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**Taxation, Regulation, and Addiction:
A Demand Function for Cigarettes
Based on Time-Series Evidence**

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Abstract

In this paper we analyze the effects of prices (in turn influenced by taxes) income, and anti-smoking regulations on the consumption of cigarettes. In addition, we analyze the structure of lags between price changes and consumption changes. Analysis is based on monthly time-series data for California from January of 1980 through December of 1990. The results indicate, first, no lagged (or anticipatory) effects of price on consumption. This result is not consistent with economic models of addiction. Second, our evidence indicates that the price elasticity of demand for cigarettes, even in the short run, is significantly less than zero, about .35 at the mean value of our data set. However, our results indicate that, as prices rise, demand becomes more elastic, as well, so that, after the tax was imposed in California, the price elasticity was more of the order of -.6 to -.7 Third, it would appear from our results that increasing antismoking regulations in California over the 1980's played some role in reducing smoking; however, this result is ambiguous, given the intercorrelation between our regulation index and a time trend, also included in our analysis of cigarette demand to measure change in social customs.

TAXATION, REGULATION, AND ADDICTION: A DEMAND FUNCTION FOR CIGARETTES BASED ON TIME-SERIES EVIDENCE

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Cigarette-smoking has adverse health consequences, and, for some years, public policy-makers have attempted to reduce it. Much more controversial than the health effects of smoking is the question as to what public policies are most effective in reducing it.

A substantial body of research by health economists, built up over more than two decades, suggests that large taxes on cigarettes can have a potent effect in reducing cigarette consumption. Empirical analyses have suggested that a 10 per cent increase in the price of cigarettes can reduce the consumption of cigarettes by 5 to 8 per cent, or even more.[1]

In the 1990's, this basic result has been challenged or at least modified by two developments. First, there is reason to believe that anti-smoking regulations could play a strong role in reducing cigarette consumption. Indeed, one study[2] has found, using highly disaggregated cross-section data for the United States, that once differences in regulation among states are

[1]For a survey of evidence on this, see, for example, Harris, 1987.

[2]Wasserman, Manning, Newhouse, and Winkler, 1991.

controlled for, the effects of price differences become quite small, with price elasticities of 0 to -.28.

The second group of researchers, Becker, Grossman, and Murphy (1991) has applied the model of rational addiction of to cigarette consumption, and has found the theory confirmed.[3] Very briefly stated, this theory suggests the hypothesis that current cigarette consumption is a function of both past and future cigarette prices, and that, as a result, accurate estimates of the effects of price changes on demand must take account of future and lagged prices, as well as current ones.

Both sets of hypotheses from these recent studies are controversial, and it is the aim of the present study to develop them in a new light and to test them with a data set affording a unique opportunity to understand the determinants of the demand for cigarettes.

California voters approved a measure which dramatically increased the tax on cigarettes, which increased the price substantially, by 25 cents per pack, on January 1, 1989. Earlier in the 1980's on the other hand, various cities, counties, and communities enacted anti-smoking regulations of varying severity.

In this paper, we develop a model of the demand for cigarettes incorporating prices, regulatory policies, and rational addiction, and we test hypotheses relating to each theoretical argument, using monthly time series data for the period 1980 through 1990 (by using monthly time series data over

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[3]Becker, Grossman, and Murphy (1991) and Chaloupka (1991).

a relatively short period of time, we should largely avoid the often-cited problem that over the longer term, tastes change, and those changes in taste make such time-series modeling unreasonable).

In the next section, the model of rational addiction is integrated with a distributed lag model, and it is shown that with adaptive expections, it is impossible to distinguish between rational addiction (wherein consumption is based on past and future prices) and myopic addiction (wherein consumption is based on past prices alone). Although rational addiction is still tested for under the assumption of perfect foresight, this theoretical perspective on rational addiction must be kept in mind when the results are interpreted.

In the second section, data and sources are discussed. The third section presents a discussion of estimation procedures and the fourth reports results. The final section summarizes our conclusions and their implications for the literature on the demand for cigarettes.

