# UC Berkeley
## Other Recent Work

**Title**

the Impact of 1989 California Major Anti-Smoking Legislation Cigarette Consumption: Three Years Later

**Permalink**

https://escholarship.org/uc/item/280289bg

**Authors**

Hu, Teh-wei
Bai, Jushan
Barnett, Paul G.

**Publication Date**

1992-09-01

Peer reviewed

UNIVERSITY OF CALIFORNIA AT BERKELEY

Department of Economics

Berkeley, California  94720

# The Impact of 1989 California
# Major Anti-Smoking Legislation
# on Cigarette Consumption:  Three Years Later

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

September 1992

---

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 1991, adjusted for seasonal variation and time trend, show that consumption of cigarettes in January, 1989 was about 25 percent less than would have been expected in the absence of the tax. By December, 1989 consumption was reduced to 9.5 percent below the pre-tax trend, an amount sustained throughout 1991.

*Professor Teh-wei Hu*
Department of Social and
 Administrative Health Sciences
School of Public Health
University of California at Berkeley

*Professor Theodore E. Keeler*
Department of Economics
University of California at Berkeley

*Paul G. Barnett, Ph.D. student*
Department of Economics
University of California at Berkeley

*Professor Jushan Bai*
Department of Economics
Massachusetts Institute of Technology

# The Impact of 1989 California Major Anti-Smoking Legislation
## on Cigarette Consumption: Three Years Later

## Introduction

In November 1988, California passed Proposition 99 which increased the state excise tax on cigarettes by an additional 25 cents per pack, to be effective January 1989. In addition, the Proposition required that part of the revenue gained from the tax be allocated for local media and health education anti-smoking campaigns. An earlier study based on the two years (1989 and 1990) after Proposition 99 went into effect concluded that the impact of the California tax reduced cigarette consumption slightly less than 5 percent to 7 percent, but was not able to differentiate the short-term from the long-term effects of the tax increase.[1] As acknowledged by the earlier study, estimating the long-term effects of the state tax can be tenuous due to other possible confounding facts, such as the initiation of anti-smoking campaigns and interstate bootlegging. In view of this limitation, this study does not attribute the effect of Proposition 99 solely to the tax increase it caused, although that is the center piece of the legislation, but instead looks at the overall effect of the Proposition. This study analyzes the short-term and long-term effects of Proposition 99 on cigarette consumption based on the aggregate time-series monthly data from 1984 through 1991. By using the statistical time-series intervention model, this study attempts to differentiate the short-term (within the first year)

from the long-term (after the first year) effects, and to re-examine the future options of anti-smoking legislation.

## Methods

### Data

Cigarette consumption data are obtained from the California Stat Board of Equalization, reported on the basis of monthly sales of cigarette tax stamps. 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 influence of the 1983 Federal cigarette excise tax increase we began our data series in January 1984 and ended it in December 1991. The series includes 36 months after the implementation of the Proposition 99 tax, a period sufficiently long to display the impact of the tax on cigarette consumption. It should be noted, however, that beginning January 1991 there was a Federal excise tax increase of 4 cents per pack. In estimating the short-term and long-term effects of Proposition 99, we have taken into account the Federal tax and also have compared the different effects of the state tax and the Federal tax.

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 age 15 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 1991.

The use of state sales data may often raise the question as to whether the smuggling of cigarettes from neighboring states biases the results. In this case, Nevada changed its cigarette tax rate to match California. The tax difference between Oregon and California during 1989 to 1991 was only 7 cents. Moreover, relatively few Californians live close to the state's borders. The smuggling issue may not be a major concern.

Statistical Analysis

An efficient procedure for examining the effect of the cigarette tax is the Box-Tiao time-series intervention analysis.[2] One of the features of this method is its ability to model the error term, taking into account the seasonal variation and random monthly fluctuations, and to simultaneously introduce explanatory variables into the model.

Several explanatory variables need to be included in the Box-Tiao model. As shown in Figure 1, per capita cigarette consumption has been declining over the past years, and probably will continue to decline, even without Proposition 99.

Proposition 99 was passed in November 1988, but did not go into effect until January 1, 1989. During November and December 1988, retailers and consumers probably purchased additional cigarettes in anticipation of the January 1, 1989 tax increase.

To control for this effect, two separate dichotomous variables (NOV, assigned a value of one for November 1988 and a value of zero for all other 95 months; DEC assigned a value of one for December 1988 and a value of zero otherwise) are introduced into the model. A dummy variable for the 1991 Federal tax (addition 4 cents per pack) is also introduced into the model.

