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TARIFF REFORM IN THE PRESENCE OF  
SECTOR-SPECIFIC DISTORTIONS

by

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TARIFF REFORM IN THE PRESENCE OF SECTOR-SPECIFIC DISTORTIONS\*

by

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Abstract

The problem of choosing second-best trade policies is modified by including sector-specific policies as well as tariffs. We obtain conditions under which reduction of the largest tariff is welfare improving. Formulae for the optimal tariff and sector-specific subsidy are used to study the design of optimal policy menus. The theory is illustrated by an empirical general equilibrium model of the U. S. economy which emphasizes agriculture. The model suggests that reductions in agricultural protection in the United States would be welfare improving.

## 1. Introduction

There is widespread recognition that lowering a particular distortion when other distortions are held constant may not improve welfare. Despite the absence of universally applicable prescriptions, there has been considerable progress in understanding what sort of reforms are beneficial. There have been two prominent lines of research in this area. The first seeks sufficient conditions to insure that a reform, such as a decrease in the largest tariff or a proportional cut in all tariffs, will increase economic welfare. The papers by Bertrand and Vanek (1971), Hatta (1977), Fukushima (1979), Falvey (1988), and Fukushima and Kim (1989) present the chief results. The second line of research (e.g., Dixit and Newbery (1985) and Dahl *et al.* (1986) determines optimal tariffs in the presence of fixed distortions.

Most studies of second-best policy changes assume that all distortions can be expressed as tariff equivalents (Corden and Falvey (1985), and Falvey (1988) are notable exceptions). In practice, of course, many important policies are sector specific; treating a producer subsidy as a tariff may seriously bias a conclusion. Since theoretical models are intended to provide insights rather than precise prescriptions, the simplifying assumption may be justified. Nevertheless, it is worth pointing out that the theoretical results may not be very robust.

In section 2 we modify the standard analysis of welfare-improving policy reform (e.g., Hatta [1977]) by including sector-specific policies in addition to tariffs. Hereafter, we designate any sector-specific policy, such as a production subsidy/tax or factor subsidy/tax, as simply a "subsidy." Producers in different sectors face different price vectors when subsidies are used. Under the standard assumptions of substitutability, reduction of the largest

tariff has ambiguous welfare effects. We obtain stricter conditions under which reduction of the largest tariff is welfare improving.

We also provide the formulae for the optimal tariff and subsidy in a particular sector, holding other distortions fixed. These formulae show: (i) how the optimal level of protection in a sector depends on whether a subsidy or tariff is used and (ii) how the optimal level of a policy depends on whether the distortions in other sectors are tariffs or subsidies (i.e., sector specific).

A tariff has direct economy-wide effects, to the extent that the tariff-ridden commodity is an input in the production of other commodities. Therefore, a tariff may be capable of offsetting the economy-wide effect of other distortions. A (sector-specific) subsidy may indirectly influence other sectors via the price of nontradables or factors such as labor. Since this influence is likely to be weak, a subsidy has little power to offset the economy-wide effect of other distortions. In the following sections, we discuss the implications on policy design of the difference between the two instruments.

We illustrate these remarks with an empirical general equilibrium model of the U. S. economy. The model consists of 38 sectors, of which 7 are agricultural. Distortions in three of the agricultural sectors are separated into tariffs and sector-specific subsidies; distortions in the remaining sectors are treated as tariffs. We calculate the optimal agricultural distortions when different sets of instruments are available, holding fixed nonagricultural distortions.

The current GATT negotiations heighten interest in attempts to reduce international trade barriers. Wholesale dismantling of these barriers in

unlikely, but there is some possibility of reform. Previous rounds of negotiations have succeeded in reducing nominal rates of protection on manufactured goods. The United States has emphasized the importance it places on agricultural reform in the current round. Other countries and coalitions (the EC, Japan, and the Cairns group) have also made agricultural reform central to their negotiating position (Tutwiler and Rossmiller, 1987). It is important to determine to what extent changes in nonagricultural distortions can make compromises in agricultural policy more or less palatable.

## 2. The Theoretical Model

The theoretical model is used to illustrate two points. First, we show that well-known results on the welfare effects of piecemeal reform are affected by the introduction of sector-specific distortions, but that weaker results hold under plausible conditions. Second, we use the necessary conditions for optimality of the tariff and subsidy to show the different response of the two instruments to existing (fixed) distortions.

