The Effect of Cigarette Taxes on Cigarette Consumption, 1955 through 1994

ABSTRACT

Objectives. This study examines the effectiveness of state and federal taxes in reducing the consumption of cigarettes, estimates the impact of government health warnings, and shows how warnings and taxes interact.

Methods. By means of a pooled time-series analysis from 1955 through 1994 with the 50 states as units of analysis, the impact of excise taxes on cigarette consumption for several different models and econometric techniques is assessed.

Results. From 1955 through 1994, increases in state taxes were effective in reducing cigarette use. Federal tax increases, however, appear to have been more effective. This difference is partly the result of the "bootlegging" of cigarettes across state lines and the size of the increases in the federal tax. Cigarette consumption also declined when health warning labels were added.

Conclusions. Increases of taxes on cigarettes are associated with declines in the consumption of tobacco. Because of inflation, increased health concerns, and the declining percentage of smokers, however, large reductions in consumption require large tax increases. (*Am J Public Health.* 1997;87:1126–1130)

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Introduction

Governments levy excise taxes on cigarettes for two reasons: to raise revenues and to discourage smoking. Before the surgeon general's 1964 report on the ills of smoking,[1] these taxes were justified primarily in terms of raising revenue. After the report, however, some form of regulation was needed to battle the newfound public health hazard. Although many other forms of regulation were attempted, excise taxes became an integral part of this new regulation.[2] Discussions about tobacco taxes now typically focus on reducing tobacco consumption and improving public health.[3]

The logic of tobacco taxes is taken directly from economic theory. Since a rise in the tax rate increases the cost of cigarettes, the law of supply and demand suggests that fewer cigarettes will be consumed if taxes on them are raised. Kaiserman and Rogers, for example, report that since the early 1980s, tobacco consumption has been falling faster in Canada than in the United States as a result of Canada's higher tax rates.[4] Perkurinen and Valtonen found that price was the single most important determinant of demand for tobacco products in Finland.[5] Several other studies have demonstrated the usefulness of excise taxes in reducing cigarette consumption in the United States.[6–12]

Our research extends these previous studies by examining the effectiveness of state and federal taxes in reducing the consumption of cigarettes. While this project is similar to previous research in its general thrust, it introduces several innovations. First, our analysis covers the period from 1955 through 1994, a longer and more up-to-date time span than any prior work. Second, unlike previous studies, we include federal cigarette taxes. Third, we employ some of the more sophisticated procedures from econometrics, offering a more precise and accurate estimate of the impact of tobacco taxes on consumption. Fourth, we incorporate the public health effort to discourage smoking and document the effectiveness of excise taxes in the context of public health concerns and a smaller overall pool of smokers.

Data

Cigarette consumption rates—the number of packs per capita consumed in a state in a year—were obtained from the Tobacco Institute's annual historical compilation. These figures were available for each state in all years that a tobacco tax was levied. For most (41) states, these data exist for the entire time period 1955 through 1994. Data for Alaska and Hawaii begin in 1959 and 1960 when they became states. Data for other states, such as North Carolina, start when they adopted an excise tax on cigarettes.

The two major independent variables are the state and federal tax rates in cents per pack; both were taken from the Tobacco Institute's historical compilation. These were converted to changes in taxes in constant dollars by means of the consumer price index. When the tax rate in a state was changed during the year, that change was coded as taking place in

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Note. The data used in this analysis are available from the State Policy Archive at Florida State University; email: cbarrile@garnet.acns.fsu.edu.

the next year if more than half of the current year was over.

Methods

Our analysis uses a pooled time series of all states from 1955 through 1994. A preliminary analysis of cigarette consumption revealed that the data were not stationary; that is, correlations between one year's data and subsequent years did not decrease exponentially as the length of time increased.[13(pp444–447)] The first five autocorrelations were .91, .86, .81, .75, and .70. The problem with performing regression analysis on nonstationary data is that spurious relationships are highly likely.[14] The solutions are either to difference the data (subtract the previous year's value from the current year's value; the differenced data are stationary) or to include a lagged version of the dependent variable as an explanatory variable.[13(pp561–562)] One theoretical reason for using the lagged dependent variable is that cigarettes are addictive; no matter whether one considers addicts "rational" or "myopic," past consumption influences current consumption. The appropriate way to consider addiction statistically is to lag the dependent variable.[15,16] As a check on the validity of our findings, however, we do our analysis both with differenced data and with a lagged dependent variable. The first five autocorrelations of the differenced data were all below .10, indicating a stationary series.

