



Cigarette Price, Smoking, and Excise Tax Policy

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In 1986, Congress converted a temporary doubling of the federal cigarette excise tax into a permanent tax change. The principal motivation was the need for additional revenue. A second consideration was the belief that the higher tax would discourage hundreds of thousands of Americans from starting or continuing to smoke. In particular, Congress perceived that children and teenagers would be most influenced by the tax increase. If true, ultimately this could translate into avoiding many tens of thousands of smoking-related premature deaths and a great deal of smoking-related illness and disability.

Congress' expectations on both revenue yield and the consumption effects of the tax resulted from economists' studies of the price elasticity of demand, a measure of consumers' response to price changes. Examining data on cigarette consumption and price, over time and across states, economists have used a statistical technique known as multiple regression analysis (described below)

to estimate the effect that price changes have on sales of cigarettes. These estimates, in turn, have been used by other analysts to predict the revenue and consumption effects of a tax change. The estimates of consumption impacts were then combined with epidemiological data on the health effects of smoking to estimate the number of premature deaths that would be avoided as the result of a tax increase, or caused by a tax decrease.

There is nothing unique about the use of regression analysis to estimate the elasticity of demand for cigarettes, nor of the use of the resultant estimates to influence policy. In the private sector, economists toil daily to relate consumer demand to product pricing. The price charged for a new car, for example, may be determined in part by regression analysis of whether a price increase (or decrease) will have a greater effect on unit revenue or on sales volume. Total revenue (TR , the total value of car sales) equals the price per car (that is, the unit revenue, P) multiplied by the number, or quantity (Q), of cars sold. Thus, for example, if a 2% decrease in price increases car sales by more than 2%, say, by 3%, total revenue will grow. This is because $0.98P \times 1.03Q > PQ$ because $0.98 \times 1.03 = 1.0094 > 1$, where $0.98P$ represents a 2% decrease in price and $1.03Q$ measures a 3% increase in quantity sold. If, in percentage terms, the price decrease exceeds the increased sales volume, total revenue will fall. In the previous example, if the 2% price decrease ($0.98P$) produces only a 1% increase in car sales ($1.01Q$), $0.98P \times 1.01Q < PQ$. (That is, $0.98 \times 1.01 = 0.9898 < 1$.) Whether the price or volume impact will be larger must be estimated by using the best data and statistical techniques available.

In this essay, we will examine how elasticity of demand is defined and calculated, how statistical analysis permits its estimation, and how it can be used to predict the tax revenue and cigarette consumption effects of a change in the federal cigarette excise tax. Drawing on published elasticity studies, we will produce specific estimates of the numbers of children, young adults, and older adults likely to have been discouraged from smoking by the 1986 decision to make the doubling of the federal tax permanent. And we will see how regression analysis and elasticity estimation can be used—and indeed were used—to inform both fiscal policy and health policy.

DEFINITION AND CALCULATION OF PRICE ELASTICITY OF DEMAND

The price elasticity of demand for a product is a measure of how much consumers change their demand for the product as a result of a change in the product's price. Technically, price elasticity is defined as the percentage change in the quantity of the product demanded in response to a 1% change in the price of the product.

While *elasticity* is a technical term in economics, its qualitative meaning is actually quite similar to what we mean by everyday use of the word *elastic*: A rubber band is elastic in the sense that it responds a lot (stretches) when pulled in opposite directions. In contrast, a pencil is inelastic in that it does not expand

when both ends are pulled. Similarly, the demand for a product is elastic if it changes relatively more than the price that causes it to change (the price here being the exerted "force"). Demand is inelastic if it does not change as much in percentage terms as the price of the product. In the extreme, demand is perfectly inelastic if it does not change at all when the price of the product changes. This is analogous to the inelasticity of a heavy metal pipe when a person attempts to bend it using only bare hands.

Typically, demand for a good increases when the price of the good falls; demand decreases when the price increases. This relationship makes good intuitive sense: we all know that we want to buy more of something when it is less expensive; when it gets more expensive, we are inclined to buy less of it. Obviously we are more responsive to some prices than to others. For example, a 25% increase in the price of salt might not alter the amount of salt that we buy at all—our demand would be quite inelastic with respect to price; but a 25% increase in the price of a new car might cause us to postpone a new car purchase or to consider buying a used car or a less expensive new car than the one we had been considering. In this case, our demand for the car in question is quite price responsive, or elastic.