The model allows producers in different sectors to face different relative prices. This enables us to consider sector-specific subsidies as well as tariffs. For purposes of exposition, we suppose that the economy can be divided into the set of sectors that face  $p^a = (\underline{1} + \underline{t} + \underline{g})Q$  and the set that faces price  $p^b = (\underline{1} + \underline{t})Q$ ;  $\underline{1}$  is a row vector of 1's;  $\underline{t}$  and  $\underline{g}$  are row vectors of ad valorem tariffs and subsidies<sup>1</sup>, respectively; and  $Q$  is a diagonal matrix with world prices on the main diagonal. Hereafter, we refer to the two sets of sectors as firm a and firm b. The assumption that there are only two firms is dropped in the empirical section. We ignore consumption taxes, so that consumers face price  $p^b$ . We assume that nontradables are not taxed; the price of nontradables is the vector  $p^N$ .

There are T traded and N nontraded goods. The compensated demand system of the representative individual is denoted  $\underline{c}(p^b, p^N, u)$  where the column vector  $\underline{c}$  is partitioned so that the first T elements are traded goods and the last N elements are nontraded; u is the level of utility. The (column) netput vectors of the two firms are  $\underline{y}^a(p^a, p^N)$  and  $\underline{y}^b(p^b, p^N)$ , which are partitioned in the same manner as  $\underline{c}$ . Excess demand is  $\underline{z}(p^a, p^b, p^N, u) = \underline{c} - \underline{y}^a - \underline{y}^b$ . Equilibrium in the balance of nonpayments requires

$$(1) \quad \underline{1} \ Q \ \underline{z}_T = 0$$

and equilibrium in the nontraded sector requires

$$(2) \quad \underline{z}_N = 0$$

where  $\underline{z}_T$  and  $\underline{z}_N$  denote the first T and the last N elements of  $\underline{z}$ , respectively.

We define the matrix Z as the Jacobian of  $\underline{z}$ , i.e.,

$$\frac{\partial \underline{z}}{\partial (p^T; p^N)} = \begin{bmatrix} Z_{TT} & Z_{TN} \\ Z_{NT} & Z_{NN} \end{bmatrix}$$

The vector  $p^T$  denotes the price of tradables, either  $p^a$  or  $p^b$ . Thus, for example,

$$Z_{TT} = \frac{\partial c_T}{\partial p^b} - \frac{\partial y_T^a}{\partial p^a} - \frac{\partial y_T^b}{\partial p^b}$$

Differentiating (2) implies

$$(3) \quad dp^N = Z_{NN}^{-1} (\underline{c}_{Nu} du + Z \underline{Q} dt' - Y \underline{Q} ds')$$

in which Y is defined as the Jacobian of  $y^a$ , i.e.,

$$\frac{\partial y^a}{\partial (p^T; p^N)} = \begin{bmatrix} Y_{TT} & Y_{TN} \\ Y_{NT} & Y_{NN} \end{bmatrix} = Y.$$

The vector  $\underline{c}_{Nu}$  (respectively,  $\underline{c}_{Tu}$ ) is the partial derivative with respect to  $u$  of the demand for nontradables (respectively, tradables). Differentiating (1) and substituting (3) into the result implies

$$(4) \quad Bdu = \underline{1}Q(DQdt' + D^aQds'),$$

which uses the definition

$$B = \underline{1}Q(\underline{c}_{Tu} - Z_{TN} Z_{NN}^{-1} \underline{c}_{Nu}), \quad D = Z_{TT} - Z_{TN} Z_{NN}^{-1} Z_{NT}'$$

$$\text{and } D^a = -Y_{TT} + Z_{TN} Z_{NN}^{-1} Y_{NT}.$$

We adopt the following:

ASSUMPTION 1. (i) There are no inferior goods. (ii) The goods which share the highest (lowest) tariff rate are substitutable for all other goods in consumption and in production of firms a and b. (iii) Nontradable goods are substitutable for all other goods in consumption and in production of firms a and b. Conditions (ii) and (iii) are stronger than substitutability in excess demand required by theorem 1 of Fukushima (1979).

To obtain comparative statics results, multiply (4) by  $(1 + \tau) > 0$  and use the homogeneity in prices of  $z_T$  to rewrite (4) as

$$(5) \quad (1 + \tau)B du = [(\underline{t} - \underline{\tau})QDQ + sQD^aQ]d\underline{t}' - (1 + \tau)QD^a Qds', \text{ where } \underline{\tau} = \underline{\tau}\underline{1}.$$

We assume that the goods are ordered so that  $t_1$  is larger (smaller) than all other tariffs. Replacing  $\tau$  in (5) by  $t_1$  leads to Fukushima's Theorem 1 for the case where  $\underline{s} = 0$ ; this theorem states that a decrease in the largest (increase in the smallest) tariff improves welfare, given Assumption 1.

