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THE ACCURACY OF EFFECTIVE PROTECTION ESTIMATES

by

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INTRODUCTION:

In the past decade a number of economists have called attention to the significance of a tariff structure that distinguishes between intermediate and final goods.[1] The essence of the argument was expressed initially by Barber in 1955 as follows: "...in attempting to assess the protection given by a particular tariff rate it is important to distinguish between the formal or published rate and...the tariff's effective level."[2] The "effective" tariff rate, in turn, depends "on the proportion of final value of the industry's product that consists of raw material and supplies and on the terms on which these materials can be purchased."[3]

Recently Harry G. Johnson presented the concept in the more operational terms of an input-output system.[4] A number of scholars have subsequently used the Johnson formulation to develop empirical estimates of effective protection for certain countries, and others are in preparation.[5]

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[1]The major contributors include Clarence L. Barber, "Canadian Tariff Policy," Canadian Journal of Economics and Political Science (November, 1955); W.M. Corden, "The Tariff," in Alex Hunter, ed., The Economics of Australian Industry (Melbourne: Melbourne University Press, 1963); Harry G. Johnson, "The Theory of Tariff Structure with Special Reference to World Trade and Development," in Harry G. Johnson and Peter B. Kenen, Trade and Development (Geneva: Librairie Droz, 1965); Santiago Macario, "Proteccionismo e Industrializacion en America Latina," Boletin Economico de America Latina (March, 1964); Swedish Customs Tariff Commission, Revision of the Swedish Customs Tariff (Stockholm, 1957); and W.P. Travis, The Theory of Trade and Protection (Cambridge: Harvard University Press, 1964).

[2]Op. cit., p. 523.

[3]Op. cit., p. 524.

[4]Op. cit.

[5]Completed studies include B. Balassa, "Tariff Protection in Industrial Countries: An Evaluation," Journal of Political Economy (December, 1965), which presents estimates of effective rates of protection for the U.S.,

In considering the impact of the national protective structure on domestic resource allocation, accurate estimates of effective rates of protection can be useful guides to policy makers. At the same time, however, one should be aware of the limitations of the analysis, and the nature of the biases that may be present due to the assumptions made or to incomplete and inaccurate data. In a recent article, Corden[6] has outlined the implications of the concept and how the calculations must be interpreted. The implications of inaccurate data, however, remain to be explored. It is this gap in the literature that the present paper attempts to fill. The appraoch is to first specify the analytical framework (Section I), then proceed to an evaluation of the formulas (Section II), and finally (Section III), to explore the types of biases that are likely to be found in empirical estimates of effective rates of protection.

I. ANALYTICAL FRAMEWORK:

The national protective structure introduces a divergence between per unit value added at actual domestic prices and value added in the absence of protection (i.e., at world prices), in a given industry. Expressing this divergence as a proportion of per unit value added at world prices, the effective rate of protection of value added in industry j is

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5(continued)
the U.K., the E.E.C., Sweden, and Japan; G. Basevi, "The U.S. Tariff Structure: Estimates of Effective Rates of Protection in U.S. Industries and Industrial Labor," Review of Economics and Statistics (forthcoming); and R. Soligo and J.J. Stern, "Tariff Protection, Import Substitution and Investment Efficiency," The Pakistan Development Review (Summer, 1965), which presents estimates for Pakistan. Studies under way include a project headed by B. Balassa to derive estimates for several LDC's and further work in Pakistan.

[6] W.M. Corden, "The Structure of a Tariff System and the Effective Protective Rate," The Journal of Political Economy (June, 1966).

defined as:

$$(1) \qquad f_j = \frac{v_j' - v_j}{v_j}$$

where:

v_j = value added per unit value of output in industry j, at world prices,

v_j' = value added per unit value of output in industry j, at domestic prices.

Under certain conditions one can use nominal tariff rates and input-output coefficients to calculate f_j. The necessary assumptions are:[7]

(a) The domestic price of each good, net of domestic taxes and subsidies, is exactly equal to the world price plus the per unit tariff that is or would be paid to import that good.

(b) The physical inter-industry relationships are fixed.

(c) The elasticities of demand for exports and of supply of imports and non-traded goods are infinite.

(d) The elasticity of supply of factors to the domestic industries is less than infinite.

(e) The foreign exchange rate is fixed.

Using coefficients representing value at world prices, the formula for calculating the effective rate of protection that the tariff structure affords industry j is:[8]

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[7]Except for assumption (a), treated in Section III below, this paper will not attempt to duplicate Corden's discussion of the relevance and meaning of these assumptions, op. cit., 1966.

[8]See Appendix for derivations.

