SOME PRELIMINARY ESTIMATES OF THE BORDER PRICE EFFECT ON CIGARETTE SALES

By
David Peterson
(dpeters2@dor.state.wi.us)

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This paper is designed to address the issue of lost revenue that may occur when a state raises its cigarette tax rate and neighboring states do not, thereby providing a stronger incentive for cross-border shopping. There is undoubtedly a strong incentive for tobacco users to shop across jurisdictions for the best price, especially when the price differential becomes large. Large price differentials, essentially due to excise tax differences on packs of cigarettes, can also lead to increased profits from smuggling.

This issue of a border effect due to large price differences arises at a time when other factors may also be at work in determining cigarette consumption, and thus make the analysis of potential border effects more complex. Some of the factors that may influence taxable cigarette consumption, in addition to price, are income, age, Internet sales, and other trends that may be unique to states or regions. The amount spent on health programs and anti-tobacco advertising by states that is a result of the tobacco lawsuit settlements are certainly not uniform across states. These factors also need to be considered in the analysis to the extent they can be quantified.

Standard Cigarette Demand Analysis

The first step in this analysis is to estimate a standard demand equation for cigarettes. Nearly all of the research on tobacco consumption has found that the demand for tobacco is price inelastic. This means that for any change in price, the percentage change in quantity demanded is less than the percentage change in price. Quantitative estimates of the price elasticity of demand for cigarettes have ranged from –0.4 to –0.8, meaning that a 10% price increase will result in a 4% to 8% decrease in quantity demanded. Wealthier nations are thought to have lower price elasticities than poorer nations, and teenage smokers are thought to have greater price elasticities than adult smokers. The overall price elasticity of demand for cigarettes in the United States is likely to be closer to –0.4 than to –0.8.

The standard model of cigarette demand used in this analysis can be specified as:

$$Q_{st} = b_0 + b_1P_{st} + b_2Y_{st} + b_3Z_{st} + e_{st} \qquad (1)$$

where Q_{st} is quantity demanded in state s and time period t, P_{st} is the price in state s and time t, Y_{st} is a measure of income, and Z_{st} is a vector of other determinants for state s and time t, and e_{st} is the error term.

The data set used to estimate equation (1) is taken from *The Tax Burden on Tobacco, Historical Compilation, Volume 37, 2002.* This volume contains observations on tax-paid consumption of cigarettes (in number of packs) by state by fiscal year for all states and the District of Columbia, the average retail price prevailing during a fiscal year for all states and D.C., and the state cigarette tax rates in effect for all states. Most states have imposed a cigarette tax since 1950, and all states have imposed a cigarette tax since 1970. Average retail prices are available for all fiscal years since 1955. The data from *The Tax Burden on Tobacco* has been supplemented with income data from the Bureau of Economic Analysis, and population data from the Census Bureau. Thus, if we use 48 years of time series observations combined with 51 cross-sectional observations, we have a potential of 2,448 observations in a pooled, cross-sectional data set. Because not all states taxed cigarettes as early as 1955, we have a total usable panel (unbalanced) consisting of 2,333 observations.

The terms of equation (1) can now be more precisely defined to correspond to the data. Q_{st} is tax-paid sales of cigarettes per capita, measured in packs, for state s in time t. P_{st} is the average retail price of a pack of cigarettes in state s for time t, expressed in constant dollars by using the chain-weighted deflator for all consumption items from the National Income and Product Accounts. Y_{st} is real per capita personal income in state s for time t.

In addition, we use the proportion of the population aged 15 through 19 to measure the special demand effect represented by teenagers as part of the vector Z_{st}. Teens are known to be the target of tobacco advertising (both pro and con) and teens are thought to have larger price and income elasticities than the general adult population. Thus, the relative size of the teenage population across states and over time may influence the aggregate demand for cigarettes as a factor distinct from price and income.

We also know that Internet sales of tobacco products are likely eroding the excise revenue stream for states, but that there is no true measure of the magnitude of such transactions or the amount of lost revenue. The U.S. Census Bureau now has e-commerce retail sales estimates, but only from the fourth quarter of 1999 forward. Since we are analyzing the patterns of cigarette consumption since 1955, and we know that Internet transactions could have started as early as 1993, we elect to use a simple linear time trend from 1993 forward to represent the possibilities of increasing Internet sales of cigarettes.