However the sign of  $\underline{s} QD^a Qd\underline{t}'$  is ambiguous, so the welfare effect of the proposed policy change cannot be determined.

The following proposition provides a sufficient condition for a proposed tariff change to increase welfare in presence of subsidies.



PROPOSITION 1. Suppose that Assumption 1 holds, and that when  $t_1$  is decreased (respectively, increased)  $s_1$  is either increased (decreased) by the same amount or  $s_1$  is chosen optimally. If  $s < 0$  (respectively,  $s > 0$ ) after the policy change, the change is welfare improving. Proof: See appendix.

Proposition 1 has a straightforward interpretation in the case where only the first good has a subsidy, i.e.,  $s_1 \neq 0$ ,  $s_j = 0$  for  $j \geq 2$ . A reduction in  $t_1$  reduces the nominal distortion on commodity 1 facing consumers and firm b. If  $-ds_1 = dt_1$ , the nominal distortion on commodity 1 in firm a is unchanged; if  $s_1 < 0$ , firm a faces a smaller distortion than consumers and firm b, so a reduction in  $t_1$  does represent a "harmonization" of distortions. If, on the other hand,  $s_1 > 0$ , a reduction in  $t_1$  may fail to be welfare improving for much the same reason that the reduction of an arbitrary (i.e., not the largest) distortion may fail to improve welfare.

Following Proposition 1, we have

COROLLARY 1. Under Assumption 1, if  $s_1$  is chosen optionally or  $ds_1 = -dt_1$ , and if all goods are tradable, a reduction (increase) in the largest (smallest) tariff improves welfare. Proof: See appendix.

The formulae for the optimal tariff and subsidy on sector 1 holding the other distortions fixed, are obtained from (5) (with  $r = 0$ ) and from homogeneity in prices of  $y^a((\underline{1} + \underline{\tau})QD^a = (\underline{\tau} - \underline{\epsilon})QD^a + \underline{s}Q(Y_{TT} + Y_{TN} Z_{NN}^{-1} Y_{NT}))$ .

$$(6a) \quad du/dt_1 = (\underline{\tau}QD + \underline{s}QD^{a'}) Q\epsilon'_1 = 0 \quad , \text{and}$$

$$(6b) \quad du/ds_1 = [\underline{\tau}QD^a + \underline{s}Q(-Y_{TT} - Y_{TN} Z_{NN}^{-1} Y_{NT})] Q\epsilon'_1 = 0 \quad \text{with } \epsilon_1 = (1, 0, \dots, 0).$$

Define  $t^*$  and  $s^*$  as the optimal values of  $t_1$  and  $s_1$ . System (6) expresses  $t^*$  and  $s^*$  as linear combinations of the fixed distortions; the coefficients of  $\underline{\tau}$  and  $\underline{s}$  in (6) are generally nonlinear functions of  $\underline{\tau}$  and  $\underline{s}^2$ . We modify

Assumption 1 so that condition 1.ii refers to commodity 1, which is chosen arbitrarily and is not necessarily the good with the highest or lowest tariff. This gives:

ASSUMPTION 1'. (i) There are no inferior goods. (ii) Commodity 1 is substitutable for all other goods in consumption and in firms a and b. (iii) Nontradable goods are substitutable for all other goods in consumption and in firms a and b.

We then have the following:

PROPOSITION 2. Given Assumption 1', the optimal distortion (tariff or subsidy) is more sensitive to existing fixed tariffs than to existing fixed subsidies. Proof: See appendix.

In order to interpret Proposition 2, we use (3) to rewrite (6) as

$$(7a) \quad \left( \underline{t}Q \frac{dz_T}{dt} - sQ \frac{dy_T^a}{dt} \right) \underline{e}'_1 = 0$$

$$(7b) \quad \left( \underline{t}Q \left( - \frac{\partial y_T^a}{\partial s} + \frac{\partial z_T}{\partial p^N} \frac{dp^N}{ds} \right) - sQ \frac{dy_T^a}{ds} \right) \underline{e}'_1 = 0.$$

Using (7a), the optimum tariff,  $t^*$ , is

$$(8) \quad t^* = \sum_{j \neq 1} \rho_j t_j q_j + \sum_j \gamma_j s_j q_j \quad \text{where}$$

$$\rho_j = - \frac{[d(c_j - y_j^a - y_j^b)/dt_1]}{(dz_1/dt_1)}, \quad \text{and} \quad \gamma_j = \frac{(dy_j^a/dt_1)}{dz_1/dt_1}.$$