The central theme of this paper is to examine the possible effect of Proposition 99. The dichotomous variable (D, assigned a value of one for months in which the tax had been increased, and zero before 1989) is introduced to test and measure the effect of taxation during the 1989 - 1991 period.

As shown in Figure 1, there was a very strong initial decline in cigarette consumption in January 1989. In was assumed that this decline was a temporary effect which would diminish over time. This assumption is made based on observation of the data, and is consistent with the following hypotheses: consumer purchases increased as their stocks of hoarded cigarettes were depleted; there was recidivism among consumers who had temporarily quit in response to the higher price of cigarettes; the real effect of the tax was gradually eroded by inflation and increases in consumer income.

The model of declining temporary effect was created by using an intervention variable ($I_t$), set to one if the month was January 1989, or zero otherwise. The deterioration of this temporary effect is expressed as:

$$a_6(I_t + a_7 I_{t-1} + a_7^2 I_{t-2} + a_7^3 I_{t-3} + \ldots)$$

Thus, the temporary effect in January 1989 is $a_6$, the speed of declining is $a_7$, in February 1989 it is $a_6 a_7$, in March 1989 it declines to $a_6 a_7^2$, and so forth. As the effect is diminishing, $a_7$ is less than one, and this geometric series may be expressed as:

$$\frac{a_6}{(1 - a_7 L)} I_t$$

where L is the lag operator, which operates on the intervention variable.

We found significant serial correlation in data, in the form of monthly, quarterly, and annual cycles. Past observations of quantity, lagged by one, four and 12 months, were found to provide significant explanation of fluctuations in the observations. These lagged values were used to control for cyclical variation.

Using Box-Jenkin time-series three estimation procedures (i.e., identification, estimation, and diagnostic checking)[3] the following model was derived:

$$Y_t = a_0 + a_1 T_t + a_2 NOV + a_3 DEC + a_4 D_1 + a_5 D_2 + \left(\frac{a_6}{1 - a_7 L}\right) I_t$$

$$+ (1 + b_1 L)(1 + b_2 L^4)(1 + b_3 L^{12}) e_t$$

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.

NOV & DEC are two separated dichotomous intervention variables: assigned a value of 1 for November 1988, zero otherwise; assigned a value of 1 for December 1988, zero otherwise.

$D_1$    is the dichotomous variable Proposition 99: assigned a value of 1 beginning January, 1989 to denote the tax increase and a value of 0 before 1989.

$D_2$   is the dichotomous variable for the 1991 Federal tax: assigned a value of 1 beginning January 1991 and a value of 0 before 1991.

$I_t$   is the dichotomous variable for January 1989: assigned a value of 1 for January 1989 (t=1), and zero otherwise.

L   is the lag operator (i.e., for $LI_t = I_{t-1}$, $L^2 I_t = I_{t-2}$, etc.; for $Le_t = e_{t-1}$, $L^2 e_t = e_{t-2}$, etc.)

$e_t$   is the error term

The dependent variable was expressed both as actual amount and as 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).

The analysis shows that since 1984 there has been a continuous decline in the per capita cigarette consumption, whether in absolute terms (-0.034 pack per capita per month) or in percentage terms (-0.3 percent). As shown in Table 1 all coefficients, including the parameters of the moving averages, are statistically significant ($p < .05$), except for the coefficient of NOV (November 1988). The nonsignificance of NOV implies that hoarding behavior could not be detected in November 1988 sales figures. There was significant increase in cigarette sales (1.03 packs per capita or a 10 percent increase) in the following month (December 1988).

The coefficient of $D_1$ variable is an estimate of the long-term effect observed throughout the post-proposition period (1989 to 1991). This long-term reduction was .075 packs (or 9.5 percent)

per capita each month.

The temporary effect was even larger. In the first month after the tax increase (January 1990), per capita cigarette consumption was reduced by an addition 1.25 packs (or 16.2 percent). When both short-term and long-term effects are considered, January 1989 per capita consumption was reduced by 2 packs (1.25 + 0.75 = 2.00), or 25.7 percent (9.5% + 16.2%). As shown in Table 2, the temporary effect deteriorated quickly, vanishing by the end of 1989.

While the coefficient of $D$ measures the effect of the tax on the level of consumption, the preceding model does not allow for the possibility that the tax may have also had an effect of the rate at which consumption had been declining. This possibility was tested by evaluating the interaction of D and T. The coefficient of the interaction of these terms was positive, but not significantly different from zero.

