UNIVERSITY OF CALIFORNIA AT BERKELEY

Department of Economics

Berkeley, California 94720

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A Dynamic Simultaneous-Equations Model for Cigarette Consumption in the Western States

Hai-Yen Sung, Teh-Wei Hu
and Theodore E. Keeler

University of California at Berkeley

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The authors are, respectively, Ph.D. student in Agricultural and Resource Economics, Professor of Health Economics, and Professor of Economics at the University of California at Berkeley. This research was supported by funds provided by the Cigarette and Tobacco Surtax Fund of the State of California through the Tobacco-Related Disease Research Program of the Institute of Business and Economic Research at the University of California at Berkeley, Grant Number RT12. They acknowledge the helpful comments of Willard G. Manning and Paul G. Barnett.

Abstract

This paper presents a rational addiction model, which integrates the addictive behavior of smokers toward cigarette consumption and the dynamic, profit-maximizing behavior of an oligopoly of cigarette producers. This model is tested on a panel data for eleven western states over the period of 1967-1990, using simultaneous estimation techniques. The results suggest the following conclusions: first, cigarette consumption is price-sensitive, with a demand elasticity of about -.33 in the short run and -.44 in the long run. These elasticities are smaller than those reported in most previous studies. Second, our results at least partially confirm the theory of rational addiction. Third, our model of oligopoly behavior confirms the hypothesis that the tobacco companies often do, as a part of their oligopoly behavior, raise end-market prices by more than the amount of the tax. Fourth, our results indicate that antismoking ordinances matter in reducing cigarette consumption, though their estimated significance is marginal. Finally, our results indicate that a tax increase, such as that imposed in California as a result of Proposition 99 effective in January 1989, can have a strong effect on reducing cigarette consumption, ranging between 8 percent in the short run and 11 percent in the long run.

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I. Introduction

As a result of Proposition 99, California's excise tax on cigarettes increased from 10 cents to 35 cents per pack beginning in January 1989. The purpose of this study is to evaluate the impacts of this increase on cigarette price and cigarette consumption in California compared with ten other western states for the period 1967 to 1990. The traditional approach to evaluating the impact of a tax increase is to use a static single-equation demand model for cigarettes. This paper takes an alternative approach, using a dynamic simultaneous demand and supply equations model that incorporates the addictive nature of smoking in a way not done by previous studies.

Taxation has long been used by the Federal, state and local government to raise revenues. Since the release of the First Surgeon General's Report on smoking and health (U.S. Public Health Service 1964), taxation has also been used as an economic tool to cut cigarette smoking. With increasing antismoking sentiment, other governmental smoking control policies besides increasing excise taxes have been implemented. These policies can be categorized into two types: regulating smoking in public places and private workplaces, and providing the public with information and education about the hazards of tobacco use. This paper compares the effectiveness of taxation and one of the antismoking regulations, namely, the local smoking ordinances, in reducing cigarette consumption.

Partly due to different antismoking sentiment in different states, disparities among state excise taxes on cigarettes have become wider and incentives for interstate cigarette bootlegging have been increased. That is, consumers residing in high-price states buy increasing quantities of cigarettes in low-price states. The potential existence of interstate bootlegging raises the question as to whether increasing state excise taxes is an effective way either to reduce cigarette smoking or to increase state tax revenues. To investigate this question, we have constructed variables reflecting bootlegging incentives and have included them in our simultaneous-equations model.

This theoretical dynamic simultaneous two-equation model is specified in Section II. Variables reflecting local smoking regulations and cigarette bootlegging are discussed and incorporated in our model in Sections III and IV, respectively. Section V describes the data used in the empirical analysis. Structural equations and estimation methods are included in Section VI. Section VII presents empirical results. Section VIII presents policy simulations and conclusions.

II. Theoretical Model

In this section, we develop a new model of rational addiction, based not only on dynamic behavior of the consumer, as set forth by Becker and Murphy (1988) and Becker, Grossman, and Murphy (1991), but also on rational, profit-maximizing behavior by an oligopoly of cigarette producers, which takes account of the dynamic demand behavior inherent in rational addiction. To motivate this theoretical extension of the rational addiction model, we must first discuss previous theoretical models of cigarette demand embodying addictive behavior.

Most studies of the impact of taxation on cigarette consumption have been based on a single-equation demand model that is designed to test the responsiveness of cigarette consumed to cigarette price. Such a model assumes that the cigarette industry is perfectly competitive and that supply is perfectly elastic so that excise tax changes will be fully reflected in cigarette prices (Lewit and Coate 1982). Evidence suggests, however, that the cigarette industry is not perfectly competitive and that when cigarette taxes rise, prices have often risen by more than the amount of the excise tax increases (Barzel 1976; Sumner 1981; Applebaum 1982). Therefore, we need to examine more closely the way in which the changing excise tax affects cigarette price. This is necessary to correctly measure the impact of taxation on cigarette consumption, using a simultaneous demand and supply framework.

Only a few studies in the cigarette literature consider the simultaneity of demand and supply for cigarettes. Bishop and Yoo (1985) apply a neoclassical system-wide approach to build a static simultaneous demand and supply model for cigarettes. Though they relax the assumption that supply is perfectly elastic, they assume a perfectly competitive industry with a one-to-one correspondence between price and quantity supplied. They define the cigarette supply to be a function of cigarette price, input price index, and other supply-side exogenous variables. Working with a system of simultaneous demand and supply equations, they use three-stage least squares estimation with correction for first-order autocorrelation, and find that the cigarette supply equation is elastic and the cigarette demand equation is inelastic.

Porter (1986) also considers the simultaneity of demand and supply for cigarettes. He assumes an oligopoly market structure in the cigarette industry as a basis for specification of the instrumental variable for price equation. Both Bishop and Yoo and Porter ignore the addictive nature of cigarette smoking in their models. Kao and Tremblay (1988) modify Bishop and Yoo's model by including a lagged consumption variable in the demand equation to account for the habit-forming nature of cigarette smoking. They then apply Porter's instrumental variable method to cigarette price equation, arguing that no one-to-one relationship exists between price and quantity produced in a concentrated industry. Their results do not support the hypothesis that cigarette consumption is addictive because the coefficient for lagged consumption is not significant.

