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \mu\alpha_1 \left(P_{i,t} + E_{i,t}\right) + \mu\alpha_2 \mathbf{i}\left(\mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t}\right) + \mu\alpha_3 A_{i,t} + \mu\alpha_4 \mathbf{i}\mathbf{A}_{\mathbf{r},t} \\ & + \mu\alpha_5 \left(P_{i,t} + E_{i,t}\right) A_{i,t} + \mu\alpha_6 \left(\mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} \Big] N_{i,t} \end{aligned} \tag{24}$$

From equation (24), we see that

$$\begin{aligned} dQ_{i,t} / dP_{i,t} &= N_{i,t} \left(\partial q_{i,t} / \partial P_{i,t}\right) \\ &= \mu\Big[\alpha_1 + \alpha_2 \mathbf{i}\left(\partial \mathbf{P}_{\mathbf{r},t} / \partial P_{i,t}\right) + \alpha_5 A_{i,t} + \alpha_6 \left(\partial \mathbf{P}_{\mathbf{r},t} / \partial P_{i,t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t}\Big] N_{i,t} . \end{aligned} \tag{25}$$

During the period of our sample, firms tended to change prices at the same time and to price identically. Let $P_{j,r,t}$ be an element of $\mathbf{P}_{\mathbf{r},t}$; then $\mathbf{i}\left(\mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t}\right) = 5\left(P_{j,r,t} + E_{i,t}\right)$ where $P_{j,r,t} = P_{i,t} \; \forall \; j$. Furthermore, if firms anticipated identical changes in the rivals' prices, we have $\partial P_{j,r,t} / \partial P_{i,t} = 1$ as the conjectural variation in prices, so $\partial \mathbf{P}_{\mathbf{r},t} / \partial P_{i,t}$ is a five-dimensional unit vector. Defining total rivals' advertising as $A_{R,t} \equiv \mathbf{i}\mathbf{A}_{\mathbf{r},t} = \sum_{j \neq 1}^{6} A_{j,t}$ we can then rewrite equations (24) and (25) as

$$\begin{aligned} Q_{i,t} \equiv N_{i,t} q_{i,t} = \Big[& \mu\alpha_0 + \mu\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \mu\alpha_1 \left(P_{i,t} + E_{i,t}\right) + \mu\alpha_2 \mathbf{i}\left(\mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t}\right) + \mu\alpha_3 A_{i,t} + \mu\alpha_4 \mathbf{i}\mathbf{A}_{\mathbf{r},t} \\ & + \mu\alpha_5 \left(P_{i,t} + E_{i,t}\right) A_{i,t} + \mu\alpha_6 \left(\mathbf{P}_{\mathbf{r},t} + \mathbf{E}_{\mathbf{r},t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} \Big] N_{i,t} \\ = \Big[& \mu\alpha_0 + \mu\boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + \left(\mu\alpha_1 + 5\mu\alpha_2\right)\left(P_{i,t} + E_{i,t}\right) + \mu\alpha_3 A_{i,t} + \mu\alpha_4 A_{R,t} \\ & + \mu\alpha_5 \left(P_{i,t} + E_{i,t}\right) A_{i,t} + \mu\alpha_6 \left(P_{i,t} + E_{i,t}\right) A_{R,t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} \Big] N_{i,t} \end{aligned} \tag{26}$$

and $$dQ_{i,t} / dP_{i,t} = N_{i,t} \left(dq_{i,t} / dP_{i,t}\right) = \mu\Big[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 \left(\partial \mathbf{P}_{\mathbf{r},t} / \partial P_{i,t}\right)^{\mathrm{T}} \mathbf{A}_{\mathbf{r},t}\Big] N_{i,t}$$

[15] If we had data on how many antismoking commercials there were, we could incorporate this as a separate variable; but we lack such data.

$$= \mu\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 A_{R,t}\right] N_{i,t}. \tag{27}$$

In determining the price function, we employ a generalized Leontief cost function (Diewert, 1971) instead of the linear function specified in the original Bresnahan model. Allowing for diseconomies of scale, we specify the cost function as

$$C_{i,t} = \left(\omega_1 W_{i,t} + \omega_2 R_{i,t} + \omega_3 \sqrt{W_{i,t} R_{i,t}}\right) Q_{i,t}^2,$$

so $$MC_{i,t} = \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) Q_{i,t} = \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t}$$

where $\beta_i = 2\omega_i$, i = 1, 2, 3.

Because $dQ_{i,t} / dP_{i,t} = \mu\left(dQ_{i,t}^* / dP_{i,t}\right)$ and allowing for policy interventions to affect market power, we can rewrite the dynamic Bresnahan optimal price equation as

$$P_{i,t} - \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right]\left[\frac{N_{i,t+1} q_{i,t+1}}{\mu(1+\rho_i)\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t+1} + \alpha_6 A_{R,t+1}\right] N_{i,t+1}} - \frac{(1+\mu) N_{i,t} q_{i,t}}{\mu\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 A_{R,t}\right] N_{i,t}}\right]$$

$$= P_{i,t} - \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right]\left[\frac{q_{i,t+1}}{\mu(1+\rho_i)\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t+1} + \alpha_6 A_{R,t+1}\right]} - \frac{(1+\mu) q_{i,t}}{\mu\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 A_{R,t}\right]}\right]$$

$$= \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_2 \sqrt{W_{i,t} R_{i,t}}\right) Q_{i,t} = \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_2 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t} = MC_{i,t} \tag{28}$$

where $\mathbf{C}_t = \begin{pmatrix} D_{68} & D_{71} \end{pmatrix}$ is a vector of policy intervention binary variables that potentially affect λ; T is the transpose operator, $\boldsymbol{\alpha}_\lambda = \begin{pmatrix} \alpha_{\lambda,68} & \alpha_{\lambda,71} \end{pmatrix}$ is a vector of coefficients associated with policy interventions; where an element may be zero if a particular policy intervention does not affect market power; $W_{i,t}$ is the wage rate; and $R_{i,t}$ is the cost of tobacco. Rearranging the last equation, we get

$$P_{i,t} = \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t} + \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right] \times \left[\frac{q_{i,t+1}}{\mu(1+\rho_i)\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t+1} + \alpha_6 A_{R,t+1}\right]} - \frac{(1+\mu) q_{i,t}}{\mu\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 A_{R,t}\right]}\right] \tag{29}$$