Pooled time-series analysis often has major problems with both autocorrelation and heteroscedasticity. Both can affect the efficiency of the regression estimates. In each of our regressions, we will test for autocorrelation using a pooled Lagrange multiplier, the appropriate test whether or not the regression contains a lagged dependent variable.[17(pp541–542)] In each case, we test for significant autocorrelation of up to five lags. Heteroscedasticity was assessed by means of the White test.[17(p204)]

Results

Table 1 examines the change in cigarette consumption (the differenced data) as the result of changes in state and federal tax rates. By differencing the data, we are looking at immediate changes in consumption that occur precisely when taxes increase. Factors that affect cigarette smoking but that change only slowly (e.g., age, gender, race, and income) are unlikely to affect these changes because they influence the overall level of consumption rather than year-to-year changes (see below). A 1-cent increase in state excise taxes per pack of cigarettes is associated with a 0.631-pack per capita reduction in consumption. This relationship is only about one half the federal impact, which shows a 1.12-pack per capita reduction for a 1-cent increase in the cigarette tax. (We address this difference below.) The diagnostics show that the equation has no significant autocorrelation or heteroscedasticity, so ordinary least squares estimates are appropriate.

TABLE 1—The Impact of State and Federal Taxes on Cigarette Consumption, 1955 through 1994

Independent Variable	Slope	*t*	Significance
Change in state taxes	−.631	13.96	.0000
Change in federal taxes	−1.119	9.71	.0000
R^2	.128		
Adjusted R^2	.127		
White heteroscedasticity test	.355		
P (2 *df*)	.84		
Lagrange multiplier	.905		
P (5 *df*)	.97		

Note. Dependent variable = change in packs used per capita; no. of cases = 1929.

To provide an alternative view of the tax–consumption relationship, to verify that our results are not the result of how we specified the equation or any hidden error pattern, and to incorporate the addictive nature of tobacco, Table 2 estimates a similar model but uses actual consumption levels as the dependent variable and includes consumption for the previous year as a control variable. These equations provide a better view of the dynamics of the relationships between taxes and consumption.

The first column presents the ordinary least squares estimates. The striking finding is that the regression coefficients are remarkably similar in size to those in Table 1. A 1-cent-per-pack increase in excise taxes is associated with a reduction in cigarette consumption of 0.636 packs per person for state taxes and 1.132 packs for federal taxes. With a lagged dependent variable, this is the impact for the first year of a tax increase. The impact for the second year of a tax increase is equal to these slopes times the regression coefficient for the lagged dependent variable; for state taxes, this is 0.636 × 0.983, or about 0.63 packs per capita, the second year. Impacts for subsequent years can be calculated in a similar manner. This pattern is what is termed a "geometric distributive lag."[18(pp204–210)] Initial reductions in smoking continue into the future at a gradually declining rate. This finding is similar to that of Becker et al., who find the long-term impacts of cigarette taxes exceed the short-term impacts.[9]

Although the diagnostics for the ordinary least squares equation in Table 2 show no problems with autocorrelation or heteroscedasticity, which means that the coefficients are thus unbiased and consistent,[19(p228)] we estimated this equation in four different ways to verify this. Since the other estimation techniques require no missing data, we first estimated the ordinary least squares model for the 41 states with no missing data. The second column of Table 2 shows results similar to the 50 state results. The least squares dummy variable estimates in column three control for both heteroscedasticity and autocorrelation by including a series of dummy variables that represent the individual states and the individual years (less one of each to permit estimation).[20(chap16)] Column four presents the generalized least squares estimates using a modified Parks procedure, which corrects for first-order autocorrelation (via a Prais-Winston procedure) and then adjusts for both heteroscedasticity and cross-correlations. Column five provides the error components estimates, which correct for first-order autocorrelation and then deal with heteroscedasticity by including terms that account for the mean deviation of each state from the overall regression.

These estimations demonstrate that our findings are robust and are not threatened by any problems generated by either autocorrelation or heteroscedasticity. The coefficient for state taxes ranges between −.600 and −.652 regardless of

TABLE 2—The Impact of State and Federal Taxes on Cigarette Consumption, 1955 through 1994, Alternative Specifications

Independent Variable	Ordinary Least Squares: 50 States (n = 1929)[a]	Ordinary Least Squares: 41 States (n = 1640)[a]	Least Squares Dummy Variables[b] (n = 1640)[a]	Generalized Least Squares[c] (n = 1640)[a]	Error Components (n = 1640)[a]
Lagged consumption[d]	.983 (242.08)	.984 (229.73)	.963 (125.90)	.978 (188.21)	.973 (157.36)
Differenced state taxes[d]	−.636 (14.17)	−.652 (14.04)	−.632 (13.18)	−.600 (16.04)	−.638 (13.46)
Differenced federal taxes[d]	−1.132 (9.93)	−1.141 (9.37)	−1.150 (9.43)	−.903 (9.12)	−1.145 (9.47)
Rho correction	NA	NA	NA	.08	.08
R^2	.969	.970	.971	.965	.939
White heteroscedasticity test	2.95	3.01	NA	NA	NA
P (3 *df*)	.40	.39	NA	NA	NA
Lagrange multiplier	.98	1.08	NA	NA	NA
P (5 *df*)	.96	.96	NA	NA	NA

