

UC Berkeley

Other Recent Work

Title

the Impact of a Large Tax Increase on Cigarette Consumption: The Case of California

Permalink

<https://escholarship.org/uc/item/3v9919fh>

Authors

Hu, Tah-wei
Bai, Jushan
Keeler, Theodore E.
et al.

Publication Date

1991-07-01

Peer reviewed

UNIVERSITY OF CALIFORNIA AT BERKELEY

Department of Economics

Berkeley, California 94720

Working Paper No. 91-174

**The Impact of a Large Tax Increase
on Cigarette Consumption:
The Case of California**

Teh-wei Hu, Jushan Bai,
Theodore E. Keeler, and Paul G. Barnett*

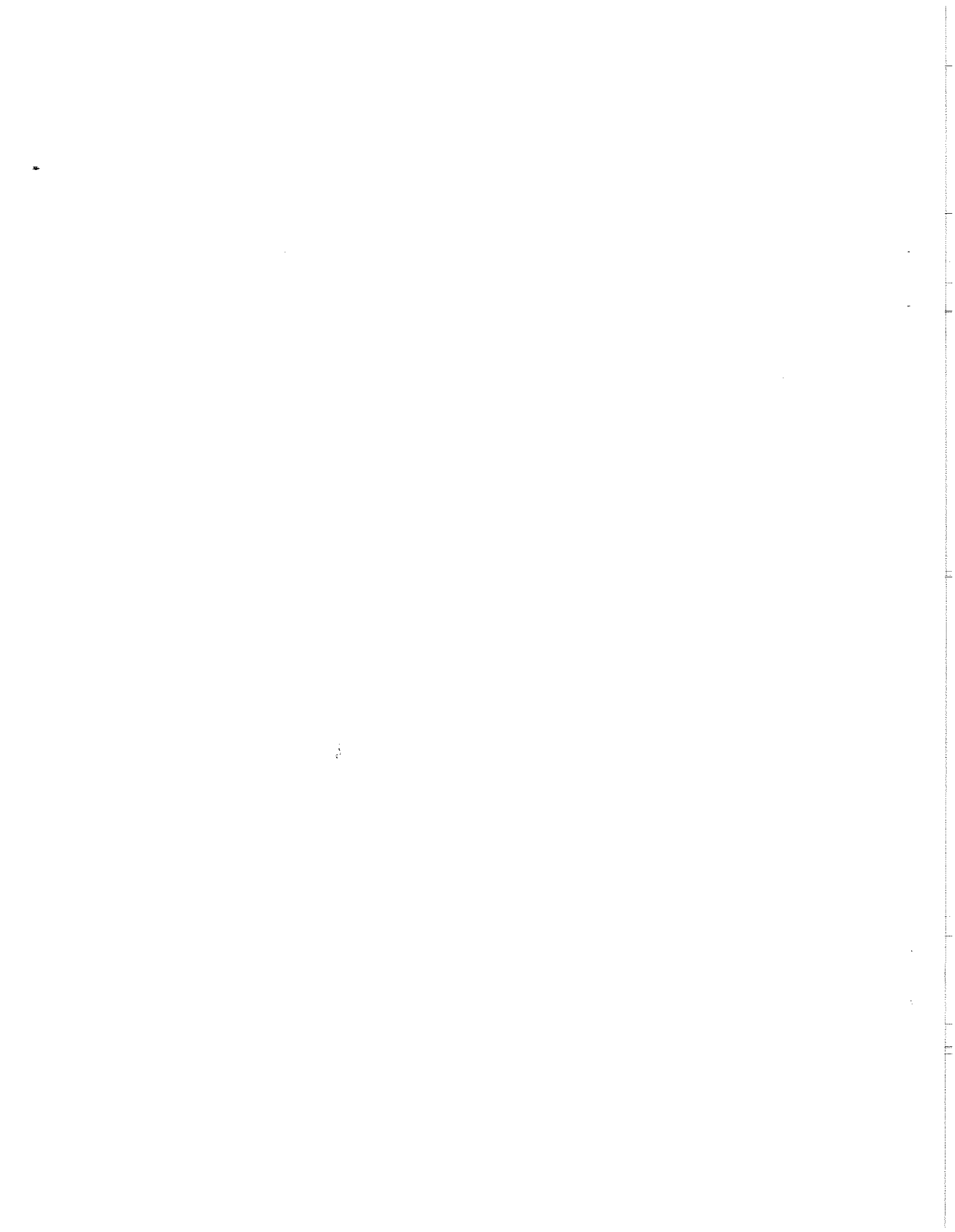
University of California
Berkeley, CA 94720