Now we turn to the advertising equation. Assuming that firm *i* believes that, in response to changes in its own advertising, its rivals will adjust their advertising to maintain previous advertising ratios among firms, $dA_{R,t} / dA_{i,t} = \Sigma_{j \neq i}^{6} A_{j,t} \big/ A_{i,t} \equiv \Upsilon_i$.[16] From equation (26), we see that

$$dQ_{i,t} / dA_{i,t} = N_{i,t} \left(dq_{i,t} / dA_{i,t} \right)$$

$$= \mu \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \left(dA_{R,t} / dA_{i,t} \right) \right\} N_{i,t}$$

$$= \mu \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \Upsilon_i \right\} N_{i,t} .$$

Noting that $dQ_{i,t} / dA_{X,t} = \mu \left(dQ^{*}_{i,t} / dA_{X,t} \right)$ for *X* = *i* or *R* (for rival), equation (19) becomes

$$P_{i,t} - \left(\partial C_{i,t} / \partial Q_{i,t} \right) = \frac{-M_{i,t+1}}{\mu \left(1 + \rho_i \right) \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t+1} + E_{i,t+1} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t+1} + E_{i,t+1} \right) \right] \Upsilon_i \right\} N_{i,t+1}}$$

$$+ \frac{\left(1 + \mu \right) M_{i,t}}{\mu \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \Upsilon_i \right\} N_{i,t}} .$$

Thus the firm will set

$$\frac{\left(1 + \mu \right) M_{i,t}}{\mu \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \Upsilon_i \right\} N_{i,t}}$$

$$= P_{i,t} - \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}} \right) N_{i,t} q_{i,t}$$

$$+ \frac{M_{i,t+1}}{\mu \left(1 + \rho_i \right) \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t+1} + E_{i,t+1} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t+1} + E_{i,t+1} \right) \right] \Upsilon_i \right\} N_{i,t+1}}$$

$$\Rightarrow M_{i,t} = \left[P_{i,t} - \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}} \right) N_{i,t} q_{i,t} \right] \times$$

$$\frac{\left\{ \mu \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \Upsilon_i \right\} N_{i,t} \right\}}{1 + \mu}$$

$$+ \frac{M_{i,t+1} \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t} + E_{i,t} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t} + E_{i,t} \right) \right] \Upsilon_i \right\} N_{i,t}}{\left(1 + \rho_i \right) \left(1 + \mu \right) \left\{ \left[\alpha_3 + \alpha_5 \left(P_{i,t+1} + E_{i,t+1} \right) \right] + \left[\alpha_4 + \alpha_6 \left(P_{i,t+1} + E_{i,t+1} \right) \right] \Upsilon_i \right\} N_{i,t+1}} . \qquad (30)$$

---

[16] To see this result, note that if $A_i / A_r = \left(A_i + dA_i \right) / \left(A_r + dA_r \right) \Rightarrow A_i \left(A_r + dA_r \right) = A_r \left(A_i + dA_i \right)$
$\Rightarrow A_i dA_r = A_r dA_i \Rightarrow dA_r / dA_i = A_r / A_i$

V. Specification of the Regression Equations

We will estimate regression equations using results obtained in the last section. The demand function for the representative firm is equation (26). We get the per capita consumer demand function for the representative firm dividing equation (26) by $N_{i,t}$, the firm's potential market, where we assume that its potential market is 1/6 of the smoking age population, N_t, so that $N_{i,t} = (N_t/6)$. We set $\delta_1 = \alpha_1 + 5\alpha_2$ because we are not able to identify the coefficients α_1 and α_2 in the subsequent regressions, but this is not necessary. The firm should take into account its rivals actions and perceive the demand function as we specify it below. For the representative firm, $A_{i,t} = A_{T,t}/6$ where $A_{T,t}$ is total industry advertising in time t and, given five rivals each with average expenditure $A_{T,t}/6$, we set $A_{R,t} = (5/6)A_{T,t}$. Due to identification problems, we set $\delta_2 = \alpha_3 + 5\alpha_4$ and $\delta_3 = \alpha_5 + 5\alpha_6$. Then, adding an error term $\varepsilon_{q,i,t}$, we obtain

$$
\begin{aligned}
q_{i,t} &= \mu\alpha_0 + \boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + (\mu\delta_1)(P_{i,t} + E_{i,t}) + \mu\alpha_3 A_{i,t} + \mu\alpha_4 A_{R,t} \\
&\quad + \mu\alpha_5 (P_{i,t} + E_{i,t}) A_{i,t} + \mu\alpha_6 (P_{i,t} + E_{i,t}) A_{R,t} + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} + \varepsilon_{q,i,t} \\
&= \mu\alpha_0 + \boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + (\mu\delta_1)(P_{i,t} + E_{i,t}) + \mu(\alpha_3 + 5\alpha_4)(A_{T,t}/6) \\
&\quad + \mu(\alpha_5 + 5\alpha_6)(P_{i,t} + E_{i,t})(A_{T,t}/6) + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} + \varepsilon_{q,i,t} \\
&= \mu\alpha_0 + \boldsymbol{\alpha}_D \mathbf{D}_t^{\mathrm{T}} + (\mu\delta_1)(P_{i,t} + E_{i,t}) + \mu\left[\delta_2 + \delta_3 (P_{i,t} + E_{i,t})\right](A_{T,t}/6) \\
&\quad + \mu\alpha_7 y_{i,t} + (1-\mu) q_{i,t-1} + \varepsilon_{q,i,t}\,. \qquad (31)
\end{aligned}
$$