I. A DEMAND FUNCTION WITH RATIONAL ADDICTION AND ADAPTIVE EXPECTATIONS

In this section, we develop a simple model of the demand for cigarettes with price as independent variable and with addictive behavior incorporated by way of a finite distributed lag.

With rational addiction, current consumption is a distributed lag on past and future prices:

$$C_t = a_0 + \sum_{i=0}^{N} b_i P_{t-i} + c\ P_{t+1} \tag{1}$$

With adaptive expectations, the expected future price functions as a distributed lag on past values of price:

$$P_{t+1e} = \sum_{j=0}^{M} b_j P_{t-j} \tag{2}$$

Select N large enough so that it is greater than or equal to M, with the appropriate a's and b's equal to zero.

Then, combining (1) and (2), we have

$$C_t = a_0 + \sum_{i=0}^{N} a_i P_{t-i} + \sum_{i=0}^{N} c\ b_i P_{t-i} \tag{3}$$

or, collecting terms,

$$C_t = a_0 + \sum_{i=1}^{N} [a_i + c\ b_i] P_{t-i} \tag{4}$$

A further refinement would be to allow multiple (L) independent variables. In this case, think of the desired level of consumption as a response to many variables, including price. Then the desired level is

$$C^* = C^*(X_1,\ X_2, \ldots, X_L). \tag{5}$$

With rational addiction, one can think of actual consumption in time T as a distributed lag on desired consumption from previous periods (because habits change slowly), and on desired consumption one period into the future.

Therefore, with rational addiction

$$C_t = \sum_{i=0}^{N} a_i C^*_{t-i} + c\ C^*_{t+1} \tag{6}$$

where it is reasonable to impose the restriction that

$$\sum_{i=0}^{N} a_i + c = 1. \tag{7}$$

With adaptive expectations, the expected amount for future desired consumption is

$$C^*_{t+1} = \sum_{j=0}^{M} b_j C^*_{t-j} \tag{8}$$

where, again, it is reasonable to impose the restriction that

$$\sum_{j=0}^{M} b_j = 1. \tag{9}$$

Equation (6) can once again be estimated with distributed lags on values of the independent variables (here again, we define N as a sufficiently long period to incorporate both lags).

$$C_t = \sum_{i=0}^{N} a_i C^*_{t-i} + c\ C^*_{t+1} \tag{10}$$

$$= \sum_{i=0}^{N} a_i C^*_{t-i} + c\ [\sum_{i=0}^{N} b_i C^*_{t-i}] \tag{11}$$

$$= \sum_{i=0}^{N} [a_i + c\ b_i] C^*_{t-i} \tag{12}$$

It can be shown that restricting the distributed lag coefficients to add to one causes actual and desired consumption levels to converge in a long-run steady state.

In such a steady state, $C^* = C_0$, for all periods. Hence,

$$C_t = \sum_{i=0}^{N} a_i C^*_{t-i} + c\ [\sum_{i=0}^{N} b_i C^*_{t-i}] \tag{13}$$

$$= \sum_{i=0}^{N} a_i C_0 + c\ [\sum_{i=0}^{N} b_i\ C_0] \tag{14}$$

$$= \sum_{i=0}^{N} a_i C_0 + c\ C_0 \tag{15}$$

(because the sum of the b's is 1)

$$= C_0 \tag{16}$$

(because the sum of the a_i plus c is one)

We now consider the implications the above analysis for specification of a demand function for cigarettes. With addiction (either myopic or rational with adaptive expectations), total demand per capita will be

$$\ln C_t = a_0 + a_1\ L\{\ln P_t\} + a_2 \ln I_t + a_3 REG_{it} \tag{17}$$

where C is consumption per capita, L is a distributed lag operator (further discussed below) P is price per pack, I is income, and the REG_i is a regulatory variable, to be discussed below.

As regards the lag operator, some previous studies have used a Koyck lag. This lag structure has two serious difficulties for the present analysis: first, it imposes strong restrictions on the shape of the lag structure, one which may or may not be valid. Second, it requires the inclusion of a lagged endogenous variable, which introduces serious estimation problems. Both problems can be avoided through the use of a more general form of lag. For present purposes, we use three alternative lag structures: the Koyck lag, the polynomial lag first developed by Almon (1965), and a free-form lag that does not attempt to impose any structure on the results.