July 1991

Key words: Cigarette, Taxation

JEL Classification: 324, 913

* From the Department of Social Administrative Health Sciences, School of Public Health (Hu) and Department of Economics (Bai, Keeler, and Barnett), University of California, Berkeley. All are associated with the Institute of Business and Economic Research, University of California, Berkeley. This study is supported by the Tobacco-Related Disease Research Program, University of California. The authors are grateful to Willard Manning and Hai-Yen Sung for their helpful comments on this work.



The Impact of a Large Tax Increase on Cigarette Consumption:
The Case of California

Abstract

In 1988, California voters enacted Proposition 99, increasing the tax on cigarettes by 25 cents per pack, effective January, 1989. Monthly sales data reported by the California State Board of Equalization between 1984 and 1990, adjusted for seasonal variation and time trend, show that consumption of cigarettes in January, 1989 was 1.22 packs per capita less than would have been expected in the absence of the tax. By December, 1990 consumption was only .64 packs below the pre-tax trend. If this trend continues, the effect of the tax may dwindle to nothing by mid 1993. An additional tax or a different type of tax, i.e., an ad valorem tax, must be considered if the effects of the tax are to be sustained.

In 1988, California voters enacted Proposition 99, increasing the tax on cigarettes by 25 cents per pack. The increase became effective in January, 1989. This was the single largest, one-time increase in cigarette excise taxes in the country. One objective of the proponents of Proposition 99 was to reduce the incidence of tobacco related disease by discouraging cigarette smoking. Preliminary analysis from several cross-sectional survey data indicates that Proposition 99 may have caused a significant reduction in tobacco consumption.¹ This paper analyzes the effect of the Proposition on cigarette sales based on the aggregate time-series monthly data from 1984 through 1990. The policy implications of the findings may guide future legislation.

Method

Data

This study estimates the effect of the cigarette tax using data on monthly sales of cigarette tax stamps, as reported by the California State Board of Equalization. In this paper we assume that the sale of a tax stamp is equivalent to the consumption of a single pack of 20 cigarettes. To avoid the confounding influence of changes in Federal excise tax rates we began our data series in January, 1984 and ended it in December, 1990. During the 84 month period studied, there was no Federal tax increase and only one change in the State tax, the 25-cent increase which began January, 1989. The series includes 24

months after the implementation of the tax, a period sufficiently long enough to display the impact of the tax on consumption.

Consumption is expressed as pack per civilian adult.

Population figures are used as the denominator to adjust for the effect of population growth on cigarette sales. Adults are defined as persons 15 years of age and older. Military personnel are excluded because cigarettes sold at federal military installations are exempt from state taxes. Annual population estimates were obtained from the U.S. Bureau of the Census. Monthly population was estimated with interpolation, based on a constant exponential growth trend. Figure 1 illustrates monthly per adult capita consumption of cigarettes between January, 1984 and December, 1990.

The use of state sales data may often raise the question of whether the smuggling of cigarettes from neighboring states biases the results. In California, smuggling is not a major concern. Nevada has changed its cigarette tax rate to match California. The tax difference between Oregon and California during 1989 and 1990 was only 7 cents, too little to induce individuals to smuggle either way.

Statistical Analysis

An efficient procedure to examine the effect of the cigarette tax is the Box-Tiao time-series intervention analysis,² in which the intervention variable is the cigarette tax (a dummy variable with a value of one beginning January, 1989 and a value of zero before 1989). Three intervention variables are included.

in the model: a time trend variable, a dummy variable for the tax intervention, and the interaction between the dummy variable and the time trend.

