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THE INTERACTION OF AGRICULTURAL POLICIES AND HEALTH REGULATION: THE CASE OF TOBACCO

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Abstract

Key Words:

David Zilberman is professor of agricultural and resource economics at the University of California at Berkeley and Richard E. Just is professor and Erik Lichtenberg is assistant professor of agricultural economics at the University of Maryland.

THE INTERACTION OF AGRICULTURAL POLICIES AND HEALTH REGULATION: THE CASE OF TOBACCO

There has been a growing awareness of the interdependency between agricultural and environmental health regulations and the need to coordinate and develop consistency between environmental and commercial policies concerning agricultural inputs (water, land, and pesticides) and their relationship to commercial policies. Land management and retirement programs, in particular, were designed to meet both environmental and commercial objectives.

Inputs are not the only sources of environmental and health concerns in agriculture. Some agricultural products generate substantial negative externalities which are subject to much concern and regulations. Tobacco is an obvious example; but excessive consumption of agricultural and food products such as wine and beer, sugar, beef, and animal fats may also result in substantial health problems. The environmental and health externalities associated with such agricultural products have not been given much weight in evaluating policies to regulate the marketing of these products. Similarly, regulation of the external effects has paid little attention to the realities of the agricultural markets that produced the externalities in the first place.

This paper will introduce a simple framework to link commercial and environmental health policies affecting an agricultural product which generates consumption externalities. This framework will be used to assess regulations on tobacco and cigarettes and will consider some health costs and benefits associated with commercial policies regulating other products.

I. Conceptual Framework

The conceptual analysis, as well as some of the empirical results of this paper, will analyze the economics of one product—tobacco—which is assumed to be produced by a competitive industry, consumed by domestic consumers, exported, and a source of utility as well as a cause of negative externalities. Obviously, this analysis simplifies many of the multimarket aspects associated with the move up the product chain from tobacco to cigarettes and other tobacco products. Moreover, realistic policy mixtures are likely to regulate simultaneously different markets (as in the case of the

tobacco program and cigarette excise taxes). Nevertheless, one product analysis is useful to an initial understanding of key issues and we will modify some of the results to accommodate multiproduct aspects of the tobacco problem.

First, let us consider a basic partial equilibrium model of output determination. The product demand curve is DD, a marginal cost-supply curve is SS, and a marginal externality cost curve is ME (figure 1). The nonregulated free market will result in an equilibrium output price combination (Q_0, P_0) associated with point A. Subtracting the marginal externality cost from demand will result in the net demand curve, ND. The social optimum is at point C, with output Q_1 and consumer price P_1^S . An antipollution tax of BC is one policy that will attain this optimum. In this case producer price will be V_1, with the area $P_1P_1^S CB$ denoting tax revenue. A standard limiting output to the level Q_1 is another policy that yields optimal resource allocation. It results in consumer and producer prices of P_1; and the area, $P_1P_1^S CB$, under the tax that went to the government is now available to the producers. Of course, implementation of a direct regulation that leads to output level of Q_1 is not simple. One possibility is the introduction of production quotas or licenses. When these quotas are transferable, the quota rent will be equal to $P_1 - P_1^S$.

Both the tax and the standard yield the optimal resource allocation but have different distributional outcomes. These are infinite policy combinations which include an output standard of Q_1 and a tax between zero to $P_1 - P_1^S$ that can attain optimal resource allocation. These policies differ in their distributional implications. Buchanan and Tullock argue that the prevalence of standards (without any taxes) is because this policy is most favored by producers who have much to say (they may "capture" the regulators) about the policies to which they are subjected.

On the surface, it seems that this framework is useful for explaining the regulation of tobacco and cigarettes since current policies restrict the output of tobacco and tobacco products are taxed. However, international trade plays a major role in the tobacco market as well as in the economics of many agricultural products. Thus, the standard partial equilibrium model has to be modified to incorporate international trade considerations.

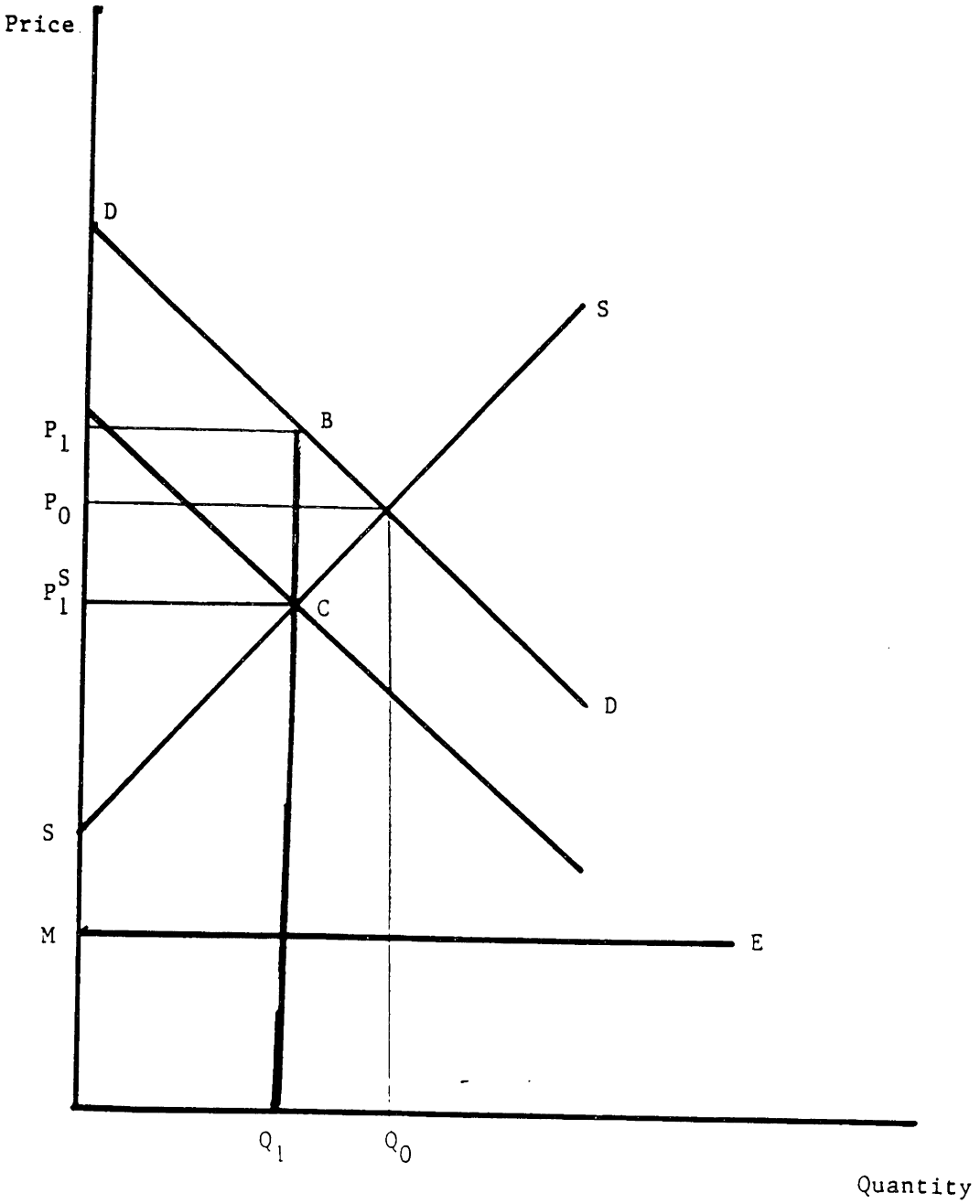

Figure 1. Competitive and Optimal Resource Allocation with Externality-Closed Economy