The Federal tax variable, $D_2$, indicates that the 4 cents per pack has reduced sales 0.28 pack per month or a 5 percent reduction per month. Alternative models have been specified to detect possible hoarding behavior before the tax (December 1990) or to detect the declining temporary effect, neither of which are statistically significant. The relative magnitude of the effect of the Federal tax compared to the effect of the state tax, with respect to the amount of tax increase (4 cents versus 25 cents), suggests that Federal tax is more effective than state tax in terms of reducing cigarette consumption. In spite of the effectiveness

of the Federal tax imposed in 1991, the effectiveness and magnitude of the impact of Proposition 99 was not diminished or reduced. This study has compared the results before the Federal tax period (1984-1990) and the period including the Federal tax (1984-1991). The coefficient of $D_1$, and the estimated results in Table 2 are almost the same. Thus, the estimated effect of Proposition 99 has maintained a 9 percent reduction rate after three years.

## Discussion

These data show that Proposition 99 was effective in reducing cigarette consumption. The Proposition had two effects, a temporary 16 percent decline in consumption, which quickly eroded, and additional long-term effect, a 9 percent decline, which persisted throughout the remaining two years. The erosion of the temporary effect can be explained by the depletion of stocks of hoarded cigarettes; by the addictive nature of cigarette smoking behavior, and by the slight erosion of the tax by inflation. Thus the tax deterred the consumption more in the short-run than long-run.

The findings of the long-term effect, a 9 percent reduction, is higher than the previous study.[4] The estimated price elasticity obtained from the time-series data in one econometric study suggests that a 10 percent increase in the price of cigarettes would lead to a 4.0 to 5.0 percent reduction in consumption in the long run.[5] Between 1988 and 1989, the overall price increase was 23 percent, which would lead to about a 9.0 to 10.0 percent

reduction in cigarette consumption. Thus the findings are quite consistent with either an econometric model or a time-series model.

To sustain the effect of cigarette taxes, it would be appropriate to increase the cigarette tax periodically, or to asses them on an ad valorem basis. There have been complementary activities in smoking prevention funded by the revenue generated by Proposition 99. These activities, which began mid 1990, include an educational program and a media campaign for smoking prevention. 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 campaigns during the 36-month period. Thus the statistical analysis of this study provides an overall picture of the reduction of cigarette consumption since Proposition 99, and does not claim that the reduction is due solely to the 25 cent tax increase.

The findings from the 1991 Federal tax on cigarettes suggests that it has an additional effect on the reduction of cigarette consumption and that its effect is quite strong. To achieve greater results in reducing cigarette consumption, Federal and state legislation should work together.

# References

1.  Flewelling, Robert L., Kenney, K., Elder, J.P., Pierce, J., Johnson, M., and Bal, D.G. (June 1992). First-year impact of the 1989 California cigarette tax increase on cigarette consumption, <u>American Journal of Public Health</u>, Vol. 82, No.6, pp.867-869.

2.  Box, G.E.P. and Tiao, G.C. (1975). Intervention analysis applications to economic and environmental problems, <u>Journal of American Statistical Association</u>, Vol. 70, pp. 70-79.

3.  Box, G.E.P. & Jenkins, G.M. (1970). <u>Time-Series Analysis, Forecasting and Control</u>, San Franciscan, Holden Day, Inc.

4.  Flewelling, Robert L. et. al. (June 1992), op. cit.

5.  Keeler, Theodore E, Hu, T.W., Barnett, Paul, and Manning, Willard. (July 1992). Taxation, Regulation, and Addiction: A Demand Function for Cigarettes Based on Time-Series Evidence. Working paper series, Institute of Business and Economic Research, University of California, Berkeley.