In this paper, a simultaneous two-equation demand and supply model for cigarettes is formulated in a dynamic framework based on the theory of rational addiction. It will be shown that, given the dynamics of cigarette consumption, the producer's supply response is also reflected in a dynamic structure.

Dynamic Demand Model

Becker and Murphy (1988) develop the theory of rational addiction, asserting that the individual is aware of the dependence of current consumption on past consumption and the dependence of future consumption on current and past consumption.

Becker, Grossman and Murphy (1990) empirically test the theory of rational addiction in a study of the demand for cigarettes, using aggregated data from 50 states and Washington, D.C. for the period 1955 to 1985. They assume a time-nonseparable utility function for individual at time t dependent on consumption of cigarettes in that period (D_t), consumption of cigarettes in the previous period[1] (D_{t-1}), and other goods. The consumer makes the optimal smoking decision

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[1] In the original theory of rational addiction (1988), current utility depends on past consumption stock, S, which satisfies the law of motion:

$$\dot{S}(t) = D(t) - \delta S(t)$$

where $\dot{S}$ means the rate of change in stock over time, D is cigarette smoking, δ measures the depreciation rate of disappearance of the physical and mental effects of past consumption. Therefore, in the full model of rational addiction, the lagged price and future price of cigarettes are also included as explanatory variables. However, as δ equals to 1, the full model coincides with the simplified model as specified here. Evidence shown in the Surgeon General's report that many of the withdraw symptoms and physiological effects of smoking disappear shortly after cessation implies a high depreciation rate.

by maximizing the expected lifetime utility subject to a expected lifetime budget constraint. Assuming a quadratic utility function and that tastes and time preference are constant, the first-order condition for optimality derives the following dynamic equation for cigarette consumption at time t:

$$D_t = b_0 + b_1P_t + b_2D_{t-1} + b_3D_{t+1} + b_4Z_t + \epsilon_t \tag{1}$$

where P_t = cigarette price at time t,

Z_t = other demand determinants such as income or policy at time t,

and ϵ_t = disturbance term at time t.

The coefficient for cigarette price, b_1, is negative. The rational addiction theory suggests $0 < b_2, b_3 < 1$ with the argument that past and future consumption are complementary with current consumption, and $b_3 < b_2$ by proving that b_3 is equal to b_2 multiplied by a discount rate.

In contrast to rational addiction model, the more traditional demand model of persisting habits, developed by Houthakker and Taylor (1970), McGuinness and Cowling (1975), Fuji (1980), Baltagi and Levin (1986), and Seldon and Boyd (1991) accounts for the dependence of current consumption on past addictive consumption but ignores the future effects of addiction. The habit persistent model differs from Equation (1) by excluding the future consumption term and is referred to by Becker, Grossman and Murphy (1990) as the "myopic addiction model". Whether consumers are addicted or not, and whether they are rationally or myopically addicted can be tested empirically through the coefficients for D_{t-1}, and D_{t+1}. The results of Becker, Grossman and Murphy show that the signs of coefficients for both the lagged consumption and future consumption are positive. That is, the more cigarettes consumed in the previous period (or future period), the more consumed in the current period. Chaloupka (1991) uses a disaggregated cross-sectional data from the second National Health and Nutrition Examination Survey from 1976 to 1980 and also finds support for the theory of rational addiction.

Rational Addiction with Dynamic Oligopoly Supply Response

Previous models of addictive behavior have fully modeled the functioning of the consumer. But they have stopped short of analyzing the dynamic behavior of the tobacco firm and industry in response to consumer's rational addiction. The model we develop here extends the theory of addictive behavior to account for this firm and industry response.

We first assume that the tobacco industry is a Chamberlin oligopoly that it is able to behave as if it were a perfectly collusive oligopoly, or a monopoly. Given the dynamic demand model in Equation (1), the producers will make optimal dynamic production plans by maximizing the expected lifetime profits, V_t, which is equal to the sum of the expected profit at each period, $E(\pi)$, discounted by the discount rate β, as follows:

$$\begin{aligned} V_t &= \sum_{\tau=t}^{\infty} \beta^{\tau-t} E(\pi_\tau) \\ &= [P_t(Q_t)Q_t - C_t(Q_t, W_t)] + \beta[P^e_{t+1}(Q^e_{t+1})Q^e_{t+1} - C^e_{t+1}(Q^e_{t+1}, W^e_{t+1})] \\ &+ \ldots\ldots \end{aligned} \tag{2}$$

where E denotes the expectation operator; P(Q) is the inverse demand function faced by the producers; Q_t is the quantity of output supplied at time t; C(.) is the cost function; W is the input price vector; the superscript "e" denotes the expected future level by producers at time t. The inverse demand equation faced by producers at time t can be converted from Equation (1):

$$P_t = -(b_0/b_1) + (1/b_1)\,D_t - (b_2/b_1)\,D_{t-1} - (b_3/b_1)\,D_{t+1} - (b_4/b_1)\,Z_t - (1/b_1)\,\epsilon_t \qquad (3)$$

At market equilibrium, it is assumed that the quantity demanded equals the quantity supplied at each period such that $D_t=Q_t$, $D_{t-1}=Q_{t-1}$, and so forth. Differentiating Equation (2) with respect to Q_t, we find the first-order condition for Q_t:

$$\frac{\partial V}{\partial Q_t} = P_t + Q_t\left(\frac{\partial P_t}{\partial Q_t}\right) - \frac{\partial C_t(Q_t, W_t)}{\partial Q_t} + \beta\left(\frac{\partial P^e_{t+1}}{\partial Q_t}\right) Q^e_{t+1} = 0 \qquad (4)$$

Substituting the equilibrium condition and Equation (3) into Equation (4) derives the equation below:

$$P_t\left(1 - \frac{1}{\eta}\right) = MC_t(Q_t, W_t) + \beta\left(\frac{b_2}{b_1}\right) Q^e_{t+1} \qquad (5)$$

where MC is the marginal cost function, and η is the demand elasticity as perceived by the cartel of firms.