Since the United States is a net exporter of tobacco, we will analyze the economics of an exported product (figures 2a and 2b). The curve EX (in figure 2a) denotes the excess export demand for the product, and MX denotes the associated marginal revenue curve. As in figure 1, the curve DD denotes domestic demand, the curve SS denotes supply, and the curve ND denotes net domestic demand. Under free trade and no intervention, total output will be denoted by Q_0; output price, P_0; domestic consumption, Y_0; and export, X_0. An optimal policy which preserves free trade while taking into account externality damage in the domestic market will reduce production to Q_1 and domestic production to Y_1 and increase export to X_1. Consumer price will be P_1; if externality control is through a tax of $P_1 - P_1^S$, producer price will be P_1^S. An alternative control will be to restrict domestic consumption to Y_1 and, if it is introduced without a producer tax, price will be P_1. Note that, when the product involved is exported, restricting total production to Q_1 will not yield the optimal resource allocation. Restriction of total output, not accompanied with taxation or control of domestic consumption, will result in "too much" domestic consumption and "too little" export compared to Y_1 and X_1. When the externality causing output is an export product, domestic consumption quota and not production quota can replace tax in attaining the optimal externality level. Since consumption quota is more difficult to implement than production quota, the use of taxes for externality control seems more likely in the case of an exported good.

When export demand is inelastic, the exporting country is tempted to develop trade policy that takes advantage of this situation. Let $TW(Y)$ be a monetary measure of welfare derived domestically from consumption. In essence, $TW(Y)$ is the area under the demand curve and is the sum of consumer surplus and expenditure on the product. The first derivative of $TW(Y)$, $P^D(Y) = \partial TW/\partial Y$ is the inverse demand function denoting domestic consumer price as a function of domestic consumption. Let $R(X) = P^X(X) \cdot X$ denote net export revenue and $P^X(X)$ is the increase of export excess demand for the production. The cost function is $C(Q) = C(X + Y)$, and its derivative $MC(Q) = (\partial C/Q)/\partial Q$ is the marginal cost curve which also serves as the supply curve of the competitive industry. Let domestic externality cost be denoted by $E(Y)$, and the

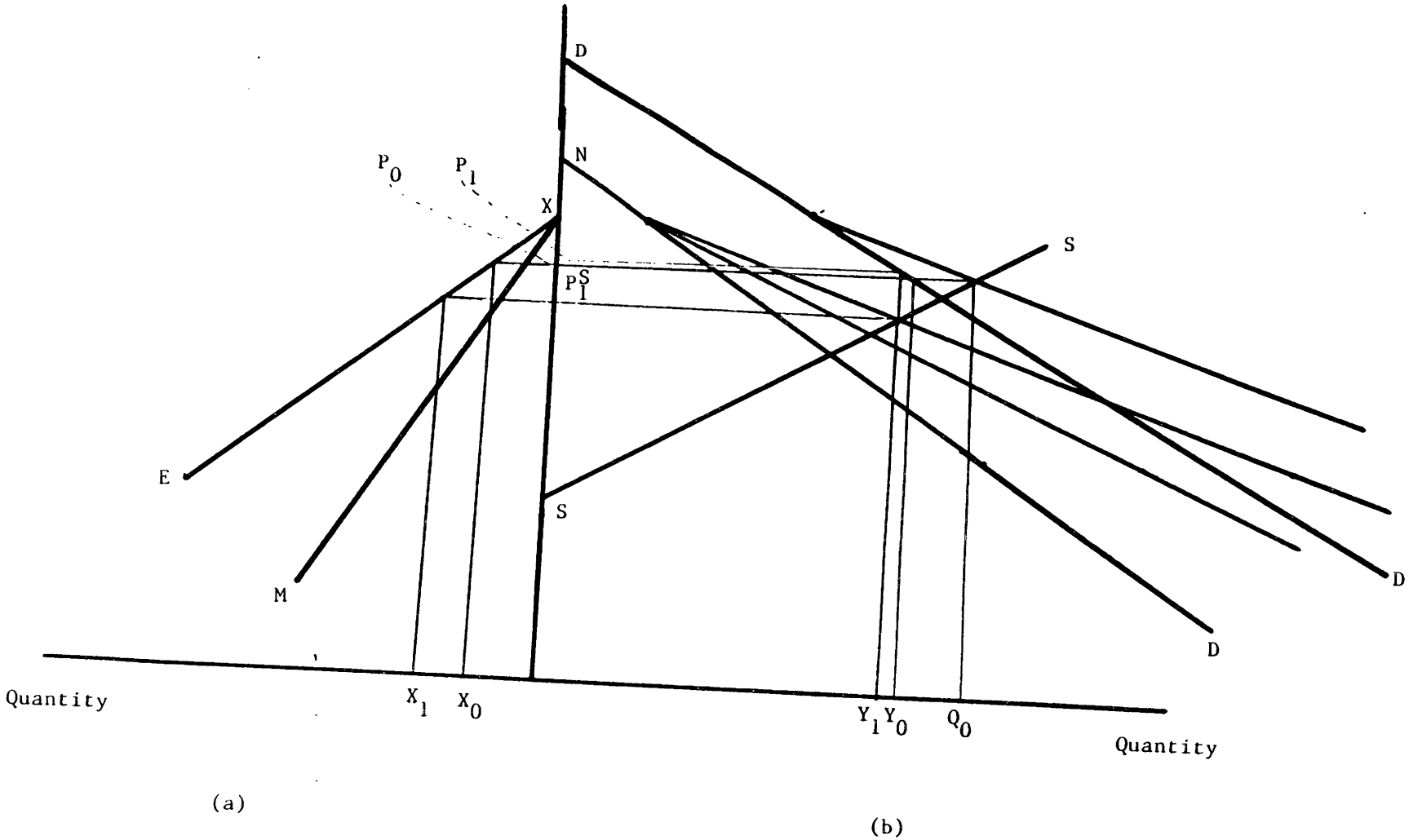

Figure 2. Free-Trade Equilibrium With and Without Externality Control

resulting marginal externality curve is ME. When externalities are ignored, the welfare optimization problem is

$$\max_{Y,X} TW(Y) + R(X) - C(X + Y) \tag{1}$$

and the optimal allocation rules are

$$P^D(Y) = MC(Q)$$

$$MR(X) = MC(Q).$$

This outcome is depicted in figure 3a and 3b. Using the same notation as in figure 2a and 2b and adding the marginal export revenue curve to the domestic demand curve yields the kinked curve DAC'. Its intersection with the supply curve yields total output, Q_2, which results in export and domestic consumption levels of X_2 and Y_2, respectively. In this case domestic price is P_2^D and export price is $P_2^X > P_2^D$. To implement this policy, we have an export tax of $P_2^X - P_2^D$. If implemented, domestic consumption will be Y_2 and export, X_2.

