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DANIEL A. SUMNER
and
MICHAEL K. WOHLGENANT

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ABSTRACT

This report analyzes some likely effects of the recently passed federal cigarette tax increase. An equilibrium displacement model of the cigarette industry is developed. It includes relationships for international trade in cigarettes and tobacco, federal cigarette taxes, and market interrelationships between cigarettes and tobacco and other inputs in cigarette manufacturing. A range of values for the demand and supply elasticities is used to examine the sensitivity of the calculations. The major results of this study are: (a) the price of cigarettes will rise by almost the full amount of the tax increase; (b) the cigarette price increase will lead to about a 5 to 6 percent reduction in domestic sales of cigarettes, but some increase in quantities exported will offset domestic sales declines; (c) national distribution of cigarette sales will be altered slightly because relative price increases will be largest where current prices (and state tax rates) are lowest; (d) the effect of the tax increase on the price of domestic tobacco will be small -- even holding the production of tobacco constant -- because of the importance of international trade in cigarettes and tobacco as well as substitution with other inputs; and (e) a reduction of the real support price of tobacco in response to the tax increase will cause a fall in average tobacco quota lease rates.

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I. Introduction

In August 1982 the U.S. Congress passed, and the president signed into law, general tax legislation that increases the federal excise tax on cigarettes from eight to sixteen cents per pack.[1] Public discussion concerning the effects of this tax increase has been extensive, especially in parts of the country where tobacco is grown and cigarettes are manufactured. Political leaders of both parties, industry spokesmen and others have joined in opposing or defending this measure.

This report analyzes some likely effects of a federal cigarette tax increase. We use a simple model of the U.S. cigarette industry that includes relationships for the various important input markets. The major purpose of this report is to present estimates of expected changes in relevant prices, quantities, incomes, tax revenues and other important variables. This report uses current data and estimates of demand and supply parameters to calculate the effects of the tax increase. With more detailed information and modelling, more accurate and specific

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[1]This tax began on January 1, 1983, and is explicitly temporary. It is scheduled to expire in late 1985. We do not incorporate the temporary nature of the tax in our calculations because it seems likely that the tax will be continued with further legislation after that date.

results could be obtained. This report should also be useful as an example of the uses of a simple derived demand model in policy analysis.

Our approach is to develop a simple model incorporating the major features of supply and demand in cigarettes and tobacco. The federal excise tax is treated as one of the costly inputs in the production and sale of cigarettes. A change in the excise tax rate changes supply and demand conditions and we trace these effects throughout the related industries.

The next two sections give a background to the modelling and calculations by sketching the pattern of cigarette excise tax rates and by briefly describing the cigarette and tobacco industries. The model and results follow, including discussion of how our results depend on particular parameters and assumptions. Readers mainly interested in results might move directly to Section V and especially to the tables in that section.

Though we have a series of empirical results in this report, it will not be a trivial task to evaluate these results. Our model and calculations apply to changes caused by the changes in the tax rate increase. If all other factors affecting the cigarette and tobacco industries did not change in the next few years, then it would be relatively easy to measure the effects of the tax. But, of course, other things will change and have already changed. For example, recent changes in tobacco policy themselves will have a major impact on tobacco prices, quantities, and quota lease rates. It will take a careful and detailed analysis to separate the effects of the change in the tax rate from other factors to evaluate the success of our model simulations.

II. The History and Pattern of Cigarette Taxes and Prices

The federal excise tax on cigarettes is paid by the manufacturing firms for all cigarettes sold in the domestic market. There has been such a tax since the 19th century but receipts first became substantial in the 1920's after cigarette consumption increased significantly and the tax rate was trebled to $3.00 per thousand cigarettes. From 1920 to 1940 the federal tax remained constant, but 26 states began their own excise taxes on cigarettes. From 1940 through 1951 the federal excise tax rose in three stages to $4.00 per thousand where it remained for the next 30 years, on through 1982 (see Table 1).

The wholesale list price for cigarettes includes the federal excise tax. Wholesalers and chain stores, that act as their own wholesale distributers, buy cigarettes from the manufacturers at the list price minus various discounts that depend on promptness of payment and other conditions. For some buyers and for some periods the actual transacted net price may be well below the list price. Cigarette firms employ a large sales staff that provide marketing services to wholesalers and retailers. They also pay directly for display space and store space used for special promotions. Despite these factors, changes in the wholesale list prices reflect basic changes in underlying demand and costs. Table 1 lists recent wholesale list prices of cigarettes. These prices are generally the same for all major firms and for every region of the country. The prices have varied slightly by length of the cigarette. The table shows the wholesale list prices for 85 millimeter filter-tip cigarettes at selected dates for the last four decades. The federal excise tax has fallen from over 50 percent to less than 20 percent of the wholesale list price over this period.

During the period in which the real federal tax rate was falling, state taxes on cigarettes were increasing. The number of states taxing cigarettes continued to increase until 1970 when North Carolina became

Table 1. Cigarette Taxes and Prices, 1920-1981

Date	Federal Tax	Wholesale Price[a]	State Taxes			Average Retail Price[a]
			Minimum	Median	Maximum	
	(cents per pack of 20 cigarettes)					
1920	6.0	N/A	0.0	0.0	0.0	N/A
1930	6.0	N/A	0.0	0.0	8.0	N/A
1940	6.5	11.75	0.0	0.0	8.0	N/A
1950	7.0	14.50	0.0	3.0	8.0	N/A
1951[b]	8.0	15.50	0.0	3.0	8.0	N/A
1961	8.0	18.00	0.0	5.0	8.0	26.9
1971	8.0	20.50	2.0	12.0	18.0	40.0
1981	8.0	40.40	2.0	13.0	21.0	69.7

[a]The wholesale price is for kingsize-filter-tips. The retail price is a weighted average by type of cigarette and type of sale.

[b]Beginning with 1951, figures are for November 1 of the year noted.

Sources: "Tobacco Outlook and Situation," USDA, September 1982. The Tax Burden on Tobacco, Tobacco Tax Council, 1981.

the last state to add an excise tax on cigarettes. Throughout the 1960's the total of federal and state taxes remained at about 50 percent of the average retail price of cigarettes. State tax rates failed to keep up with inflation during the 1970's, however, so that by the end of 1981 the state and federal taxes only made up about 30 percent of the retail price of cigarettes. The wholesale list price was nearly 60 percent of the retail price in November 1981.

Table 2 indicates the variations in cigarette taxes and prices across the country. By August of 1982 state cigarette taxes varied from 2 cents to 25 cents per pack, and the average retail price varied from 61 cents to 94 cents. In Wisconsin, taxes comprised over 37 percent of the retail price while in North Carolina taxes comprised 18 percent of the retail price of cigarettes. Sales taxes also vary across states as does the applicability of sales taxes to cigarettes. In some states cigarettes are exempt from the state ad valorem sales tax while in others the sales tax base excludes the state specific excise tax on cigarettes. Also some cities and counties tax cigarettes. The average retail price of cigarettes varies across the country mainly because of tax differences although some variation is due to local distribution costs [Sumner, 1981]. The differences in cigarette taxes and prices across the country imply that the effects of the increase in the federal excise tax will likely vary. Simple projections of retail price and quantity effects are shown in Table 2. If the federal tax increase were to cause an increase in retail prices of exactly eight cents, the implied percentage increases in the retail prices are as shown in the third column, Table 2. The implied percentage price changes range from a low of 9 percent to a high of 13 percent in North Carolina. The effects of these price changes on the quantity of cigarettes bought in each state depend on the elasticity of demand for cigarettes. The last column in Table 2 shows the percentage fall in the quantity of cigarettes demanded if the price elasticity of demand in each state were -0.5. These price and quantity changes do not take into account effects of changes in the price of tobacco or interstate tax avoidance or other factors that are discussed in more detail in the next sections.