Figure 1: Monthly Per Adult Capita Cigarette Consumption (January, 1984 --December, 1991)
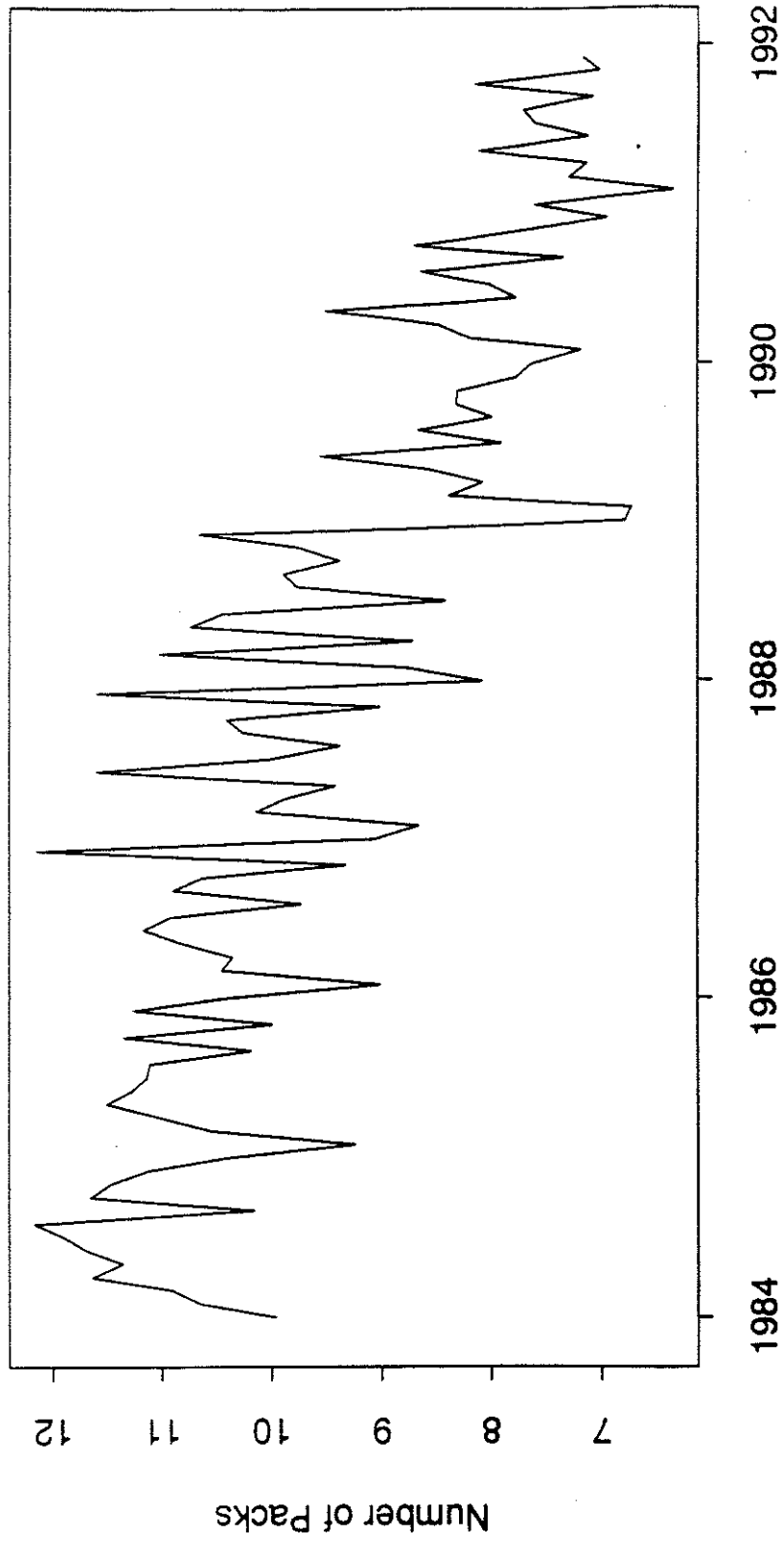
## TABLE 1

### CALIFORNIA CIGARETTE CONSUMPTION
### MONTHLY TIME-SERIES INTERVENTION ANALYSIS
### (PER ADULT CAPITA CONSUMPTION IN PACKS)
### JANUARY, 1989 - DECEMBER, 1991

| PARAMETERS | DEPENDENT VARIABLE IN NOMINAL VALUE (1) | DEPENDENT VARIABLE IN LOG VALUE (2) |
|---|---|---|
| $a_0$ | 11.460 (177.18) | 2.442 (375.87) |
| $a_1$ (T) | -0.034 (17.72) | -0.003 (17.44) |
| $a_2$ (NOV) | 0.185 (0.39) | 0.014 (0.31) |
| $a_3$ (DEC) | 1.031 (2.12) | 0.102 (2.01) |
| $a_4$ ($D_1$) | -0.749 (6.08) | -0.095 (8.06) |
| $a_5$ ($D_2$) | -0.281 (2.92) | -0.050 (5.18) |
| $a_6$ | -1.255 (3.53) | -0.162 (3.93) |
| $a_7$ | 0.688 (5.86) | 0.601 (4.67) |
| $b_1$ | 0.388 (3.78) | 0.390 (3.75) |
| $b_2$ | 0.564 (5.91) | 0.590 (6.16) |
| $b_3$ | -0.507 (4.77) | -0.537 (4.88) |

Note:  Value in parentheses is the t statistic.