The price function follows immediately from equation (29). We specify

$$
\begin{aligned}
P_{i,t} &= \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t} + \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right] \times \\
&\quad \left[\frac{q_{i,t+1}}{\mu(1+\rho_i)\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t+1} + \alpha_6 A_{R,t+1}\right]} - \frac{(1+\mu) q_{i,t}}{\mu\left[\alpha_1 + 5\alpha_2 + \alpha_5 A_{i,t} + \alpha_6 A_{R,t}\right]}\right] + \varepsilon_{P,i,t} \\
&= \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t} + \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right] \times \\
&\quad \left[\frac{q_{i,t+1}}{\mu(1+\rho_i)\left[\delta_1 + (\alpha_5 + 5\alpha_6)(A_{T,t+1}/6)\right]} - \frac{(1+\mu) q_{i,t}}{\mu\left[\delta_1 + (\alpha_5 + 5\alpha_6)(A_{T,t}/6)\right]}\right] + \varepsilon_{P,i,t} \\
&= \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t} + \left[\lambda + \boldsymbol{\alpha}_\lambda \mathbf{C}_t^{\mathrm{T}}\right] \times \\
&\quad \left[\frac{q_{i,t+1}}{\mu(1+\rho_i)\left[\delta_1 + \delta_3 (A_{T,t+1}/6)\right]} - \frac{(1+\mu) q_{i,t}}{\mu\left[\delta_1 + \delta_3 (A_{T,t}/6)\right]}\right] + \varepsilon_{P,i,t}\,. \qquad (32)
\end{aligned}
$$

Because $A_{T,t}/6$ and $A_{R,t} = (5/6)A_{T,t}$, the advertising conjectural variation is $\Upsilon_i \equiv dA_{R,t} / dA_{i,t} = A_{R,t}/A_{i,t} = \left[(5/6)\,A_{T,t}\right]/\left(A_{T,t}/6\right) = 5$. The advertising equation (30) becomes

$$M_{i,t} = \left[P_{i,t} - \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t}\right] \times \frac{\left\{\mu\left\{\left[\alpha_3 + \alpha_5\left(P_{i,t} + E_{i,t}\right)\right] + \left[\alpha_4 + \alpha_6\left(P_{i,t} + E_{i,t}\right)\right]5\right\} N_{i,t}\right\}}{1+\mu}$$

$$+ \frac{M_{i,t+1}\left\{\left[\alpha_3 + \alpha_5\left(P_{i,t} + E_{i,t}\right)\right] + \left[\alpha_4 + \alpha_6\left(P_{i,t} + E_{i,t}\right)\right]5\right\} N_{i,t}}{\left(1+\rho_i\right)\left(1+\mu\right)\left\{\left[\alpha_3 + \alpha_5\left(P_{i,t+1} + E_{i,t+1}\right)\right] + \left[\alpha_4 + \alpha_6\left(P_{i,t+1} + E_{i,t+1}\right)\right]5\right\} N_{i,t+1}} + \varepsilon_{A,i,t}$$

$$\Rightarrow M_{i,t} = \left[P_{i,t} - \left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t}\right] \left\{\frac{\mu\left[\delta_2 + \delta_3\left(P_{i,t} + E_{i,t}\right)\right] N_{i,t}}{1+\mu}\right\}$$

$$+ \frac{M_{i,t+1}\left[\delta_2 + \delta_3\left(P_{i,t} + E_{i,t}\right)\right] N_{i,t}}{\left(1+\rho_i\right)\left(1+\mu\right)\left[\delta_2 + \delta_3\left(P_{i,t+1} + E_{i,t+1}\right)\right] N_{i,t+1}} + \varepsilon_{A,i,t}\,. \qquad (33)$$

We suppose that the error terms are serially correlated so, for instance, $\varepsilon_{Y,i,t} = \rho_{Y,i}\varepsilon_{Y,i,t-1} + \eta_{Y,i,t}$, where $Y = q, P, A$; and $\eta_{Y,i,t}$ is a well-behaved error term. We include the precise lagged error term in the equation and estimate a serial correlation coefficient for each regression, then apply a *t* test to the serial correlation coefficient. If the serial correlation coefficient is statistically insignificant, the lagged error term can be omitted and the system can be reestimated. For instance, letting

$$M_{i,t} = \Psi_{i,t}\Phi_{i,t} + \Lambda_{i,t+1} + \varepsilon_{A,i,t}$$

where the subscripts indicate the period of the variables in the term, the advertising equation will be estimated as

$$M_{i,t} = \Psi_{i,t}\Phi_{i,t} + \Lambda_{i,t+1} + \rho_{A,i}\left[M_{i,t-1} - \left(\Psi_{i,t-1}\Phi_{i,t-1} + \Lambda_{i,t}\right)\right] + \eta_{A,i,t}\,,$$

where $\rho_{A,i}$ is the autocorrelation coefficient, and similarly for the other equations, with autocorrelation coefficients $\rho_{q,i.t}$ and $\rho_{P,i,t}$. Thus, the coefficients of the advertising equation and the serial correlation coefficient are estimated simultaneously.[17]

[17] We also considered a model with the square root of advertising, rather than advertising itself, in the demand function, as in Gasmi, Laffont, and Vuong (1992). In the demand and price equations, this merely required changing the advertising variables to square roots, but the advertising equation changed considerably. To our surprise, the statistical results were very similar to the results (reported below) from the model explicated above.

VI. Regression Results

Estimation was performed using nonlinear two-stage least squares using SAS Version 8.2 for Windows. The data are described in the Appendix. Because of the lags and leads, the first two years and the last year of our sample are excluded from the regressions due to missing data. Thus, the regressions cover the years 1952-1984.

In Table 1, we show the full model, Model 1, and a final model, Model 2. We explored the binary variables associated with the various policy interventions in both the consumption and price equations. D_{68} and D_{71} are extremely insignificant in the demand equation of Model 1 and are excluded from Model 2, while D_{64} is retained. In the price equation of Model 1, D_{68} is insignificant and is excluded from $\mathbf{C}_t$, leaving only D_{71} in $\mathbf{C}_t$ in Model 2. As one can see, the remaining estimated coefficients are stable between the two specifications. The autocorrelation coefficients are all well within the expected range of $(0,1)$ and all are significant at the 10 percent level or better in one-tailed tests.[18]

[Place Table 1 Here]

Because the coefficients are similar between the two models, we refer in the following to estimates from Model 2. In this model, the coefficient α_7, associated with income, is negative and significant.[19] The coefficient $\alpha_{D,64}$ associated with the binary variable D_{64} is negative, as expected, and significant at the five percent level. The HP/BL coefficient, μ, rounds to 0.55 and is significant at the one percent level. This suggests that the representative consumer can adjust his/her consumption by better than half of the desired adjustment within a year (see equation (7)).