Calculation of the elasticity of demand is a simple matter if one knows the *demand curve* for the product. The demand curve is a graph showing the quantity of the product that consumers would buy at each of several different prices. Elasticity between any two points on the curve is calculated by measuring the percentage difference between the two quantities associated with the two points and dividing it by the percentage difference between the two prices associated with the two points.

ESTIMATING ELASTICITY OF DEMAND

The real world is rarely so kind as to present us with a well-defined demand curve. Rather, economists wishing to estimate the price elasticity of demand for cigarettes must find data on quantities of cigarettes smoked, prices, and other relevant variables (identified below) and then use them to estimate demand, in a form of statistical analysis known as multiple regression analysis (discussed below).

There are two basic approaches to estimating the demand for cigarettes. One, known as *time series analysis*, uses annual data on the variables of interest. In cigarette demand studies, national data have been used in time series analyses. The dependent variable in such studies is typically annual adult per capita cigarette consumption, defined as total cigarette sales divided by the size of the population over age 17. Cigarette sales data are available from the U.S. Department of Agriculture and are based on a variety of objective measures, including federal cigarette excise tax collections. Population data are available from the Bureau of the Census. The average retail price of cigarettes has been calculated by both governmental and nongovernmental agencies. A publication distributed by the Tobacco Institute (1988) provides detailed tax and price data

and is used by many economists studying cigarette demand. Other annual data, such as income levels, are available from governmental sources.

The second basic approach to estimating demand for cigarettes relies on cross-sectional data. In a cross-sectional study, the analyst takes data from a single year for a number of different observational units. The most common unit for cigarette demand studies (as well as for many other demand analyses) is the state. Thus the analyst uses data on states' cigarette consumption levels and average retail prices (and average incomes, and so forth).

As all states impose their own excise taxes on cigarettes, each state has reliable data on tax-paid sales. While these data are an accurate measure of tax-paid sales, they do not necessarily accurately portray the actual levels of cigarette consumption by the states' residents because sizable differences in prices among the states, owing primarily to differences in excise tax levels, encourage cigarette smuggling—purchasing cigarettes in one (low-tax) state for use or resale in another (high-tax) state. Some smuggling represents the efforts of organized crime; but much of it is informal or casual bootlegging in which residents of one state living close to a low-tax state buy their own cigarettes in the neighboring state. Perhaps the most striking evidence of this phenomenon is the difference in tax-paid sales in Massachusetts and neighboring New Hampshire. In 1985, Massachusetts (with a cigarette tax of 26 cents per pack) had annual tax-paid sales of 117.2 packs per capita, while New Hampshire (17 cents per pack) had annual tax-paid sales of 201.1 packs, fully two-thirds greater than the national average (Tobacco Institute, 1988). There is no evidence that residents of New Hampshire smoke significantly more than residents of other states. There is evidence, however, of substantial interstate smuggling of cigarettes across the Massachusetts–New Hampshire border (Advisory Commission on Intergovernmental Relations, 1985).

Given the distortion that smuggling can introduce into cross-sectional studies, most analyses have relied on survey data from such sources as the National Health Interview Survey, conducted annually by the National Center for Health Statistics. These large surveys provide data on the health and health habits and demographic characteristics of Americans. By employing respondents' self-reported smoking habits, analysts believe that they are capturing actual smoking behavior better than if they relied on state tax-paid sales data. Analysts use the self-reported data on smoking behavior for the dependent variable, and use the state-specific price data as one of the independent variables (discussed below). To account for the possibility of cross-border bootlegging, recent sophisticated analyses also include neighboring states' prices when survey respondents live close to other states having considerably lower taxes. (See for example, Lewit and Coate, 1982.)

Surveys, however, are an imperfect source of data for a number of reasons. Foremost among these is people's tendency to underreport the amount of their smoking. One study found that, in 1975, respondents to a federal government survey reported less than two-thirds of all the cigarettes that were actually sold in the United States that year (Warner, 1978). Most cigarette demand analysts recognize this problem and address it in their studies.