We now extend the Chamberlin model to a Cournot oligopoly model with non-identical firms in the cigarette industry. Following Cowling and Waterson (1976), we can expand[2] Equation (5) into:

$$P_t\left(1 - \frac{H_t}{\eta_t}\right) = MMC_t(Q_t, W_t) + \beta\left(\frac{b_2}{b_1}\right) MQ^{e}_{t+1} \tag{6}$$

where H denotes the Herfindahl Index for the industry, MMC is the weighted average marginal cost of all firms in the industry, and MQ_{t+1} is the weighted average future output at t+1. Note that if the industry is perfectly competitive (i.e., H=0), Equation (6) will be reduced to $P_t = MC_t$, because any single producer's output would not change market price at current period or next period. Since evidences show that cigarette industry is highly concentrated, Equation (6) represents a dynamic supply equation when producers acknowledge that consumers are addicted[3].

Given our assumption of a dynamic demand for cigarettes, the producer's optimal production strategy at time t depends on the expected output level at next period. The positive values of β and b_2 and negative value of b_1 imply a negative coefficient for the expected output in Equation (6). That is, the consumers' addiction to cigarette consumption will make any shocks expected to

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[2] Here, we set the conjectural variation parameter to be 1, under the assumption of Cournot oligopoly that any firm believes other rivals do not respond to the changes in its output. Our assumption is consistent with the empirical results found by Barnett, Keeler and Hu (1992), that the conjectural variation in the cigarette industry was very close to 1 during 1955-1989.

[3] The dynamic price equation as shown in Equation (6) can be derived from either rational addiction model or myopic addiction model, because both models imply a non-negative coefficient for lagged consumption, b_2.

occur in future, such as the change of excise tax, negatively influence a producer's current pricing strategy. If the shocks reduce the future consumption, which is equivalent to quantity supplied under the condition of market equilibrium, then the producer will increase current price to raise the short run and long run profits.

Therefore, under the theory of rational addiction, Equations (1) and (6) constitute a simultaneous system of demand and supply responses for cigarettes.

III. Smoking Regulations

Beginning in mid-1970s, a number of state and local governments enacted legislation restricting cigarette smoking in public places. These restrictions are a consequence of public concern about the effects of cigarette smoking on the health of nonsmokers or environmental tobacco smoke. These laws generally prohibit smoking in retail stores, on public transportation, in public meeting rooms, schools, health care facilities; they often require non-smoking sections in the restaurants. The most restrictive of these laws also prohibit smoking in private workplaces. These types of antismoking laws include Clean Indoor Air Acts enacted by state governments, and local smoking ordinances enacted by city or county governments.

Several empirical studies have found that the Clean Indoor Air Acts have discouraged cigarette smoking (Chaloupka and Saffer 1988; Wasserman et al. 1991; Peterson et al. 1992). In our study, we test the impact of antismoking regulation laws based on the data of major local smoking ordinances published by Americans for Nonsmokers' Rights (Pertschuk and Shopland, 1989). Since, in general, local smoking ordinances are stronger, more comprehensive, and have more enforcement power than statewide smoking laws or regulations, the variable derived from local smoking ordinances data is a better measure for smoking regulation.

To derive the regulation variable, we first assigned a score to represent the level of stringency of smoking ordinances for each city or unincorporated area of a county. In a similar manner as developed by Warner (1981), the Surgeon General's 1986 report (U.S. Department of Health and Human Services 1986) and Wasserman et al. (1991), scores of 1, .75, .5, .25, or 0 were assigned depending on whether there are, respectively, restrictive ordinances in private workplaces, restaurants, more than two other public places, less than two other public places, or not listed. We then use the size of the population, living in the restricted cities or counties, to derive the population weighted statewide regulation index, SMREG.

The demand model as specified in Equation (1) can be modified by adding this regulation variable, SMREG:

$$D_t = b_0 + b_1 P_t + b_2 D_{t-1} + b_3 D_{t+1} + b_4 Z_t + b_5 SMREG_t + \epsilon_t \qquad (7)$$

IV. Bootlegging Problem

The cigarette smuggling has long been a problem due to wide disparities among state excise taxes. The Advisory Commission on Intergovernmental Relations (ACIR 1977, 1985) reported that state and local governments lost about $391 ($309) million dollars of cigarette revenues in 1975 (1983) due to smuggling. To prevent it, the Federal Cigarette Contraband Act was enacted in 1978 to make smuggling cigarettes across state lines a Federal crime. According to the 1985 ACIR report, the magnitude of commercial or organized interstate smuggling has declined dramatically since passage of this legislation. However, as shown in Table 1 by the measure of standard deviations, the disparities among state excise taxes have increased over years so that the incentives for informal or casual cigarette smuggling (bootlegging) have increased. Also, the illegal sales of cigarettes to civilians on military bases and/or Indian reservations have become a major source of current revenue losses for many states.

To deal with the cigarette bootlegging in those locales where one higher-priced area borders another that has lower-priced cigarettes, three alternative approaches have been used in the literature: (1)omission from the data of the border areas for studies using disaggregated data (Lewit, Coate, and Grossman 1981; Lewit and Coate 1982; Wasserman et al. 1991), (2)taking the average of the local price and the border price of cigarettes (Chaloupka 1991), and (3)creating an incentive variable to measure the demand for bootlegging in studies using aggregated data (Sumner 1982; Baltagi and Levin 1986; Becker, Grossman, and Murphy 1990). These empirical studies all found that estimated demand elasticities are biased unless the analysis controls for bootlegging.

This study uses the aggregated state tax-paid sales as the dependent variables. There is no direct information on actual cigarette consumption by state residents. The result is that per-capita taxed sales are too high in states from which cigarettes are bootlegged and too low in states to which cigarettes are bootlegged. Therefore, without accounting for the incentives for bootlegging, the price elasticities for cigarette demand will be biased upwards. To eliminate estimation bias from the true price elasticity, we include the exogenous variables to represent the bootlegging demand. Let C measure the tax-paid sales in a given state. It can be decomposed by tax-paid sales by residents and tax-paid sales by neighboring state residents. Tax-paid sales by residents is equal to the actual residents' consumption, D, minus bootlegged imports from other states. Tax-paid sales by neighboring state residents is considered as bootlegged exports. Hence, the relation among consumption, sales, and smuggling can be expressed as:

$$C_t = Q_t^{T(\text{resident})} + Q_t^{T(\text{bootlegged exports})}$$

$$= [D_t - Q_t^{(\text{bootlegged imports})}] + Q_t^{T(\text{bootlegged exports})} \quad (8)$$

Combining Equations (7) and (8), we can incorporate the demand for bootlegging in the dynamic cigarette consumption model by:

$$C_t = b_0 + b_1 P_t + b_2 C_{t-1} + b_3 C_{t+1} + b_4 Z_t + b_5 SMREG_t + b_6 IMP_t + b_7 EXP_t + \epsilon_t \quad (9)$$

where IMP_t and EXP_t are the incentive variables for import and export bootlegging, respectively.