In addition, each state plus the District of Columbia is allowed to have its own fixed effect represented by a constant term.

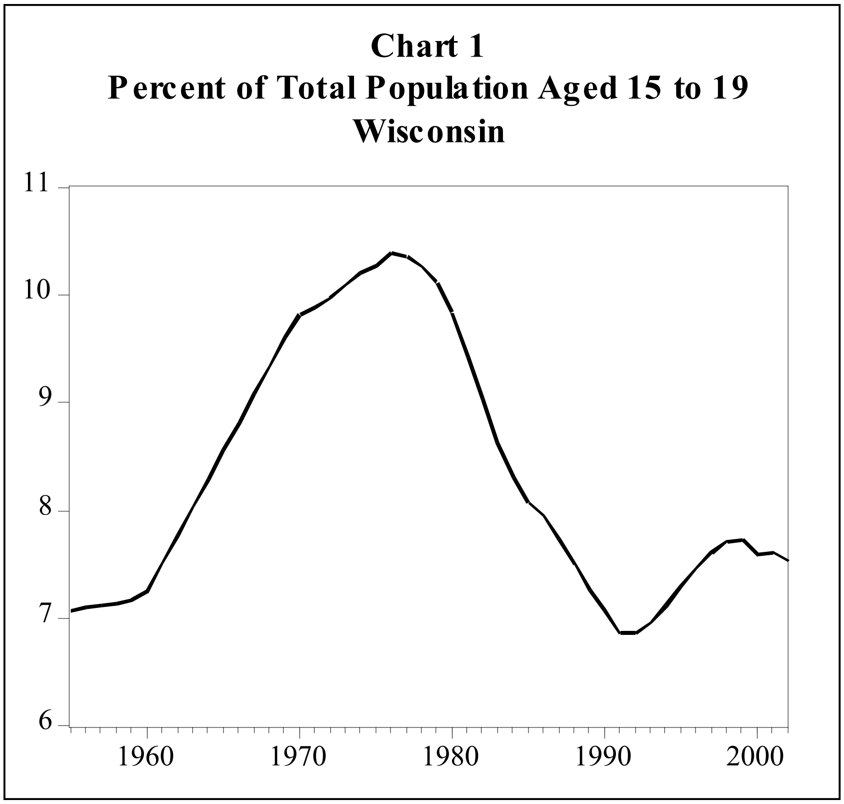
The results of a GLS regression with cross-section weights on the full panel data set are shown in Table 1. This particular estimation technique implicitly assumes the presence of cross-section heteroskedasticity and uses estimated cross-section residual variances as cross-section weights.

TABLE 1

Variable	Coefficient	Std. Error	t-stat
Log(price)	-0.611007	0.014426	-42.35556
Log(income)	0.162459	0.007395	21.96920
Log(teen/pop)	0.206567	0.014907	13.85668
Trend – 1994--2002	-0.003134	0.001523	-2.05761
Observations=2384	Weighted R^2 =0.997	D.W.=0.351044	S.E.=0.119903

The estimation results shown in Table 1 indicate that the price elasticity (-0.611) is within the broad range of results typically found for tobacco demand, and that the income elasticity of demand is positive, but small. A 10% increase in real per capita income will induce a 1.6% increase in cigarette purchases. Similarly, a 10% increase in the teenage population will increase cigarette consumption by 2.1%. Chart 1 shows the percentage of the total population aged 15 to 19 in Wisconsin. Most states have a similar pattern, which reflects the baby boomer bulge in the 1960s and 1970s. There was over a 3 percentage point drop in the proportion of teenagers in the 1980's, which helped reduce the demand for cigarettes by roughly 0.7%.

This standard demand analysis can provide insights into the factors that influence cigarette sales, but there is no revealed interdependency among taxing jurisdictions. We now turn to an analysis of how to address those interdependencies.