Table 2. Cigarette Taxes, Retail Prices and the Approximate Effect of the Eight-Cent Federal Tax Increase by State

State	State Cigarette Tax[a]	Average Retail Price[b]	Percent Expected Retail Price Increase[c]	Percent Expected Retail Quantity Reduction[d]
Alabama	16.0	80.4	10.0	5.0
Alaska	8.0	80.1	10.0	5.0
Arizona	13.0	80.6	10.0	5.0
Arkansas	17.75	79.3	10.1	5.1
California	10.0	80.1	10.0	5.0
Colorado	10.0	76.5	11.9	6.0
Connecticut	21.0	94.2	8.5	4.3
Del ware	14.0	81.5	9.8	5.0
D.C.	13.0	82.3	9.7	4.9
Florida	21.0	86.9	9.2	4.6
Georgia	12.0	74.6	10.7	5.4
Hawaii	19.5	83.1	9.6	4.8
Idaho	9.1	74.4	10.7	5.4
Illinois	12.0	76.6	10.4	5.2
Indiana	10.5	71.6	11.2	6.5
Iowa	18.0	80.1	10.0	5.0
Kansas	11.0	71.6	11.2	5.6
Kentucky	3.0	61.9	12.9	6.5
Louisiana	11.0	77.3	10.3	5.2
Maine	16.0	76.7	10.4	5.2
Maryland	13.0	72.0	11.1	5.6
Massachusetts	21.0	86.1	9.3	4.7
Michigan	21.0	85.8	9.3	4.7
Minnesota	18.0	78.9	10.1	5.1
Mississippi	11.0	76.1	10.5	5.3
Missouri	13.0	75.6	10.6	5.3
Montana	12.0	72.2	11.1	5.6
Nebraska	18.0	81.1	9.9	5.0
Nevada	10.0	78.8	10.2	5.1

Table 2 (continued)

State	State Cigarette Tax[a]	Average Retail Price[b]	Percent Expected Retail Price Increase[c]	Percent Expected Retail Quantity Reduction[d]
New Hampshire	12.0	76.3	10.5	5.3
New Jersey	24.0	89.3	9.0	4.5
New Mexico	12.0	76.3	10.5	5.3
New York	15.0[b]	79.8	10.0	5.0
North Carolina	2.0	61.0	13.0	6.5
North Dakota	12.0	74.6	10.7	5.4
Ohio	14.0	74.0	10.8	5.4
Oklahoma	18.0	78.9	10.1	5.1
Oregon	19.0	79.6	10.1	5.1
Pennsylvania	18.0	76.8	10.4	5.2
Rhode Island	23.0	84.3	9.5	4.8
South Carolina	7.0	68.1	11.7	5.9
South Dakota	15.0	74.8	10.7	5.4
Tennessee	13.0	75.1	10.7	5.4
Texas	18.5	81.2	9.9	5.0
Utah	12.0	77.1	10.4	5.2
Vermont	12.0	73.5	10.9	5.6
Virginia	2.5	62.0	12.9	6.2
Washington	23.0	91.6	8.7	4.4
West Virginia	17.0	82.6	9.7	4.9
Wisconsin	25.0	88.0	9.1	4.6
Wyoming	8.0	70.7	11.3	5.7

Table 2 (continued)

[a]State tax rates are given in cents per pack as of August 1, 1982. States also vary in the impact of sales taxes and city and county cigarette excise taxes. (See The Tax Burden on Tobacco, The Tobacco Institute, Washington, D.C., formerly published by the Tobacco Tax Council.)

[b]Retail prices in cents per pack are based on the Tobacco Tax Council's November 1981 Survey of Cigarette Prices adjusted for an average inflation of 10 percent and for the full impact of any state excise tax changes between November 1981 and August 1, 1982. The November 1982 Survey prices are not used because they reflect major wholesale price increases in the fall of 1982 that were made by manufacturers after the federal tax increase was passed but before it officially took effect.

[c]The figures in this column are calculated by dividing the average retail price into 8.0. This assumes that the retail price rise due to the federal tax is eight cents in every state.

[d]The figures in this column are based on multiplying the percent price increase by 0.5 to reflect a price elasticity of demand, at the price mean, of -0.5 in every state.

III. A Brief Description of the Cigarette and Tobacco Industries

Over 700 billion cigarettes are produced in the United States each year. Almost all the manufacturing takes place in the Southeast and over half the output is from North Carolina. U.S. cigarettes are sold throughout the world. Shipments to foreign markets are exempt from U.S. cigarette taxes and currently amount to about 13 percent of production. While there is some specialization for the international trade, the export price of cigarettes is about the same as the domestic wholesale price net of the federal excise tax. Cigarettes made in this country dominate the domestic market. Imported cigarettes have a negligible market share. Cigarettes are shipped from domestic manufacturers (with the federal excise tax already paid) to wholesale and chain stores around the country. The wholesalers are responsible for paying state and local excise taxes and for distributing cigarettes to retailers.

In recent years close to 40 thousand workers with earnings over $500 million dollars have worked at the wholesale level in the cigarette industry. Wholesale firms also use other resources, especially transportation services and warehouse space. At the retail level, cigarettes are sold mainly at stores that handle many other products. The amount of retail labor accountable to cigarettes, however, has been estimated at over 100 thousand workers with earnings over a billion dollars. Cigarette manufacturing firms employ a salesforce close to 10 thousand employees to facilitate the local marketing of cigarettes. Major advertising and promotion expenses of cigarette manufacturers total over a billion dollars per year. The manufacturing firms also provide a variety of discounts, special promotions and other marketing incentives used at the wholesale and retail levels.

Several major inputs besides tobacco are used in the manufacture of cigarettes. Employment is about 50 thousand workers earning close to one billion dollars. The manufacturing process is itself capital intensive involving specialized machinery in each process from stemming

through packaging. Material inputs include paper products, tow and filter rods, aluminum foil, plastics and flavorings. Expenses for these are about one billion dollars. Additional costs include energy, insurance, transportation and taxes. [See Wharton (1979) for further description.]

Tobacco is the major input into cigarette manufacturing and because of the public policy and international trade issues, the tobacco industry will be considered in some detail.

In the 1950's over 90 percent of the tobacco used in U.S. cigarettes was domestic burley and flue-cured types. Most of the remainder was imported oriental tobacco used for blending. Recently, imports of burley and especially flue-cured tobacco have become important. Imports now make up nearly one-third of the tobacco used in U.S. cigarettes. As the share of imported tobacco has risen, the share of domestic flue-cured tobacco has fallen while the domestic burley share remained roughly constant. It seems likely that there is significant substitutability between the three major sources of tobacco, though imported tobacco has tended to be lower priced and lower quality than most domestic tobacco. Thus import policy and tobacco supply conditions in other countries are important to the U.S. cigarette and tobacco industries.

While several types of tobacco are grown in the United States, flue-cured and burley account for most of the total output and are the major tobacco types used in cigarettes. Both types are grown mainly in the southeast with North Carolina and Kentucky the leading states. In recent years about 50 percent of the domestic flue-cured and 20 percent of the burley tobacco crops have been exported. U.S. exports have been a large but declining share of world trade. Both tobacco and cigarette production has increased in other countries.

Tobacco farming is particularly labor intensive. Recently as many as 0.5 million workers have been employed in tobacco farming for at least part of the year. Much hired labor is used during the harvest season with family workers providing most of the non-peak season work. Tobacco also intensively uses other inputs such as fertilizer, chemicals, energy, equipment and barns. Taxes, insurance and marketing fees are

also significant costs in tobacco farming. Land input is small relative to the value of the crop produced. The most costly input into tobacco production is the (possibly implicit) lease of the federal quota rights to market the crop.