V. Data

Our study is concerned with the period from 1967 to 1990 for the eleven western states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. This generates a total of 264 observations[4]. As mentioned in Section I, a main purpose of this paper is to evaluate the impact of Proposition 99 on cigarette price and consumption in

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[4] In our empirical estimation, only 242 observations are used during 1968 and 1989 because the missing values for the lagged variables in 1967 and the missing values for the lead variables in 1990.

California. For more precise estimation, we need to consider the possibility of bootlegging from California to its neighboring states resulted from the 25-cent tax increase. Therefore, we choose the eleven states in the West region as a sample unit so that we can incorporate the data of states which border on California to test the existence and importance of bootlegging. Also, we believe that the state data based on the West region represent a homogenous unit because of their distance from the eastern tobacco producing states[5], in which smoking is more favored as a social acceptable custom and consumers probably have stronger taste for smoking. Since these tobacco-producing states often levy the minimum state excise taxes on cigarettes[6], the far distance between the western states and tobacco-producing states makes the organized or formal smuggling less likely to occur.

The data on per-capita cigarette sales, retail prices and taxes were published by the Tobacco Institute (1990). The base used to calculate per-capita sales was the resident population for all age groups estimated by the U.S. Bureau of Census (1960, 1970, 1980). The cigarette retail price data were obtained from the annual survey by the Tobacco Institute. They are the weighted-average price per pack, using national weights for types of cigarettes and types of transaction. These prices do not include local excise cigarette tax and sales tax. If evidence of city and county taxes on cigarettes is available for a

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[5] The five most important producing states for tobacco and cigarettes are North Carolina, Kentucky, Tennessee, Virginia and South Carolina.

[6] In 1990, the state excise taxes on cigarettes are 2, 3, 13, 2.5, and 7 cents for North Carolina, Kentucky, Tennessee, Virginia and South Carolina, respectively.

particular state[7], the figures for gross city and county taxes are then divided by state tax-paid cigarette sales to calculate the local tax per pack, and added to the original retail cigarette price.

Per-capita incomes at state level are from Survey of Current Business. The input costs are derived from Census of Manufactures. Demographic variables include sub-population data for different age, sex, and race groups from Census of Population (1960, 1970, 1980, 1990) and Current Population Survey (1960-1989). Religious affiliation data are from the National Council of Churches and Glenmary Research Center (1952, 1971, 1980, 1990). Values for intervening years were based on interpolations with the assumption of exponential growth.

To account for the differentials in the cost of living across states and time periods, we develop a composite price index to adjust all the monetary variables such as prices, costs, tax rates or incomes based on a state consumer price index measured in 1967 (Fuchs, Michael and Scott, 1979) and U.S. consumer price index for all items. It is assumed that the structure for relative state prices did not change for years other than 1967.

The cigarette sales data from the Tobacco Institute are reported on the basis of fiscal year ending June 30th. To be consistent, all the other variables have been converted to the same fiscal year basis. The detailed definitions of the endogenous and exogenous variables are attached in the Appendix. Their descriptive statistics are shown in Table 2.

VI. Structural Equations and Estimation Methods

Given the dynamic supply and demand model for cigarettes in Equations (6)

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[7]These states are Arizona(1970-1973), California(1967-1968), Colorado(1967-1973), and New Mexico(1967-1974).

and (9), the corresponding structural retail price equation[8] and demand equation for empirical estimation are :

$$DPRICE_{ti} = a_0 + a_1*DSTAX_{t.} + a_2*DFTAX_{ti} + a_3*DFPI_{t.} + a_4*H_{t.} + a_5*USSALE_{t+1,.} + a_6*D71_{t.} + \epsilon_{1ti} \quad (10)$$

$$CON_{ti} = b_0 + b_1*DPRICE_{ti} + b_2*CON_{t-1,i} + b_3*CON_{td+1,i} + b_4*DPCDI_{ti} + b_5*POPO65_{ti} + b_6*POPU18_{ti} + b_7*MALE_{ti} + b9_8*BLACK_{ti} + b_9*OTHRACE_{ti} + b_{10}*MORM_{ti} + b_{11}*CATHOL_{ti} + b_{12}*SBAPT_{ti} + b_{13}*DPHOTEL_{ti} + b_{14}*MILTARY_{ti} + b_{15}*INDIAN_{ti} + b_{16}*F_{t.} + b_{17}*SMREG_{ti} + b_{18}*DTAXIMP_{ti} + b_{19}*DTAXEXP_{ti} + \epsilon_{2ti} \quad (11)$$

where ϵ_{1ti} and ϵ_{2ti} are the error terms, the subscript "t" denotes year t, "i" denotes state i, and "." means that the data only vary over time and not across states.

Equations (10) and (11) are in the system of recursive equations. In Equation (10), the retail price (DPRICE) is a function of the state tax (DSTAX), the Federal tax (DFTAX), average input cost (DFPI), Herfindahl Index (H), the future level of U.S. aggregated output of cigarettes (USSALE), and a dummy variable representing broadcast advertising ban effective in January 1971 (D71). In Equation (11), per-capita cigarette consumption (CON) is a function of cigarette price, lagged cigarette consumption, future cigarette consumption, per-capita disposable income (DPCDI), the vector of demographic variables (POPO65,

[8] Equation (6) represents the wholesale price faced by the producers. To derive the retail price equation faced by the consumers, the Federal and state excise tax rates need to be included. The distribution cost is assumed to be zero here. For the discussion of relationship between wholesale price and retail price, see Barnett, Keeler and Hu (1992).

POPU18, MALE, BLACK, OTHRACE), the vector of sales versus consumption adjustment variables (DPHOTEL, MILTARY, INDIAN), the vector of religious affiliation (MORM, CATHOL, SBAPT), market share of filter cigarettes (F), local smoking regulation index (SMREG), and bootlegging incentive variables (DTAXIMP, DTAXEXP).