Taken separately, the coefficient associated with price, δ_1, is negative and significant at the one percent level. However, to consider the full effect of price we must take the derivative of quantity with respect to price, and this will involve the coefficient associated with the price and advertising interaction term, δ_3, which is positive and insignificant in Model 2; but the sign of the derivative remains to be

---

[18] The one-tailed *t* test is uniformly most powerful, whereas the two-tailed test is not (Hogg, McKean, and Craig, 2005, pp. 425-35). Unless otherwise specified, one-tailed *t* tests will be used throughout the following.

[19] The negative coefficient may be explained by the nature of our model, which is based on per capita demand using aggregated data. In models of individual demand, cigarette consumption is often negatively related to income, while in aggregated market models the opposite is often found.

determined, and the derivative as a whole may be more significant than its components taken separately because it depends in part on the covariance between δ_1 and δ_3. In the short run, the derivative is

$$\partial q_{i,t} / \partial P_{i,t} = \mu\left[\delta_1 + \delta_3\left(A_{T,t}/6\right)\right]$$

and in the long run it is

$$\partial q_{i,t} / \partial P_{i,t} = \delta_1 + \delta_3\left(A_{T,t}/6\right).$$

The coefficient associated with advertising, δ_2, is positive and significant at the one percent level. Once again, we are interested in the derivatives. In the short run, the derivative is

$$\partial q_{i,t} / \partial A_{i,t} = \mu\left[\delta_2 + \delta_3 P_{i,t}\right]$$

and in the long run it is

$$\partial q_{i,t} / \partial A_{i,t} = \delta_2 + \delta_3 P_{i,t}.$$

These derivatives for the short run and long run are shown in Tables 2A and 2B for each year of the effective sample, 1952-1984, that was included in the regression equation. Both the price and advertising derivatives are significant at the one percent level in all years for the short and long run, and have the expected signs: the price derivatives are negative and the advertising derivatives are positive.[20] The resulting price and advertising elasticities of demand are found in Table 3. The elasticities are very small; the price elasticities are smaller than Baltagi and Levin (1986), where the short-run price elasticity was calculated as −0.20. Our short-run (resp. long-run) price elasticities range from −0.023 to −0.060 (resp. −0.042 to −0.108), which our short-run (resp. long-run) advertising elasticities range from 1.63×10^{-12} to 3.85×10^{-12} (resp. 2.96×10^{-12} to 6.98×10^{-12}). This suggests that we might expect nontrivial market power, in contrast to the conclusions of previous research. These elasticities are certainly much lower in absolute value than that found by Sumner (1981), who found a price elasticity of −13.5, the highest reported elasticity of which we are aware.

[Place Table 2 Here]

[Place Table 3 Here]

Before continuing our discussion of the coefficients, we consider what part advertising plays in terms of the demand function in price-quantity space. The positive sign of δ_2, the coefficient associated with advertising, means that if advertising increases, *ceteris paribus*, then the demand intercept increases, shifting the demand function outward, as we would expect. The positive sign of δ_3, the coefficient

[20] The derivatives are small, but this can be attributed to units. For instance, the price derivative is the change in thousands of cigarettes per dollar increase price.

associated with the interaction between advertising and price, suggests that as advertising increases, *ceteris paribus*, the slope of the demand function decreases in absolute value, making demand more inelastic, as we might expect. Thus, the demand function shifts from D_1 to D_2 in Figure 1, precisely as one might expect.[21]

[Place Figure 1 Here]

The coefficients β_1, β_2, and β_3, associated with the wage rate, the price of tobacco, and the square root of the product of wage and tobacco price in the marginal cost function, all have the expected signs and are significant at the one percent level. The marginal cost is $\left(\beta_1 W_{i,t} + \beta_2 R_{i,t} + \beta_3 \sqrt{W_{i,t} R_{i,t}}\right) N_{i,t} q_{i,t}$. As shown in Table 4, the marginal cost is positive in all years. In the earlier years, until 1961, it is insignificant, but the significance of the individual coefficients, as shown in Table 1, and the significance of marginal cost in later years, as shown in Table 4, are reassuring.[22] Also, and as one would expect, it is less than wholesale price, which is also included in Table 4 for comparison purposes.

[Place Table 4 Here]

The main point of this paper is the effect of the broadcast advertising ban on market power. Before the ban, in the years 1952-1970 inclusive, the index λ is 0.05 and significant at the one percent level. After the ban, from 1971 through 1984, $\lambda + \alpha_{\lambda,71} = 0.03$ and is significant at the one percent level. This indicates that the broadcast advertising ban actually reduced the market power, in terms of the price-cost margin of cigarette companies, in contrast to the findings of, *inter alia*, Eckard (1991) and Gallet (1999).

The Bresnahan indices estimated here are small relative to the maximum possible level of unity. It is instructive to also consider the Lerner index because the Bresnahan index does not increase at the same rate as the Lerner index as market power increases.[23, 24] Over the periods 1952-1970 and 1971-1984, the

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[21] The authors apologize for Alfred Marshall, who inverted the axes for the dependent and independent variables from the usual mathematical practice.

[22] The marginal cost is significant between the one percent to the 10 percent level for 24 of the 36 years.

[23] Recall that, using the Bresnahan index, we can write the Lerner index as $(P - MC)/P = \lambda / |\eta_P|$, where η_P is the price elasticity of demand. So long as η_P is not constant, the rate of increase will differ between the two.