Note. Dependent variable = packs consumed per capita.
[a]n = no. of cases.
[b]Joint F test for least squares dummy variables = .70 (*P* = .93).
[c]Modified Parks procedure.
[d]*t* scores in parentheses.

the estimation procedure. The coefficient for federal taxes is slightly more volatile but remains in a reasonably tight range, from −.903 to −1.150. Clearly, our findings are not the result of a specific estimation procedure.

State vs Federal Taxes

Why might federal taxes appear to be so much more "effective" than state taxes? One obvious reason is that our dependent variable measures not cigarettes consumed in a state but cigarettes purchased. After a state tax increase, some citizens can cross state lines to purchase cheaper cigarettes in nearby states that have lower tax rates.[9,21–23] This "bootlegging" means state purchases drop even more than consumption. Federal taxes are relatively immune to bootlegging and, thus, have more impact. Baltagi and Goel estimate that the "bootleg-free" impact of cigarette taxes is 19% through 51% less than the impact of cigarette taxes for states with potential bootlegging.[24] To include an assessment of bootlegging, we subtract from a state's tax rate the average tax rate in the states that border it. A positive score indicates an economic incentive to bootleg cigarettes, probably by crossing state lines to purchase them.

Bootlegging is only one reason for the difference in federal and state tax impact; the size of tax changes could be another. With some recent exceptions, states tend to increase their cigarette taxes relatively frequently by a small amount. Smokers are less likely to notice small increases. Except for a 1-cent increase in 1951, federal tax increases have been substantial, 8 cents in 1983, and 4 cents in both 1991 and 1993.

Bootlegging and the size of federal tax increases, we feel, tell only part of the story. Economic factors are only one element in determining cigarette consumption. Another is the impact of the public health warnings of the 1960s. Before the surgeon general's report and the health effects of tobacco became common knowledge, tobacco was much like any other economic commodity. The demand for tobacco was simply a function of price. In economic terms, tax increases provided a motivation to reduce consumption. After the surgeon general's report and the requirement of warning labels on cigarette packages, however, smokers had two reasons to limit consumption—cost and health concerns. In such a context, taxes may have no impact on the decision of *some* smokers to reduce consumption. Thus, declines in consumption would occur independently of the tax rate and, as a result, reduce a tax's estimated impact. Full understanding of public health policy in regard to cigarettes requires that cigarette consumption be modeled as the result of both economic factors and health warnings.

To assess our argument, we put three more variables into our model. One is a dummy variable coded 1 beginning in 1966 when the government required warning labels on cigarettes and coded as a zero before then. Our coding is meant to represent the government's official stance of discouraging the consumption of tobacco rather than the specific influence of warning labels per se. The second is the dummy variable multiplied by the overall change-in-taxes variable. The third is our bootlegging measure. This equation will tell us several things. First, the tax slope can now be interpreted as the impact on consumption of tax increases before the warning labels on packages. Second, the coefficient for the multiplied variable will tell us how much the impact of taxes changed after the report. Third, we will get direct estimates of the impact of the warning labels and bootlegging on consumption. The results are in Table 3.

Table 3 shows that after the adoption of warning labels, tobacco consumption dropped by 1.65 packs per capita, all other things being equal. Recall that with a lagged dependent variable, this was the impact for the first year only. Additional, though slightly smaller, impacts occurred in subsequent years. The sum of these declines is substantial. The table also shows that a 1-cent increase in state excise taxes was associated with a reduction of 0.77 packs per capita before the warning. After the warning, this association was reduced by 0.255 to −0.515 (−0.77 + 0.255 = −0.515), or a reduction of about 0.52 packs per 1-cent increase in excise taxes. The effectiveness of federal taxes dropped from −1.284 packs per capita to −1.029 packs. These findings are consistent with the notion that some of the decline in the effectiveness of cigarette excise taxes was the result of publicity about health dangers of smoking. Bootleg-

ging also mattered. State "consumption" decreased by 0.106 packs per capita for every 1 cent that a state's tax was above the mean of bordering states.

This change in the impact of taxes after the health warnings is also probably linked to one other factor—the decline in the number of smokers. In 1965, 46.1% of adults smoked; in 1992, this percentage had dropped to 26.7%.[25] Our dependent variable, by necessity, is consumption per capita, not per smoker. To illustrate, in the 1960s, a 1-cent real increase in taxes reduced consumption by 0.774 packs per capita or 1.68 packs per smoker. In 1992, with only 26.7% smokers, a per-smoker reduction of 1.68 packs translates into only 0.45 packs per capita. In short, even if the relationship for smokers remained the same, the relationship for the entire population would have declined.