Given the recursive relationship, Equation (10) is first estimated. The predicted value of retail price is then replaced into Equation (11) to estimate the demand model. Since Equation (11) includes the future and lagged endogenous variable, the method of instrumental variable[9] is applied for future and lagged consumption. The predicted values of future and lagged consumption are replaced for actual values of future and lagged consumption in Equation (11) before estimation.

To pool the eleven western states' data for the period 1967 to 1990, we need to specify our estimation method that appropriately captures the cross-sectional state effects as well as time effects. We assume that all the coefficients are invariant across states and time periods, and the disturbances follow a heteroscedastic and autoregressive process[10]. Since, at any given time, the disturbances for different states are likely to reflect some common unmeasurable or omitted variables, it is likely that they exhibit some contemporaneous

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[9] The lead consumption is an instrumental variable regressed by next period's values of state tax, federal tax, and all the exogenous variables in the demand and price equations. The lagged consumption is an instrumental variable regressed by previous period's values of state tax, federal tax, and all the exogenous variables in the demand and price equations. Unlike Becker, Grossman and Murphy (1990), we do not include cigarettes prices as instruments for future and lagged consumption because we allow price to be an endogenous variable.

[10] We applied the Breusch-Pagan (1979) method to test heteroscedasticity and found that the residuals for the observations depend on the size of state resident population. After the heteroscedasticity was corrected, we then calculated the correlation coefficients and partial correlation coefficients to check whether residuals follow AR, MA, or ARMA process. The results show that the residuals follow AR(1) process.

correlation. Thus, we should estimate the above-mentioned recursive equations system for the supply and demand equations using a cross-sectionally correlated and time-related autoregressive method.[11] That is, the coefficients are the same for all states, the disturbance vector for a given state follows a first-order autoregressive process, the variances of the disturbances for different states are different, and the disturbances for different states are contemporaneously correlated.

V. Empirical Results

As shown in Table 3, all the coefficients in the retail price equation are significant at 5% level. The coefficient of the state tax and the Federal tax is 1.37 and 2.27, respectively. In other words, a 1-cent increase in the state tax will increase the retail price by 1.37 cents, while a 1-cent increase in the Federal tax will increase the retail price by 2.27 cents. Our results support the argument that the cigarette industry is not perfectly competitive, because the burden of the tax increments has passed to consumers so that the prices have risen by more than the increase in tax. The average elasticities of price with respect to state tax and Federal tax, measured at sample means, are .30 and .38, respectively. The Federal tax appears to have a stronger impact on price than the state tax. This is consistent with the argument by Harris (1987) that the state tax is less effective than the Federal tax because of possible bootlegging. Our estimates are similar to other empirical results. For the impact of combined state and Federal tax on retail price, Bishop and Yoo (1985) estimate an

[11] Our estimation is based generalized least squares method, using PROC TSCS procedure in SAS/SUGI Supplemental Library Version 5 with the option of PARKS method. For details about the model and estimation procedure, see Kmenta (1986) and Parks (1967).

elasticity of 0.387, and Porter (1986) estimates it ranging from 0.304 to 0.445.

The average cost of inputs for cigarettes, which include production and advertising factors, shows positive effects on retail price with an elasticity of 0.19. Therefore, our results indicate that the state or Federal tax has a stronger effect on the retail prices than the average factor cost. The positive coefficient for the Herfindahl Index supports the hypothesis of oligopoly pricing: the price is higher if the industry is more concentrated. The coefficient of future output[12] has a negative sign as expected. The positive coefficient for the broadcast advertising ban implies that this ban has increased the costs to selling the cigarettes, probably because advertising tools other than broadcasting are less effective.

Column 1 of Table 4 presents the estimated results for rational addiction demand equation. The positive and significant coefficients for future and lagged consumption support the theory of rational addiction. However, the coefficient for future consumption is 0.339 and bigger than the coefficient for lagged consumption, 0.228. This is not consistent with the argument of rational addiction theory. The average short run and long run own-price elasticities[13]

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[12] Assuming perfect foresight, the future output at next period expected by the producers at current period is equal to the actual output at next period.

[13] The short run and long run elasticities are calculated based on the formula given in Becker, Grossman and Murphy (1990, P.12). For any exogenous variable X, its short run and long run elasticities are:

$$\eta^{SR}(X) = b_X \cdot \frac{\overline{X}}{CON} \cdot F_{SR} \qquad ; \; \eta^{LR}(X) = b_X \cdot \frac{\overline{X}}{CON} \cdot F_{LR}$$

where b_X is the coefficient of X in the per-capita consumption equation as shown in Equation (11); F_{SR} and F_{LR} are the short run and long run factors expressed as:

are -0.33 and -0.44, respectively. Our estimated short run price elasticity is consistent with other cigarette demand studies while the long run price elasticity is low. Table 5 illustrates our empirical findings about price elasticities along with other cigarette demand studies.

To test the robustness of our results, we also estimate both a myopic addiction version and a static version of simultaneous demand and supply model, with the results shown in Columns (2) and (3) in Table 4, respectively. The short run own-price elasticity is -0.33 and long run elasticity[14] is -0.45 in myopic addiction model. The own-price elasticity in the static model is -0.42. Our estimated own-price elasticities show to be robust across these three model specifications.

Demographic variables are used to control the state differences toward smoking. The higher the ratio of younger population (less than 18 years old) in a state, the greater its cigarette consumption. This is consistent with recent research findings that most smokers started smoking prior to age 18, and that the rate of increase in smoking prevalence rate among teenagers is greater than the adults. The higher the population ratio of males or blacks, the greater the per-capita cigarette consumption in a state. The coefficients for percent elderly

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$$F_{SR} = \frac{1}{b_2(1-\phi_1)(\phi_2)} \quad ; \; F_{LR} = \frac{1}{b_2(1-\phi_1)(\phi_2-1)}$$

b_2 is the coefficient of lagged consumption. ϕ_1, and ϕ_2 are the two roots in the second-order difference equation, which we calculate as 0.37 and 4.01, respectively.