Given recent policy it is the quota that is the limiting input for both flue-cured and burley tobacco production in the United States. Farmers with experience growing tobacco could expand production without increasing per unit cost if more quota were available. Federal policy concerning quota, allotment and price support is important to understanding the effects of the change in the federal tax. We will briefly summarize the basic features of tobacco policy up through 1981 and then list the major changes that were made for the 1982 season and beyond. For further discussion of the policy of the recent past see Pugh [1978]. Evans [1981] provides a chronology of policy changes through 1980.

An acreage allotment for tobacco was established in the 1930's that established the basis for the current poundage quota. Quota could be sold only in conjunction with parcels of land to which an original allotment was assigned. Quota could be leased to growers in the same county as the original allotment. A farm could market somewhat less or more than its quota in a given year and make up the difference by under- or over-marketing in the subsequent year. Quota lease rates depend on cost of production per pound in each county. The higher the other costs of production the lower the lease rate per pound of quota. See Hoover and Todoulos [1973], Hoover and Pugh [1981] and Pugh and Chappell [1982] for discussions of the markets for flue-cured tobacco quotas. Also see Seagraves [1969] and Seagraves and Williams [1981] for discussion of the capitalized values of quota as determined from land transactions.

From 1960 to 1981 the support prices for both burley and flue-cured tobaccos have been based on the following formula:

$$SP_t = k \cdot \overline{PPI}_t$$

where SP_t is the average support price in year t, k is the ratio of the support price in 1959 to the index of prices paid by farmers in 1959, and $\overline{PPI}_t$ is the average of the index of prices paid by all farmers in the 3 years prior to year t. During the marketing period any tobacco not bought by private buyers at a price above the support price was

taken by cooperatives and put into storage for sale when the market price increased. The quota system nsured that stocks did not simply accumulate over time as is the tendency for some supported agricultural commodities. In setting the quota for various types, the secretary of agriculture considered potential yields, demand factors and the amount of tobacco in storage from previous seasons. The national quota was set such that the market price would be just above the support price. If the quota was set too high, stocks accumulated. If the quota was too low, the market price would be well above the support price and potentially profitable output was foregone. In response to a factor that reduced the demand for tobacco, a reduction of the quota was necessary to maintain the market price at the support price.

The "no net cost" tobacco legislation of 1982 entails several important modifications. Fees have been set to make the program self-supporting. For flue-cured tobacco, quota may be sold within counties and certain owners must sell their quota. Finally, the secretary of agriculture is allowed to set the support price at a level below that given by the "parity" formula. The support price may be increased by as little as 65 percent of that dictated by the increase in the prices-paid index. This option was used in 1982 and resulted in a support price about 3 percent below the "parity" formula price. Over years of significant growth in the prices-paid index, the real decline in support price may be quite large. Pugh and Chappell [1982] describe the effect of these changes on expected quota values. Implications of this change in policy for the effects of the federal excise tax rate change are explored in the following sections.

IV. A Model of Effects of an Increase in the Federal Excise Tax on Cigarettes

Models of industry response to the exogenous demand and supply changes have been developed and applied to a range of problems [e.g., Muth, 1966; Gardner, 1975; Perrin and Scobie, 1981]. The model developed here can be viewed as an application of the general industry model developed by Wohlgenant [1982] with modifications to incorporate international trade and specific characteristics of the U.S. cigarette and tobacco industries.

We assume competitive behavior of the U.S. cigarette industry. Sumner [1981] found the firm level demand curves facing U.S. cigarette manufacturers to be highly price elastic. Thus, in the output markets for cigarettes, approximate price-taking behavior by individual cigarette manufacturers is implied. In the markets for tobacco, federal government quota and price support policies directly affect the price and quantity of domestically grown tobacco. Also, federal tariff and quota provisions influence the markets for imported tobacco. The effects of these policies are discussed below.

The following set of equations represent the basic demand-supply structure of the U.S. cigarette-tobacco industries.

Domestic demand for cigarettes is represented by

$$Q_{cd} = f_{cd}(P_{cd}, Z_d) \tag{1}$$

where Q_{cd} is the quantity of cigarettes sold in the domestic market by cigarette manufacturers, $f_{cd}(\cdot)$ is the domestic demand function for cigarettes facing the U.S. manufacturers, P_{cd} is the wholesale list price of cigarettes, Z_d represents exogenous retail marketing and distribution costs (including cigarette taxes applied at the state and local levels), and consumer demand shifters (e.g., income, population, prices of substitutes, etc.).

Foreign demand for cigarettes is represented by

$$Q_{ce} = f_{ce}(P_{ce}, Z_e) \tag{2}$$

where Q_{ce} is the quantity of cigarettes sold in foreign markets, $f_{ce}(\cdot)$ is the demand function by foreign countries facing U.S. manufacturers, P_{ce} is the export wholesale price, and Z_e represents exogenous cost and demand shifters affecting the sale and distribution of cigarettes in foreign markets.

Total cigarette production, Q_c, equals the sum of quantity demanded in domestic and foreign markets,

$$Q_c = Q_{cd} + Q_{ce}. \tag{3}$$

Changes in cigarette stocks from one year to the next are assumed to be negligible so equation (3) represents supply-demand equilibrium in the cigarette market.

Cigarette manufacturing costs depend upon the price of domestically produced tobacco (P_{td}), the price of imported tobacco (P_{ti}), prices of other manufacturing inputs including marketing and advertising (P_ℓ), and federal excise taxes on cigarettes (T). Setting the domestic wholesale price of cigarettes equal to per unit costs (which includes a normal rate of return on equity, etc.) we have,

$$P_{cd} = C_d(P_{td}, P_{ti}, P_\ell) + T. \tag{4}$$

This specification means that other inputs cannot be substituted for taxes in cigarette production, and that one unit of tax is required for each unit of cigarettes.

Competitive, price-taking behavior of individual cigarette manufacturers implies the net prices of cigarettes sold in the domestic and foreign markets be equal because costs of production and marketing in the two markets are equal. The relationship between P_{cd} and P_{ce} is therefore

$$P_{ce} = P_{cd} - T. \tag{5}$$

Price-taking behavior by cigarette manufacturers for tobacco and other inputs implies, for a given rate of output, that the inputs be purchased to the point where the marginal product per dollar spent on each input be equal. This input demand behavior can be described by

$$Q_{td} = f_{td}(P_{td}, P_{ti}, P_{\ell}, Q_c), \tag{6}$$

$$Q_{ti} = f_{ti}(P_{td}, P_{ti}, P_{\ell}, Q_c), \text{ and} \tag{7}$$

$$Q_{\ell} = f_{\ell}(P_{td}, P_{ti}, P_{\ell}, Q_c), \tag{8}$$

where $f_{td}(\cdot)$, $f_{ti}(\cdot)$, and $f_{\ell}(\cdot)$ are manufacturers' demand functions for domestic tobacco (Q_{td}), foreign tobacco (Q_{ti}) and other inputs (Q_{ℓ}). The federal tax rate, T, enters these input demand functions through Q_c. With other input prices and output held constant, input quantities purchased are unaffected by changes in the tax rate because of the lack of substitution possibilities. The effect of the tax enters through changes in the price of tobacco and output. The price of the domestic tobacco input depends on federal policy and supply and demand conditions and will be discussed in more detail. We assume that for all other inputs, supply prices are unaffected by quantities purchased by cigarette manufacturers.

Export demand for U.S. tobacco is

$$Q_{te} = f_{te}(P_{td}, Z_{te}), \tag{9}$$

where Q_{te} is the quantity of tobacco exported, $f_{te}(\cdot)$ is the export demand function for tobacco and Z_{te} represents policy variables and exogenous determinants of derived demand for U.S. tobacco by foreign countries.