When externality costs are ignored and the supposed optimal export tax is introduced, domestic consumption is greater than under free trade ($Y_2 > Y_1$) and export is smaller. The supposed welfare gain can be decomposed to a reduction in overall cost, an increase in private consumer surplus, and an increase in export revenues. If one incorporates the domestic externality cost into this welfare calculus, it may be found that the free-market solution is superior to an export tax solution since the increase in domestic consumption from Y_2 to Y_1 entails an extra externality cost that may be bigger than the private welfare gain associated with the introduction of the tax.

The use of an export tax is disallowed by the U. S. Constitution and, besides, it is a flagrant violation of the "free-trade" policies the United States is trying to promote and doing this might invite retaliation. A production-control regulation limiting overall output produced does not

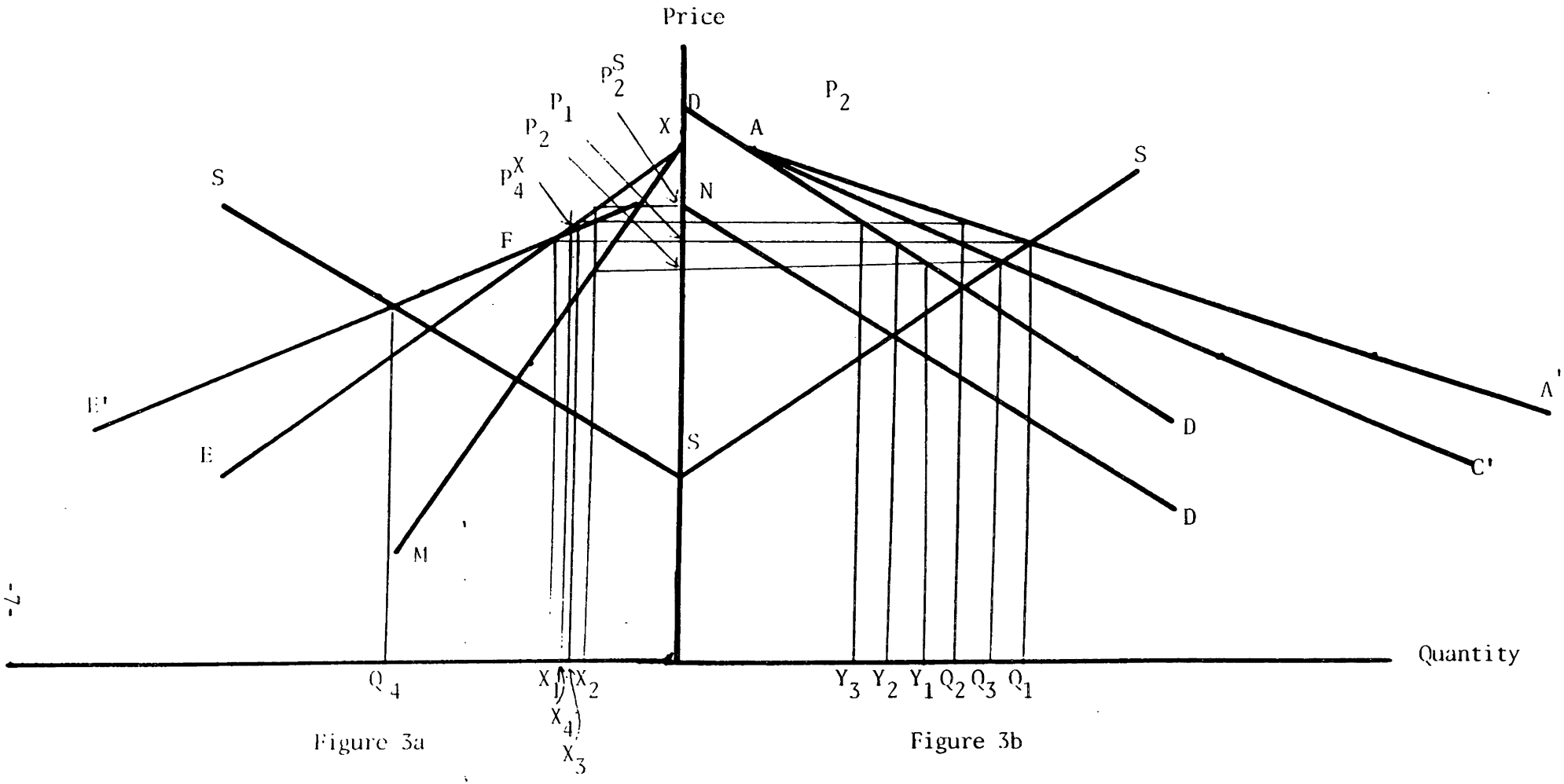

Figure 3a

Figure 3b

Figure 3. Alternative Equilibrium Solutions

yield the "optimal" resource allocation attainable by an export tax, but it seems quite benign to foreigners and can improve the welfare of the exporting country relative to free trade. Sumner and Alston argue convincingly that this logic is behind the establishment of the tobacco production quota in the United States and, therefore, the impacts of such quotas will be analyzed here.