One of the features of the Box-Tiao time-series intervention model is its ability to model the error term, taking into account the seasonal variation and random monthly fluctuations, and simultaneously introducing explanatory variables into the model. This type of time-series intervention model has been successfully applied elsewhere, such as in testing the effect of air pollution control.³ An extended Box-Tiao time-series model by Harvey and Durbin analyzed the effects of seat-belt legislation on British road casualties.⁴ Using Box-Jenkin time-series three estimation procedures (i.e., identification, estimation, and diagnostic checking)⁵ the following model has been obtained:

$$Y_t = a_0 + a_1T + a_2D + a_3DT_t + (1 + b_1L)(1 + b_2L^4)(1 + b_3L^{12})e_t$$

Where

- Y_t can be expressed either in actual per capita monthly consumption (in packs) or in logarithmic value.
- T_t is the time trend, the number of months from the beginning of the series, with January, 1984 as 1.
- D is the dummy intervention variable: a value of 1 beginning January, 1989 to denote the tax increase and a value of 0 before 1989.
- DT_t is the interaction term, the product of T and D .
- L is the lag operator (i.e., $Le_t = e_{t-1}$, $L^2e_t = L(Le_t)$) etc.
- e_t is the error term

The variable T was used to estimate the trend of reduced consumption over time in the absence of tax increases. The D

variable was used to test and measure the one-time effect of the taxation. DT was used to detect the change of trend in cigarette consumption over time after the tax increase. The dependent variable was expressed both as actual amount and as a logarithmic value. The coefficient in the equation of the actual value measures the effect in the actual amount of packs of cigarette consumption, while the logarithmic equation indicates changes in percentage terms. Analyses were conducted with the maximum likelihood estimation subroutine for Box-Tiao time-series intervention analysis in the Statistical Analysis System (SAS). Figure 2 demonstrates the extent to which the model fits the observed data.

The analysis shows that since 1984 there has been a continuous decline in the per capita cigarette consumption, either in absolute terms (-0.031 pack per capita per month) or in percentage terms (-.3%). As shown in Tables 1 and 2, all coefficients, including the parameters of the moving averages, are statistically significant ($p < .05$).

The coefficients of the dummy variable and the interaction variables suggest that there was an initial reduction after Proposition 99 of 1.22 packs per month, or 13.8 percent. However, this additional decline diminished with time. By December, 1990 consumption was only .645 packs below the pre-tax trend. By setting $a_2 + a_3T = 0$, one can solve for the value of T to project the number of months it will take for the effect of Proposition 99 to disappear. If the trend continues based on

results in Table 1, when $T=110$, or by February, 1993 the effect of Proposition 99 will have disappeared. Obviously, this projection ignores the effect of other anti-smoking activities and the effect of the federal tax increase which began in January 1991. Table 3 illustrates the predicted change of the effect over time since January, 1989.

Discussion

The first 24-month experience after Proposition 99 was enacted indicates that the decline in per capita cigarette consumption was accelerated, but that this effect is disappearing. The decline of cigarette consumption could be attributed largely to the increase in the retail price of cigarettes. For instance, the 25-cent increase in cigarette tax represented a 21 percent increase in the November 1988 nominal price of \$1.174 per pack. Given the reported price elasticities of the demand for cigarettes by other studies,⁶ which range from $-.55$ to $-.65$, this price increase would be expected to reduce cigarette consumption of 11 and 14 percent. This predicted magnitude is quite comparable to our estimated 1989 figures as shown in Table 3, from the time-series model.

There have been complementary activities in smoking prevention funded by the revenue generated by Proposition 99. These activities include an educational program and a media campaign in smoking prevention, which began in mid 1990. In addition, most Californians now live in a jurisdiction where

local ordinances regulate smoking in public places such as restaurants. With this time-series model, it is difficult to separate the effect of taxation from the effect of the media and educational campaign during the 24-month period. However, since these health promotion programs may take many months before having an effect, we believe that the decline in cigarette use during the study period was caused mainly by the effect of the tax.

There are two explanations for the diminishing effect of this cigarette tax. First, the magnitude of the 25-cent tax is being eroded by inflation. Secondly, since cigarette smoking is addictive, the effect of a tax may deter the consumption only in the short run. As consumers get used to price increase, levels of previous consumption may slowly resume. Our results suggest that to reinforce the reduction in smoking, it would be appropriate to tax cigarettes on an ad valorem basis, that is, as a percent of sales price, or else periodically increase the excise tax to account for inflation. To sustain the effect of the cigarette tax, it would be appropriate to supplement any tax increase with an educational and media campaign that promotes smoking cessation.