The supply of U.S. produced tobacco depends on the market price of tobacco, prices of inputs in tobacco production, and federal policy variables regarding allotment, quotas, and price supports. This supply function is represented by

$$Q_{td} = f_t(P_{td}, Z_t). \tag{10}$$

Total domestic production of tobacco is the sum of the amounts demanded by U.S. manufacturers and foreign countries,

$$Q_t = Q_{td} + Q_{te}. \tag{11}$$

To determine the effect of the increase in the federal excise tax on cigarettes on prices and quantities, we first solve equations (1) - (11) for prices and quantities as a function of T, substitute these reduced form solutions back into (1) - (11), and totally differentiate these equations to find the equilibrium displacement of prices and quantities to a given change in the tax rate. Assuming all partial

elasticities and input and output shares are (approximately) constant over the relevant range, these effects in percent changes are given in Table 3 by equations (12) through (20).[2] The economic reasoning and interpretations of these equations are discussed below. The next section uses these equations with current data to yield quantitative implications of the tax effects. Appendix A sketches the derivations.

Table 3. Effects of a Change in the Federal Excise Tax

	Dependent Variable of Interest	Equation
(12)	Price of Domestic Tobacco	$\%\Delta P_{td} = - \phi \%\Delta T$
(13)	Price of Domestic Cigarettes	$\%\Delta P_{cd} = (\alpha_T - \alpha_{td}\phi)\%\Delta T$
(14)	Price of Exported Cigatettes	$\%\Delta P_{ce} = - [1/(1-\alpha_T)]\alpha_{td}\phi \%\Delta T$
(15)	Quantity of Domestic Cigarettes	$\%\Delta Q_{cd} = - \eta_{cd}(\alpha_T - \alpha_{td}\phi)\%\Delta T$
(16)	Quantity of Exported Cigarettes	$\%\Delta Q_{ce} = \eta_{ce}[1/(1-\alpha_T)]\alpha_{td}\phi \%\Delta T$
(17)	Quantity of Domestic Tobacco[b]	$\%\Delta Q_{td} = - (\beta_{cd}\eta_{cd}\alpha_T - \lambda_{dd}\phi)\%\Delta T$
(18)	Quantity of Imported Tobacco[b]	$\%\Delta Q_{ti} = - (\lambda_{id}\phi + \beta_{cd}\eta_{cd}\alpha_T)\%\Delta T$
(19)	Quantity of Other Imports[b]	$\%\Delta Q_{\ell} = - (\lambda_{\ell d}\phi + \beta_{cd}\eta_{cd}\alpha_T)\%\Delta T$
(20)	Quantify of Exported Tobacco	$\%\Delta Q_{te} = \eta_{te}\phi \%\Delta T$

[a]The expression "%Δ" is read "approximate percentage change." Other ymbols are defined on the following page and in Table 4.

[b]These equations refer to use by U.S. cigarette manufacturers.

[2]The shares and elasticities are assumed to be constant to facilitate the use of the model. The log differentials (multiplied by 100) are interpreted as approximate percentage changes. The results are unaffected by this approximation within the range of accuracy implied by uncertainty about the estimates of the elasticities themselves.

The total effect of a 1 percent change in the federal cigarette tax on the price of domestic tobacco is described by the parameter ϕ in equation (12). The change in the tax shifts the derived demand curve for tobacco and hence changes the equilibrium market price of tobacco. The equation for ϕ, derived in Appendix A, is

(21) $\phi=\beta_{td}\beta_{cd}\eta_{cd}\alpha_T/\{\varepsilon+(1-\beta_{td})\eta_{te}+\beta_{td}\alpha_{td}(\sigma_{dd}+\beta_{cd}\eta_{cd}+(1-\beta_{cd})\eta_{ce}/(1-\alpha_T))\}$

The interpretation of this complicated expression may be illustrated by two simple special cases. First, if federal policy causes the support price to be constant [equivalently the supply curve of U.S. tobacco is horizontal ($\varepsilon \to \infty$)], the tobacco price, P_{td}, is unaffected by changes in the tax rate, i.e., the percentage change represented by equation (12), ϕ, equals zero. Second, if supply of domestic tobacco is fixed ($\varepsilon = 0$), there is no substitution for domestic tobacco ($\sigma_{dd} = 0$), and international trade is inflexible ($\eta_{te} = \eta_{ce} = 0$), then $\phi = \alpha_T/\alpha_{td}$. Reality is in between these extremes.

Equations (13) and (14) describe the effects of the tax rate change on domestic and foreign wholesale prices of cigarettes. In the special case where there are no feedback effects of the tax change on the domestic market price of tobacco, i.e., $\phi = 0$, the domestic cigarette price rises by the full amount of the tax increase (equivalently, $\%\Delta P_{cd} = \alpha_T\%\Delta T$), and the foreign cigarette price is unaffected.

Equations (15) and (16) describe the effects of the tax increase on quantities of cigarettes sold in domestic and foreign markets. These effects are calculated by multiplying the percent changes in cigarette price in each market by the appropriate demand elasticity.

Equations (17) - (19) describe the effects of the tax on quantities of inputs employed by cigarette manufacturers. The demand parameters λ_{dd}, λ_{id}, and $\lambda_{\ell d}$ are derived in the appendix and may be written here as,

(22) $\lambda_{dd} = \{\sigma_{dd} + \beta_{cd}\eta_{cd} + (1-\beta_{cd})[1/1-\alpha_T)]\eta_{ce}\}\alpha_{td}$,

(23) $\lambda_{id} = \{\sigma_{id}-\beta_{cd}\eta_{cd} - (1-\beta_{cd})[1/(1-\alpha_T)]\eta_{ce}\}\alpha_{td}$, and

(24) $\lambda_{\ell d} = \{\sigma_{\ell d}-\beta_{cd}\eta_{cd} - (1-\beta_{cd})[1/(1=\alpha_T)]\eta_{ce}\}\alpha_{td}$.

They take into account any substitution of domestic tobacco for other inputs and output effects of the tax increase. For example, in equation

(17), the term, $\lambda_{dd}\phi$, describes the indirect effect of the tax increase on substitution of domestic tobacco for imported tobacco and other inputs. In equations (18) and (19) these substitution effects are described by the cross-price demand elasticities λ_{id} and $\lambda_{\ell d}$. With a less than infinitely elastic supply curve of tobacco, the price of domestic tobacco decreases relative to other manufacturing input prices. The ease with which domestic tobacco can replace other inputs in cigarette manufacturing would be important in determining the employment effects of the tax increase.

Finally, equation (20) describes the effects of the tax increase on export sales of tobacco. Evidence indicates that the export demand elasticity, η_{te}, may be large so the effect of the tax increase on foreign sales could be dramatic.[3]

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[3]J.S. Mann [1974], using time series data over the period 1954-72, constructed an econometric model of the U.S. tobacco economy to analyze the impact of potential policy and technological changes, including the effects of a one cent increase in federal and state cigarette taxes on prices and quantities. The directions of changes he calculates are consistent with ours.

V. Empirical Application: Some Quantitative Effects of the Increase in the Federal Cigarette Excise Tax

In this section we use the model described in Section IV together with estimates and assumptions of parameter values to calculate some quantitative effects of the recently passed increase of the federal cigarette excise tax. Some of the effects of the tax rate increase depend on policy response by state and federal governments. We point out the nature of this dependence and discuss the impacts of alternative policies.

The parameter values used in the calculations have been listed in Table 4. The market shares and cost shares are approximately the current levels. For the elasticities, we consider a range of values to examine the sensitivity of the calculations. The only factor of production allowed to have an upward sloping supply curve is domestic tobacco. Thus, the prices of all other inputs are unchanged, no matter what parameter values are used. We maintain the assumption that there is no substitution between the tax and other inputs, and that there are constant returns to scale in cigarette production.