The term  $dy_T^a/dt$  is the sum of the direct effect of  $\underline{t}$  on  $y^a$ ,

via  $p^a$ , and the indirect effect, via  $p^N$ ,

$$\text{i.e.,} \quad \frac{\partial Y_T^a}{\partial t} + \frac{\partial Y^a}{\partial p^N} \frac{dp^N}{dt}$$

The matrix

$$\frac{dy_T}{ds} = \frac{\partial y_T^a}{\partial p^a} \frac{\partial p^a}{\partial s} + \frac{\partial y_T^a}{\partial p^N} \frac{dp^N}{ds}$$

is analogous to the definition of  $dy_T^a/dt$  used above;  $dy_T^a/ds$  differs from  $dy_T^a/dt$  since the sector-specific subsidy and the economy-wide tariff have different effects on the price of nontradables. Therefore, the fixed subsidies may have very different effects on the optimal levels of  $t_1$  and  $s_1$ .

It is plausible that an optimally chosen policy is more sensitive to a distortion that directly affects a price throughout the economy than to sector-specific distortions. This intuitive result is guaranteed if the two types of distortions have the same qualitative effect on each component of excess demand, as Assumption 1' implies. In the absence of such an assumption, there are several possibilities. For example, if commodities 1 and  $j$  are substitutes in firm a but complements in either consumption or in firm b, it may be the case that  $\gamma_j > \rho_j > 0$ , and a subsidy on  $j$  in firm a has a greater effect on the optimal tariff of commodity 1 than would a tariff on commodity  $j$ .

This example illustrates the difficulty of designing the policy menu. Producers in a given sector are indifferent between protection generated by a tariff or a production subsidy, but policy-makers care about the extent to which the two policies generate demand for reform in other sectors. In the absence of very strong assumptions about substitutability, we cannot determine either the extent or direction of demands for reform generated by the two policies.

A related question is which policy instrument justifies a higher degree of protection, holding other distortions fixed. For example, agricultural lobbyists may invoke the theory of the second best in order to justify agricultural protection; the strength of their argument depends on which instrument they seek to change. Policymakers interested in circumventing this

type of argument will be more successful if they restrict themselves to the appropriate instrument<sup>3</sup>.

The assumption of substitutability does not imply which of the two optimally chosen instruments is greater, even if all fixed distortions have the same sign. Assumption 1' guarantees that the off-diagonal elements of  $D - D^a$  are positive, as are the corresponding elements of  $D^{a'} + Y_{TT} + Y_{TN} Z_{NN}^{-1} Y_{NT}$ . However, the (1, 1) element of  $D$  is greater in absolute value than is the (1, 1) element of  $-Y_{TT} - Y_{TN} Z_{NN}^{-1} Y_{NT}$ . For example, the supply or derived demand response of commodity 1 in firm a may be nearly 0, in which case the fixed distortions are likely to have a larger effect on  $s^*$  than on  $t^*$ . In the absence of Assumption 1', the signs of  $t^*$  and  $s^*$  as well as the relative magnitudes are ambiguous.

The analysis provides no strong conclusions regarding which policy instrument generates a greater demand for reform in other sectors or which instrument justifies a higher level of protection. Equation (7) does, however, reveal one important and general result. Although both a subsidy and a tariff are chosen to offset all distortions, the subsidy is chosen principally to offset the effect of those distortions within the firm; we refer to these effects of the internal targets. The optimal tariff, on the other hand, is chosen to offset the effects, on the entire economy, of all distortions (i.e., both internal and external [to firm a] targets). This difference is apparent from comparison of the coefficients on the existing tariffs in equation (7a) (the rule for  $t^*$ ) and in equation (7b) (the rule for  $s^*$ ). The effect of  $s_1$  on the external targets is felt only indirectly, through the price of nontradables; unless this indirect effect is particularly strong, the internal targets comprise the chief determinant of  $s^*$ . The optimal tariff directly

affects a price throughout the economy, and no distinction is made between internal and external targets. Since a subsidy has only a weak effect outside the firm, the effects outside the firm of distortions have little influence on the optimal level of the subsidy.

This very commonsensical conclusion, nevertheless, has important implications for the design of the policy menu. Allowing agricultural policy-makers (for example) to choose the optimal tariff on an agricultural product or input implicitly charges them with addressing the nonagricultural effects of nonagricultural policies (i.e., external targets). This might be reasonable if nonagricultural distortions were, in fact, fixed; however, it is more reasonable to think of these policies as being fixed only from the standpoint of the agricultural policy-makers. It is reasonable to expect agricultural policies to offset the effect on agriculture of manufacturing policies; it is less reasonable to expect agricultural policies to offset the effect on manufacturing of manufacturing policies.