Again, consider the case when externalities are ignored. The government will establish production quotas to maximize the sum of private domestic consumers' surplus and producers' surplus when prices to domestic and foreign consumers are constrained to be equal. Thus, the optimization problem leading to the quota is

$$\max_{X,Y} TW\ (Y) + R(X) - C(X + Y) \tag{2}$$

subject to

$$P^D(Y) - P^X(X) = 0.$$

Let X be the shadow of the free-trade constraint and, by using it, the optimality conditions become

$$P^D(Y) = MC - \lambda \frac{\partial P^D}{\partial Y}, \tag{3}$$

$$MR(X) = P^X(X) + X \frac{\partial P^X}{\partial X} = MC + \lambda \frac{\partial P^D}{\partial X}, \tag{4}$$

and

$$P^D(Y) = P^X(X). \tag{5}$$

From these conditions, one can easily obtain

(6) $$X = \frac{X}{\left(\frac{\partial P^D / \partial Y}{\partial P^X / \partial X}\right) + 1}.$$

This condition suggests that the $\lambda > 0$, and therefore supply price *(MC)* is smaller than domestic consumer and foreign consumer prices but bigger than the marginal revenue of the export.

$$MR(X) < MC < P^X(X) = P^D(Y).$$

Therefore, the production quota (denoted by Q_3) in figure 3a and 3b is between the free-trade production level, Q_1, and the export-tax production level, $Q_2 < Q_3 < Q_1$. The consumer and export price associated with Q_3 is obtained from the aggregate demand curve *DAD'* and is denoted by P^3. This price is bigger than the free-market price and domestic price in the case of export tax, and thus domestic consumption under the quota Y_3 is smaller than both free-trade and export-tax output. More specifically, $Y_3 < Y_1 < Y_2$.

When one introduces externalities to the analysis, the lower domestic output associated with the production quota makes it look even more favorable. The lower domestic output it entails increases the edge this policy has over free trade and, if the externality costs are substantial, the quota policy becomes more desirable from the perspective of the exporting country than the export tax of $P_2^X - P_2^D$.

Now let us consider the externality in the selection of the optimal policy. The social optimization problem becomes

(7) $$\max_{X,Y} TC(Y) - E(Y) + R(X) - C(X, Y).$$

The equilibrium conditions for this case are

(8) $$P^D(Y) - ME = MC$$

and

$$MR(X) = P^X(X) + X\,\frac{\partial P^X}{\partial X} = MC\ . \tag{9}$$

At the first-best solution from the perspective of the exporting country, resources are allocated such that private marginal benefit from domestic consumption equals the sum of marginal production cost and marginal externality cost and marginal revenue of export equals marginal cost. One way to attain this optimal resource allocation is by simultaneous imposition of a domestic consumption tax of ME dollars and export tax of $X(\partial P^X/\partial X)$. However, when optimal domestic consumer price is bigger than the export price, the optimal solution is attainable also by a production quota and consumption tax combination. Figure 3a illustrates this point when we use it to obtain the equilibrium. To this end, we will add net domestic demand to the marginal export curve to form the curve XEE'. Total production in this case is Q_4, and domestic consumption and export are denoted by Y_4 and X_4. Domestic consumer price in this case will be P_4^D and export price, P_4^X. One possible policy combination to attain this outcome is through a domestic consumption tax of $P_4^D - P_4^S$ and an export tax of $P_4^X - P_4^S$. In this case, producer price is P_4^S. An alternative mechanism is through a production quota of Q_4 and a domestic consumption tax of $P_4^D - P_4^X = ME(Y) - P^X X$. $P_n - U_n = ME(Y) - P^X X$. This tax may be substantially smaller than the marginal externality cut. It gets smaller as export demand elasticity declines and optimal export increases. In the rare case when $ME(Y) = P^X X$, the production quota by itself may yield the optimal outcomes from the domestic exporter perspective without any taxes.

The second policy mixture, a production quota and a tax, improves producers' welfare substantially relative to the two tax regimes since their producer price will be P_4^X and producers will obtain quasi-rent of $P_4^X - P_4^S$. Thus, the argument of Buchanan and Tullock can be extended to this case, and it suggests that a mixture of a production quota and consumption tax is more likely to be introduced because of producers' support.

Returning to the tobacco issues, the above results imply the need for coordination in shaping policies that will maximize U. S. welfare, taking into account trade and environmental considerations. In particular, we found that a combination of tobacco taxation (maybe through the taxation of the tobacco content of cigarettes) and tobacco programs are tools that can be combined to attain the best policy from domestic perspective. However, the two policy parameters cannot be established separately but interdependently.

As we will argue later, it seems that currently there is separation between commercial tobacco policies that address trade and other commercial issues and cigarette policies that raise revenue (by taxes) and address health issues by education and control of advertisements. Overall, we may be far away from social optimum. Yet, the existing production quotas (which, according to Alston and Sumner, are aimed to maximize domestic surplus and result in equilibrium quantities Q_4, X_4, and Y_4) are superior to free trade because of the consumption reduction entailed and are likely to be superior to an export tax because of public-health consideration (production quotas result in lower domestic consumption than free trade). Better assessment of these policies requires more empirical discussion of tobacco and cigarette markets and health effects of smoking.

II. The Economic Literatures on Cigarettes and Tobacco: Empirical Estimates and Results

The previous theoretical discussion suggests that effective social policy on tobacco and cigarettes has to incorporate production, trade, and health considerations. It seems that, up to now, policies and decision-making procedures have been developed independently, each policy or procedure specializing in its specific aspect. This is not surprising if one realizes that even economic research that is supposed to lead to new policy ideas has been compartmentalized to several bodies of literature which grow independently without much acknowledgment or interaction with each other.

We can identify two main bodies of literature.

1. *Traditional micro and welfare economic studies of cigarette and tobaccos, dominated by North Carolina's state economists.* This literature estimated cigarette and tobacco demand

(Wohlgenant and Sumner), the welfare aspects of the tobacco program (Alston and Sumner), and the competitiveness of the cigarette industry (Sumner). It has not addressed health or environmental problems associated with smoking.

2. *The economics of public health of smoking*. This literature is dominated by economists in schools of public health and is emphasizing (a) estimation of the social cost of smoking (see the survey by Rice *et al.*), (b) the impacts and effectiveness of antismoking measures (Warner), and (c) taxation of cigarette characteristics, in particular nicotine and tar (see Harris). This literature has paid little attention to tobacco and cigarette supply problems and no attention to tobacco programs.

We will present first some findings of the public health literature; then some of the tobacco literature; and, finally, incorporate them within our conceptual results to assess existing tobacco regulations.

A. Smoking Behavior and Its Impacts

For welfare economic analysis of smoking, we would like to know what is the cost incurred to nonsmokers (externality cost) and society as a whole from smoking and how these costs change with smoking levels (measured by cigarette or tobacco consumption). The costs of smoking can be decomposed to several elements. They include health care and property losses due to fires; damages to property due to insidious odors; and most important, the smoking-related health costs. While fire and property costs are coincidental in time with the consumption of tobacco, smoking-related diseases result from cumulative exposure over years. Thus, estimation of smoking-related disease costs requires dynamic analysis. The appropriate measure of disease costs associated with increased consumption of tobacco in the present is the sum of discounted extra disease costs that are likely to be incurred in the present and future periods.