Table 4. Definitions of Symbols and Values Used in the Calculations

Symbol	Definition	Values
η_{cd}	Domestic wholesale cigarette price elasticity of demand	0.3
η_{ce}	Export wholesale cigarette price elasticity of demand	3.0
β_{cd}	Share of U.S. cigarettes sold in the domestic market	0.87
α_{td}	Domestic tobacco share of domestic wholesale cigarette costs	0.15
α_T	Tax share of domestic wholesale cigarette cost	0.18
σ_{id}	Elasticity of substitution between domestic tobacco and imported tobacco	0 or 0.5
$\sigma_{\ell d}$	Elasticity of substitution between domestic tobacco and other manufacturing inputs	0 or 0.5
σ_{dd}	Own elasticity of substitution for domestic tobacco $(\alpha_{td}\sigma_{dd} = \alpha_i\sigma_{id} + \alpha_\ell\sigma_{\ell d})$	0 or 2.2
η_{te}	Domestic tobacco export price elasticity of demand	2 or 5 or 10
β_{td}	Share of domestic tobacco used by U.S. cigarette manufacturers	0.6
ε	Domestic tobacco supply elasticity	0 or 1 or ∞

Note: Data for cost and market shares for cigarettes and tobacco come from Wharton Applied Research Center [1980] and USDA, "Tobacco Outlook and Situation," (various issues). Estimates of domestic demand elasticities for cigarettes are summarized in Pugh [1978]. See also Sumner [1982], Coate and Lewit [1981] and Lewit, Coate and Grossman [1981], Export demand elasticities for tobacco are adopted from Norton [1981] Evans and Seagraves [1983]. Domestic tobacco supply elasticities adopted from Pugh [1978], Pugh and Chappell [1982], Evans [1981], Seagraves [1983], Mann [1974], and Norton [1981]. For more discussion see Appendix B.

Consider first a special case of extreme lack of flexibility in the market. The conditions are: (a) quantity of domestic tobacco quota, (b) no substitution between inputs including imported tobacco in making cigarettes, and (c) fixed quantities of exported cigarettes and tobacco. Under these circumstances, we get the following simple expression from equation (12):

$$\%\Delta P_{td} = - (\alpha_T/\alpha_{td})\%\Delta T,$$

i.e., the percentage fall in the price of tobacco is equal to the ratio of tax cost to the domestic tobacco cost share times the rise in the tax rate. The large increase in T contained in the recent legislation would reduce the price of tobacco by more than 100 percent. This case illustrates that more flexibility must be allowed to model the response to the tax rate change. The economic relationships simply cannot be that rigid. Among the places in which flexibility is considered are: (a) substitutability between inputs in cigarette production, (b) the price elasticity of demand for exported cigarettes, (c) price elasticity of supply of domestic tobacco. If we allow for non-zero values for any of these parameters, the effect of the tax increase on the price of domestic tobacco is much smaller.

Table 5 lists the changes in the price of domestic tobacco that would follow from the increase in the cigarette tax rate for various demand and supply elasticities. This table shows that when plausible parameters are used, quite small changes in the price of tobacco are implied by the large cigarette tax increase. Some price elasticity of demand for exports of cigarettes or tobacco is enough to limit the effect on the price of tobacco to about 3 percent even if there is no substitution of domestic tobacco for other inputs and the quantity of domestic tobacco is constant. With a supply elasticity of unity, some input substitution, and an export demand elasticity of 10.0, the price of domestic tobacco falls by only 0.5 percent from the 100 percent increase in the federal excise tax.

In Table 5 three underlying parameters are allowed to vary to show the quantitative effects on ϕ. The most likely combination of parameters are $\lambda_{dd} = .44$, $\eta_{te} = 2$, and $\varepsilon = 0$. These lead to a 2.6 percent fall in the price of tobacco from the recent eight-cent in-

Table 5. Effects of the Increase in the Federal Cigarette Excise Tax on the Domestic Market Price of Tobacco

Domestic Derived Demand Elasticity λ_{dd}	Export Derived Demand Elasticity η_{te}	Supply Elasticity ε	Percent Change in Price of Domestic Tobacco from 100% Increase in the Tax Rate, Equation (13) $-\phi x100$
0.11	2	0	-3.2
0.11	2	1	-1.5
0.11	5	0	-1.4
0.11	5	1	-0.9
0.11	10	0	-0.7
0.11	10	1	-0.6
0.44	2	0	-2.6
0.44	2	1	-1.4
0.44	5	0	-1.2
0.44	5	1	-0.9
0.44	10	0	-0.7
0.44	10	1	-0.5

Note: The values of $\lambda_{dd} = 0.11$ are for $\sigma_{id} = \sigma_{\ell d} = 0$, i.e., fixed proportions. The values of $\lambda_{dd} = 0.44$ are for $\sigma_{id} = \sigma_{\ell d} = 0.5$ (see equation 22). For the expression for ϕ underlying these calculations, see equation 21.

crease in the federal excise tax on cigarettes. It seems likely that there is some substitutability between domestic tobacco and other inputs in cigarette manufacturing. At least for imported tobacco and domestic flue-cured tobacco, there is a history of substitution and filter-tips and additives probably make substitution easier. The gross derived demand elasticity for exports for small changes in the range of current prices is probably in a range of 2.0. Finally, the supply elasticity of domestic tobacco depends directly on public policy. Recent changes in price support policy allows for a falling real support price. Approximating this by a supply elasticity only slightly above zero seems reasonable. During 1982 and 1983 the policy changes included in the "no net cost" tobacco legislation and characteristics of, especially, the flue-cured tobacco market implied that the Secretary would hold nominal support price increases to a minimum. Still, however, excess supply meant that quantities of tobacco quota would be reduced. In this setting, the impact of the tax increase was to increase pressure to reduce both price and quantity of domestic tobacco. It is useful, however, to examine the impact of a fall in either price or quantity to investigate the effects of each. The percentage change in the lease rate for tobacco quota from a change in the excise tax depends on the induced change in the price of domestic tobacco. If the quantity of quota is fixed then

$$\%\Delta R = (1/\lambda_q)\%\Delta P_{td} \tag{25}$$

where R is the lease rate and λ_q is the cost share of quota in the production of tobacco. The share varies in proportion with R and inversely with other cost of production across counties to which tobacco quotas are assigned. Table 6 lists representative effects on the lease rates for tobacco quota. For counties in which λ_q is small, the percentage change in quota lease rates may be high. [For a discussion of flue-cured lease rates, see Pugh and Chappell, 1982].

Table 7 lists the quantitative effects of the increase in the cigarette tax on the other variables represented in equations (13)-(20). The simplest case is that of horizontal supply curves for all inputs including domestic tobacco. These results are in column (1). With no change in the price of tobacco (i.e., $\epsilon \to \infty$), the supply curve for cig-

Table 6. Effect of the Increase in the Federal Cigarette Excise Tax on the Rental Rate of Tobacco Quota, Under Alternative Conditions

Share of Quota Lease in Cost of Production	Percent Change in Price of Domestic Tobacco	Percent Change in Quota Lease Rate
λ_q	$-\phi x100$	$\%\Delta R$
0.1	-3.2	-32
0.2	-3.2	-16
0.3	-3.2	-11
0.1	-1.2	-12
0.2	-1.2	- 6
0.3	-1.2	- 4

Note: This table is based on equation (25). The values for ϕ are taken from Table 5. The representative values for λ_q are from Pugh and Chappell [1982] and represent the range found in different county markets.