Problems of estimation bias. Almost all estimation of demand equations is subject to problems of estimation bias, given the fact that the price is jointly determined by demand and supply.[4] Since the price elasticity of demand for cigarettes is a key parameter for estimation in this paper, it is important to account for this simultaneity in our estimation procedure. The procedure used here is instrumental variables, using the logarithm of the real tax per pack of cigarettes as an instrument for the real price; correction for first-order autocorrelation is achieved by way of the method of Fair (1970).[5]

Another source of bias in the estimate of the price coefficient comes from the possibility of bootlegging across state lines. If California raises the tax on cigarettes, and

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[4]In this context, supply can refer to oligopoly price behavior, as well as a competitive supply curve. The instrumental-variables procedure used here does not require that the situation be restricted to competition or oligopoly. See below.

[5]Thus, in a situation with no autocorrelation correction, no lagged price variable, and no squared term for price, the estimation procedure is the equivalent of two-stage least squares with the log of price an endogenous variable, all the other structural variables exogenous, and log tax an additional exogenous (instrumental) variable. In addition, whether or not a time trend variable is used in the final equation, a time trend variable t is always used as an instrument. To implement Fair's procedure, we have additionally included as instruments lagged values of each of the exogenous variables, as well as a lagged value of the endogenous variables, quantity sold and price, and estimated with AR(1) correction. When lagged or future values of price are used, they are always treated as endogenous variables, with equivalent lagged or future values of tax as exogenous variables, plus a value of price lagged one period beyond the most lagged value desired in structural estimates as an instrument, consistent with Fair's procedure. Thus, if a coefficient price lagged three periods is desired, then price lagged four periods is included as an instrument. In the case of Almon lags, if a distributed lag on log price is included in the final equation, then an equivalent distributed lag on log tax is included as an instrument. Furthermore, consistent with Fair's procedure, if estimation is for a twelve-period Almon lag on price, then price lagged 13 periods is included as an instrument.

other states (and Mexico) do not go along, then the estimated demand elasiticity will be greater than the true one, for the estimated elasticity will reflect increased bootlegging as the price rises. While this may be a source of bias in our estimates, there are reasons to believe that the bias is unlikely to be substantial. First, most of the population in California is a long way from state borders. Second, the quantity of cigarettes which an individual can import tax-free from Mexico is tightly restricted. Third, none of the states surrounding California tax tobacco products at the really low level of the tobacco-producing states. Fourth, one state, Nevada, has tended to raise its taxes along with California's so as to produce little if any advantage to Californians in bootlegging.

II. DATA

To estimate the demand equation discussed above, it is necessary to have data on quantities consumed, prices, and income. Beyond that, to test for the relative importance of taxation and regulation, we develop a series taking account of both the percent of the state's population affected by regulation, and the intensity of regulation for the population covered.

Quantity. Monthly quantity of cigarette consumption is based on tax-paid wholesale sales reported to the California Board of Equalization. Per-capita adult consumption was calculated by dividing these amounts by civilian population 15 years of age or older, using the annual intercensus estimates of the U. S. Bureau of Census. A logarithmic interpolation (constant growth rate) was used to estimate population in any given month. As relates to the quantity sold, it is worth considering at what point in the sales process the quantity was measured--at the wholesale sales point, the retail sales point, or the collection of the tax. Data for this measure of quantity are based on the number of tax stamps sold in a given month. Since retailers have basically no incentive to hoard tax stamps, this measure should not reflect inventory behavior of retailers or wholesalers.[6]

Price. We created a monthly California cigarette price index using unpublished data of the Bureau of Labor Statistics Consumer Price Index survey. Tobacco retail price indices for the Los Angeles, San Francisco, and San Diego metropolital areas were divided by the CPI for allgoods in that metropolitan area. A weighted average of these real indices was created, with weights determined by population. Metropolitan area populations were calculated from the annual estimates of resident civilian population of counties prepared by the Population Research Unit of the California Department of Finance.