The literature on the economics of smoking has not emphasized obtaining the exact relationship desired for marginal welfare analysis of smoking regulation. Most studies have emphasized the current health costs of smoking and costs that are the results of past behavior rather

than predicting present and future costs patterns. Moreover, there is not much quantitative information relating health damage to the extent of smoking. Still, the literature does provide sufficient information to assess the order of magnitude of policy regulation and provides a decent base for quantitative policy analysis.

According to a recent report of the Surgeon General, in 1985 the total smoking-attributable mortality was about 390,000 individuals. That year, smoking accounted for 87% of lung cancer deaths, 21% of coronary heart deaths, and 82% of chronic obstructive pulmonary disease (emphysema and chronic bronchitis). There have been substantial increases in morbidity rates because of smoking. Annually, there are approximately 80 million person-days of time lost at work and 150 million person-days of bed disability (Warner). Smoking is also the cause of interrupted pregnancies and increased infant mortality.

Most studies converting the health cost into monetary terms consider only the impacts of smoking on cancer, cardiac diseases, and respiratory diseases. Two types of costs are enumerated—direct costs of medical treatment and indirect costs (costs associated with loss of productivity).

Table 1, based on a 1985 staff memo of the Office of Technology Assessment of the U. S. Congress, has a decomposition of estimates of such costs for that year. The survey by Rice *et al.* demonstrates that several studies of the health costs of smoking for the early 1980s have obtained very close estimates. Studies may differ in attribution between direct and indirect costs categories, but it seems that mean-value estimates of total costs are between $60 billion and $65 billion annually.

While these costs are very substantial, they do not capture the overall cost of smoking. They do not include the cost (other than loss of productivity) of loss or pain associated with mortality and morbidity caused by smoking; they ignore relocation, transportation costs, and time loss by relatives and friends because of cigarette-induced illnesses. These last costs are found to be quite substantial (Rice *et al.*). The social costs of smoking should also include the costs of

Table 1. Smoking-Related Health Cost

Disease	Direct medical health care cost			Production losses			Sum total all ages
				Total			
	under 65	65 & over	all ages	under 65	65 & over	all ages	
	millions of dollars						
Cancers							
Low estimate	2,900	1,600	4,400	11,500	900	12,400	16,800
Middle estimate	4,400	2,500	6,900	17,500	1,400	18,900	25,800
High estimate	5,500	3,100	8,700	22,000	1,700	23,800	32,500
Circulatory system diseases							
Low estimate	3,100	600	3,700	9,800	200	10,000	13,700
Middle estimate	5,800	2,200	8,000	16,600	800	17,400	25,600
High estimate	8,700	3,800	12,500	24,100	1,400	25,400	37,900
Respiratory system diseases							
Low estimate	2,500	800	3,400	4,100	500	4,600	8,000
Middle estimate	5,000	1,600	6,700	6,400	700	7,100	13,800
High estimate	10,000	3,300	13,400	10,300	1,000	11,300	25,700
Total—three disease groups							
Low estimate	8,500	3,000	11,500	25,300	1,600	26,900	38,400
Middle estimate	15,200	6,400	21,600	40,500	2,900	43,400	65,000
High estimate	24,300	10,200	34,500	56,400	4,100	60,500	95,000

smoking-induced fires [between $.5 billion to $1 billion annually (Warner)] and damages to property from cigarette fumes.

The social costs of tobacco smoking are obviously substantial but, as long as they are borne by smokers, there does not seem to be a reason for government intervention. Therefore, allocation of costs between smokers and nonsmokers is of value. Warner estimated that in 1980 37.5% of the tobacco health costs were borne by smokers and 62.5% by nonsmokers. Using the OTA 1985 middle estimate of about $65 billion for tobacco-induced health costs for 1985, the nonsmoker share is about $40 billion.

Warner attempted to estimate the distribution of smoking-related cost and benefits among groups in the 1980s. Using a simple linear-demand curve, he estimated annual consumer surplus of smokers to be about $30 billion, their health cost to be $15 billion, and their annual net gain from smoking to be $15 billion. Nonsmokers' loss was estimated to be $25 billion and producers' surplus, $8.5 million. He concluded that, while some groups win from smoking and others lose, overall society does not gain from smoking and may actually lose. Warner's results may actually overestimate the social gain from smoking. Its consumer surplus analysis ignored the fact that smoking has an element of addiction (Surgeon General report) and that smoking demand may not represent free choice. Secondly, some of the producers' surplus is a result from export rather than domestic sales. Thus, one can interpret Warner's welfare results as indicating that, while revenue and profit from tobacco and cigarette exports are positive contributors to the United States welfare, the overall welfare impacts resulting from the present levels of domestic consumption of tobacco products are likely to be negative. This does not imply that optimal level of domestic consumption is zero and tobacco should be produced only for export. Some positive levels of domestic consumption may be optimal, but it is likely to be substantially smaller than present consumption and should be obtained by government intervention.

The size of the estimated total externality cost is another indicator that domestic consumption of cigarettes is excessive. While we are not aware of a reliable estimate of marginal externality costs of smoking at the aggregate, there are reliable estimates of the impacts of smoking

on the extent and duration of health-risk costs of individuals. The tables in Oster, Colditz, and Kelley indicate that, for individuals, the marginal health costs of smoking seem to increase with cigarette and tobacco intake. It is not trivial to infer from this microlevel evidence that the economywide marginal health costs of smoking are increasing, but this is a reasonable assumption. According to the U. S. Department of Agriculture statistics, about 600 billion cigarettes were consumed in 1985 and, using $40 billion as an estimate of total health externality costs, a reasonable estimate of average externality costs of smoking for 1985 is $1.33 per pack of cigarettes. Marginal costs are likely to be higher if we have increasing marginal health costs of smoking. Since the retail price of a cigarette pack was less than $1.00 per pack (Warner), there is obviously an excess generation of an externality, namely, smoking, which calls for intervention.

There has been a wide array of public health policies aimed to reduce exposure to the health risk of smoking, mostly through education and behavioral restrictions. These policies include restriction of cigarette advertisements, introduction of warning labels, prohibition of sales of cigarettes to minors, restriction of smoking in public places, and educational campaigns. There is sufficient evidence that these efforts have been effective in reducing the demand for cigarettes and exposure to smoking risks. According to the 1988 Surgeon General report, between 1967 and 1987, the prevalence of cigarette smoking has declined substantially among men (from 50 to 31 % for men 20 years of age or older), slightly among women, and hardly at all among those without a high school diploma (U.S Department of Health and Human Services 1988). Between 1967 and 1987, annual per capita consumption of cigarettes among adults has declined by 26% and the quit ratio has doubled. Moreover, the market share of filtered cigarettes has increased from 1% in 1952 to 94% in 1986, and the market share of low tar cigarettes has increased from 2% in 1967 to 86% in 1987. These reductions in exposure have had substantial health impacts. The Surgeon General reports that, as a result of the antismoking campaign, an estimated 789,000 deaths were postponed during the period 1964 through 1985, 112,000 in 1985 alone, and the average life expectancy gained per postponed deaths was 21 years. Warner evaluated the economic impacts of the

antismoking campaign between 1964-1978, and estimated its net health benefits to be between $5 billion to $20 billion (1980). The costs of these programs were below $3.5 billion (1980).