[24] Pyndick (1985) is concerned with the estimation of market power that "reflects the trajectory of monopoly power over time, weighted by the firm's revenues (and consumer expenditures" (p.195). For the purposes of this paper, we are concerned only with the extent to which firms were able to raise price above marginal cost. In fact, our use of the Lerner index is justified by Pyndick. He states (p. 213), that in contrast to some situations where the estimation of true market power can be complex, "The fact that

average Lerner indices, based on wholesale price and estimated marginal cost, are 0.88 and 0.59. Our estimated demand function is relatively price inelastic compared to the estimates of other studies. The small absolute values of the price elasticity of demand (see Table 3) tend to increase the value of the Lerner Index relative to what they could have been with more elastic demand.

The Bresnahan and Lerner indices suggest a spread between price and marginal manufacturing cost, hence between price and average cost of production.[25] This allows the firms to make a profit over their manufacturing cost that affords them the latitude to engage in advertising. On the other hand, firms would welcome the opportunity to reduce advertising expenditures if they could be assured that their rivals would do likewise; thereby escaping the prisoners' dilemma of advertising. The broadcast advertising ban provided this assurance. The decrease in advertising expenditures that accompanied the ban would have the effect of shifting demand inward and rotating it similar to a movement from D_2 to D_1 in Figure 1.[26] Then, with more elastic demand, the Bresnahan and Lerner indices would fall relative to what they would have been without the ban.[27] At the same time, however, and despite the lower price-manufacturing cost margins in the latter period, the firms could make a larger profit once the costly broadcast advertising media were abandoned. Although the price-cost margin fell, the ban spared the firms marketing expenditures, with the likely effect of increasing the profit of the manufacturers, as suggested by Mitchell and Mulherin (1988).[28]

VII. Conclusion

In this paper, we estimate the magnitude of market power among cigarette firms over the period 1952-1984, a period when cigarette firms priced at the same levels, and marketed their products in similar packages. We employ a dynamic analog to the Bresnahan (1982) model at the firm level with a third equation to take into consideration optimal advertising. We are particularly interested in the effect of advertising policy on market power. We find that the 1971 advertising ban effectively decreased market power, in contrast to some previous findings.

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demand is dynamic will not by itself cause the standard Lerner index to be biased as an instantaneous measure of [market] power."

[25] Given the form of our cost function and the fact that marginal cost increases with quantity, average cost will be ½ of marginal cost.

[26] Our measure of advertising messages in the industry as a whole fell 22.39 percent from 1970 to 1971.

[27] The short-run price elasticity of demand over the period 1952-1970 was −0.0336 while over the period 1971-1984 was −0.0372, so the average elasticity increased in absolute value by 10.7 percent. The long-run price elasticity changed over these periods from −0.061 to −0.068, an increase of 11.5 percent.

[28] More recently, Lamdin (1999) calls into question the conclusions of Mitchell and Muherin.

Previous research, reviewed in the introduction, has investigated market power among cigarette firms and has concluded that market power is not great. For instance, Sullivan (1985) and Ashenfelter and Sullivan (1987) find a moderate level of competition; while Sumner (1981) finds very high competition. Sumner suggests that firm demand functions are very elastic. None of these studies estimated indices of market power as we do.

In our effort to estimate indices of market power, we derive results that are quite different from these studies. Our results are more in line with the former articles rather than the latter. We find Bresnahan indices of 0.05 over the period 1952 through 1970 and 0.03 over the period from 1971 through 1984, and average Lerner indexes of 0.88 and 0.59 over these same periods. However, the stark contrast between our results and Sumner's deserve further comment. Sumner attempted a simple model that did not require measurement of marginal cost, and such a model could indeed be useful. However, such a simple model may result in estimates that differ widely from more conventional models. On the other hand, our model is more complex than previous models. Because of the complexity and the attendant necessity of imposing specific assumptions, our model may also result in estimates that differ from more conventional models. As always, it is left to the reader to decide if our assumptions are reasonable.

Appendix: Data

In this appendix, we describe the data, their sources, counting units, and how certain of the data were constructed. Descriptive statistics are found in Table A1.

[Place Table A1 Here]

Total cigarette consumption is from Maxwell (1986). Then cigarette consumption per capita ($q_{i,t}$, in thousands of cigarettes) is constructed by dividing the total consumption for cigarettes (in thousands) by the population 16 years and above, which we define as the smoking age population. Population 16 years and over (N_t) is constructed using data from *Historical Statistics of the United States, Colonial Times to 1970* and *The Economic Report of the President (1997)*.

Wholesale prices ($P_{i,t}$) per thousand (excluding taxes, in dollar units) are from various issues of *Tobacco Situation and Outlook Report*, which reports prices for king size, standard, filter tip and 100 mm cigarettes at given points in time as the prices changed. For a point in time, we calculate a simple average of the wholesale prices for the various types of cigarettes. Then to calculate the price over a year if prices changed during the year, we use a weighted average where the weight is the number of months during which a price is in effect divided by 12. This price is then deflated by the 1982-based all-commodities PPI.

For the years 1954-85, the markup ($E_{i,t}$) is calculated from the difference between the retail prices ($P_{i,t}^R$, described below) and the wholesale prices ($P_{i,t}$). For the years 1950-53, the markup is backcasted. The markup is deflated by the 1982-based all-commodities PPI.

For the years 1954-85, retail price ($P_{i,t}^R$) per thousand cigarettes are constructed from the 1993 issue of The Tobacco Institute's *The Tax Burden on Tobacco 1993*. This reports annual average retail price per pack, and we multiply this by 50 packs (20 cigarettes per pack) to get the retail price of a thousand cigarettes, tax included, in dollar units, which is then deflated by the 1982-based CPI from *The Economic Report of the President*. For the years 1950-53, the real retail price is obtained as the sum of the real wholesale price and the real markup.

Total disposable income is from the 1997 *Economic Report of the President*. This was then divided by the total population, not just population 16 years and over, because individuals less than 16 years of age account for a share of total disposable income, to obtain per capita disposable income ($y_{i,t}$) in nominal dollars. $y_{i,t}$ is deflated by the 1982-based CPI from *The Economic Report of the President (1997)*.