### 3. The Empirical Model

The results of the previous section are illustrated by a 38 sector-empirical model of the U.S. economy which we use to calculate optimal agricultural distortions. The own- and cross-price effects on production and consumption required for these calculations are obtained from a linearized computable general equilibrium model as in Dixit and Newbery (1985). The approach is based on a Ricardo-Viner model of production. Production requires primary inputs, produced in the economy or purchased abroad, and capital and labor, which are in fixed supply. Primary inputs obey a Leontief technology and the value added exhibits constant elasticity of substitution between capital and labor. Labor is mobile and capital is sector specific. These

assumptions allow for complementary of goods in production. Demand is represented by a single consumer having a Cobb-Douglas utility function,  $u$ , with an associated expenditure function,  $e(p^c, u)$ .

To account for the fact that many current policies use sector-specific subsidies rather than tariffs, our model allows different sectors to face different price vectors. Each set of sectors which faces the same price vector is treated as a multiproduct firm. The derivation of optimal tariff and subsidy formulae is presented in Beghin and Karp (1990).

The chief advantages of the approach used here are the modest demands on data and the transparency of sensitivity studies. The assumptions of the model and the level of aggregation imply that many actual features of the U. S. economy are obscured. Therefore, our results should not be regarded as precise policy recommendations. However, the direction of reform suggested by the results is robust (see the discussion of sensitivity studies). The results illustrate the issues discussed in the previous section. We maintain the assumption that foreign and domestic tradable goods are perfect substitutes. We mention the effects of relaxing the small-country assumption below.

#### 4. Data.

The most recent available input-output table of the U.S. economy dates from 1982, which is chosen as the reference year for the rest of the data set. A description of the data and of the U.S. agricultural policies is contained in Beghin and Karp (1990). All direct payments received by farmers in 1982 (deficiency, diversion, storage and disaster payments) are included in the computation of the distortions in the agricultural sectors as production subsidies (in ad valorem form)<sup>4</sup>. The wholesale price of the commodities, adjusted for transportation to the market place, is used as the domestic

producer price. The world price--adjusted by the cif/fas ratio in case of net imports--is subtracted from domestic producer price to obtain a tariff equivalent of the trade distortions. The subsidy and tariff equivalents in ad valorem form are weighted by the relative value of output of the corresponding markets to yield an average measure of the subsidy and tariff per sector. The data sources for these distortions are the U. S. Department of Agriculture (1983, 1985, 1988), the World Bank (1985), the Commodity Research Bureau (1985), the U. N. Conference on Trade and Development (1985), and Duncan (1985).

There was a substantial difference between the subsidy and tariff equivalent for three agricultural sectors--food grains, feed grains, and cotton/oil-bearing crops. These policy levels are shown in parentheses in rows 3 through 5 of table 1. The sum of the tariff and subsidy gives the existing producer distortion. These three sectors are modeled as separate firms. For the other four agricultural sectors, the direct subsidy was small so that the existing producer distortion can be adequately described as a tariff equivalent.

The estimation of the tariff equivalents of the distortions in the manufacturing sectors is based on tariff equivalents of nontariff barriers (NTBs) computed by Morici and Megna (1983). The tariff equivalents of the NTBs are added in ad valorem form to the tariff rates of the 1982 custom duties of the U. S. International Trade Commission (1986) to give ad valorem tariff equivalents of the various market interventions in the manufacturing sectors. Table 1 contains the tariff equivalents of four sectors that are strongly related to agriculture via the input-output table. The producer distortion for

TABLE 1

Existing (1982) Tariffs and Production Distortions for  
U. S. Agriculture and Related Sectors

Sector number and nomenclature	Existing protection (tariff, subsidy) percent
1 Dairy, poultry, eggs	26.02
2 Meat and livestock	27.37
3 Good grains <sup>a</sup>	(-7.12, 7.22) 0.10
4 Feed grains and grass seeds <sup>a</sup>	(-3.84, 2.73) -1.11
5 Cotton and oil-bearing crops <sup>a</sup>	(-2.24, 8.84) 6.60
6 Fruits, vegetables, and tree nuts	23.93
7 Tobacco, sugar, and other agriculture	43.93
8 Food, beverage, and tobacco products	5.57
9 Textiles	13.82
10 Wood and wood products	2.54
11 Leather and leather products	9.77
12 Farm equipment and motor vehicles	3.46

<sup>a</sup>The producer protection is the sum of tariff and direct payments to farmers. The first number in parentheses gives the tariff, and the second one gives the subsidy.



the nontraded sectors is the difference between the producer price and shadow price for that sector. (The shadow prices are derived in Beghin and Karp (1990)).

