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

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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, 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. An extended Box-Tiao time-series model by Harvey and
Durbin analyzed the effects of seat-belt legislation on British
road casualties.

Using Box-Jenkin time-series three estimation
procedures (i.e., identification, estimation, and diagnostic
checking) the following model has been obtained:

$$Y_t = a_0 + a_1 T + a_2 D + a_3 D T_t + (1 + b_1 L) (1 + b_2 L^2) (1 + b_3 L^{12}) e_t$$

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.
- $D$ is the dummy intervention variable: a value of 1 beginning
  January, 1989 to denote the tax increase and a value of 0
  before 1989.
- $D T_t$ is the interaction term, the product of $T$ and $D$.
- $L$ is the lag operator (i.e., $L e_t = e_{t-1}$, $L^2 e_t = L(L e_t)$ 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, which range from $-0.55$ to $-0.65$, 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.
References


3. Ibid.


TABLE 1
CALIFORNIA CIGARETTE CONSUMPTION MONTHLY
TIME-SERIES INTERVENTION ANALYSIS
(PER ADULT CAPITA CONSUMPTION IN PACKS)

\[ x_t = a_0 + a_1 T_t + a_2 D + a_3 D T_t + (1 + b_1 L)(1 + b_2 L^4)(1 + b_3 L^{12}) e_t \]

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ESTIMATE</th>
<th>STANDARD ERROR</th>
<th>T RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a_0 )</td>
<td>11.476</td>
<td>0.084</td>
<td>136.36</td>
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<tr>
<td>( a_1 )</td>
<td>-0.031</td>
<td>0.002</td>
<td>13.19</td>
</tr>
<tr>
<td>( a_2 )</td>
<td>-2.745</td>
<td>0.632</td>
<td>4.34</td>
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<tr>
<td>( a_3 )</td>
<td>0.025</td>
<td>0.009</td>
<td>2.72</td>
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<tr>
<td>( b_1 )</td>
<td>0.334</td>
<td>0.109</td>
<td>3.05</td>
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<tr>
<td>( b_2 )</td>
<td>0.492</td>
<td>0.103</td>
<td>4.79</td>
</tr>
<tr>
<td>( b_3 )</td>
<td>-0.529</td>
<td>0.112</td>
<td>4.73</td>
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</table>

Data Range: 1984.01 - 1990.12
### Table 2

**California Cigarette Consumption Monthly Time-Series Intervention Analysis (Per Adult Capita Consumption in Packs)**

\[
\log(X_t) = a_0 + a_1 T_t + a_2 D + a_3 D T_t + (1 + b_1 L)(1 + b_2 L^4)(1 + b_3 L^{12}) e_t
\]

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ESTIMATE</th>
<th>STANDARD ERROR</th>
<th>T RATIO</th>
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</thead>
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<tr>
<td>(a_0)</td>
<td>2.442</td>
<td>0.008</td>
<td>287.39</td>
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<tr>
<td>(a_1)</td>
<td>-0.003</td>
<td>0.0002</td>
<td>12.86</td>
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<tr>
<td>(a_2)</td>
<td>-0.291</td>
<td>0.064</td>
<td>4.55</td>
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<tr>
<td>(a_3)</td>
<td>0.0025</td>
<td>0.0009</td>
<td>2.71</td>
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<tr>
<td>(b_1)</td>
<td>0.329</td>
<td>0.110</td>
<td>2.98</td>
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<tr>
<td>(b_2)</td>
<td>0.521</td>
<td>0.102</td>
<td>5.10</td>
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<tr>
<td>(b_3)</td>
<td>-0.569</td>
<td>0.114</td>
<td>4.99</td>
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Data Range: 1984.01 - 1990.12
TABLE 3
PREDICTED EFFECT\(^a\) ON CIGARETTE CONSUMPTION
1989-1993

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<th>ACTUAL COUNT OF REDUCTION (PER CAPITA MONTHLY, IN PACKS)</th>
<th>PERCENT OF REDUCTION</th>
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<tr>
<td>1989.01</td>
<td>-1.220</td>
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<td>1989.06</td>
<td>-1.100</td>
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<td>1990.06</td>
<td>-0.825</td>
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<tr>
<td>1990.12</td>
<td>-0.645</td>
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<tr>
<td>1993.02</td>
<td>-0.000</td>
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</table>

\(^a\) Calculated from results in Tables 1 and 2.
Figure 1. Monthly Per Adult Capita Consumption (January, 1984 --December, 1990)
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