Tobacco prices ($R_{i,t}$) are from various issues of the U.S. Department of Agriculture's *Tobacco Situation and Output Report*. Wages ($W_{i,t}$) are an index of average hourly earnings data of production workers in the cigarette industry obtained from the *Bureau of Labor Statistics*. Both the tobacco prices and the wages are deflated by the 1982-based PPI.

The long-term discount rate, ρ_i, is taken for the period 1950-85, which includes the years used in our final regressions. We first obtain the mean in any given year of the real cost of capital for all of the five publicly held U.S. cigarette manufacturers as the ratio of dividends plus interest to the value of outstanding stocks and bonds, as suggested in Jorgenson and Stephenson (1967). We use data from *Moody's Industrial Manual* and firm's corporate reports. Data for Brown and Williamson are not available. Then we calculate the geometric average over the entire period of the yearly cost of capital to obtain the discount rate.

The advertising series (messages and cost of a message) are constructed from several sources. First, total advertising expenditures by cigarette firms for 1963-85 are from the Federal Trade Commission (2003). To make the data for 1974-85 comparable to earlier years, we subtract point-of-sales, promotional allowances, sampling distribution, public entertainment, and specialty item distribution expenses from the reported totals. For 1950-62, the FTC data are backcast using percentage changes in advertising from Schmalensee (1972). Second, an index of advertising cost for the years 1960-85 is obtained from data provided by *McCann-Erickson, Inc*., of New York (personal correspondence) and from Schmalensee (1972). We use the McCann-Erickson cost per thousand person audience for the years 1960-85. For years after 1970, when the broadcast advertising ban was in effect, we construct a Divisia index using the indices for various media excluding the broadcast media. For 1950-59, the McCann-Erickson data are backcast using percentage changes in the cost per million person index from Schmalensee.

Finally, we use this data to construct the series of advertising messages in the following manner. The number of advertising messages ($A_{i,t}$) is constructed by dividing nominal advertising expenditures (the total cost of all messages sent by cigarette firms) by an index of advertising cost per thousand messages. Because we employ the percentage form of this advertising index, the index can be interpreted as the cost of the number of messages that $100 would buy in the base year, 1982, where those messages (or fraction thereof) would reach an audience of 1,000. The counting units of advertising messages are unknown, but are consistent. Dividing this into the number of advertising messages gives us the quantity of messages in the units implicitly specified by dividing the 1982 expenditures by 100. Because the cost index tracks nominal costs, we then deflated the index by the all commodities producer price index to yield our cost-of-advertising variable ($M_{i,t}$).

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Table I. Non-linear 2SLS estimates of cigarette demand, advertising, and price coefficients

Coefficients	Model I	Model II
α_0	5.469***	5.400***
	(0.3657)	(0.335)
$\alpha_{D,64}$	−0.145**	−0.149**
	(0.085)	(0.084)
$\alpha_{D,68}$	−0.045	−
	(0.080)	(−)
$\alpha_{D,71}$	0.045	−
	(0.119)	(−)
δ_1	−0.015***	−0.015***
	(0.005)	(0.005)
δ_2	4.18×10^{-7}***	4.18×10^{-7}***
	(7.50×10^{-8})	(7.50×10^{-8})
δ_3	8.21×10^{-10}	8.03×10^{-10}
	(1.01×10^{-9})	(1.02×10^{-9})
α_7	-1.30×10^{-4}***	-1.20×10^{-4}***
	(5.80×10^{-5})	(5.50×10^{-4})
μ	0.548***	0.552***
	(0.139)	(0.141)
β_1	7.39×10^{-8}***	7.45×10^{-8}***
	(1.66×10^{-8})	(1.64×10^{-8})
β_2	2.50×10^{-7}***	2.55×10^{-7}***
	(1.00×10^{-7})	(9.84×10^{-8})
β_3	-2.66×10^{-7}***	-2.70×10^{-7}***
	(7.97×10^{-8})	(7.85×10^{-8})
λ	0.048***	0.047***
	(0.015)	(0.015)
$\alpha_{\lambda,68}$	−0.004	−
	(0.004)	(−)
$\alpha_{\lambda,71}$	−0.014***	−0.013***
	(0.006)	(0.005)
$\rho_{q,i.t}$	0.778***	0.776***
	(0.078)	(0.080)
$\rho_{P,i,t}$	0.450***	0.442***
	(0.171)	0.169)
$\rho_{M,i,t}$	0.125*	0.126*
	(0.095)	(0.095)

Note: The standard errors are given in parentheses
***Significant at 1% level
**Significant at 5% level
*Significant at 10% level
Significance levels are based on one-tailed *t*-tests