As noted above, data such as these are used to perform a multiple regression analysis to study cigarette demand. A *multiple regression analysis* examines

how a number of factors (called independent variables) relate to still another factor (the dependent variable). All of the factors take on a variety of values (hence the name *variables*). The assumption is that the independent variables vary "on their own" (thus the label *independent*), while the dependent variable is affected by (that is, "depends on") the movement of the independent variables. Thus a multiple regression analysis of the demand for cigarettes uses a measure of the quantity of cigarettes smoked as the dependent variable, and the quantity is said to *depend on* the values of the independent variables, which typically include the price of cigarettes and people's income levels. Other independent influences, often included as independent variables, are indices of antismoking publicity (which is believed to discourage smoking) and measures of recent previous smoking levels (reflecting the habitual or addictive nature of smoking). In each case, fluctuation in the independent variable is assumed to affect the number of cigarettes smoked or the number of smokers—the dependent variable.

Technically, multiple regression analysis, as with all statistics, identifies *correlations* between variables. As such, it cannot tell us that movement in one variable *causes* movement in another, but rather that the pattern of change in one is *related to* the pattern of change in the other. The function of multiple regression analysis is to sort out the multiple correlations among the independent variables and the dependent variable. To the extent that we can infer causality—or its likelihood—the regression analysis suggests how variation in each of the independent variables influences the value of the dependent variable. When, for example, we are interested in the relationship between quantity smoked and cigarette price, the analysis controls for (or fixes) the effects of the other independent variables and produces an estimate of the correlation between quantity smoked and price.

The results of a multiple regression analysis inform the analyst whether or not each independent variable is statistically significantly correlated with the dependent variable and, if so, how large the estimated effect is. Statistical significance means that the identified correlation is very unlikely to have occurred by chance. Technically, if the selected level of significance is .05, this means that the indicated correlation would occur by chance (that is, randomly) only 1 time in 20 if the variables are not related.

A statistically significant coefficient associated with the price variable estimates the amount by which the quantity of cigarettes smoked would decrease, given a one unit increase in price. By combining this estimate with the mean value of price and quantity, analysts can estimate the price elasticity of demand for cigarettes.

PREDICTING THE REVENUE AND CONSUMPTION EFFECTS OF A TAX CHANGE

Once we have an estimate of the elasticity and data on current consumption and price, it is relatively simple to predict the tax revenue and cigarette consumption effects of a change in the federal cigarette excise tax. For expository

purposes, we will describe the effects of a tax decrease. The effects of a tax increase would be calculated in a precisely analogous manner, subject to replacing the word *decrease* with *increase*, and vice versa, throughout the discussion.

To estimate the consumption impact, recall that elasticity equals the consumption increase divided by the price decrease, both expressed in percentage terms. We know all of the essential information except the new level of consumption resulting from a tax decrease. The elasticity was calculated from the regression analysis. The percentage decrease in price is simply the amount of the tax decrease divided by the average price. Since we know the initial consumption level, we simply solve the elasticity equation for its one unknown, the new (post-tax) consumption level.

Estimating the tax revenue impact is also straightforward. The change in tax revenue accompanying a federal tax decrease is calculated by subtracting revenue in the year preceding the tax decrease from the estimate of revenue in the year following the decrease. In any given year, total cigarette tax revenue equals the tax per pack times the number of packs sold. In the year preceding the tax decrease, revenue equaled the original tax rate times the original quantity. In the year after the decrease, total revenue would be estimated as the new tax rate times the expected quantity estimated as just described.

Interest in the revenue impact of a tax change lies in the aggregate effect. Regarding consumption effects, however, interest may focus on subgroups within the population. That is, legislators (or health professionals or others) may want to know the impact of the tax on smoking by teenagers, since teens constitute the new generation of smokers and potential smokers. Alternatively, consumption effects of a tax change on older smokers may be of special concern since these are the individuals in whom smoking-related diseases will emerge soonest and hence they might derive the most rapid health benefit from quitting. Drawing on consumption data from surveys, economists can estimate demand functions for specific subgroups of the population, with age and sex the most common distinguishing variables. As we will see in the next section, this procedure has permitted economists to differentiate price elasticities for the various age groups and thereby makes possible estimation of differential consumption effects.