The manufacturing sector is modeled in less detail than agriculture since, for the former, no distinction is made between tariffs and subsidies. This is because we rely on previously published calculations for the manufacturing sector. Since we are interested in comparing actual to optimal distortions in agriculture, it is important to have a more detailed description of policy levels in that sector.

The vector of consumption taxes is estimated by the vector of "total indirect business taxes" paid by each sector which appears in the value-added data of Adelman and Robinson (1986). These taxes are computed as percentages of world price. They underestimate the true consumption tax rates because they do not include sales taxes.

Elasticities of substitution between labor and capital are taken from Whalley (1985); the input-output table comes from Adelman and Robinson (1986). The Hessian of the expenditure function is calculated using expenditure shares and total expenditure given by the 1982 final demand data of Adelman and Robinson (1986). Total expenditure is the sum of private consumption and investment. The shares are the ratio of the expenditure for each sector divided by total expenditure.

## 5. Results

The principal results are presented in Table 2. For all of these calculations, we set the consumption taxes equal to 0, as was assumed in the theoretical section. We discuss alternative assumptions below.

Column 1 of Table 2 presents the optimal tariffs under the (incorrect)

TABLE 2  
Optimal Agricultural Distortions

Sector Nomenclature	(1)		(2)		(3)		(4)		
	Optimum Tariff Ignoring Subsidies		Optimum Tariff with Fixed Production Subsidies		Optimum Production Subsidies with Fixed Tariff		Optimum Tariffs and Subsidies		
	Tariff	Total Protection	Tariff	Total Protection	Subsidy	Total Protection	Tariff	Subsidies	
1. Dairy and Poultry	4.447	4.750	4.750	4.750	0	26.020	0.543	0	.543
2. Meat and Livestock	4.428	4.400	4.400	4.400	0	27.370	- 0.555	0	-.555
3. Food Grains	2.732	3.498	-3.722	3.498	11.863	4.743	-85.792	89.089	3.297
4. Feed Grains	1.941	4.412	1.682	4.412	8.917	5.077	- 8.361	11.790	3.429
5. Cotton and oil-bearing crops	41.000	46.358	37.518	46.358	8.177	5.937	92.929	-88.817	4.032
6. Fruits and & vegetable	4.658	4.992	4.992	4.992	0	23.930	4.586	0	4.586
7. Tobacco, Sugar, & other agriculture	4.517	4.837	4.837	4.837	0	43.930	4.321	0	4.321

assumption that there are no sector-specific subsidies, and column 2 shows the optimal tariffs given the existing subsidies in sectors 3-5 (see Table 1). Agricultural producers receive about the same benefits whether or not subsidies are correctly accounted for. The suggested optimal tariffs differ somewhat for sectors 3-5, in one case leading to a sign reversal. Therefore, industries that use the outputs of sectors 3-5 may care whether the subsidies are properly accounted for. However, the difference between the two sets of results is moderate; similar differences in magnitudes are obtained by changing parameters such as elasticities of substitution between capital and labor.

These results suggest that using rough aggregates of distortions, such as tariff equivalents, in a few sectors provides a reasonable approximation for empirical work. The results do not shed any light on the cumulative effect of using aggregate measures for most of the economy as we have done for the non-agricultural sectors.

Comparison of Table 1 with either columns 1 or 2 of Table 2 indicates that the sectors which are highly protected (sectors 1, 2, 6, and 7) cannot appeal to the theory of the second best for justification of that protection. This conclusion is very robust; it is not altered by substantial changes in elasticities of substitution between capital and labor, or by different assumptions regarding consumer taxes. This provides strong evidence that the high protection enjoyed by these sectors is motivated by political or social rather than efficiency considerations. Although not surprising, this conclusion helps to clarify the debate surrounding agricultural policy.

The opposite conclusion obtains for sector 5, cotton and oil-bearing crops. There, the existing level of protection is quite moderate; the optimal level is substantially larger. This is due to the high level of protection on textiles,

sector 9. Raising the tariff on cotton and oil-bearing crops increases the domestic price of cotton, which is an important input into textiles; this decreases the effective rate of protection on textiles. To verify this relationship, we performed sensitivity studies on the rate of protection in textiles. Increasing (respectively, decreasing) the level of protection in textiles by 50% caused the optimal tariff for cotton to rise to 67% (respectively, fall to 11%). The higher the nominal rate of protection on textiles, the more the tariff on cotton is used to reduce the effective rate of protection.

We performed similar experiments with the food, beverage, and tobacco products sector (sector 8). Changes in the tariff in that sector had substantial effects on the optimal policies in agriculture; these effects were not as pronounced as those caused by changes in the tariff on textiles.