Table 7. Effect of the Federal Excise Tax on Prices and Quantities Under Alternative Conditions

Dependent Variable	Percent Change in the Dependent Variable with Constant Tobacco Support Price (1)	Percent Change in the Dependent Variable with Constant Tobacco Quantity (2)
$\%\Delta P_{td}$, eq. (12)	0.0	-3.2
$\%\Delta P_{cd}$, eq. (13)	18.0	17.5
$\%\Delta P_{ce}$, eq. (14)	0.0	-0.6
$\%\Delta Q_{cd}$, eq. (15)	-5.4	-5.2
$\%\Delta Q_{ce}$, eq. (16)	0.0	1.8
$\%\Delta Q_{td}$, eq. (17)	-4.7	-4.3
$\%\Delta Q_{ti}$, eq. (18)	-4.7	-4.3
$\%\Delta Q_{\ell}$, eq. (19)	-4.7	-4.3
$\%\Delta Q_{te}$, eq. (20)	0.0	6.4

Note: The constant price column (1) is calculated under the assumption the supply curve of tobacco is horizontal, i.e., $\varepsilon \to \infty$. The constant quantity Column (2) is calculated assuming the supply curve is vertical, i.e., $\varepsilon = 0$ that all inputs in cigarette manufacturing are used in fixed proportions, i.e., $\sigma_{id} = \sigma_{\ell d} = 0$, and the derived demand elasticity for exported tobacco, η_{te}, is 2.0.

arettes is horizontal and the price increases by 8 cents per pack or 18 percent at the wholesale level. This implies (with $\eta_{cd} = 0.3$) a 5 percent to 6 percent reduction in the quantity of cigarettes bought on the domestic market and in most of the resources used in domestic distribution. The 100 percent tax rate increase will increase federal cigarette tax revenues by 90 percent. Total output including exports and all inputs into cigarette production experience a 4 percent to 5 percent fall in their quantity demanded by domestic cigarette manufacturers. Since half of the flue-cured and a quarter of the burley

tobacco crops are exported, the total quantity of the flue-cured would fall by 2 percent to 3 percent and for burley tobacco quantity demand would fall by 3 percent to 4 percent.

Given the recent changes in federal tobacco policy it is likely that the market price of domestic tobacco will be lower in response to the cigarette tax. Column 2 of Table 7 lists the results under the conditions that: (a) tobacco supply elasticity is zero, (b) there exists no substitution among inputs, and (c) the elasticity of demand for exports is 2.0. As Table 5 has shown, this combination implies that the price of domestic tobacco would fall by 3.2 percent. Because this is a small change in the price of tobacco, and domestic tobacco has a small share in total costs of cigarette production, the results in column (2) are close to those listed in column (1). Other parameter combinations yield other results for prices and quantities that are also similar to the two cases listed.

The model and calculations have applied at the wholesale level and correspond to national industry changes. Several further issues may be discussed very briefly that imply more detailed effects of the federal tax increase. First, demographic variables and income affect smoking behavior [Sumner, 1982]. Further, Lewit, Coate and Grossman [1981] argue that sensitivity to price is stronger for younger people. This would suggest that states with a higher proportion of population in the 18-25 age group would have a more elastic price response. However, given the degree of uncertainty about the level of the price elasticity, it seems inappropriate to incorporate variation in elasticities across states without more detailed econometric investigation. Second, the change in the federal excise tax could result in differential changes in the retail price of cigarettes if it caused different responses in state cigarette taxes. However, there is no evidence that the pattern of state excise taxes, sales taxes and other wholesale and retail marketing costs are systematically affected by the higher federal excise tax. Third, our model abstracts from interstate cigarette smuggling. Since state tax rate differentials are not affected by the increased federal tax, the incentive to smuggle interstate is not changed. A smuggler who buys cigarettes at the new

higher price, however, has more capital invested and more potential loss if a shipment is confiscated so there is a tendency for smuggling to fall. [See Sumner, 1982 and Lewit, 1982, for further discussion of interstate smuggling.] Fourth, legal cigarette wholesalers also have higher capital investments in inventories after the tax increase and this leads to higher costs by $\theta r \Delta T$ where r is the yearly nominal interest rate and θ is the proportion of a year the cigarettes are in the "pipeline." Fifth, the federal tax is the same per thousand cigarettes of any length with or without filters. The increase in the tax raises the cost of shorter cigarettes relative to the 100mm cigarettes that have been priced higher. Thus, as suggested by Barzel [1976], the tax effect will be to increase output of long versus short cigarettes, and to enhance quality per cigarette. These offsetting effects are likely to be small so we assume that the retail price increase implied by the federal tax increase is roughly 8 cents per pack in every state.

Finally, our model does not relate to the timing of price or quantity changes. A recent paper by Sumner and Ward [1981] argues that any particular price change will in part "catchup" for general inflation that has accumulated since the last price increase on that item. Specific tax changes usually come in large discrete jumps so they provide a natural occasion for a price increase larger than the cost change itself. The federal tax change of January 1983 is clearly this kind of large discrete cost change, and we may well observe a larger than four dollar per thousand short-run price increase. This affects the timing of price changes, not the long-run price level. In fact cigarette manufacturers have chosen to raise their wholesale list prices in several stages before the date of the tax change, presumably in part to "smooth" the shock of a large price change.

VI. Conclusions

In the plausible cases examined, the price of cigarettes will rise by roughly the full amount of the tax. This is because the derived supply curve for cigarettes is nearly horizontal. This price increase will entail a reduction in domestic quantities sold by 5 to 6 percent, but the quantities exported will increase some to offset domestic sales declines. The national distribution of cigarette sales will be altered because the proportional price increase will be largest where current prices (and state tax rates) are lowest. International trade in cigarettes and tobacco as well as substitution with other inputs implies that the effect of the tax increase on the price of domestic tobacco will be small. This is true even if production of tobacco is held constant. The reduction in derived demand implies a fall in either the price or quantity of domestic tobacco. With a price fall the impact of the tax increase will be on the real rental rate for quota. If the price of quota is reduced, other effects are minimized.

Given all the recent changes in policy related to the tobacco industry, it will be difficult to clearly separate the impact of the cigarette excise tax from other factors. This report has provided a framework using previous estimates of supply and demand parameters to guide measurement of tax effects. Many refinements to the model and further econometric evidence on parameters would be useful to more detailed and accurate calculations.

Finally, we note that the model used in this paper is broadly applicable to tax or input price changes in other industries.

LIST OF REFERENCES

Barzel, Y. 1976. An alternative to the analysis of taxation. Journal of Political Economy 84: 1177-92.

Coate, D., and E. M. Lewit. 1981. The potential for using excise taxes to reduce smoking. NBER Working Paper Series No. 764, National Bureau of Economic Research, Cambridge, Mass.

Evans, David S. 1981. An Economic history of the U.S. flue-cured tobacco program. Unpublished Master's thesis, North Carolina State University, Raleigh, N.C.

Gardner, B. L. 1975. The farm-retail price spread in a competitive food industry. Amer. J. Agr. Econ. 57: 399-409.

Gubala, J. J., ed. 1979. Coordinator. National Association of Tobacco Distributors, Inc., New York.

Hoover, D. M., and S. I. Efstratoglou Todoulos. 1973. Economic Effects of Intercounty Transfer of Flue-Cured Tobacco Quota. Economics Research Report No. 23, North Carolina State University, Raleigh, N.C.

Hoover, D. M., and C. R. Pugh. 1981. Lease rates in North Carolina counties under the program for flue-cured tobacco. Paper presented at the 29th Tobacco Workers Conference, Lexington, Kentucky, January 19-22.

Lewit, Eugene M. 1982. The interstate market for smuggled cigarettes. Paper presented at the 1982 meeting of the American Economics Association, New York, New York.

Lewit, E. M., D. Coate, and M. Grossman. 1981. The effects of government regulation on teenage smoking. J. Law Econ. XXIV (3): 545-570.

Mann, J. S. 1974. Dynamics of the U.S. Tobacco Economy. Technical Bulletin No. 1499, ERS, USDA, Washington, D.C.

Muth, R. F. 1966. The derived demand curve for a productive factor and the industry supply curve. Oxford Econ. Pap. 16: 221-34.