CONSUMPTION AND REVENUE EFFECTS OF THE 1986 FEDERAL CIGARETTE TAX MEASURE

The 1982 Tax Equalization and Fiscal Responsibility Act (TEFRA) included a doubling of the federal cigarette excise tax from 8 to 16 cents per pack, effective January 1, 1983. Defined as a temporary revenue raising measure, the tax was scheduled to remain in effect only until October 1, 1985, at which time the tax would return to the pre-TEFRA level. In part due to concern about losing the additional revenue, and in part out of fear that reducing the tax would encourage smoking, congressional legislators debated, and in early 1986 passed, legislation making the tax change permanent. (Between October 1 and the

passage of the final legislation, the 16-cent tax was continued twice on a temporary basis.)

The legislators' understanding of the implications of the tax change benefited substantially from economic analysis that relied on studies of the demand elasticity of cigarettes to estimate the consumption and revenue impacts of permitting the tax's sunset provision to take effect. The analysis began with data on the national average retail price of a pack of cigarettes in 1984 (97.8 cents), a variety of measures of the quantity of smoking (including numbers of smokers in each of several age brackets and their annual consumption), and elasticity estimates for the various age groups, differentiating "participation" and "total" elasticities. Participation elasticities measured how decisions whether or not to smoke were influenced by price, while total elasticities assessed the traditional concern: how total cigarette consumption (the product of numbers of smokers and their average annual consumption) responded to price changes.

Table 1 presents estimates of cigarette demand and price elasticities derived by Dr. Eugene Lewit and his colleagues at the National Bureau of Economic Research. The overall adult elasticity (for ages 20-74), 0.42, means that a 10% increase in price would decrease consumption by adults by 4.2%. As can be seen in the table, and as seems eminently logical, older, more habituated (and likely more affluent) smokers are less price sensitive than are younger adults; that is, the elasticities fall as age increases. Consistent with this pattern and with the expectation, the overall elasticity for teenagers, 1.40, is higher than that of the youngest adults. For teens, a 10% price increase should decrease consumption by fully 14%.

From a health perspective, the participation elasticities are of greater interest, for they provide the "bottom line" indication of how many people would be influenced not to smoke by a price increase. The 0.26 participation estimate for all adults indicates that a 10% increase in price would discourage smoking by 2.6% of all adults who would have smoked in the absence of the price increase. Once again, participation elasticity falls as age increases.

Table 1 Cigarette demand and price elasticities

Age Group (Years)	ELASTICITIES	
	Total	Participation
12-17	1.40	1.20
20-25	0.89	0.74
26-35	0.47	0.44
36-74	0.45	0.15
All adults (20-74)	0.42*	0.26*

*Elasticities for all adults are calculated from separate regressions. This explains why the total elasticity is lower than the elasticity for each subgroup.

** Author note: The above tables are based on two separate studies, listed in source. These studied age group 12-17 in one study, and age group 20-74 in the other. Table 3 is based on an extrapolation between the two.

Source: Lewit and Coate (1982) and Lewit, Coate, and Grossman (1981).

Table 2 Expected percentage increases in cigarette consumption resulting from an 8-cent decrease in the Federal Cigarette Excise Tax

Age Group (Years)	Total	Participation
12-17	11.9	10.2
20-25	7.6	6.3
26-35	4.0	3.7
36-74	3.8	1.3
All adults (20-74)	3.6	2.2

For teenagers, the basic smoking decision seems to constitute the vast majority of the total elasticity. At 1.20, the teen participation elasticity means that a 10% price increase would discourage from smoking 12% of teens who would otherwise be smokers. Note that two groups comprise this 12%: teens induced to quit as the result of the price increase and teens discouraged from starting to smoke who otherwise would have done so. With the teen participation elasticity so high, price increases would appear to be a powerful tool to discourage children from adopting, or maintaining, tobacco habits.

The next step in converting the elasticities in Table 1 into estimates of the impacts of the specific federal tax change was a simple one: Analysts converted the originally legislated tax decrease into a price change. From a base price of 97.8 cents, the tax decrease of 8 cents would produce a new price of 89.8 cents, other things held constant (for example, assuming that manufacturers would not change the wholesale price). The percentage price change would be $8 / [(1/2) \times (97.8 + 89.8)] = 0.0853$, or 8.53%. (The denominator of the fraction is the average of the old and new prices.) If this figure is the denominator in an elasticity equation, the various elasticities from Table 1 can be inserted into the equation and the equation can be solved for the numerator, the percentage change in quantity demanded.