[14] The long-run price elasticity in the myopic addiction model is:

$$\eta^{LR} = \frac{b_1}{(1-b_2)} \cdot \frac{\overline{DPRICE}}{\overline{CON}}$$

where b_1 is the coefficient for cigarette price (DPRICE) and b_2 is the coefficient for lagged consumption in Equation (11). Note that the myopic addiction model implies that the coefficient for future consumption is zero.

and the "other" ethnic variables are not significant. The religious affiliation variables confirm the expectation that a state with more Mormons has lower cigarette consumption on average.

Per-capita hotel expenditures can serve as a proxy variable for the purchasing of cigarettes by tourists. The results show that higher per-capita hotel expenditures are associated with increases in per-capita sales of cigarettes. Since state excise tax is not levied on military installations and Indian reservations, it was expected that a higher ratio of military population or population living on Indian reservations in a given state will increase the possibility of illegal cigarette sales, thus decreasing the tax-paid per-capita sales. The coefficient for the military population ratio, which is negative and significant, supports our hypothesis[15]. The coefficient for population on Indian reservations is not significant.

The period 1967-1990 witnessed a significant change in attitude and taste toward smoking. For example, people have become more aware of the health consequences of smoking: fewer people are smoking and more smokers are switching to filter or low-tar cigarettes. To capture the change in consumer tastes, we use the market share of filter cigarettes as a proxy variable. The results show that the increasing market share of filter cigarettes has been accompanied by decreasing per-capita consumption of cigarettes with statistical significance level of 15%.

The impact of local smoking ordinances in any state is shown to have a

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[15] The military population variable has another impact on per-capita cigarette sales. The dependent variable in our analysis is the state tax-paid cigarette sales divided by state resident population, which includes military population. While the military population's purchase of cigarettes is tax exempted, the inclusion of the military population in the state's resident population will cause a downward-bias of the dependent variable.

negative influence on cigarette consumption at significance level[16] of 14%. The average short run (long run) elasticity of regulation on consumption is -0.003 (-0.004) which seems negligible. However, since the sample mean value of the smoking regulation variable, SMREG, is only 4.89, there is much room for implementing smoking regulation policy in order to cut smoking. For example, assume that one-third of a state area is regulated by the laws restricting smoking in restaurants, then SMREG[17] equals to 25 and the short run (long run) elasticities measured at that level is 0.014 (0.019). If these areas implement the more restricted laws such as to restrict smoking in the workplaces, then SMREG will change from 25 to 33.3 by 33.2% increase, which will cut per-capita cigarette consumption by 0.46%. Alternatively, if the rest areas of this state also implement the same ordinances to restrict smoking at the restaurants as the other one-third areas, then SMREG will change from the level of 25 to 75 by 200% increase which will reduce per-capita cigarette consumption by 2.8% (3.8%) in the short run (long run). Therefore, either by strengthening the stringency level of smoking ordinances or by enacting the antismoking laws in more cities or counties, the state's per-capita cigarette consumption can be reduced. Wasserman et al. (1991) find that per-capita smoking will decrease by 5.9% when the state changes the regulation from the level of .25 to 1 (which corresponds to a change of SMREG from 25 to 100 according to our variable specification). Our model indicates that a similar regulation policy will reduce per-capita consumption by 4.2% in short run and 5.6% in long run.

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[16] Both myopic addiction model and static model show a very significant negative impact of anti-smoking regulations on cigarette consumption at 1% level.

[17] The stringency index for the ordinances restricting smoking at restaurants is 0.75. According to the definition SMREG shown in the Appendix, 0.75*(1/3)*100 equals to 25.

Both the coefficients for import and export bootlegging incentive variables are statistically significant and negative. The average short run (long run) elasticity of import bootlegging is -0.04 (-0.06). The average short run (long run) elasticity of export bootlegging is 0.01 (0.01). Therefore, interstate bootlegging for cigarettes does exist in the western states but controlling for it has very small influence on coefficients.

VIII. Policy Implications and Conclusions

Based on our estimated elasticity figures evaluated at the sample means, we can compare the effectiveness of taxation and antismoking regulations on reducing cigarette consumption. Assume that an average state in the West region introduces the most stringent antismoking ordinances in all areas. Then the SMREG will increase from the sample average value of 4.89 to 100 by 1945%, which would reduce short run consumption by 5.8%. On the other hand, if the state government raise excise tax from the average value of 12.51 cents to 25.02 cents per pack by 100%, the cigarette consumption will reduce by 9.9%. These results indicate that while antismoking ordinances play an important role in reducing smoking, nevertheless, their potential for further reducing smoking on the margin may be low compared with the effects of further increases in taxation.

These policy simulations are based on the "average" state in the west region. Our linear model specification implies that the elasticities for each state differ because of different tax structure, antismoking sentiments and severity of bootlegging. Hence, the policy simulation would differ for each state.

Since a primary purpose of our study is to evaluate the impacts of Proposition 99 in reducing cigarette consumption in California, we focus on the policy implications in California. Proposition 99 increased the sum of all state taxes on cigarettes[18] from 18 cents in 1988 to 43 cents in 1990[19] by 138.9%. According to Table 6, which exhibits the own-price elasticities and tax elasticities in California during 1967-1990, this would increase the retail price by 18.47%, and then would reduce per-capita cigarette consumption by 8.3% in short run and 11.0% in long run from 1988 to 1990.

The 25-cent increase in excise tax has made California switching from a net export bootlegging state in 1988 to a net import bootlegging state in 1990. Its net bootlegged exports of cigarettes were 0.13 packs per-capita in 1988. Its net bootlegged imports were 0.17 packs per-capita in 1990, which were equivalent to 1.8 million-dollar loss in excise tax revenue for California. In response to California's Proposition 99, Nevada also raised its excise tax to 35 cents in July of 1989, while the other two bordering states did not change their tax rates. If Nevada had its tax rate left unchanged, then Californians would import more bootlegged cigarettes by additional .21 packs per-capita in 1990 and the state government would lose further by another 2.2 million dollars in tax revenues.

The increasing antismoking sentiments in California has made it very stringent in local antismoking ordinances since middle 1980s. From 1988 to 1990, California's SMREG slightly changed from 71 to 72.6 with 2.3% increase which reduced per-capita cigarette consumption by only 0.05%. However, true effect of all changes from 1967 to 1990 is much stronger.

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[18] All state taxes on cigarettes include state excise tax, local excise tax and sales taxes if applicable.