Norton, D. T. 1981. Institutional intervention in the market for an international trade commodity: U.S. flue-cured tobacco. Unpublished thesis, Department of Economics and Business, North Carolina State University, Raleigh, N.C.

Perrin, R. K., and G. M. Scobie. 1981. Market intervention policies for increasing the consumption of nutrients by low income households. Amer. J. Agr. Econ. 63: 73-82.

Pugh, Charles R 1978. Provisions of the tobacco program, consequences of their elimination and alternatives. Workshop Discussion Paper, North Carolina State University, Raleigh, N.C.

Pugh, Charles R., and Joe S. Chappell 1982. Adjustments in the Tobacco Price Support Program, and Their Effect on Future Lease Income and the Value of Flue-cured Quotas. Economics Special Report No. 76, North Carolina State University, Raleigh, N.C.

Seagraves, J. A. 1969. Capitalized values of tobacco allotments and the rate of return to allotment owners. Amer. J. Agr. Econ. 51: 320-334.

Seagraves, James A. 1983. The life cycle of the flue-cured tobacco program. Working Paper No. 34, Department of Economics and Business, North Carolina State University, Raleigh, N.C.

Seagraves, J. A., and Fred E. Williams. 1981. Returns to Investors in Flue-cured Tobacco Allotments, 1975-80. Economics Research Report No. 41, Department of Economics and Business, North Carolina State University, Raleigh, N.C.

Sumner, D. A. 1981. Measurement of monopoly behavior: An application to the cigarette industry. J. Polit. Econ. 89: 1010-19.

Sumner, D. A. 1982. Cigarette smuggling. Paper presented at the 1982 meeting of the American Agricultural Economics Association, Logan, Utah.

Sumner, Michael T., and Robert Ward. 1981. Tax changes and cigarette prices. J. Polit. Econ. 89 (6): 1261-1265.

Tobacco Institute. 1982. Monthly state cigarette tax report. September issue. Washington, D.C.

Tobacco Tax Council. 1981. The Tax Burden on Tobacco, Historical Compilation. Vol. 16. Richmond, Virginia.

U.S. Department of Agriculture. 1982. Tobacco Outlook and Situation. September 1982 and various issues. U.S. Government Printing Office, Washington, D.C.

Wharton Applied Research Center. 1980. A Study of the U.S. Tobacco Industry's Economic Contribution to the Nation, Its Fifty States, and the District of Columbia, 1979. University of Pennsylvania, The Wharton School, Philadelphia, Pennsylvania.

Wohlgenant, M. K. 1982. The retail farm price ratio in a competitive food industry with several marketing inputs. Faculty Working Paper No. 12, Department of Economics and Business, North Carolina State University, Raleigh, N.C.

Appendix A. Mathematical Derivations

To determine the effects of an increase in the federal excise tax on cigarettes, equations (1) - (11) are totally differentiated (holding the exogenous variables Z_d, Z_e, P_{ti}, P_ℓ, Z_{te}, and Z_t constant), and converted to relative changes to yield:

(A1) $$EQ_{cd} = - \eta_{cd} EP_{cd}$$

(A2) $$EQ_{ce} = - \eta_{ce} EP_{ce}$$

(A3) $$EQ_c = \beta_{cd} EQ_{cd} + (1-\beta_{cd}) EQ_{ce}$$

(A4) $$EP_{cd} = \alpha_{td} EP_{td} + \alpha_T ET$$

(A5) $$[1/(1-\alpha_t)](EP_{cd} - \alpha_t ET)$$

(A6) $$EQ_{td} = -\alpha_{td} \sigma_{dd} EP_{td} + EQ_c$$

(A7) $$EQ_{ti} = \alpha_{td} \sigma_{id} EP_{td} + EQ_c$$

(A8) $$EQ_\ell = \alpha_{td} \sigma_{ld} EP_{td} + EQ_c$$

(A9) $$EQ_{te} = - \eta_{te} EP_{td}$$

(A10) $$EQ_t = \beta_{td} EQ_{td} + (1-\beta_{td}) EQ_{te}$$

(A11) $$EQ_t = \varepsilon EP_{td}.$$

E(x) indicates the d(x)/x operator so these equations (A1) - (A11) describe equilibrium displacements of prices and quantities in response to a change in the federal excise tax rate on cigarettes, all in the neighborhood of the equilibrium point. We assume that the scale elasticities of the input demand functions, (A6) - (A8), are unity. This follows from the condition that, in the neighborhood of the equilibrium point with competitive conditions and input prices held constant, proportionate changes in output bring about proportionate changes in input usage.

Incidence of Tax on P_{td}, P_{cd}, and P_{ce}

The effects of the tax change on prices and quantities can be determined directly by solving equations (A1) - (A11) with matrix inversion methods, or equivalently, through a sequence of substitutions. The latter approach is taken here to emphasize the economic reasoning behind the derived elasticities. We first solve for relative changes in total cigarette production (EQ_c) as a function of changes in the domestic tobacco price (EP_{td}) and changes in the tax rate (ET). This is obtained by substituting (A4) and (A5) into (A1) and (A2), and these results into (A3):

$$(A12) \qquad EQ_c = -\{\beta_{cd}\eta_{cd} + (1-\beta_{cd})[1/(1-\alpha_T)]\eta_{ce}\}\alpha_{td}EP_{td} - \beta_{cd}\eta_{cd}\alpha_T ET .$$

This output change is then substituted into equation (A6) to obtain an expression for relative changes in derived demand for tobacco by U.S. manufacturers.

$$(A13) \qquad EQ_{td} = -\lambda_{dd}EP_{td} - \beta_{cd}\eta_{cd}\alpha_T ET \text{ where}$$

$$(A14) \qquad \lambda_{dd} = \{\sigma_{dd} + \beta_{cd}\eta_{cd} + (1-\beta_{cd})[1/(1-\alpha_T)]\eta_{ce}\}\alpha_{td}$$

is the absolute value of the derived demand elasticity for domestic tobacco by U.S. manufacturers.

Next, substitute (A13) and (A9) into (A10) to get the change in total derived demand for tobacco implied by the tax change:

$$(A15) \qquad EQ_t = -\lambda EP_{td} - \beta_{td}\beta_{cd}\eta_{cd}\alpha_T ET, \text{ where}$$

$$(A16) \qquad \lambda = \beta_{td}\lambda_{dd} + (1-\beta_{td})\eta_{te}$$

is the absolute value of the total derived demand elasticity for tobacco, i.e., a weighted average of derived demand for tobacco by U.S. manufacturers and derived demand for tobacco by foreign countries.

Finally, equating (A15) with (A11) and solving for EP_{td} we get

$$(A17) \qquad EP_{td} = -\phi ET, \text{ where}$$

$$(A18) \qquad \phi = \beta_{td}\beta_{cd}\eta_{cd}\alpha_T/(\lambda+\varepsilon).$$

The parameter, $-\phi$, is the total elasticity of the domestic price of tobacco with respect to a one percent change in the tax rate.