A complete framework for regulating all aspects of production and use of tobacco should determine antismoking campaign and regulation levels and cigarette and tobacco taxes and quotas simultaneously. Lichtenberg and Zilberman's recent model, which incorporates health-risk generation equations into a welfare-economic framework can be applied to this end. For simplicity, the educational and exposure-regulating activities, and the demands they affect, are taken here as given and a more traditional welfare framework is used.

B. Economic Controls of Cigarettes and Smoking

State and federal excise taxes on cigarettes have been in existence for a long time. They were introduced mostly as a means for raising government revenues, and only recently their values as tools to combat smoking externalities have been recognized (Sumner and Wohlgenant, Warner). The current excise tax on cigarettes is 16 cents per pack; in 1987 the state excise tax on cigarettes varied from 2.0 cents per pack (in tobacco-producing states of the southeast) to 38.0 cents per pack. Differences in excise tax rates between states (Massachusettes, New Hampshire, Washington, and Oregon) have resulted in substantial illegal diversion and organized smuggling activities [see 1989 Surgeon General Report (U.S. Department of Health and Human Services 1989) and economic analyses by Sumner and Warner]. The increase of the Federal Excise Tax rate on cigarettes in 1983 has been a source of much controversy and has resulted in some interesting economic analyses. Much of these estimates are based on the cigarette demand elasticities derived by Lewit and by others and presented in the 1989 Surgeon General's Report. These studies estimated that the cigarette demand elasticity declines with age. It is -1.40 for children of 12 to 17 years of age, -.42 for all adults, and -.47 overall. Based on these estimates, Warner estimated that an 8-cent increase in tax will reduce total consumption of cigarettes by 3.3% for adults and by 11.1% for teenagers between the ages of 12 and 17 (Warner).

Apparently, the federal cigarette tax increase triggered state tax increases and manufacturing and retail price increases[1] that raised the real retail price of cigaretttes between 1981 and 1984 by 26%, while consumption declined by 11 to 12% (U.S. Department of Health and Human Services 1989, Harris 1987). Note that these two events are predictable using a cigarette price elasticity of -.49.

Much of the analysis of the impacts of cigarette tax increases was not complete. It did not present a complete system to explain why increases in excise taxes have resulted in higher increases in prices and ignored the links between cigarettes and tobacco as well as between cigarettes/tobacco and international trade. Sumner and Wohlgenant addressed these issues; they presented a system of equations to show the impact of a 100% increase in the federal excise tax on cigarettes. Even though they assumed price-taking behavior by the manufacturer (following Sumner), their result demonstrates the tendency of cigarette prices to rise above the increases in tax. They estimated that an 8-cent-per-pack tax increase would reduce smoking by slightly over 5%. With estimated annual externality costs of $40 billion in 1985 and assuming increasing marginal externality costs, the Sumner and Wohlgenant estimates suggest that the 8-cent tax increase resulted in more than a $2 billion reduction in annual externality costs. Moreover, the 12% decrease in consumption from the total increase in the retal price between 1981 and 1984 reduced annual externality costs by close to $5 billion annually.

It seems that the experience of the tax increase in 1983 established cigarette taxation as a viable tool to reduce health problems from smoking (U.S. Department of Health and Human Services 1989). Taxation of cigarettes per se may be less effective than taxation of the substances they contain since these substances are the direct causes of detrimental health effects from smoking. Barzel argued that cigarette taxation discourages on an equal basis—smoking high-tax cigarettes or low-tax cigarettes. Using health damage functions for cigarettes, Harris (1980) developed a two-tier taxing scheme based on tar content and demonstrated empirically reasonable situations where this scheme was substantially superior to a uniform taxation scheme.

Here we will consider taxation of the tobacco content of cigarettes and other tobacco products consumed domestically. We consider such a policy since tobacco is perceived to be the health culprit in many forms of use. This approach allows us simplicity of analysis and a better focus on health implications of the tobacco control policies. We are aware of some of the drawbacks of such taxation that have to be addressed if it is ever to be implemented. For example, cigarette manufacturers may substitute tobacco with other substances that are also health hazards. Implementation of a tobacco-use taxation may be difficult and may result in complicated schemes of taxation of the final products.

III. Regulations on Tobacco and Their Impacts

Tobacco is one of the major field crops of the United States. It is grown in over 640,000 acres (1988) and generates an annual revenue of about $2.25 billion, with an annual production of between 1.2 billion and 2.0 billion tons in the 1980s. About 35% of the product is exported and 65% is used domestically (U.S. Department of Agriculture). Alston and Sumner presented a detailed and insightful analysis of the economics of the regulation of tobacco. We relied on their overview of the industry and used their data for our empirical analysis.

Using what they consider the most plausible parameter values, the domestic demand equation used here is

$$Y = 1.8 - .6P^{D},$$

the export excess demand equation in

$$X = 6 - 1.6P^{X},$$

and the supply equation is

$$Q = .96 + 6.25P^{S}.$$

The quantity here, measured in billions of pounds and price unit, is dollars per pound.

These relationships will be used for analyzing and comparing three alternative policy combinations. Each combination will include taxation of dometic use of tobacco and a trade policy.[2]

Table 2. Outcome Under Domestic Tobacco Tax and Free Trade

Tax	Domestic price	Marginal cost	Export	Domestic consumption	Total production	Consumer surplus	Tax revenue	Producer surplus	Private surplus
.00	1.28	1.28	.96	1.03	1.99	.89	.00	.32	1.21
.10	1.37	1.27	.97	.98	1.94	.80	.10	.30	1.10
.20	1.46	1.26	.98	.92	1.90	.71	.18	.29	1.00
.30	1.56	1.26	.99	.87	1.86	.62	.26	.28	.90
.40	1.65	1.25	1.00	.81	1.81	.55	.32	.26	.81
.50	1.74	1.24	1.01	.75	1.77	.47	.38	.25	.72
.60	1.84	1.24	1.02	.70	1.72	.41	.42	.24	.65
.70	1.93	1.23	1.03	.64	1.68	.34	.45	.23	.57
.80	2.02	1.22	1.05	.59	1.63	.29	.47	.21	.50
.90	2.11	1.21	1.06	.53	1.59	.24	.48	.20	.44
1.00	2.21	1.21	1.07	.48	1.54	.19	.48	.19	.38
1.10	2.30	1.20	1.08	.42	1.50	.15	.46	.18	.33
1.20	2.39	1.19	1.09	.36	1.46	.11	.44	.17	.28
1.30	2.49	1.19	1.10	.31	1.41	.08	.40	.16	.24
1.40	2.58	1.18	1.11	.25	1.37	.05	.35	.15	.20
1.50	2.67	1.17	1.13	.20	1.32	.03	.30	.14	.17
1.60	2.76	1.16	1.14	.14	1.28	.02	.23	.13	.15
1.70	2.86	1.16	1.15	.09	1.23	.01	.15	.12	.13
1.80	2.95	1.15	1.16	.03	1.19	.00	.05	.11	.11