The results of these calculations are presented in Table 2. The table indicates that the 8-cent tax decrease would increase total adult cigarette consumption by 3.6%, and the number of adult smokers by 2.2%, while teenage smoking would increase by almost 12% (11.9%), including an increase in the number of smoking teens by 10.2%. Conversely, rescission of the mandated tax decrease would avoid these percentage increases in smoking.

To convert the percentage change figures in Table 2 into numbers of smokers and cigarettes, we merely multiply the former by the numbers of smokers in each age category and their total annual cigarette consumption. Aggregate consumption data have been drawn from federal government surveys.

The results of this simple arithmetic are presented in Table 3. [The addition of two age groups (18-19 and 75+) in Table 3 and the underlying survey data are explained in Warner, 1986.] This table provides the answer to one of the two questions of interest to Congress: how many people would be encouraged to smoke if the legislated tax decrease takes effect; or, how many people would *not* smoke if the decrease were rescinded?

Table 3 Estimated increases in cigarette smoking attributable to an 8-cent decrease in the Federal Cigarette Excise Tax

Age Group (Years)	No. Smokers (Thousands)	No. Cigarettes (Billions)
12-17	334	2.3
18-19	130	1.0
20-25	609	4.8
26-35	508	4.1
36-74	351	8.2
75+	13	0.2
Total	1,945	20.6

The numbers are impressive. Altogether, almost 2 million additional Americans would smoke if the tax decrease took effect. Of these, almost half a million (464,000) would be teenagers (age groups 12-17 and 18-19). More than half a million (609,000) would be in the youngest adult category, 20-25. In the category including middle-aged and older adults, the largest group of smokers, the numbers are smaller—351,000—but remain a substantial number of people. The analysis indicates that annual cigarette consumption would rise by 20.6 billion cigarettes.

All of these numbers appear to be quite large, including hundreds of thousands of people and tens of billions of cigarettes. In an absolute sense, the numbers *are* large. They reflect a lot of potential additional smoking and, with it, a considerable additional amount of smoking-related illness. But in *relative* terms, the indicated impacts are modest. Recognizing that some 56 million Americans are smokers, the participation effect of the 8-cent tax change amounts to only 3.5% of the smoking population. Similarly, the projected impact on total cigarette consumption is only about 5% of the cigarettes that people report that they smoke. Thus the consumption impact of the 8-cent tax change must be judged as modest, relative to the overall magnitude of the nation's smoking habit. But it is substantial in absolute terms: precisely because there are so many smokers consuming so many cigarettes each year, even a small percentage effect on smoking can translate into an important public health impact.

A crude estimate of that public health impact can be derived from the fact that one-quarter to one-third of lifelong cigarette smokers die as the direct result of their smoking habits (Mattson, Pollack, and Cullen, 1987). As such, if the 8-cent tax decrease took effect (and its real value were maintained over time), at least an additional half a million Americans would die prematurely as a result, although most of these deaths would occur several decades from now. Each would entail a loss of life expectancy of from 15 to 20 years. In addition to this most tragic outcome of a tax decrease, a substantial increase in smoking-related illness and disability could be anticipated.

Given the analysis of the consumption effects of a tax decrease, estimating the revenue implications of the mandated tax decrease is a trivial matter. Prior to the tax change, the tax per pack was 16 cents, and aggregate consumption

was about 28.5 billion packs of cigarettes. Thus the total federal excise tax revenue, the product of these two figures, was \$4.56 billion. If the tax fell by 8 cents, the new rate would equal 8 cents, while aggregate consumption would grow. According to Table 3, consumption would increase by 20.6 billion cigarettes, or just over a billion packs. But this estimate was derived from surveys, on which people have been shown to underreport their daily consumption by about a third, as discussed above. A better way to estimate the new level of cigarette consumption is to use the elasticity formula with an estimate of the overall (national) price elasticity of demand for cigarettes (produced by Lewit and colleagues) of 0.47. Doing this, we determine that the new consumption level would be 29.66 billion packs of cigarettes, an increase of 1.16 billion packs. Total excise tax revenue following a halving of the tax rate would be \$2.37 billion. The tax loss accompanying a halving of the excise tax would be \$4.56 billion minus \$2.37 billion, or \$2.19 billion.