The relative impact of federal versus state taxes, therefore, can be explained by the phenomenon of bootlegging and the size of the federal tax increases. Even after several decades of efforts to discourage smoking, federal taxes remain a highly effective tool in reducing cigarette consumption.

TABLE 3—Cigarette Consumption: Taxes and the Surgeon General's Report, 1955 through 1994

Independent Variable	Slope	*t*	Significance
Differenced state taxes	−.774	7.55	.0000
Differenced federal taxes	−1.284	8.03	.0000
Warning labels	−1.650	5.42	.0000
Warning × taxes	.255	2.26	.0241
Lagged consumption	.978	227.18	.0000
Bootlegging	−.106	4.57	.0000
R^2	.969		
Adjusted R^2	.969		
White heteroscedasticity test	3.26		
P (6 *df*)	.77		
Lagrange multiplier	2.57		
P (5 *df*)	.77		

Note. Dependent variable = packs used per capita; no. of cases = 1929.

TABLE 4—Cigarette Consumption and Taxes with Controls for Other Factors, 1982 through 1992

Independent Variable	Model 1	Model 2
Change in state taxes[a]	−.306 (3.72)	−.274 (3.36)
Change in federal taxes[a]	−.406 (3.31)	−.416 (3.44)
Lagged consumption[a]	.959 (122.71)	.945 (113.80)
College population[a]	. . .	−.192 (3.23)
Hispanic population[a]	. . .	−.067 (2.28)
R^2	.966	.967
Adjusted R^2	.966	.967
White heteroscedasticity test	.25	.54
P (3 and 4 *df*)	.92	.99
Lagrange multiplier[b]	5.20	5.30
P (5 *df*)	.39	.38

Note. Dependent variable = packs used per capita; no. of cases = 550.
[a]*t* scores are in parentheses.
[b]Lagrange multiplier calculated as *P* × F from the Gauss-Newton regression owing to the small number of time points.

Other Controls

In a commentary on Peterson et al.,[6] Wasserman criticizes the use of first differences as a method for determining the impacts of tax increases, suggesting that other determinants of smoking must be controlled for.[26] Although our approach is regression based, rather than a simple comparison of means as is Peterson et al., we need to determine if our findings hold even when other factors that may influence smoking are introduced into the model. In Table 4 we examine the period from 1982 through 1992. Model 1 simply reestimates our base model for this time period. To this model, we add controls for state unemployment, religion, college graduation, real income, urbanization, percentage of the population that is Black, percentage of the population that is Hispanic, divorce rates, female labor force participation rates, and age. Only two of these controls, college graduation and Hispanic population, are statistically significant. Model 2 presents the core model controlling for these two factors, and the negative findings for federal and state tobacco taxes remain. Similar results are found with all the control variables in the model (results not shown). These models suggest that our findings are not the result of omitting key variables that also influence tobacco consumption.

Conclusion

We investigated the relationship between state and federal cigarette taxes and consumption using data from all 50 states from 1955 to 1994. Our findings corroborate earlier findings that increases in excise taxes are associated with subsequent reductions in the consumption of tobacco. This relationship survives any of several acceptable econometric estimation procedures.

Although many studies have demonstrated the impact of state taxes[6–12] and others have shown the impact of federal taxes,[27] none of the prior studies examined both in the changing context of the rise of public health concerns. Hamilton[28] and Bishop and Yoo[29] each demonstrated the impact of government policy on consumption, but Hamilton did not consider taxes, and federal taxes were constant during the Bishop and Yoo study. Neither study showed how taxes interact with government policy.

As a result of the longer time period and the pooled nature of our study, we could extend the existing literature by distinguishing between state and federal taxes and demonstrating that federal taxes are much more effective in reducing smoking. We also found evidence that the public health concerns of the 1960s had a significant impact on cigarette consumption. Finally, we discovered that health warnings combine with excise taxes in an interesting way. With the existence of

health warnings, individuals have reasons other than economic ones to stop smoking. As a result, the impact of a 1-cent increase in taxes is actually less after the adoption of the health warnings than it had been before.

These findings have implications for public health policy. Excise tax increases are clearly one policy weapon that is effective in reducing the consumption of tobacco. Given the smaller pool of smokers, however, larger tax increases are necessary to get the same reduction in smoking. This suggests that the large state tax increases of the 1990s, as illustrated by Michigan's 1994 increase of 50 cents per pack, may have a substantial effect on the demand for cigarettes. Because high state taxes can be partially circumvented by bootlegging, however, increases in the federal excise tax will remain more effective than state tax increases. □

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