Measuring the Border Effect

A simple metric of the cigarette price advantage/disadvantage for a given state is the ratio of the cigarette tax rate for that state to the simple average of the cigarette tax rates for all bordering states. Again, using Wisconsin as an example, the variable $Border_{WI}$ can be computed as follows:

$$BORDER_{WI}=RTXCIG_{WI}/((RTXCIG_{IL}+RTXCIG_{IA}+RTXCIG_{MN}+RTXCIG_{MI})/4)$$

Chart 2 shows the results of this computation for Wisconsin, in addition to a population-weighted ratio, which takes into account relative state size as measured by population. The pattern over time of the two ratios is quite similar. Chart 2 shows that Wisconsin's cigarette tax rate was as much as 1.6 times higher than its neighboring states for the period 1955 to 1990. Wisconsin's cigarette tax rate briefly dropped below the average rate for Illinois, Iowa, Minnesota, and Michigan during the early 1990's, but now the ratio is again above one.

A measure of the border price ratio (both a simple average and a population weighted average) was computed for all states and the District of Columbia for the years 1955 to 2002. The ratios for Alaska and Hawaii were set equal to one. The population weighted ratios for all states for 1960, 1970 1980, 1990, and 2002 are shown in Table 3. Population weighted ratios are a preferred metric over the simple average ratio because the former allows for both size and growth rates to influence the ratio.

While it is certainly true that state cigarette excise tax rates do not account for all of the price differences between states, it is hypothesized that cigarette tax rates account for most of the differences and can be used as an additional conditioning variable in equations to estimate cigarette consumption. A measure such as $Border_{st}$, when added to the previous estimated equation, is expected to have a negative sign.

Border Effect Results

The results from adding the variable $Border_{st}$ to the previous estimated equation are shown in Table 2. An examination of the residuals by state revealed strong time trends associated with the error term. The GLS regression was re-estimated with each state having dual fixed effects; i.e., a constant and a time trend. Forty-one states had statistically significant negative time trends; six states had statistically significant positive time trends; and four states had statistically insignificant time trends.

TABLE 2

Variable	Coefficient	Std. Error	t-stat
Log(price)	-0.406878	0.011203	-36.32009
Log(income)	0.302418	0.026740	11.30956
Log(teen/pop)	0.245569	0.013164	18.65405
Trend – 1994--2002	-0.013080	0.000961	-13.61032
Border	-0.082923	0.005901	-14.05148
Observations=2380	Weighted R^2=0.998	D.W.=0.519497	S.E.=0.066324

The addition of $Border_{st}$ is significant and has the expected negative sign. Moreover, the variables retained from the first GLS regression retain their significance but are somewhat changed in value. The price elasticity is lower, dropping from -0.611 to –0.407. The estimate of income elasticity rises from 0.162 to 0.302. The coefficient on the teenage share of the population increased from 0.207 to 0.246. The trend coefficient (a proxy for potential Internet sales from 1994 to 2002) changed from –0.003 to –0.013.

An interpretation of the $Border_{st}$ variable, since it is a log ratio, is that for every 10 percentage points that a state cigarette tax is above the average of its neighboring states, there will be an additional 0.8% reduction in within state taxable sales of cigarettes. Conversely, if a state maintains a cigarette tax rate significantly below the average of neighboring states, that state will see a small boost in cigarette sales and revenue. For Wisconsin the border effect evaluated at a ratio value of 1.1 (10% higher than surrounding states) translates into an estimated value of nearly $23 million in lost revenue, out of a total of $293.7 million in fiscal year 2002. This border price effect may be especially significant for some states when we consider that the highest value of the $Border_{st}$ measure is already above 4.6 for Maryland.

The measure of the border effect as described thus far is intended to capture the general aspects of consumer behavior associated with commuting patterns, and one or two day excursions into border states. Moreover, the estimated coefficients are representative of all states as a group and may not apply exactly to a specific state, although individual state equations could be developed with the same data set.

Future research on the issue of a border price effect on tobacco consumption and revenue should include at least three additional questions not addressed in this paper. First, cigarette tax rates for municipalities should be included in the analysis, as exemplified by the questions surrounding the recent large increase in the cigarette tax rate for New York City. Second the question of how differences in sales taxes across states may impact on the border price effect should be addressed. Cigarettes are subject to the sales tax in some, but not all, states. Finally, for those states that border Canada and Mexico, there is also an unanswered question of the size of an international border effect.