This time-series model based on the monthly sales data is an efficient approach to provide an overall picture of the reduction of cigarette consumption since Proposition 99. However, it cannot address the question of how the reduction in consumption was being achieved (i.e., the extent to which it is from

quitting, from cutting back, or from the deterrence of new smokers). We are currently working with the California Behavioral Risk Factors Survey, a cross-sectional individual annual survey since 1984, and the 1987 and 1989 National Health Interview Survey, California Sample to investigate these questions.

1. Peirce, John P., Burns, David M., Berry, Charles, et.al. (1991). Reducing tobacco consumption in California: Proposition 99 seems to work, letter in JAMA, March 13, 1991, Vol. 265, No.10, pp.1257-58.
2. Box, G.E.P. & Tiao, G.C. (1975). Intervention analysis applications to economic and environmental problems, Journal of American Statistical Association, 70, pp. 70-79.
3. Ibid.
4. Harvey, A.D. & Durbin, J. (1986). The effects of seat belt legislation on British road casualties: A case study in structural time series modelling, Journal of the Royal Statistical Society, 149, part 3, pp.187-227.
5. Box, G.E.P. & Jenkins, G.M. (1970). Time-Series Analysis, Forecasting and Control, San Francisco, Holden-Day, Inc.
6. Harris, J.E. (1987). The 1983 increase in the federal cigarette excise tax. In L.H. Summers (Ed.) Tax Policy and the Economy. National Bureau of Economic Research and MIT Press Journals, 1, pp.87-111.

TABLE 1

CALIFORNIA CIGARETTE CONSUMPTION MONTHLY
 TIME-SERIES INTERVENTION ANALYSIS
 (PER ADULT CAPITA CONSUMPTION IN PACKS)

$$X_t = a_0 + a_1T_t + a_2D + a_3DT_t + (1+b_1L)(1+b_2L^4)(1+b_3L^{12})e_t$$

PARAMETER	ESTIMATE	STANDARD ERROR	T RATIO
a_0	11.476	0.084	136.36
a_1	-0.031	0.002	13.19
a_2	-2.745	0.632	4.34
a_3	0.025	0.009	2.72
b_1	0.334	0.109	3.05
b_2	0.492	0.103	4.79
b_3	-0.529	0.112	4.73

Data Range: 1984.01 - 1990.12

TABLE 2

CALIFORNIA CIGARETTE CONSUMPTION MONTHLY
 TIME-SERIES INTERVENTION ANALYSIS
 (PER ADULT CAPITA CONSUMPTION IN PACKS)

$$\log(X_t) = a_0 + a_1T_t + a_2D_t + a_3DT_t + (1+b_1L)(1+b_2L^4)(1+b_3L^{12})e_t$$

PARAMETER	ESTIMATE	STANDARD ERROR	T RATIO
a ₀	2.442	0.008	287.39
a ₁	-0.003	0.0002	12.86
a ₂	-0.291	0.064	4.55
a ₃	0.0025	0.0009	2.71
b ₁	0.329	0.110	2.98
b ₂	0.521	0.102	5.10
b ₃	-0.569	0.114	4.99