Column 3 of Table 1 shows the optimal level of subsidies in sectors 3-5, holding fixed all other distortions. The resulting level of protection for sectors 3 and 4 is not substantially changed. However, the level of protection for cotton and oil bearing crops falls from over 40% (with the tariff) to approximately 6% with the subsidy. The latter is roughly the historical level (of 1982). The sector-specific subsidy has virtually no influence on the effective rate of protection in textiles, which was the chief rationale for the large tariff on cotton. Changes of 50% in the tariff on textiles have virtually no effect on the optimal subsidy of cotton and oil bearing crops; recall that the effect on the optimal tariff was substantial.

We remarked in the theoretical section that comparisons of the sensitivity and magnitude of the tariff and subsidy are ambiguous in general. To illustrate this, we compared the coefficients of the tariff and subsidy rules

for sectors 3, 4, and 5. This gives three sets of rules, each with 32 coefficients. In approximately 90% of the comparisons the coefficient in the tariff rule was larger in absolute value than in the subsidy rule; there is a tendency for tariffs to be more sensitive than subsidies. However, there were cases where the coefficients had opposite signs (the empirical model permits complementarity in production). This illustrates the possibility that the sign of the optimal rate of protection may depend on whether a subsidy or tariff is used, even if all fixed distortions have the same sign.

We also remarked that Proposition 2 need not hold in the absence of substitutability. Again, the empirical results illustrate this possibility. In nearly half the cases, the coefficients on fixed tariffs and fixed subsidies had the opposite sign in the policy rules. In these cases the qualitative effect on the optimal policy in a sector, of a fixed level of protection in another sector, depends on whether the latter relies on a subsidy or a tariff.

Column 4 of Table 2 shows the effects of allowing policy-makers to choose both tariffs and subsidies (the latter for sectors 3-5). This gives the policy-maker two types of instruments for the internal and external targets. The table shows how the two instruments are directed toward different targets. The tariff is used to offset the economy-wide effects of fixed distortions. This can be done costlessly in terms of distortions to the agricultural sector by choosing an offsetting sector specific subsidy. Therefore, a very large (in absolute value) tariff is used, but the protection within agriculture remains moderate--roughly the same for sectors 3-5 as when only a subsidy is used.

We also calculated optimal distortions within agriculture holding the consumption taxes fixed at historical levels rather than setting them at 0 as previously assumed. The levels of the consumption tax were increased in

sensitivity studies, since the data probably underestimates the true levels. (See our discussion on data.) Again, the qualitative results continued to hold.

The United States is a large agricultural exporter, so the small-country assumption previously maintained is probably not appropriate. We endogenized world price for three of the agricultural sectors (food, feed grains, and cotton) using Dixit (1985). We set cross-price elasticities for world excess demand equal to 0 and allowed the own-price elasticity to vary from -100 to -1. As expected, the optimal tariff levels are not greatly affected when world demand is very elastic, but becomes negative (an export tax) for less elastic demand. There appears to be no consensus among agricultural economists on the real magnitude of these elasticities (see U. S. Department of Agriculture (1986)). The tariffs reported in Table 2 can be regarded as upper bounds.

## 6. Conclusion

We noted that standard welfare results on policy reform are rendered ambiguous by the inclusion of sector-specific distortions and obtained conditions under which similar but weaker results hold. The formulae for the optimal tariff and subsidy formed a basis for discussion of the design of the policy menu. Strong assumptions about substitutability guarantee that optimal policies are more sensitive to fixed tariffs than to fixed sector-specific distortions. Similar assumptions cannot be used to conclude that the optimal level of protection tends to be greater or lower for subsidies rather than tariffs.

Since the empirical basis for the assumption of substitutability is questionable, that assumption provides a weak basis either for recommendations of actual (as opposed to theoretical) policy reform or for the design of the

policy menu. The analysis revealed the manner in which the choice of a sector-specific instrument forces a more modest set of objectives upon the policy-maker. We suggested, for example, that agricultural policy be used to offset the effect within agriculture of distortions rather than the effect throughout the economy of distortions. This implies a recommendation for sector-specific subsidies rather than tariffs to counter fixed distortions.

The empirical section indicates that the theory of the second best provided little support for the maintenance of high agricultural protection. The cotton sector presents the notable exception to this conclusion. Even there the recommendation for low protection in agriculture is sustained if the policy-maker chooses a subsidy rather than a tariff.

## Endnotes

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1. The propositions developed in the paper hold when each firm faces a different subsidy vector (i.e.,  $p^b = (\underline{1} + \underline{t} + \underline{d})Q$ ), where  $\underline{d}$  is a row vector of subsidies.