As with the consumption impact, the revenue impact would be modest in relative terms (that is, relative to the \$1 trillion federal budget) but more substantial in absolute terms. As the late Senator Everett Dirksen once suggested, if you take a billion dollars here and a billion dollars there, pretty soon it begins to mount up to real money.

Statistical elasticity estimation is nothing more than just that—estimation. The validity of the estimates *derived from* the elasticity studies is therefore dependent on the validity of the elasticity calculations. While it is impossible to confirm that validity with certainty, it is reassuring to note that in 1983, following the federal tax increase of 8 cents and manufacturers' price increases—a total price rise of 13.45% (after inflation)—total cigarette consumption fell by 5.13%. This implies an overall elasticity of 0.38, close to that estimated by Lewit and his colleagues. Their estimates look even better when we recognize that the smoking-age population grew from 1982 to 1983. Furthermore, the long-run impact projected by elasticity studies might well require more than one year to take full effect.

THE IMPACT OF ANALYSIS ON CONGRESSIONAL DECISION MAKING

No one would conclude that the above analysis played a major role in influencing Congress to rescind the legislated cigarette tax decrease. Political considerations—the classic “horse trading” for which Congress is justifiably famous—undoubtedly played a more significant part, as likely did the legislators' predispositions toward revenue matters in general and excise taxes (and cigarette taxes) more specifically.

Still, anecdotal evidence suggests that this analysis did sway the thinking of certain key actors in the congressional debate. One senator reportedly had planned to filibuster during the debate on the bill to rescind the tax decrease. He felt that Congress had made a commitment in 1982 to return the tax to its pre-TEFRA level and that it should uphold its commitments. According to an

aide to the senator, however, the senator was so moved by the realization that the tax decrease would cause almost half a million children to smoke that he dropped his plans to filibuster.

Public health lobbyists who followed the debate closely reported that several other members of Congress were also influenced by this finding, which was published in a leading medical journal, presented at a Senate hearing, and covered by the media. Thus, while it is impossible to assess the precise contribution of the economic analysis to the enactment of the permanent 16-cent tax, it is reasonable to conclude that economic analysis, and its underlying statistical analysis, served to inform the congressional decision-making process and to inject a note of statistically based objectivity into a proceeding that was otherwise highly politicized.

PROBLEMS

1. Explain what a “price elasticity of demand” measures. In what way(s) can elasticities assist in decision making?
2. What is a “multiple regression analysis”? Describe how it is used to estimate price elasticities.
3. The overall price elasticity of demand for cigarettes is inelastic. Should profit-maximizing cigarette manufacturers want to raise or lower their product prices? Explain.
4. Assume that the overall price elasticity of demand for cigarettes is 1.50, instead of its actual estimated value of 0.47.
 - a. Estimate the aggregate consumption and tax revenue effects of permitting the excise tax to decrease from 16 to 8 cents per pack.
 - b. Under the actual situation of inelastic demand, both revenue and public health considerations recommended maintaining the tax at 16 cents. Given your calculations in (a), would health policy and fiscal policy work together if the elasticity were 1.50? Explain your answer.
5. The implicit assumption in the statistical estimation of elasticities is that responses to price increases and decreases are symmetrical. This assumption—used in this essay for expository simplicity—leads to the conclusion that a 10% *increase* in cigarette price would result in a 4.7% *decrease* in the demand for cigarettes, just as a 10% price *decrease* would produce a 4.7% demand *increase*. Many economists believe, however, that a cigarette price increase would have a proportionately larger effect on demand than would a price decrease.
 - a. Explain why this asymmetry seems logical in the case of smoking.
 - b. Would you expect the asymmetry to be comparable for teenagers and middle-aged adults? How does your answer relate to the differential demand elasticities in Table 1?

6. Elasticity estimates derive from regression analyses. Different analyses—employing different data or functional specifications—can and do produce different elasticity estimates. Would an opponent of the 1986 recision prefer to use a higher or lower elasticity estimate to argue against maintaining the tax at 16 cents? Discuss.

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