[6]There are no capital gains on keeping tax stamps from a lower tax period to a higher-tax period. Even if the seller has an incentive to keep inventories of cigarettes (though that incentive is mitigated by the perishability of cigarettes over long periods), that does not extend to an incentive to keep tax stamps.

Income. Per capita income is based on the quarterly estimates of total personal income for California reported by the Bureau of Economic analyis of the U. S. Department of Commerce, divided by the Census Bureau population estimates and the California Consumer Price Index. The California Division of Labor Statistics and Research creates the California CPI from a population-weighted average of Bureau of Labor Statistics indices for California Metropolitan areas. Monthly per capita income is based on a logarithmic (constant-growth rate) interpolation of quarterly data.

Total tax. To calculate total tax per pack, the sum of the state tax and the Federal tax at a given time was divided by the California CPI.

Regulation Index. The index of regulation was calculated using data from a report prepared for the National Institutes of Health on local ordinances which regulate smoking in public places (Pertschuk and Shopland, 1989). These data were supplemented by analysis of all ordinances which were amended during the period under study, and by a telephone survey of county health departments. The index reflects the per cent of the state's population living in at least one jurisdiction subject to a local smoking ordinance, controlling for the severity of the ordinance. Severity was measured using the criteria of Warner (1981), as updated by Wasserman, et., al, 1991.[7]

All these data were available for each of the 12 months of the years 1980 through 1990, for a total of 132 observations.

III. RESULTS

There are really two sets of issues to be considered here: the structure of the lag distribution and the actual effects of the structural variables on smoking behavior. We first consider the structure of the lag distribution. The first part of the present section will therefore discuss only the lag structure. Issues of the meaning of the values for all the coefficients will be taken up in the next part.

Results regarding distributed lags. Rather strikingly, whatever form of distributed lag is used, neither lagged nor future values of price have an effect on demand: only current ones have an effect.

Table 1 shows the results with free-form lags, done three

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[7]Specifically, the index of severity works as follows. Each locality in each period was assigned a value ranging from zero to one, with zero entailing no (or essentially no) regulation, with one being the most strict regulation. If a locality restricted smoking in private worksites, it received a score of one. Localities restricting smoking in restaurants, but not in workplaces, were considered next most stringent, so they received a score of .75. If a locality did not restrict smoking in restaurants or in workplaces, but did so in at least four other public places, it got a score of .5, while localities that had between one and three of these smaller restrictions were given a value of .25. To calculate a state-wide index, we used population weights. Regulatory changes were assumed to take place July 1 of each year, and exponential interpolations of weighted populations were used for months in between July.

months in the future and three months in the past. Results are shown with autoregressive correction, using single-equation and simultaneous-equation estimation (as proposed by Fair, 1970). In every case, future and lagged values of price have no significant effect on current consumption: only current price matters.

Table 2 shows results with a Koyck lag structure, again using both single-equation and simultaneous-equation least squares, in both cases with autoregressive corrections. In this case, it must be remembered that the lagged endogenous variable of consumption in the previous month can cause simultaneous-equations bias if there is autocorrelation. Our estimtion procedure endeavors to correct for that, however. In our results, the lagged quantity variable is of the opposite sign from that expected for addictive behavior (such as that theorized by Becker, Grossman, and Murphy), that is, it indicates that more consumption last month means <u>less</u> consumption this month. In the equation excluding the time trend variable, this result appears to be significant. Given the difficulties involved with the lagged endogenous variable, not too much weight should probably be attached to this, but it casts doubt both on the validity of the Koyck lag structure and on addictive behavior, at least for this data sample.[8]

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[8]There is a possible rational explanation for this behavior, however: it is that there is hoarding: if price is expected to rise next month, smokers will hoard cigarettes this month. Again, however, given the problems of estimation with a lagged endogenous variable, we do not believe that this result should be emphasized strongly.