2. In the discussion below and in the empirical section, we hold these coefficients constant in calculating the optimal distortions. Since the coefficients give the slopes of the supply and demand curves, the assumption that they are constant is equivalent to taking a linear approximation of the general equilibrium relations. Thus, the policy levels which are calculated using this approximation are only approximately optimal; where there is no possibility of confusion, we refer to them as optimal.

3. Staiger and Tabellini (1987) demonstrate in a two-period model how commitment to the appropriate policy instrument reduces distortions caused by lobbying and market imperfections.

4. Since some of the programs represent factor rather than output subsidies, this aggregation overstates the actual protection on agriculture; however, the principal programs operate like production subsidies.



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Appendix

Proof of Proposition 1

We rely on the following lemma for proof.

LEMMA 1. Given Assumption 1, the off-diagonal elements in the columns of  $D - D^a$ , which correspond to the highest (lowest) tariff, are positive  $Y_{TN} Z_{NN}^{-1}(Z_{NT} + Y_{NT})$  is a positive matrix; and  $B > 0$ .

This lemma follows from the fact that  $Z_{NN}^{-1} < 0$  (Fukushima (1979)).

Proof of the Proposition. The homogeneity of  $y^a(\cdot)$  in prices implies

$$(A.1) \quad (\underline{1} + \underline{t})QD^a = (\underline{t} - \underline{t})QD^a + \underline{s}Q(Y_{TT} + Y_{TN} Z_{NN}^{-1} Y_{NT}).$$

If  $d\underline{s} = -d\underline{t}$ , we can substitute (A.1) into (5) and set  $\tau = t_1$  to obtain

$$(A.2) \quad (1 + t_1)B du = [-(\underline{t}_1 - \underline{t}) Q(D - D^a)Q + \underline{s}Q Y_{TN} Z_{NN}^{-1} (Z_{NT} + Y_{NT})Q]d\underline{t}'.$$

If, on the other hand,  $s_1$  is chosen optimally the necessary condition is that  $\underline{1} QD^a Q \underline{e}'_1 = 0$  (see (5)); this implies that  $\underline{1} QD^a Q d\underline{t}' = 0$  since  $t_1$  is the only tariff being changed. Adding this expression to (5), using the optimality of  $s_1$  and the definition in (A.1), results in an equation with the same form as (A.2). The right side of the equation is evaluated at a different point, however, since the optimal  $s_1$  and the  $s_1$  obtained by offsetting the change in  $t_1$  are not the same in general. If  $t_1$  is the largest (respectively, smallest) tariff and  $d\underline{t}' = -\underline{e}'_1$  (respectively  $d\underline{t}' = \underline{e}'_1$ ), Lemma 1 guarantees that  $-(\underline{t}_1 - \underline{t})(D - D^a)Q d\underline{t}' > 0$  and that the elements of  $Q Y_{TN} Z_{NN}^{-1} (Z_{NT} + Y_{NT})Q d\underline{t}'$  are negative (respectively, positive). Therefore, if  $\underline{s}$  is a negative (positive) vector,  $du > 0$ .

Q.E.D.

### Proof of Corollary 1

PROOF. In the absence of nontraded goods, the second term on the right side of (A.2) vanishes and the first term is positive by Lemma 1.

Q.E.D.

### Proof of Proposition 2

Lemma 1 is modified in the obvious way: The off-diagonal elements of column 1 of  $D - D^a$  are positive.

Proof of the Proposition. When  $t_1$  can be chosen, (6a) implies

$$(A.3) \quad t^*q_1 = \sum \rho_j t_j q_j + \sum \gamma_j s_j q_j$$

and Assumption 1' implies

$$(A.4) \quad \rho_j > \gamma_j > 0 \quad j = 2, 3, \dots, T$$

where  $\rho_j$  and  $\gamma_j$  are proportional to the  $j$ th element of column 1 of  $D$  and  $D^a$ , respectively, and  $q_j$  is the world price of commodity  $j$ . Inequality (A.4) is implied by (the modified) Lemma 1. The first inequality in (A.4) implies that an increase in  $t_j$  has a larger effect on  $t^*$  than does an increase in  $s_j$ . A tax on commodity  $j$  in consumption and in firm  $b$  is equivalent to an increase in  $t_j$  and an equal decrease in  $s_j$ ; this raises the price of  $j$  in consumption and firm  $b$  and leaves the price unchanged in firm  $a$ . This policy change has a smaller effect on  $t^*$  than would an economy-wide increase in the price of  $j$  since, by (A.4),  $\rho_j > \rho_j - \gamma_j > 0$ .

The proof for the case where the policy instrument is  $s$  is identical.

Q.E.D.