Table IIA. Short run 1952-1984

First derivatives of quantity with respect to price and advertising

Year	Price	Advertising	Year	Price	Advertising
1952	−0.008	2.48×10^{-7}	1969	−0.008	2.56×10^{-7}
	(0.001)	(5.90×10^{-8})		(0.001)	(5.81×10^{-8})
1953	−0.008	2.47×10^{-7}	1970	−0.008	2.56×10^{-7}
	(0.001)	(5.93×10^{-8})		(0.001)	(5.81×10^{-8})
1954	−0.008	2.50×10^{-7}	1971	−0.008	2.56×10^{-7}
	(0.001)	(5.86×10^{-8})		(0.001)	(5.81×10^{-8})
1955	−0.008	2.51×10^{-7}	1972	−0.008	2.55×10^{-7}
	(0.001)	(5.85×10^{-8})		(0.001)	(5.81×10^{-8})
1956	−0.008	2.51×10^{-7}	1973	−0.008	2.55×10^{-7}
	(0.001)	(5.85×10^{-8})		(0.001)	(5.81×10^{-8})
1957	−0.008	2.52×10^{-7}	1974	−0.008	2.54×10^{-7}
	(0.001)	(5.84×10^{-8})		(0.001)	(5.82×10^{-8})
1958	−0.008	2.52×10^{-7}	1975	−0.008	2.53×10^{-7}
	(0.001)	(5.84×10^{-8})		(0.001)	(5.82×10^{-8})
1959	−0.008	2.52×10^{-7}	1976	−0.008	2.53×10^{-7}
	(0.001)	(5.84×10^{-8})		(0.001)	(5.83×10^{-8})
1960	−0.008	2.52×10^{-7}	1977	−0.008	2.53×10^{-7}
	(0.001)	(5.84×10^{-8})		(0.001)	(5.82×10^{-8})
1961	−0.008	2.52×10^{-7}	1978	−0.008	2.53×10^{-7}
	(0.001)	(5.83×10^{-8})		(0.001)	(5.83×10^{-8})
1962	−0.008	2.52×10^{-7}	1979	−0.008	2.52×10^{-7}
	(0.001)	(5.85×10^{-8})		(0.001)	(5.84×10^{-8})
1963	−0.008	2.53×10^{-7}	1980	−0.008	2.50×10^{-7}
	(0.001)	(5.83×10^{-8})		(0.001)	(5.87×10^{-8})
1964	−0.008	2.53×10^{-7}	1981	−0.008	2.50×10^{-7}
	(0.001)	(5.83×10^{-8})		(0.001)	(5.87×10^{-8})
1965	−0.008	2.54×10^{-7}	1982	−0.008	2.52×10^{-7}
	(0.001)	(5.82×10^{-8})		(0.001)	(5.83×10^{-8})
1966	−0.008	2.54×10^{-7}	1983	−0.008	2.57×10^{-7}
	(0.001)	(5.82×10^{-8})		(0.001)	(5.80×10^{-8})
1967	−0.008	2.54×10^{-7}	1984	−0.008	2.57×10^{-7}
	(0.001)	(5.81×10^{-8})		(0.001)	(5.81×10^{-8})
1968	−0.008	2.54×10^{-7}			
	(0.001)	(5.82×10^{-8})			

Note: The standard errors are given in parentheses. All the estimates are statistically significant at the 1% level.

Table IIB. Long Run 1952-1984

First derivatives of quantity with respect to price and advertising

Year	Price	Advertising	Year	Price	Advertising
1952	−0.015	4.50×10^{-7}	1969	−0.015	4.64×10^{-7}
	(0.005)	(5.57×10^{-8})		(0.005)	(5.52×10^{-8})
1953	−0.015	4.49×10^{-7}	1970	−0.015	4.64×10^{-7}
	(0.005)	(5.61×10^{-8})		(0.005)	(5.52×10^{-8})
1954	−0.015	4.54×10^{-7}	1971	−0.015	4.64×10^{-7}
	(0.005)	(5.50×10^{-8})		(0.005)	(5.51×10^{-8})
1955	−0.015	4.55×10^{-7}	1972	−0.015	4.63×10^{-7}
	(0.005)	(5.49×10^{-8})		(0.005)	(5.50×10^{-8})
1956	−0.015	4.55×10^{-7}	1973	−0.015	4.61×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.49×10^{-8})
1957	−0.015	4.56×10^{-7}	1974	−0.015	4.60×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.47×10^{-8})
1958	−0.015	4.56×10^{-7}	1975	−0.015	4.59×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.47×10^{-8})
1959	−0.015	4.57×10^{-7}	1976	−0.015	4.58×10^{-7}
	(0.005)	(5.47×10^{-8})		(0.005)	(5.47×10^{-8})
1960	−0.015	4.56×10^{-7}	1977	−0.015	4.59×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.47×10^{-8})
1961	−0.015	4.57×10^{-7}	1978	−0.015	4.58×10^{-7}
	(0.005)	(5.47×10^{-8})		(0.005)	(5.47×10^{-8})
1962	−0.015	4.57×10^{-7}	1979	−0.015	4.56×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.48×10^{-8})
1963	−0.015	4.58×10^{-7}	1980	−0.015	4.54×10^{-7}
	(0.005)	(5.47×10^{-8})		(0.005)	(5.50×10^{-8})
1964	−0.015	4.58×10^{-7}	1981	−0.015	4.54×10^{-7}
	(0.005)	(5.47×10^{-8})		(0.005)	(5.50×10^{-8})
1965	−0.015	4.61×10^{-7}	1982	−0.015	4.57×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.47×10^{-8})
1966	−0.015	4.60×10^{-7}	1983	−0.015	4.66×10^{-7}
	(0.005)	(5.47×10^{-8})		(0.005)	(5.56×10^{-8})
1967	−0.015	4.61×10^{-7}	1984	−0.015	4.66×10^{-7}
	(0.005)	(5.48×10^{-8})		(0.005)	(5.55×10^{-8})
1968	−0.015	4.60×10^{-7}			
	(0.005)	(5.48×10^{-8})			

Note: The standard errors are given in parentheses. All the estimates are statistically significant at the 1% level.