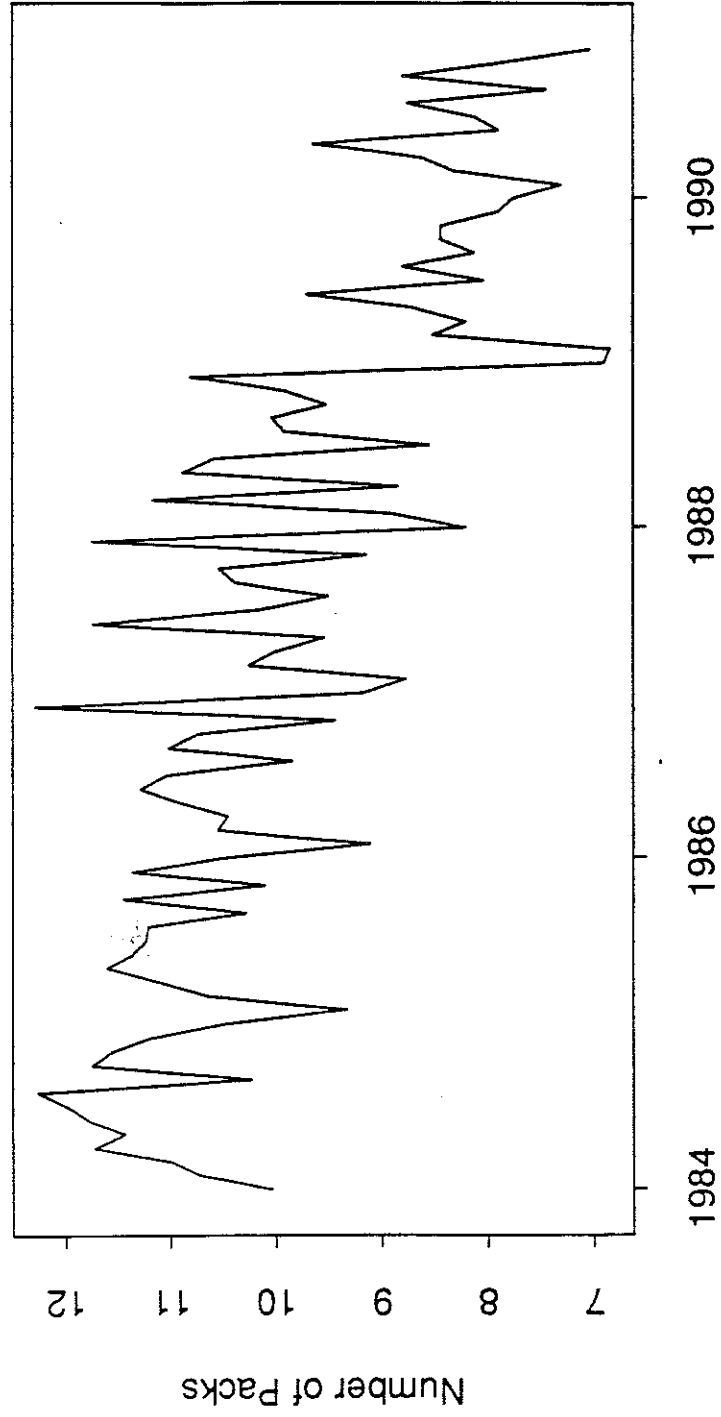
Data Range: 1984.01 - 1990.12

TABLE 3
PREDICTED EFFECT^a ON CIGARETTE CONSUMPTION
1989-1993

	ACTUAL COUNT OF REDUCTION (PER CAPITA MONTHLY, IN PACKS)	PERCENT OF REDUCTION
1989.01	-1.220	-13.8
1989.06	-1.100	-12.6
1990.06	-0.825	-9.6
1990.12	-0.645	-8.1
1993.02	-0.000	-1.6

a Calculated from results in Tables 1 and 2.

Figure 1. Monthly Per Adult Capita Consumption
(January, 1984 -- December, 1990)



July 31, 1991

**Working Paper Series
Department of Economics
University of California, Berkeley**

Individual copies are available for \$3.50 in the USA or Canada, \$6.00 to Europe/South America, \$7.00 to Japan/Middle East. Papers may be obtained from the Institute of Business and Economic Research: send requests to IBER, 156 Barrows Hall, University of California, Berkeley CA 94720. Prepayment is required. Make checks or money orders payable to "The Regents of the University of California."