Finally, Table 3 shows results using Almon lags. The results shown are for a fourth-degree polynomial approximation of a one-year lag, with no restrictions on the beginning and end values of the lag. It can be shown, however, that these results are quite insensitive to the degree of the polynomial approximation or the length of the lag.

The results shown in Table 3 indicate that the only negative and significant effect of price on consumption occurs in the current period, and possibly one lagged period: if prices from further-lagged periods are anywhere near significant, they are with positive signs; that may be an artifact of the Almon polynomial lag specification. Also, even the result of significance for a one-month lag is suspect, given the results in Table 1 for free-form lags.

The evidence from Tables 1, 2, and 3 would appear to indicate that in this sample, it is difficult to discern evidence of addictive behavior in the economic sense of the term. That does not mean that such behavior is absent: it is possible, for example, that the lag structure between price and consumption is so long and so irregular that monthly time series cannot pick it up; it may be necessary to use a panel of cross-section data over time (as used by Becker, Grossman and Murphy, 1991, and by Chaloupka, forthcoming) to discern it.

It can in any event be argued strongly that the most meaningful results from this study are those which exclude all distributed lags, and concentrate on current effects. It is to those results which we now turn.

Results based on current, non-lagged values. For purposes of the present analysis, the constant-elasticity-of-demand assumption is worth relaxing. It might readily be hypothesized that most real-world demand curves do not have constant demand elasticities, but rather the elasticity varies as the price rises: most plausibly, one would expect Marshallian price elasticity of demand to increase as price increases. Thus, while demand elasticity can easily be low at low prices, the consumer's ability to pay will fall at some very high price, and elasticity should increase.

One solution for this specification problem would be to use a linear demand curve. However, the log-linear specification used here makes good theoretical sense in a number of ways: for example, it allows for interaction of price and income in a very plausible way. Another solution is to allow for a squared term for the log of price in the equation, as well as a loglinear term. This allows for a quadratic approximation to a logarithmic form, in price, and it is the approach taken here.[9] The price variable used here is measured in standard deviations from its mean value, so that the mean value of the variable in the

[9]Collinearity prevented using this term in analyzing distributed lags (except for the Koyck lag, which is shown in Table 2 with the squared term in log price). Nevertheless, when the free-form lags of the sort shown in Table 1 were estimated with both price and price squared terms, the only term which was significant was current price: as in Table 1, the lagged and future values of both variables were insignificant and of randomly-varying sign).

equation (and its square) is zero. As is true with translog cost and demand equations, this means that the coefficient of the linear price term is the elasticity of price with price held at its mean value, and its standard error is similarly the standard error at the mean.[10]

The results, again with correction for autocorrelation, are shown both for single-equation and simultaneous-equation least squares. Also, results are shown with and without the time trend variable.

As regards price effects, the results are quite robust across specifications, with or without the time variable, with single- or simultaneous equation estimation techniques. They indicate a highly significant price elasticity of demand of about .35 at the mean value of the sample, with strongly signficant evidence that the price elasticity of demand increases as the price increases. Thus, it can be shown through simulations that at the highest price in the sample, occurring in June of 1990, 18 months after imposition of the tax, the demand elasticity goes to -.6 to -.7. Consumers are clearly highly responsive to price, and, as theory predicts, their demand elasticity rises as the price goes up. It is worth knowing that at the mean values of prices in this study, the price elasticity of demand for cigarettes is somewhat lower than the average suggested by other

[10]This can readily be seen by taking the logarithmic derivative of the equation with respect to price with price equal to zero. This has been done in estimation of numerous translog cost and production equations. See, for example, Christensen and Greene (1976).

time-series studies, as surved by Harris (1987). On the other hand, they are closer to the results of Wasserman, et. al., 1991, who find a value for adults (extrapolated to 1988) of .28. This result is certainly within a reasonable confidence range of theirs.