[19] Since our data are based on fiscal year covering from July of the previous year to June of that year, only half of 1989 data reflect the effective period of Proposition 99. We evaluate the impacts of Proposition 99 by comparing 1988 and 1990.

The research reported here suggests several important conclusions, relevant both to the research literature and to public policy.

First, cigarette consumption is price-sensitive, with a demand elasticity of about -.33 in the short run and -.44 in the long run. These elasticities are lower than those found in most other studies using state panel data. We believe that the lower values reflect several important enhancements in our study. These enhancements include stratification of our data into a more demographically homogeneous group than previous studies; more complete demographic variables; more accurate estimates of variables reflecting local antismoking regulations; and integration of a complete model of oligopoly behavior in the cigarette industry with the theory of rational addiction.

Second, our results basically confirm the theory of rational addiction, though the point estimates of the coefficients themselves are not totally consistent with that theory.

Third, our model of oligopoly behavior confirms the hypothesis, set forth by Barzel (1976), Harris (1987), and Becker, Grossman and Murphy (1990), that the tobacco companies often do, as a part of their oligopoly behavior, raise end-market prices by more than the amount of the tax. While others have suspected it to be true, our integrated model of oligopoly pricing and demand confirms it in a more systematic context.

Fourth, our results support the conclusions of Wasserman et al. (1991) that antismoking ordinances matter. Their effect on consumption in our model is in fact very similar to that found by Wasserman et al.

Finally, our results indicate that a tax increase, such as that imposed in California in 1989, can have a strong effect on cigarette consumption. By our estimates, the effects of this change in taxes ranged between 8 percent in the short run and 11 percent in the long run. These results are roughly consistent with those of Keeler et al. (1992) and Hu et al., (1992), each of which used very different data and methods from those used here.

Table 1: Average Rate of State Excise Taxes for Cigarettes[a]
(During fiscal year ending June 30)

Number of States	Average Rate of State Excise Taxes		
	1975	1985	1990
51[b]	11.94 (4.26)	15.77 (5.78)	22.07 (9.61)
11[c]	10.65 (2.41)	14.00 (4.44)	23.00 (8.61)

Source: The Tobacco Institute (1990).

Footnote: [a] Standard Deviations are included in the parentheses.
[b] 50 states and Washington, D.C.
[c] 11 western states.

Table 2: Descriptive Statistics for the Period 1967-1990

Variable	Mean	Standard Deviation	Minimum	Maximum
CON	114.59	28.31	53.39	193.33
DPRICE	57.19	9.06	36.63	88.55
DPCDI	5955.28	778.84	4130.35	7541.86
POPO65	9.61	1.66	5.74	13.85
POPU18	31.90	4.39	24.75	43.66
MALE	49.73	0.52	48.96	51.23
BLACK	2.51	2.27	0.23	7.69
OTHRACE	7.06	5.60	1.11	23.61
MORM	12.16	19.81	1.10	74.50
CATHOL	15.40	7.72	3.80	37.30
SBAPT	2.55	2.77	0.40	11.50
DPHOTEL	119.46	237.01	22.07	1212.11
MILTARY	1.08	0.59	0.04	2.87
INDIAN	2.55	2.19	0.10	6.93
F	88.21	6.76	72.00	95.00
SMREG	4.89	14.92	0	72.65
DTAXIMP	0.30	0.56	0	3.94
DTAXEXP	-0.50	0.93	-4.50	0
DSTAX	12.51	4.29	3.65	24.92
DFTAX	9.62	2.66	4.71	16.77
DFPI	14.78	2.02	10.88	20.13
H	0.24	0.03	0.21	0.29
USSALE	572.82	38.92	508.73	633.33
D71	0.81	0.38	0	1.00

Table 3: Estimated Results from Parks Method for Retail Price Equation (1968-1989)

Variable	Coefficient
Intercept	-47.103 (-7.29)*
DSTAX	1.370 (54.73)*
DFTAX	2.267 (24.90)*
DFPI	255.782 (13.78)*
H	0.730 (4.25)*
$USSALE_{t+1}$	-0.016 (-2.42)**
D71	3.408 (7.05)*

Footnote: t-statistics are included in the parentheses.
* Statistically significant at two-tail, 1% level.
** Statistically significant at two-tail, 5% level.

Table 4: Estimated Results from Parks Method for Per-Capita Cigarette Demand Equation (1968-1989)

Variable	Rational Addiction	Myopic Addiction	Static Model
	(Column 1)	(Column 2)	(Column 3)
Intercept	103.076 (-1.01)	115.392 (-1.09)	184.406 (-1.67)***
DPRICE	-0.378 (-5.51)*	-0.662 (-10.36)*	-0.840 (-11.96)*
CON_{t+1}	0.339 (10.51)*		
CON_{t-1}	0.228 (6.30)*	0.271 (7.29)*	
DPCDI	0.003 (2.74)*	0.007 (6.71)*	0.009 (7.95)*
POPO65	0.098 (0.13)	-0.400 (-0.46)	-0.573 (-0.61)
POPU18	1.172 (3.47)*	1.533 (3.63)*	2.084 (4.69)*
MALE	3.141 (1.65)***	4.979 (2.51)**	6.919 (3.47)*
BLACK	1.076 (2.12)**	1.491 (2.75)*	2.157 (4.10)*
OTHRACE	-0.080 (-0.44)	-0.344 (-1.59)	-0.705 (-2.96)*
MORM	-0.531 (-6.36)*	-0.819 (-9.46)*	-1.100 (-13.52)*
CATHOL	-0.979 (-4.09)*	-1.232 (-4.80)*	-1.450 (-5.47)*
SBAPT	1.073 (2.24)**	1.453 (2.75)*	1.800 (3.42)*
DPHOTEL	0.025 (6.13)*	0.040 (10.14)*	0.053 (15.55)*
MILTARY	-3.258 (-2.06)**	-8.468 (-5.74)*	-11.620 (-8.40)*
INDIAN	0.651 (1.35)	1.281 (2.51)**	1.360 (2.60)*
F	-0.240 (-1.45)	-0.816 (-4.21)*	-0.870 (-4.68)*
SMREG	-0.037 (-1.50)	-0.086 (-2.99)*	-0.110 (-3.76)*
DTAXIMP	-9.331 (-10.24)*	-11.095 (-11.87)*	-13.931 (-13.90)*
DTAXEXP	-1.457 (-2.61)*	-1.808 (-3.27)*	-2.717 (-4.81)*

Footnote: t-statistics are included in the parentheses.
* Statistically significant at two-tail, 1% level.
** Statistically significant at two-tail, 5% level.
*** Statistically significant at two-tail, 10% level.