Table 2 presents outcomes under domestic tobacco taxation and free trade. Tax levels vary from zero to $1.80 per pound. Under free trade, producer and export prices are the same ($P^S = P^X$), but domestic price is higher by the tax level T ($P^D = P^S + T$). The table presents several monetary measures of welfare in billions of dollars. Consumer surplus is net of tax revenue, or externality consideration and private surplus is the sum of domestic consumers' and producers' surpluses. Table 2 provides tobacco taxes that will constrain aggregate domestic use of tobacco in a free trade atmosphere.

Table 2 suggests that free trade without a tobacco tax will yield an annual production of about 1.99 billion pounds of tobacco; exports, .96 billion pounds; domestic consumption, 1.03 pounds; and price, $1.28 per pound. Currently, there are no tobacco taxes, but annual domestic production is about 1.5 billion pounds; domestic use, .90 billion pounds; export, .60 billion bushels; and price, $1.50 per pound. These deviations from the free-trade solutions are due to the tobacco programs that, according to Alston and Sumner, are aimed to increase domestic gains from trade in tobacco.

The tobacco industry is regulated by a policy combining production quotas and price support. The price support has not been effective in recent years (it was equal to or below market price). According to Alston and Sumner, tobacco quotas have been established to maximize domestic welfare (sum of consumer and producer welfare) given that export tax is disallowed. More specifically, they argued that the tobacco quotas can be approximated by the optimal solution to (3). Table 3 presents the optimal solution associated with such quota policy for tobacco tax, varying from zero to $170 per pound. In all cases, export price (P^E) is assumed to be equal to producer price (P^S) and domestic consumer price after tax (P^D - T) and larger than marginal cost.

The results of table 3 for the case of zero tax support the argument of Alston and Sumner. Specifically, the computed levels of domestic use, export, and price are very close to the current levels. Table 3 suggests that the production quota's quasi rent in the case with no taxes (the difference between market price and marginal cost) is .29 cents per pound and thus quota owners gain about $425 million from the quota. The combined surplus of consumers and producers

Table 3. Outcome Under Domestic Tobacco Tax and Production Quota

Tax	Export price	Domestic price	Domestic use	Export	Production	Marginal cost	Consumer surplus	Tax revenue	Producer surplus	Private surplus
.00	1.49	1.49	.91	.61	1.51	1.20	.69	.00	.62	1.31
.10	1.48	1.58	.85	.63	1.48	1.20	.65	.09	.60	1.24
.20	1.46	1.66	.80	.66	1.47	1.19	.62	.16	.56	1.18
.30	1.45	1.75	.75	.68	1.43	1.19	.58	.23	.54	1.12
.40	1.44	1.84	.70	.70	1.39	1.18	.54	.28	.51	1.06
.50	1.43	1.93	.64	.71	1.35	1.18	.50	.32	.49	.99
.60	1.42	2.02	.59	.73	1.32	1.17	.46	.35	.47	.93
.70	1.41	2.11	.53	.74	1.28	1.16	.42	.37	.44	.87
.80	1.40	2.20	.48	.76	1.24	1.16	.38	.38	.42	.81
.90	1.39	2.29	.43	.78	1.20	1.15	.34	.38	.40	.74
1.00	1.38	2.38	.37	.79	1.16	1.15	.30	.37	.38	.68
1.10	1.36	2.46	.32	.82	1.15	1.14	.27	.36	.35	.62
1.20	1.35	2.55	.27	.84	1.11	1.14	.22	.32	.33	.56
1.30	1.34	2.64	.22	.86	1.07	1.13	.18	.28	.32	.49
1.40	1.33	2.73	.16	.87	1.03	1.13	.14	.23	.30	.43
1.50	1.32	2.82	.11	.89	1.00	1.12	.09	.16	.28	.37
1.60	1.31	2.91	.05	.90	.96	1.11	.05	.09	.26	.31
1.70	1.30	3.00	.00	.92	.92	1.11	.00	.00	.25	.25

increase by $100 million, producers gain $300 million, and consumer's surplus declines by $200 million because of the introduction of the tobacco quota.

But when health and externality costs are taken into account, one realizes that the quota actually increases consumer welfare relative to free trade. Without free trade, domestic use of tobacco is expected to increase by about 13% (from .90 billion pounds to 1.03 billion pounds). Given the $40 billion annual externality costs and assuming increasing marginal externality costs, the externality cost saving associated with the tobacco quota is estimated to be higher than $5.2 billion annually. The externality cost-reducing impact of the tobacco programs seems to be in the same order of magnitude as that of the cigarette tax increase, and associated price increases in 1973-1984.

Table 3 suggests that, to achieve a lower level of domestic consumption of tobacco, the production quota must be modified when a tobacco tax is introduced. Reduction of domestic consumption by about one third (.59 billion pounds annually) involves a tobacco tax of 60 cents per pound and a reduction in quota by 10% (1.35 billion pounds). Such a policy will reduce producer's surplus less than 25% (from $.62 billion annually to $.47 billion annually) since some of the last revenues in domestic markets will be captured by export gains. The table suggests that a tobacco tax of about $1.70 per pound can eliminate domestic use of tobacco and still allow some profits from export, with a production quota of 1.11 billion pounds. The results for other cases with high tobacco tax levels should be viewed with caution. The predictions here are based on extrapolations from a linear system in which parameters are derived given present conditions. It seems reasonable that the degree of nonlinearity expecially in demand for cigarettes is substantial, and reliability of prediction is declining the further we deviate from present conditions.