In the equations without a time trend, regulation is also a highly significant determinant of smoking behavior: its sign is negative, as expected, and its effect would seem to be strong. With the time trend variable included, regulation still has a negative effect on smoking, but its effect is much weaker. It would appear that there is strong correlation between the time trend and regulation: they both measure the same social trends away from smoking. These results suggest that, while it is difficult to separate the effects of regulation from other trends away from smoking, nevertheless it would seem likely that regulation has played some role, though that role is difficult to distinguish in this analysis from the role of changes in tastes and customs.

IV. CONCLUSIONS

The 1989 tobacco tax increase in California offers an important opportunity to test for the effects of taxation on cigarette consumption. The results of this experience so far indicate some significant conclusions.

First, our monthly time-series analysis was unable to detect any lagged (or anticipatory) effects of price on consumption. This result is not consistent with any form of economically addictive behavior, rational or myopic. It is nevertheless possible that economically addictive behavior does occur: specifically, it is possible that either lags or anticipations are sufficiently long or irregular that the present monthly analysis is unable to pick them up. For example, if the "long-run" effects of taxation entail discouraging adolescents from deciding to smoke, it may be that these effects are too irregular to show up in this time-series analysis. Another part of the project which generated this research is concerned with analyzing the California experience in cross-sectional terms, to answer just this question.

Second, our evidence indicates that the price elasticity of demand for cigarettes, even in the short run, is significantly greater than zero, about .35 at the mean value of our data set. However, our results indicate that, as prices rise, demand elasticity rises, as well, so that, after the tax was imposed in California, the price elasticity was more of the order of .65. Our result that demand elasticity ranges by price is different from those of some other studies, though it is roughly consistent with that of Wasserman, et. al., 1991.[11] However, the range of values represented by our point estimates, .35 to .65, is not

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[11]Wasserman, et. al., find that demand elasticity rises over time. Since the real price of cigarettes has tended to rise over time, especially with taxes included, the two results would appear to be quite similar).

inconsistent with results of other studies, such as those cited by Harris (1987).

Third, it would appear from our results that increasing antismoking regulations in California over the 1980's played a strong role in reducing smoking. However, this result is somewhat ambiguous, given the intercorrelation between our regulation index and a time trend, which is often also included in time-series studies of cigarette demand to measure change in social customs.

Our results indicate strongly, however, that prices and regulations are not mutually exclusive in reducing cigarette consumption: in California, it would appear that they both have played an important role.

REFERENCES

Almon, Shirley, "The Distributed Lag between Capital Appropriations and Expenditures," Econometrica 33 (1965), pp. 178-96.

Baltagi, B. H., and D. Levin, "Estimating Dynamic Demand for Cigarettes using Panel Data: The Effects of Bootlegging, Taxation, and Advertising Reconsidered," Review of Economics and Statistics 68 (February, 1986), pp. 145-155.

Becker, Gary S., Grossman, Michael, and Murphy, Kevin, "Rational Addiction and the Effect of Price on Consumption," American Economic Review 81, no. 2 (May, 1991), pp. 237-41.

Becker, Gary S., Grossman, Michael, and Murphy, Kevin, "Rational Addiction and the Effect of Price on Consumption," forthcoming in E. P. Lazear and M. Krauss, eds., Drug Policy in the United States (Stanford, CA: Hoover Institution Press).

Bishop, J. A., and J. H. Yoo, "'Health Scare,' Excise Taxes, and Advertising Ban in Cigarette Demand and Supply," Southern Economic Journal 52 (October, 1985), pp. 402-411.

Chaloupka, F. J., "Rational Addictive Behavior and Cigarette Smoking," Journal of Political Economy, forthcoming.

Christensen, Laurits, and William H. Greene, "Economies of Scale in the U. S. Electric Power Industry," Journal of Political Economy 84 (August, 1976), pp. 655-676.

Fair, Ray, C., "The Estimation of Simultaneous Equations Models with Lagged Endogenous Variables and First-Order Serially Correlated Errors," Econometrica 38 (1970), pp. 507-516.

Fuller, D., Introduction to Time Series (New York, J. Wiley, 1978).

Grossman, Michael, "Editorial: The Demand for Cigarettes," Journal of Health Economics 10 (May, 1991), pp. 101-103.