Substituting (A17) into (A4) and (A5) then gives the relative changes in domestic and foreign cigarette prices from the change in the tax rate:

(A19) $$EP_{cd} = (\alpha_T - \alpha_{td}\phi)ET \text{ and}$$

(A20) $$EP_{ce} = -[1/(1-\alpha_T)]\phi\alpha_{td}ET.$$

Incidence of Tax on Q_{cd}, Q_{ce}, Q_{td}, Q_{ti}, Q_{ℓ}, and Q_{te}

To find the effect of the tax increase in quantities of cigarettes sold, substitute (A19) and (A20) into (A1) and (A2):

(A21) $$EQ_{cd} = -\eta_{cd}(\alpha_T - \alpha_{td}\phi)ET \text{ and}$$

(A22) $$EQ_{ce} = +\eta_{ce}[1/(1-\alpha_T)]\alpha_{td}\phi ET.$$

The effects of the tax increase in Q_{td}, Q_{ti}, Q_{ℓ}, and Q_{te} are found by substituting (A12) into (A6) - (A9) and (A17) into these results to obtain:

(A23) $$EQ_{td} = -(\beta_{cd}\eta_{cd}\alpha_T - \lambda_{dd}\phi)ET,$$

(A24) $$EQ_{ti} = -(\lambda_{id}\phi + \beta_{cd}\eta_{cd}\alpha_T)ET,$$

(A25) $$EQ_{\ell} = -(\lambda_{\ell d}\phi + \beta_{cd}\eta_{cd}\alpha_T)ET,$$

(A26) $$EQ_{te} = \eta_{te}\phi ET,$$

where the cross-price derived demand elasticities of Q_{ti} with respect to P_{td} and Q_{ℓ} with respect to P_{td} are defined by

(A27) $$\lambda_{id} = \{\sigma_{id} - \beta_{cd}\eta_{cd} - (1-\beta_{cd})[1/(1-\alpha_T)]\eta_{ce}\}\alpha_{td},$$

(A28) $$\lambda_{\ell d} = \{\sigma_{\ell d} - \beta_{cd}\eta_{cd} - (1-\beta_{cd})[1/(1-\alpha_T)]\eta_{ce}\}\alpha_{td}.$$

Effect of Tax on Total Revenue and Producer's Surplus of Tobacco Growers

The effect of the tax increase on total revenue (TR) of U.S. tobacco growers is calculated as

(A29) $$ETR = -(1+\varepsilon)\phi ET,$$

since $ETR = EQ_t + EP_{td}$, $EQ_t = \varepsilon EP_{td}$ from (A11), and $EP_{td} = -\phi ET$ from (A17).

Let p_{td}^1, Q_t^1 be price and quantity before the tax increase and p_{td}^2, Q_t^2 be price and quantity after the tax increase. Then the change in producer's surplus (PS) is

$$\Delta PS = p_{td}^2 Q_t^2 - p_{td}^1 Q_t^1 = \int_{Q_t^1}^{Q_t^2} f_t^{-1}(Q_t) dQ_t,$$

where $f_t^{-1}(\cdot)$ is the inverse supply function in (11). Assuming this supply function has the constant elasticity form, $Q_t = AP_{td}^{\epsilon}$, the change in producer's surplus can be calculated simply as

$$\Delta PS = (p_{td}^2 Q_t^2 - p_{td}^1 Q_t^1)/(1+\epsilon),$$

or expressed relative to total revenue,

(A30)
$$\Delta PS/TR = \Delta TR/TR(1+\epsilon)$$
$$\simeq - \phi ET,$$

upon substituting from (A29).

Appendix B. Data and Estimates Used in the Calculations

This appendix discusses the data, previous estimates and reasoning that led to the shares and other parameter values listed in Table 3 and used in the application reported in Section V of this report.

The Demand for Cigarettes from U.S. Manufacturers

Of the total output of about 700 billion cigarettes by U.S. manufacturers about 87 percent is sold in the domestic federally taxed market, 9 percent is sold to foreign buyers, and the other 4 percent is sold as tax exempt sales to overseas forces, etc. The wholesale list price of cigarettes was raised in August 1982 to about $22.70 per thousand for standard and filter-tip cigarettes and $23.70 for longer 100mm cigarettes which now make up approximately 30 percent of the domestic market. These prices included the federal tax of $4.00 per thousand (eight cents per pack of twenty). We take the price of exported cigarettes to be equal to the domestic wholesale price net of the federal tax. Recent data on numbers and value of exports indicate that this was approximately true. [USDA "Tobacco Outlook and Situation," various issues].

Two cigarette demand elasticities are used in the model. For exported and other tax exempt cigarettes, we use a price elasticity of -3.0. This reflects the small share of U.S. produced cigarettes in the world market and substitutability with brands produced elsewhere. The domestic elasticity of demand for cigarettes has been estimated from time-series and cross-section studies with a variety of data. Sumner 1982 estimates retail elasticities in the range of -0.5 to -0.6. Recently, Lewit, Coate and Grossman [1981] reported an elasticity of -0.42 using cross-section survey data at the retail level. They argue that most of this price effect comes from the decision to smoke by younger persons. Other estimates are in the range -0.40 to -0.80 at the retail level with various potential biases [see Pugh, 1978, for a list of studies]. We will use an estimate of -0.30 for our wholesale price elasticity since wholesale

rices are about 60 percent of retail, and at the retail level we use -0.50. These elasticities apply to the expected changes in cigarette consumption after any short-term movements in producer or consumer inventories have worked through the system.

Cost Shares for Domestic Cigarettes

Cost share estimates are for data at the wholesale level. The federal tax at the end of 1982 is approximately 18 percent of the total input value at the wholesale level. Beginning in 1983 this will rise to about 30 percent. The proportion of domestic flue-cured tobacco used in U.S. cigarettes has fallen substantially over the last 30 years and recently made up only about 35 percent of the tobacco used. The burley percentage has remained stable while the share of imported tobacco has risen to approximately 30 percent of all tobacco by weight. However, imported tobacco is cheaper so its share in value terms is lower. Total domestic tobacco is about 15 percent of wholesale costs while imported tobacco is about another 5 percent of these costs. This leaves all other inputs a share of about 50 percent after the tax increase. All these figures are approximate but changing them by a few percentage points in either direction would not change our quantitative conclusions to a significant degree. It should be noted that we do not directly observe transacted prices so list prices are used as a basis in these cost estimates.

Elasticities of Substitution

In order to develop derived demand elasticities for the various inputs in cigarette production, we need estimates of the substitutability among these inputs. Only indirect evidence of such substitution possibilities is available so we consider a range for these parameters. One case is that there are no possibilities for substitution between inputs, i.e., all partial elasticities of substitution are zero.

Our second alternative is to assume positive but limited substitution possibilities among each of the three input categories. We take the value of $\sigma_{ij} = 0.5$ for each input pair to reflect this case.

An extension of the current model and data analysis might include further disaggregation of the inputs used in the cigarette industry

allowing for differences in supply elasticities and elasticities of substitution among inputs.

Demand for Tobacco

The derived demand for domestic tobacco from U.S. cigarette producers depends on the cigarette demand, the shares and substitution possibilities discussed earlier. This leaves the demand for exports to be considered here. A broad range of export demand elasticities has been suggested in the literature. Norton [1981], using time series data for the years 1955 through 1979, estimates an elasticity of demand for U.S. exports of tobacco of -2.2. Seagraves [1983] notes that the U.S. share in total flue-cured tobacco trade and production has fallen dramatically in the last thirty years. Using assumptions about demand and supply elasticities for the rest of the world he estimates elasticities of demand for net exports (exports minus imports) in the range of -10 to -20. The U.S. now has somewhat less than 30 percent of the world exports of burley and the flue-cured tobacco, down from about 60 percent twenty-five years ago. In our calculation we use elasticities of demand for gross exports of -2.0 and -10.0 to cover the range of estimates discussed. The export share of domestic tobacco production is another ingredient in the overall demand elasticity. About 50 percent of the flue-cured crop and 25 percent of the burley crop have been exported. This amounts to some 40 percent of domestic tobacco production that is exported.

Domestic Supply of Tobacco

The domestic supply of tobacco depends crucially on provisions of the federal tobacco program which have been recently changed and are clearly uncertain in the future. Holding the support prices constant (in real terms) implies an infinite supply elasticity. Holding the quantity of quota fixed implies a zero supply elasticity over the range of demand shifts considered here. The cigarette tax effects are not large enough to drive quota lease rates to zero. To represent the intermediate case we consider a domestic tobacco supply elasticity of 1.0.

Agricultural Research Service
North Carolina State University
at Raleigh

D. F. Bateman, Director of Research