The illegality of export tax may cause the use of the quota policies presented in table 3. The conceptual analysis suggested is that, when environmental considerations result in externality taxes greater than the optimal export tax, the optimal resource allocation that is usually obtained with an export tax can be obtained without such tax. Table 4 presents such resource allocation for different levels of domestic tobacco. For each domestic tobacco tax level (from zero to $1.90 per pound),

Table 4. Outcomes Under Tobacco Tax and Optimal Export Strategy

Cigarette tax	Export tax	Marginal cost	Domestic price	Export price	Export	Domestic use	Production	Consumer supply	Tobacco tax revenue	Producer surplus	Cigarette tax with no export tax	Producer surplus higher tax
.00	.33	1.22	1.22	1.55	.53	1.07	1.60	.96	.00	.65	0	
.10	.33	1.21	1.31	1.54	.53	1.02	1.55	.86	.10	.63	0	
.20	.34	1.20	1.40	1.54	.54	.96	1.50	.77	.19	.61	0	
.30	.34	1.19	1.49	1.53	.55	.90	1.45	.68	.27	.60	0	
.40	.35	1.18	1.58	1.53	.55	.85	1.40	.60	.34	.59	.05	.88
.50	.35	1.18	1.68	1.53	.56	.79	1.35	.53	.40	.58	.15	.86
.60	.35	1.17	1.77	1.52	.57	.74	1.30	.45	.44	.57	.25	.83
.70	.36	1.16	1.86	1.52	.57	.68	1.25	.39	.48	.55	.34	.79
.80	.36	1.15	1.95	1.51	.58	.63	1.21	.33	.50	.53	.44	.76
.90	.36	1.15	2.05	1.51	.58	.57	1.16	.27	.52	.52	.54	.73
1.00	.37	1.14	2.14	1.51	.59	.52	1.11	.22	.52	.51	.63	.70
1.10	.37	1.13	2.23	1.50	.60	.46	1.06	.18	.51	.51	.73	.68
1.20	.38	1.12	2.32	1.50	.60	.41	1.01	.14	.49	.50	.82	.66
1.30	.38	1.11	2.41	1.49	.61	.35	.96	.10	.46	.49	.92	.62
1.40	.38	1.11	2.51	1.49	.62	.30	.91	.07	.42	.48	1.02	.60
1.50	.39	1.10	2.60	1.49	.62	.24	.86	.05	.36	.47	1.11	.56
1.60	.39	1.09	2.69	1.48	.63	.19	.81	.03	.30	.45	1.21	.53
1.70	.40	1.08	2.78	1.48	.63	.13	.76	.01	.22	.44	1.30	.49
1.80	.40	1.07	2.87	1.47	.64	.08	.72	.00	.14	.42	1.40	.45
1.90	.40	1.07	2.97	1.47	.65	.02	.67	.00	.04	.41	1.50	.44

we present the optimal resource allocation and surplus under the optimal export tax. In situations where the export tax can be eliminated by a lower tobacco tax, we present the lower tax and the resulting higher producer surplus.

Table 4 and table 3 suggest that, if optimal export tax on tobacco use was allowed at present when domestic tobacco use is not taxed, producer surplus would have been slightly increased (by about $30 million annually from $620 million to $650 million); but domestic surplus would have increased substantially by about $300 million annually since domestic price will decline and domestic consumption will increase from .90 billion pounds to 1.07 billion pounds. If health costs are taken into account though, this 18% increase in consumption reprepresents an immense increase in externality costs of above $7.2 billion annually. Thus, all things considered, the existing tobacco program seems to be prefered to optimal export tax with no tobacco tax. Moreover, if optimal export tax was allowed, a tax of 30 cents per pound on domestic consumption would have been needed to attain current domestic consumption levels of tobacco.

Table 4 also suggests that domestic tobacco consumption can be reduced drastically and the United States can behave as a monopoly in the international tobacco market without an export tax. For example, a domestic tobacco consumption tax of 15 cents per pound, with a production quota of 1.35 billion pounds of tobacco, will reduce domestic tobacco use to .79 billion pounds annually (12.2%, with an annual gain in externality costs of $4.8 billion) and the producer surplus will increase to $8.80 million annually (an increase of about $250 million relative to the present). A reduction of annual domestic tobacco use by more than one third to .57 billlion pounds will require a domestic tobacco tax of 59 cents per pound, a production quota of 1.16 billion pounds annually and will result in higher producer surplus than presently (by $100 million). Present producer surplus levels (about $620 million dollars annually) can be preserved by a domestic use tax of 92 cents per pound and a production quota of .96 billion pounds. Such policy will reduce domestic use by about 60% to .35 billion pounds annually.

The analysis suggests that use of taxation of domestic consumption of tobacco will allow better use of the monopolistic power of the United States in foreign markets and will preserve profitability of tobacco production while reducing domestic use and health costs drastically.

IV. Conclusions

Tobacco is, by far, the most obvious example of an agricultural product causing substantial social and health damage. The health costs attributed to tobacco outweigh the costs of other sources of concern. According to Rice, Kelman, and Dunmeyer, about 65,000 deaths in 1985 were attributed to alcohol abuse and 8,000 deaths to drug use—much less than the 300,000 deaths attributed to cigarettes. Similarly, the aggregate costs of alcohol abuse in 1985 were estimated to be about $24 billion and the cost of drug abuse to be $2 billion dollars, while the estimated health cost of cigarettes was betweem $40 billion and $90 billion. Given these numbers, it is no wonder that public health professionals from the Surgeon General down are determined to eliminate, or at least reduce substantially, domestic use of tobacco. They have been successful thus far, and it seems that regulation of tobacco use will continue. This paper shows that current tobacco policies actually contributed to the reduction of tobacco use, while supporting the well-being of farmers. We argue that combining tobacco (and cigarette) taxes with more strict production quotas can improve consumer welfare without hurting growers, at least in the long run. Our proposed policies are based on the assumption that foreign demand for tobacco will not decline. Obviously, stronger antitobacco policies overseas will put the future of the tobacco industry in jeopardy. The health impacts of other agricultural commodity programs are not as obvious as those of the tobacco program. The sugar program is not likely to have substantial health effects since it has caused substitution of sugar with corn syrup, keeping the total intake of caloric sweetness more or less constant (Kruger).

Furthermore, it is very difficult to identify food items that are wholly detrimental. Some components of food products may be harmful to human health, but others may be beneficial. For example, eggs contain much cholesterol which is "bad"; but they are the main source of choline, a

substance required for maintaining effective functioning of the brain. Thus, health information should be incorporated to enhance production of commodities with better health and nutritional content. Such an approach will not assure having a healthier population but, in the long run, perhaps wealthier farmers.

FOOTNOTES

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[1]Harris (1987) argues that oligopolistic coordination is responsible for extra increases in price; Sumner and Ward argue that tax increases present the opportunity to introduce backlogged price increases.

[2]The environmental policy we had in mind is taxation of domestic *consumption* of tobacco (taxation of *tobacco* content of products consumed), not domestic *use* since some of the domestic use is in production of exported cigarettes. Since (in 1987) less than 15 %of the domestic cigarette production went for exports—i.e., 100 billion out of 680 billion cigarettes (U.S. Economic Research Service, Tobacco Situation and Outlook Yearbook)—and we view our results as numerical illustrations of orders of magnitude we used existing domestic demand relationships for cigarettes to analyze tax on domestic use. For actual policy formation, one needs to obtain more concise estimates of consumptive domestic demand for tobacco.

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