Harris, Jeffrey E., "The 1983 Increase in the Federal Cigarette Excise Tax," in L. H. Summers, ed., Tax Policy and the Economy, NBER and MIT Press Journals, 1 (1987), pp. 87-111.

Johnston, John, Econometric Methods (New York: Rand McNally, 1972), p. 319.

Kao, Kai, and Victor J. Tremblay, "Cigarette 'Health Scare,' Excise Taxes, and Advertising Ban: Comment," Southern Economic Journal 54 (January, 1988), pp. 770-779.

Koyck, L. M., Distributed Lags and Investment Analysis (Amsterdam, North Holland, 1954).

Nicholls, William H., Price Policies in the Cigarette Industry: A Study of "Concerted Action" and Its Social Control (Nashville: Vanderbilt University Press, 1951).

Pertschuk, Mark, and Donald R. Shopland, Major Local Smoking Ordinances in the United States: A detailed Matrix of the Provision of Workplace, Restaurant, and Public Places Smoking Ordinances, Washington, D. C. (U. S. Department of Health and Human Services, National Institutes of Health Publication No. 90-479, September, 1989, prepared by Americans for Nonsmokers' Rights, Berkeley, California).

Porter, Robert H., "The Impact of Government Policy on the U. S. cigarette Industry," in Pauline Ippolito and David Scheffman, Editors, Empirical Approaches to Consumer Protection Economics (Washington, Bureau of Economics, Federal Trade Commission, 1986), pp. 447-481.

Sullivan, Daniel, "Testing Hypotheses about Firm Behavior in the Cigarette Industry," Journal of Political Economy 93 (June, 1985), pp. 586-598.

Warner, Kenneth E., "Cigarette Smoking in the 1970's: The Impact of Angismoking Campaigns on Consumption," Science 211 (1981), pp. 729-731.

Wasserman, Jeffrey, Willard G. Manning, Joseph P. Newhouse, and John D. Winkler, "The Effects of Excise Taxes and Regulations Teenage Cigarette Smoking," Journal of Health Economics 10 (May, 1991), pp. 43-64.

Table 1. Results with free-form lags

VARIABLE	COEFFICIENT	T-RATIO	COEFFICIENT	T-RATIO
C	2.11192	0.897	10.28802	7.359
LPRICE(3)	-0.16985	-0.425	-0.60980	-1.477
LPRICE(2)	0.73081	1.098	1.02081	1.494
LPRICE(1)	0.57580	0.847	0.52387	0.756
LPRICE	-2.40854	-3.557	-2.44342	-3.544
LPRICE(-1)	0.37426	0.548	0.46702	0.672
LPRICE(-2)	0.39158	0.590	0.44708	0.655
LPRICE(-3)	0.20526	0.526	-0.01300	-0.031
LINCOME	0.18150	0.801	-0.54173	-3.369
LREG	0.02522	3.333	0.00423	0.663
T	-0.00361	-4.051		
FEB	-0.03032	-0.856	-0.03417	-0.963
MAR	0.11520	3.724	0.11048	3.332
APR	0.08401	2.622	0.08432	2.527
MAY	0.09921	3.175	0.09725	2.964
JUN	0.14769	4.835	0.14361	4.505
JUL	0.12011	4.009	0.11456	3.668
AUG	0.11714	3.798	0.10906	3.393
SEP	0.09435	3.035	0.08638	2.645
OCT	0.11346	3.472	0.11562	3.387
NOV	0.05408	1.753	0.05461	1.651
DEC	0.16116	4.550	0.16303	4.595
Adjusted R^2	0.85051		0.82996	
Durbin-Watson	2.17193		2.03797	