Table 5: Comparisons of the Empirical Short Run and Long Run Own-Price Elasticities

	Short Run	Long Run
our results	-.33	-.44
Becker, Grossman and Murphy (1990)	-.4	-.77
Fuji (1980)	-.34	
Baltagi and Levin (1986)	-.2	
Mcguinness and Cowling (1975)	-.99	
Porter[a] (1986)	-.25	
Lewit and Coate (1982)	-.42	
Ippolito, Murphy and Sant (1979)	-.81	
Schneider, Klein and Murphy (1981)	-1.22	

Footnote: [a] Porter (1986) estimates the price elasticities ranging from -.20 to -.29. We assume the average of them is -.25.

Table 6: Own-Price and State Tax Elasticities in California during 1967-1990

Year	Short Run Price	Long Run Price	State Tax
1967	-0.232	-0.309	0.0818
1968	-0.321	-0.428	0.2034
1969	-0.328	-0.437	0.2107
1970	-0.331	-0.440	0.2021
1971	-0.322	-0.429	0.1930
1972	-0.306	-0.408	0.1828
1973	-0.295	-0.393	0.1747
1974	-0.282	-0.375	0.1586
1975	-0.276	-0.368	0.1544
1976	-0.273	-0.363	0.1438
1977	-0.273	-0.364	0.1380
1978	-0.302	-0.402	0.1400
1979	-0.293	-0.390	0.1326
1980	-0.272	-0.363	0.1190
1981	-0.259	-0.345	0.1059
1982	-0.273	-0.364	0.1071
1983	-0.313	-0.417	0.1069
1984	-0.348	-0.464	0.1085
1985	-0.359	-0.478	0.1139
1986	-0.381	-0.508	0.1154
1987	-0.399	-0.531	0.1249
1988	-0.449	-0.599	0.1330
1989	-0.553	-0.737	0.2362
1990	-0.684	-0.911	0.3613

APPENDIX Variable Definitions

CON	Annual per-capita state tax-paid cigarette sales (packs) in fiscal year ending June 30th. Source: Tobacco Institute (1991).
DPRICE	Average retail cigarette price (cents) per pack, deflated by U.S. consumer price index for all items in 1977 cents, and by the 1967 relative state cost of living assuming that relative state prices hold unchanged through the sample period. Source: Tobacco Institute (1991) and Fuchs, Michael and Scott (1979).
DPCDI	Per-capita disposable income, deflated by U.S. consumer price index for all items in 1977 dollars. Source: Survey of Current Business (August issue in various years).
DSTAX	Deflated all state taxes for cigarettes, which include state excise tax, weighted county and/or city taxes, and sales tax for cigarettes if applicable, in 1977 cents. Source: Tobacco Institute (1991).
DFTAX	Deflated Federal excise tax for cigarettes, in 1977 cents. Source: Tobacco Institute (1991).
DPHOTEL	Per-capita hotel expenditures (earnings in lodging industry), in 1977 dollars. Source: Survey of Current Business (August issue in various years).
MILTARY	Percent of state military population. Source: Current Population Survey.
POPO65	Percent of state resident population aged 65 and older. Source: Census of Population.
POPU18	Percent of state resident population under 18 years old. Source: Census of Population.
MALE	Percent of state male resident population. Source: Census of Population.
BLACK	Percent of state black resident population. Source: Census of Population.
OTHRACE	Percent of state resident population with race other than white and black. Source: Census of Population.
INDIAN	Percent of state resident population living on the Indian

Reservations.
Source: Census of Population.

MORM — Percent of state resident population that are Mormons.
Source: Churches and Church Membership in the United States.

CATHOL — Percent of state resident population that are Catholics.
Source: Churches and Church Membership in the United States.

SBAPT — Percent of state resident population that are Southern Baptists.
Source: Churches and Church Membership in the United States.

DTAXIMP — Deflated import bootlegging incentive variable, defined as the weighted state excise tax differences between the import state (higher tax state) and the bordering export states (lower tax states) with the weight equal to the ratio of population living within 20 miles of the border area in the import state to the total resident population living in the import state by the formula: $\sum_j \frac{population_{i(20\text{ mile with }j)}}{population_{i(total)}}(T_i - T_j)$.
where K_{ij} is the fraction of the state i population living within 20 miles of state j. The population data are based on 1980 Census of Population.
Source: County and City Data Book, and Tobacco Institute (1991).

DTAXEXP — Deflated export bootlegging incentive variable, defined as the weighted state excise tax differences between the export state (lower tax state) and the bordering import states (higher tax states) with the weight equal to the ratio of population living within 20 miles of the border area in the neighboring import state to the total resident population living in the export state by the formula: $\sum_j \frac{population_{j(20\text{ mile with }i)}}{population_{i(total)}}(T_i - T_j)$.

SMREG — Smoking ordinance regulation index, defined as the weighted stringent level of local smoking ordinances by the percent of population living in the cities or unincorporated areas of counties regulated under that ordinance.
Source: Pertschuk and Shopland (1989).

USSALE — Aggregated U.S. tax-paid cigarettes sales, in billions of cigarettes.
Source: Tobacco Institute (1991).

DFPI — Deflated input cost index for the cigarette manufacturing industry (SIC=2111), in 1977 cents. It is defined as the average cost of labor compensation, material cost, new machinery and equipment purchase and advertising expenditures per pack of cigarettes.
Source: Census of Manufacturers.

H — Herfindahl index of the percent market share of U.S. six biggest cigarette manufacturers.
Source: Porter (1985), and Business Week.

D71 — Dummy variable representing the broadcast advertising ban (=1 if fiscal year < 1971; =0.5 in 1971; =0 if year > 1971).

F — Domestic percent market share of filter cigarettes.
Source: Federal Trade Commission Report to Congress, Pursuant to the Federal Cigarette labeling and Advertising Act (1990).

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