The border effect also does not purport to capture behavior associated with smuggling operations, perhaps where cross-border shipments of cigarettes are made in large quantities, for example. Smuggling operations, looked at from the business perspective, would presumably not be limited to only border state price comparisons. The general concept of a measured border effect, however, could be extended to an examination of smuggling operations. If we construct a measure like $Border_{st}$, modified to measure the price difference between high price (high tax) states and low price (low tax) states, and adjusted for shipping distance to better account for profit potential, such a measure may be useful to examine smuggling issues.

TABLE 3
RATIO OF STATE CIGARETTE TAX RATE TO BORDER STATES' RATE (POPULATION WEIGHTED)

	1960	1970	1980	1990	2002
Alabama	1.068	0.961	0.748	0.890	0.703
Alaska	1.000	1.000	1.000	1.000	1.000
Arizona	1.015	1.030	1.199	1.023	1.149
Arkansas	0.634	1.000	1.288	0.515	0.730
California	2.888	1.403	0.917	1.466	1.535
Colorado	0.000	0.503	0.756	0.899	0.672
Connecticut	0.574	1.329	1.270	1.256	0.602
Delaware	0.572	0.828	0.830	0.704	0.392
District of Columbia	1.520	0.873	2.240	2.403	1.469
Florida	0.957	1.579	1.750	1.749	2.502
Georgia	1.291	0.809	0.947	0.802	0.602
Hawaii	1.000	1.000	1.000	1.000	1.000
Idaho	1.204	0.838	0.745	0.619	0.378
Illinois	1.148	1.427	1.151	1.666	2.230
Indiana	0.663	0.651	0.896	0.699	0.296
Iowa	1.010	0.872	0.989	1.115	0.762
Kansas	1.515	0.899	0.921	1.274	1.135
Kentucky	0.836	0.276	0.263	0.172	0.098
Louisiana	1.133	0.600	0.631	0.652	0.633
Maine	1.429	1.714	1.333	1.348	1.798
Maryland	0.688	0.549	0.738	0.984	4.676
Massachusetts	1.261	0.968	1.334	0.773	0.715
Michigan	1.206	0.842	0.783	1.243	1.876
Minnesota	1.135	1.087	1.235	1.277	0.975
Mississippi	0.982	0.812	0.853	1.129	0.901
Missouri	0.479	0.846	0.740	0.578	0.502
Montana	1.559	0.831	1.109	0.833	0.603
Nebraska	1.454	0.951	1.231	1.336	1.496
Nevada	0.986	1.053	0.947	1.088	0.459
New Hampshire	0.592	0.583	0.612	0.863	0.681
New Jersey	0.932	1.057	1.175	0.998	0.952
New Mexico	0.870	0.955	0.718	0.632	0.536
New York	0.913	0.838	0.786	1.371	2.096
North Carolina	0.000	0.206	0.231	0.232	0.572
North Dakota	1.054	0.902	0.721	0.897	1.042
Ohio	1.006	0.980	1.159	1.010	1.189
Oklahoma	0.982	1.134	1.203	1.035	0.707
Oregon	0.000	0.398	0.833	0.804	0.789
Pennsylvania	1.247	1.395	1.178	0.711	0.357
Rhode Island	1.015	0.971	0.857	1.196	1.124
South Carolina	2.156	1.309	1.027	1.008	0.819
South Dakota	1.012	1.120	0.960	0.732	0.849
Tennessee	1.709	2.058	1.693	1.392	1.170
Texas	1.174	1.338	1.276	1.378	1.612
Utah	2.140	1.067	0.925	1.135	1.448
Vermont	1.349	1.013	0.736	0.545	0.412
Virginia	0.000	0.443	0.315	0.294	0.088
Washington	4.369	2.309	1.773	1.352	1.975
West Virginia	1.155	0.735	1.381	1.277	0.472
Wisconsin	1.090	1.271	1.264	1.010	0.990
Wyoming	1.140	1.094	0.729	0.556	0.392

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