- 90-139 "Adverse Selection, Short-Term Contracting, and the Underprovision of On-the-Job Training." Benjamin Hermalin. February 1990.
- 90-140 "Why Legal Restrictions on Private Contracts Can Enhance Efficiency." Philippe Aghion and Benjamin Hermalin. April 1990.
- 90-141 "Moral Hazard and Verifiability: The Effects of Renegotiation in Agency." Benjamin E. Hermalin and Michael L. Katz. May 1990.
- 90-142 "The Financial System and the Economic Crisis of the Interwar Years." Barry Eichengreen. June 1990.
- 90-143 "Nonstandard Methods in Mathematical Economics." Robert M. Anderson. June 1990.
- 90-144 "Before the Accord: U.S. Monetary-Financial Policy 1945-51." Barry Eichengreen and Peter M. Garber. June 1990.
- 90-145 "The Impact of Permanent and Temporary Import Surcharges on the U.S. Trade Deficit." Barry Eichengreen and Lawrence H. Goulder. July 1990.
- 90-146 "Trends and Cycles in Foreign Lending." Barry Eichengreen. July 1990.
- 90-147 "Relaxing the External Constraint: Europe in the 1930s." Barry Eichengreen. July 1990.
- 90-148 "The Effects of Competitive Pressures on Executive Behavior." Benjamin E. Hermalin. September 1990.
- 90-149 "The 1933 World Economic Conference as an Instance of Failed International Cooperation." Barry Eichengreen and Marc Uzan. October 1990.
- 90-150 "Costs and Benefits of European Monetary Unification." Barry Eichengreen. October 1990.
- 90-151 "Is Europe an Optimum Currency Area?" Barry Eichengreen. October 1990.
- 90-152 "Major Fiscal Trends in the 1980s and Implications for the 1990s." George Break. October 1990.
- 90-153 "Historical Research on International Lending and Debt." Barry Eichengreen. December 1990.
- 91-154 "Risktaking, Capital Markets, and Market Socialism." Pranab Bardhan. January 1991.
- 91-155 "Is Inequality Harmful for Growth? Theory and Evidence." Torsten Persson and Guido Tabellini. January 1991.

- 91-156 "The Origins and Nature of the Great Slump, Revisited." Barry Eichengreen. March 1991.
- 91-157 "The Making of Exchange Rate Policy in the 1980s." Jeffrey Frankel. March 1991.
- 91-158 "Exchange Rate Forecasting Techniques, Survey Data, and Implications for the Foreign Exchange Market." Jeffrey Frankel and Kenneth Froot. March 1991.
- 91-159 "Convertibility and the Czech Crown." Jeffrey Frankel. March 1991.
- 91-160 "The Obstacles to Macroeconomic Policy Coordination in the 1990s and an Analysis of International Nominal Targeting (INT)." Jeffrey A. Frankel. March 1991.
- 91-161 "Highway Safety, Economic Behavior, and Driving Environment." Theodore E. Keeler. March 1991.
- 91-162 "Can Informal Cooperation Stabilize Exchange Rates? Evidence from the 1936 Tripartite Agreement." Barry Eichengreen and Caroline R. James. March 1991.
- 91-163 "Reneging and Renegotiation." Matthew Rabin. April 1991.
- 91-164 "A Model of Pre-game Communication." Matthew Rabin. April 1991.
- 91-165 "Contracting Between Sophisticated Parties: A More Complete View of Incomplete Contracts and Their Breach." Benjamin E. Hermalin and Michael L. Katz. May 1991.
- 91-166 "The Stabilizing Properties of a Nominal GNP Rule in an Open Economy." Jeffrey A. Frankel and Menzie Chinn. May 1991.
- 91-167 "A Note on Internationally Coordinated Policy Packages Intended to Be Robust Under Model Uncertainty or Policy Cooperation Under Uncertainty: The Case for Some Disappointment." Jeffrey A. Frankel. May 1991.
- 91-168 "Managerial Preferences Concerning Risky Projects." Benjamin Hermalin. June 1991.
- 91-169 "Information and the Control of Productive Assets." Matthew Rabin. July 1991.
- 91-170 "Rational Bubbles: A Test." Roger Craine. July 1991.
- 91-171 "The Eternal Fiscal Question: Free Trade and Protection in Britain, 1860-1929." Barry Eichengreen. July 1991.
- 91-172 "Game-Playing Agents: Unobservable Contracts as Precommitments." Michael L. Katz. July 1991.
- 91-173 "Taxation, Regulation, and Addiction: A Demand Function for Cigarettes Based on Time-Series Evidence." Theodore E. Keeler, Teh-wei Hu, and Paul G. Barnett. July 1991.
- 91-174 "The Impact of a Large Tax Increase on Cigarette Consumption: The Case of California." Teh-wei Hu, Jushan Bai, Theodore E. Keeler and Paul G. Barnett. July 1991.
- 91-175 "Market Socialism: A Case for Rejuvenation." Pranab Bardhan and John E. Roemer. July 1991.
- 91-176 "Designing A Central Bank For Europe: A Cautionary Tale from the Early Years of the Federal Reserve." Barry Eichengreen. July 1991.