Table III. Elasticities of demand

	Price elasticities of demand (1952-1984)		Advertising elasticities of demand (1952-1984)	
Year	Short run	Long run	Short run	Long run
1952	−0.030	−0.054	2.84×10^{-12}	5.15×10^{-12}
1953	−0.023	−0.042	3.40×10^{-12}	6.17×10^{-12}
1954	−0.039	−0.071	3.85×10^{-12}	6.98×10^{-12}
1955	−0.039	−0.071	1.63×10^{-12}	2.96×10^{-12}
1956	−0.037	−0.067	1.89×10^{-12}	3.43×10^{-12}
1957	−0.036	−0.065	2.07×10^{-12}	3.76×10^{-12}
1958	−0.034	−0.062	2.31×10^{-12}	4.19×10^{-12}
1959	−0.033	−0.060	2.37×10^{-12}	4.29×10^{-12}
1960	−0.032	−0.058	2.17×10^{-12}	3.94×10^{-12}
1961	−0.032	−0.058	2.06×10^{-12}	3.74×10^{-12}
1962	−0.031	−0.057	2.11×10^{-12}	3.82×10^{-12}
1963	−0.032	−0.058	2.33×10^{-12}	4.22×10^{-12}
1964	−0.033	−0.061	2.46×10^{-12}	4.46×10^{-12}
1965	−0.032	−0.058	2.30×10^{-12}	4.17×10^{-12}
1966	−0.031	−0.056	2.58×10^{-12}	4.68×10^{-12}
1967	−0.034	−0.062	2.68×10^{-12}	4.85×10^{-12}
1968	−0.035	−0.063	2.58×10^{-12}	4.67×10^{-12}
1969	−0.037	−0.066	2.54×10^{-12}	4.61×10^{-12}
1970	−0.038	−0.069	2.54×10^{-12}	4.60×10^{-12}
1971	−0.038	−0.068	1.97×10^{-12}	3.57×10^{-12}
1972	−0.036	−0.065	1.89×10^{-12}	3.43×10^{-12}
1973	−0.032	−0.059	1.75×10^{-12}	3.17×10^{-12}
1974	−0.029	−0.053	2.00×10^{-12}	3.62×10^{-12}
1975	−0.032	−0.058	1.97×10^{-12}	3.57×10^{-12}
1976	−0.033	−0.059	2.33×10^{-12}	4.23×10^{-12}
1977	−0.034	−0.062	2.61×10^{-12}	4.73×10^{-12}
1978	−0.035	−0.064	2.69×10^{-12}	4.87×10^{-12}
1979	−0.035	−0.064	3.08×10^{-12}	5.59×10^{-12}
1980	−0.035	−0.063	3.16×10^{-12}	5.73×10^{-12}
1981	−0.036	−0.066	3.27×10^{-12}	5.93×10^{-12}
1982	−0.043	−0.078	3.43×10^{-12}	6.21×10^{-12}
1983	−0.049	−0.090	3.14×10^{-12}	5.70×10^{-12}
1984	−0.053	−0.097	3.37×10^{-12}	6.12×10^{-12}

Table IV. Estimated real marginal cost and real wholesale price of cigarettes

Year	Real marginal cost	Real wholesale price	Year	Real marginal cost	Real wholesale price
1952	1.223	12.601	1969	2.952**	16.292
	(1.466)			(1.284)	
1953	1.258	9.589	1970	3.703***	16.829
	(1.502)			(91.146)	
1954	1.107	15.358	1971	4.016***	16.745
	(1.252)			(1.215)	
1955	1.185	15.495	1972	4.756***	16.030
	(1.344)			(1.191)	
1956	1.204	15.017	1973	4.476***	14.822
	(1.319)			(1.212)	
1957	1.262	14.968	1974	3.652***	13.514
	(1.356)			(1.386)	
1958	1.426	15.127	1975	5.178***	14.692
	(1.611)			(1.014)	
1959	1.455	15.079	1976	5.137***	14.795
	(1.461)			(1.104)	
1960	1.593	15.079	1977	6.048***	15.331
	(1.635)			(1.045)	
1961	1.703	15.127	1978	6.337***	15.680
	(1.766)			(1.074)	
1962	1.883*	15.079	1979	6.122***	15.477
	(1.369)			(1.029)	
1963	2.062*	15.475	1980	7.374***	15.212
	(1.310)			(0.930)	
1964	2.078*	15.601	1981	8.322***	15.796
	(1.301)			(0.963)	
1965	2.213*	15.263	1982	9.970***	18.340
	(1.491)			(0.970)	
1966	2.345*	14.565	1983	11.294***	19.980
	(1.435)			(0.963)	
1967	2.462**	16.048	1984	13.134***	21.447
	(1.428)			(1.062)	
1968	2.851**	16.170			
	(1.381)				

Note: Real marginal costs are estimated from the model, standard errors are given in parantheses. Real marginal cost and real wholesale price are given in dollars.
***Significant at 1% level
**Significant at 5% level
*Significant at 10% level
Significance level is based on one-tailed *t*-tests

Table AI. Descriptive statistics of data, 1950-1985

Variables	N	Mean	Standard deviation	Range
$q_{i,t}$	36	3.619	0.221	3.210 – 3.968
$P_{i,t}$	36	15.500	2.582	9.414 – 23.605
$A_{i,t}$	36	3.654×10^{-5}	6.966×10^{-6}	$2.12 \times 10^{-5} – 4.93 \times 10^{-5}$
$y_{i,t}$	36	5879.880	1570.690	3883.190 – 8672.35
$W_{i,t}$	36	8.468	2.480	4.572 – 14.254
$R_{i,t}$	36	1.862	0.128	1.600 – 2.085
$M_{i,t}$	36	108.527	10.495	90.355 – 140.806
$E_{i,t}$	36	30.323	15.193	12.601 – 41.268
N_t	36	141,059,000	23,875,079	109,140,000 – 183,174,000

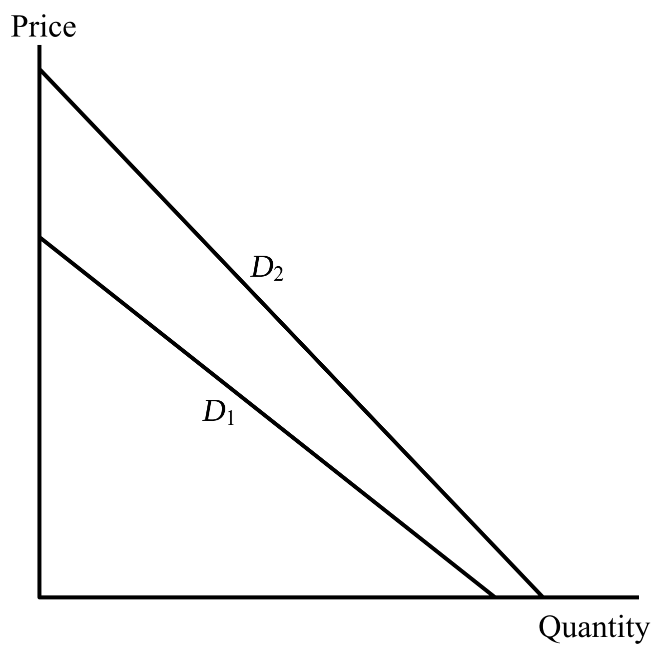

Figure I. Effect of advertising on demand