## TABLE 2

### PREDICTED TAX EFFECT OVER TIME:
$$a_5 + [a_6/(1-a_7L)]I_t$$

| TIME PERIOD | REDUCTION IN ACTUAL NUMBER OF PACKS[a] | REDUCTION IN PERCENT OF PACKS[b] |
|---|---|---|
| 1989.01 | 2.000 | 0.257 |
| 1989.02 | 1.614 | 0.193 |
| 1989.03 | 1.344 | 0.154 |
| 1989.04 | 1.159 | 0.130 |
| 1989.05 | 1.031 | 0.116 |
| 1989.06 | 0.943 | 0.108 |
| 1989.07 | 0.883 | 0.103 |
| 1989.08 | 0.841 | 0.099 |
| 1989.09 | 0.813 | 0.098 |
| 1990.10 | 0.793 | 0.097 |
| 1989.11 | 0.729 | 0.096 |
| 1989.12 | 0.770 | 0.096 |
| 1990.01 | 0.764 | 0.096 |
| 1990.02 | 0.759 | 0.095 |
| 1990.03 | 0.756 | 0.095 |
| 1990.04 | 0.753 | 0.095 |
| 1990.05 | 0.753 | 0.095 |
| 1990.06 | 0.752 | 0.095 |
| 1990.09 | 0.750 | 0.095 |
| 1990.12 | 0.750 | 0.095 |
| 1991.03 | 0.750 | 0.095 |
| 1191.06 | 0.750 | 0.095 |
| 1991.09 | 0.750 | 0.095 |
| 1991.12 | 0.750 | 0.095 |

Notes:   [a] Calculated from column (1) in Table 1
         [b] Calculated from column (2) in Table 1

October 5, 1992

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

91-184   "The Marshall Plan: History's Most Successful Structural Adjustment Program." J. Bradford De Long and Barry Eichengreen. November 1991.

91-185   "Incorporating Fairness into Game Theory." Matthew Rabin. December 1991.

91-186   "How Pervasive Is the Product Cycle? The Empirical Dynamics of American and Japanese Trade Flows." Joseph E. Gagnon and Andrew K. Rose. December 1991.

92-187   "Shocking Aspects of European Monetary Unification." Tamim Bayoumi and Barry Eichengreen. January 1992.

92-188   "Is There a Conflict Between EC Enlargement and European Monetary Unification?" Tamim Bayoumi and Barry Eichengreen. January 1992.

92-189   "The Marshall Plan: Economic Effects and Implications for Eastern Europe and the Soviet Union." Barry Eichengreen and Marc Uzan. January 1992.

92-190   "Exploring the Relationship between R&D and Productivity at the Firm Level in French Manufacturing." Bronwyn H. Hall and Jacques Mairesse. February 1992.

92-191   "Three Perspectives on the Bretton Woods System." Barry Eichengreen. February 1992.

92-192   "Are Futures Margins Adequate?" Roger Craine. April 1992.

92-193   "Heterogeneity in Organizational Form: Why Otherwise Identical Firms Choose Different Incentives for Their Managers." Benjamin E. Hermalin. May 1992.

92-194   "Investment and Research and Development at the Firm Level: Does the Source of Financing Matter?" Bronwyn H. Hall. May 1992.

92-195   "The Determinants of Efficiency and Solvency in Savings and Loans." Benjamin E. Hermalin and Nancy E. Wallace. May 1992.

92-196   "Economics of Development and the Development of Economics." Pranab Bardhan. June 1992.

92-197   "The Core and the Hedonic Core: Equivalence and Comparative Statics." Suzanne Scotchmer and Greg Engl. July 1992.

92-198   "Incorporating Behavioral Assumptions into Game Theory." Matthew Rabin. July 1992.

92-199   "Incorporating Fairness into Game Theory and Economics." Matthew Rabin. July 1992.

92-200   "A Consumer's Guide to EMU." Barry Eichengreen. July 1992.

92-201   "Macroeconomic Adjustment Under Bretton Woods and the Post-Bretton-Woods Float: An Impulse-Response Analysis." Tamim Bayoumi and Barry Eichengreen. August 1992.

92-202   "Oligopoly Structure and the Incidence of Cigarette Excise Taxes." Paul G. Barnett, Theodore E. Keeler. Teh-wei Hu. September 1992.

92-203   "The Impact of 1989 California Major Anti-Smoking Legislation on Cigarette Consumption: Three Years Later." Teh-wei Hu, Jushan Bai, Theodore E. Keeler, Paul G. Barnett. September 1992.