Table 2. Results with Koyck Lag

VARIABLE	COEFFICIENT	T-RATIO	COEFFICIENT	T-RATIO
C	4.21530	1.858	13.23337	5.449
LPRICE	-0.53538	-5.019	-1.01687	-8.564
LQUANT(-1)	-0.18303	-1.236	-0.43566	-3.663
LINCOME	0.11845	0.521	-0.54040	-2.197
LREG	0.02732	3.141	0.00805	0.856
T	-0.00322	-3.276		
FEB	-0.06509	-1.706	-0.10277	-2.617
MAR	0.06694	1.522	0.01602	0.386
APR	0.07920	2.492	0.05900	1.741
MAY	0.11003	3.386	0.08015	2.317
JUN	0.16025	5.217	0.13798	4.126
JUL	0.12094	4.063	0.11148	3.411
AUG	0.11073	3.578	0.08603	2.559
SEP	0.09526	3.070	0.06636	1.966
OCT	0.11981	3.770	0.08458	2.470
NOV	0.07422	2.459	0.04803	1.461
DEC	0.15443	4.438	0.12103	3.766
Adjusted R^2	0.84675		0.81576	
Durbin-Watson	2.00709		1.89544	

Table 3. Results with Almon lags (price coefficients and lags on next page)

VARIABLE	COEFFICIENT	T-RATIO	COEFFICIENT	T-RATIO
C	1.54137	0.609	9.77579	6.038
LINCOME	0.28584	1.120	-0.41339	-2.290
LREG	0.02311	2.970	0.01465	1.614
T	-0.00337	-4.869		
FEB	-0.02374	-0.629	-0.01455	-0.391
MAR	0.12535	3.954	0.12864	3.743
APR	0.09481	2.797	0.09234	2.592
MAY	0.12117	3.541	0.11013	3.009
JUN	0.17495	5.121	0.16161	4.450
JUL	0.11148	3.297	0.09967	2.782
AUG	0.12502	3.704	0.11049	3.102
SEP	0.11156	3.326	0.09205	2.604
OCT	0.13525	3.965	0.11226	3.162
NOV	0.09396	2.877	0.07385	2.094
DEC	0.18807	5.043	0.17549	4.694
Adjusted R^2	0.83580		0.80816	
Durbin-Watson	2.05476		1.93739	

Table 3, continued. Results with Almon lags--Price lags and Coefficients

VARIABLE	COEFFICIENT	T-RATIO	COEFFICIENT	T-RATIO
Lag Period				
0	-0.76937	-3.802	-1.05458	-4.386
1	-0.15146	-1.901	-0.22266	-2.369
2	0.15006	1.148	0.17693	1.148
3	0.23900	2.222	0.29226	2.297
4	0.20183	2.726	0.24488	2.782
5	0.10766	1.280	0.12973	1.301
6	0.00825	0.085	0.01522	0.132
7	-0.06199	-0.728	-0.05680	-0.563
8	-0.08601	-1.157	-0.07107	-0.807
9	-0.06410	-0.605	-0.03886	-0.311
10	-0.01391	-0.108	0.00199	0.013
11	0.02955	0.373	-0.01294	-0.138
12	0.01393	0.069	-0.17460	-0.730
Sum	-0.39656	-6.803	-0.77050	-12.343

Table 4. Single-period, unlagged results

VARIABLE	COEFFICIENT	T-RATIO	COEFFICIENT	T-RATIO
C	3.89208	1.714	6.60655	5.002
LPRICE	-0.32423	-4.083	-0.35681	-4.545
LPRICE ^{2}	-0.65757	-2.211	-0.97315	-4.709
LINCOME	-0.15573	-0.650	-0.44286	-3.189
LREG	-0.00657	-0.403	-0.02697	-3.186
T	-0.00154	-1.463		
FEB	-0.03404	-0.966	-0.03299	-0.941
MAR	0.10624	3.675	0.10606	3.635
APR	0.09402	3.033	0.09349	3.017
MAY	0.12750	4.192	0.12537	4.113
JUN	0.17143	5.593	0.16914	5.517
JUL	0.12300	4.024	0.12067	3.944
AUG	0.12247	3.993	0.11969	3.904
SEP	0.10633	3.477	0.10215	3.346
OCT	0.13169	4.212	0.12598	4.066
NOV	0.08014	2.729	0.07451	2.540
DEC	0.17006	4.876	0.16607	4.804
Adjusted R^2	0.84902		0.84637	
Durbin-Watson	2.13517		2.08605	

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