(2) $$f_j = \frac{t_j - \sum_i a_{ij} t_i}{v_i}$$

and with domestic value coefficients

(3) $$f_j = \frac{v_j'}{\frac{1}{1+t_j} - \sum_i \frac{a_{ij}'}{1+t_i}} - 1$$

where:

a_{ij} = the coefficient of value of input from industry i per unit value of output of industry j, in world prices,

a_{ij}' = the coefficient of value of input from industry i per unit value of output of industry j, in domestic prices,

t_j = the tariff rate on the output of industry j,

t_i = the tariff rate on the ith input to industry j.

Given these formulas, and the appropriate data, one is in a position to estimate rates of protection granted to various sectors of an economy.

II. EVALUATION OF FORMULAS:

When the data used in preparing estimates of effective protection are deficient in any way, the resulting values of f_j will misstate the true effective protection. This section is an attempt to determine the direction and sensitivity of f_j estimates to errors in the specification of nominal tariff rates. To simplify the discussion it is assumed that the ith good is the only material input used in the production of good j, and thus that there is only one input tariff rate that must be specified.

A. World Values:

With the assumption of only one input, equation (2) becomes

(2') $$f_j = \frac{t_j - a_{ij} t_i}{v_j}.$$

From (2'), with the restrictions that $0 < v_j < 1$ and $0 < a_{ij} < 1$,

it is evident that the relationship between f_j and t_j is positive, but between f_j and t_i it is negative. Thus an overstatment (understatement) of t_j inflates (deflates) f_j, and an overstatement (understatement) of t_i deflates (inflates) f_j. In addition, for marginal errors in the nominal tariff rates, f_j is more sensitive to misstatements of t_j than to misstatements of t_i because t_j acts on total output while t_i acts only on the input. Thus, for example, equal marginal overstatments of t_j and t_i will not cancel out, but instead yield an overstatement of f_j.[9]

By way of illustration one can select a set of initial values, and vary t_j and t_i in turn, noting the corresponding effect on f_j. The values selected are:

$$v_j = 0.4$$

$$a_{ij} = 0.6$$

$$t_j = 0.4$$

$$t_i = 0.2$$

for which $f_j = 0.7$

The values of f_j for different levels of t_j and t_i are contained in Table I. To facilitate interpretation of Table I, the results are plotted on double-logarithmic scales in Figure I, showing the elasticity

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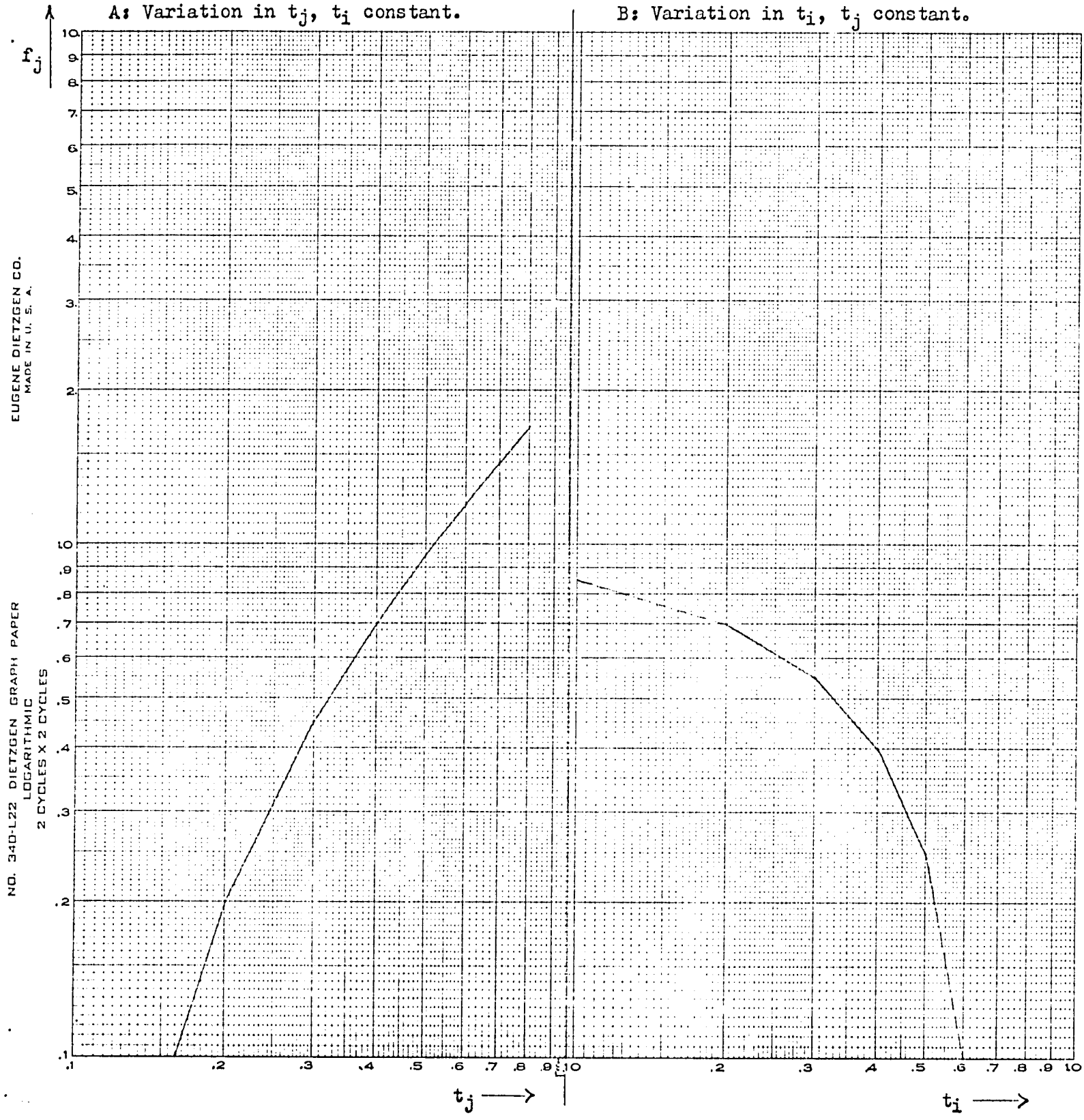
[9]This may also be seen by taking the partial derivative of (2') with respect to t_j and t_i, for since:

$$\frac{\partial f_j}{\partial t_j} = \frac{1}{v_j} \quad \text{and} \quad \frac{\partial f_j}{\partial t_i} = -\frac{a_{ij}}{v_j}$$

then $$\left|\frac{\partial f_j}{\partial t_j}\right| > \left|\frac{\partial f_j}{\partial t_i}\right|$$

FIGURE I: Effect of Variation in Nominal Tariff Rates; World Value Coefficients.



of effective protection with respect to t_j and t_i as the steepness of the curves. The elasticity with respect to t_j is positive, and remains fairly constant throughout the range plotted. However, the elasticity with respect to t_i is negative and (absolutely) becomes greater as t_i increases. Note also that at the initial values of $t_j = 0.4$ and $t_i = 0.2$, the elasticity of f_j with respect to t_j is (absolutely) greater than with respect to t_i.

Table I: Effect on f_j of Variation in t_j or t_i; World Values Formula

t_j	f_j	t_i	f_j
0.16	0.10		
0.2	0.2	0.1	0.85
0.3	0.45	0.2	0.7
0.4	0.7	0.3	0.55
0.5	0.95	0.4	0.4
0.6	1.2	0.5	0.25
0.7	1.45	0.6	0.1
0.8	1.70		

B. Domestic Values:

When using coefficients valued in domestic prices, the same relationships as above hold if the coefficients are allowed to vary as required by the tariffs.[10] However, since the domestic coefficients are already taken as given, errors in t_j or t_i distort f_j not only in the manner already explained, but also because the coefficients are not

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[10] Thus, since $1 = v_j + a_{ij}$ at world prices, then

$1(1 + t_j) = v_j(1 + f_j) + a_{ij}(1 + t_i)$, and at domestic prices $1 = v_j' + a_{ij}'$, therefore

$$v_j' = \frac{v_j(1 + f_j)}{1 + t_j} \quad \text{and} \quad a_{ij}' = \frac{a_{ij}(1 + t_i)}{1 + t_j}$$

adjusted to the error in t_j or t_i. Thus taking

$$(3') \qquad f_j = \frac{v_j'}{\frac{1}{1+t_j} - \frac{a_{ij}'}{1+t_i}} - 1$$

where: $0 < v_j' < 1$

and $0 < a_{ij}' < 1$,

as the overstatement of t_j increases, the inflation of f_j rises more than proportionately, becomes asympototic, and switches to negative values. For the same reason, as the overstatement of t_i rises, the deflation of f_j increases less than proportionately, and becomes asympototic horizontally.

By way of illustration again, one can select an initial set of values and vary t_j and t_i in turn, noting the effect on f_j. To facilitate comparison of these results with those obtained from world value coefficients, the initial nominal tariff rates selected are the same as before, and the coefficients have been adjusted for the presence of tariffs.

Thus, $v_j' = 0.4857$

$a_{ij}' = 0.5143$

$t_j = 0.4$

$t_i = 0.2$

Table II contains the values of f_j for different levels of t_j and t_i. The figures in Table II are plotted in Figure II on double-logarithmic scales.

The elasticities are similar to those found using world value coefficients. However, they are not identical. The differences may be seen graphically in Figure III. For variation in t_j or t_i, the curves have identical values at two points: the initial value of t_j or t_i and the point where $t_j = t_i = f_j$. The first identity occurs because both

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FIGURE II: Effect of Variation in Nominal Tariff Rates; Domestic Value Coefficients.

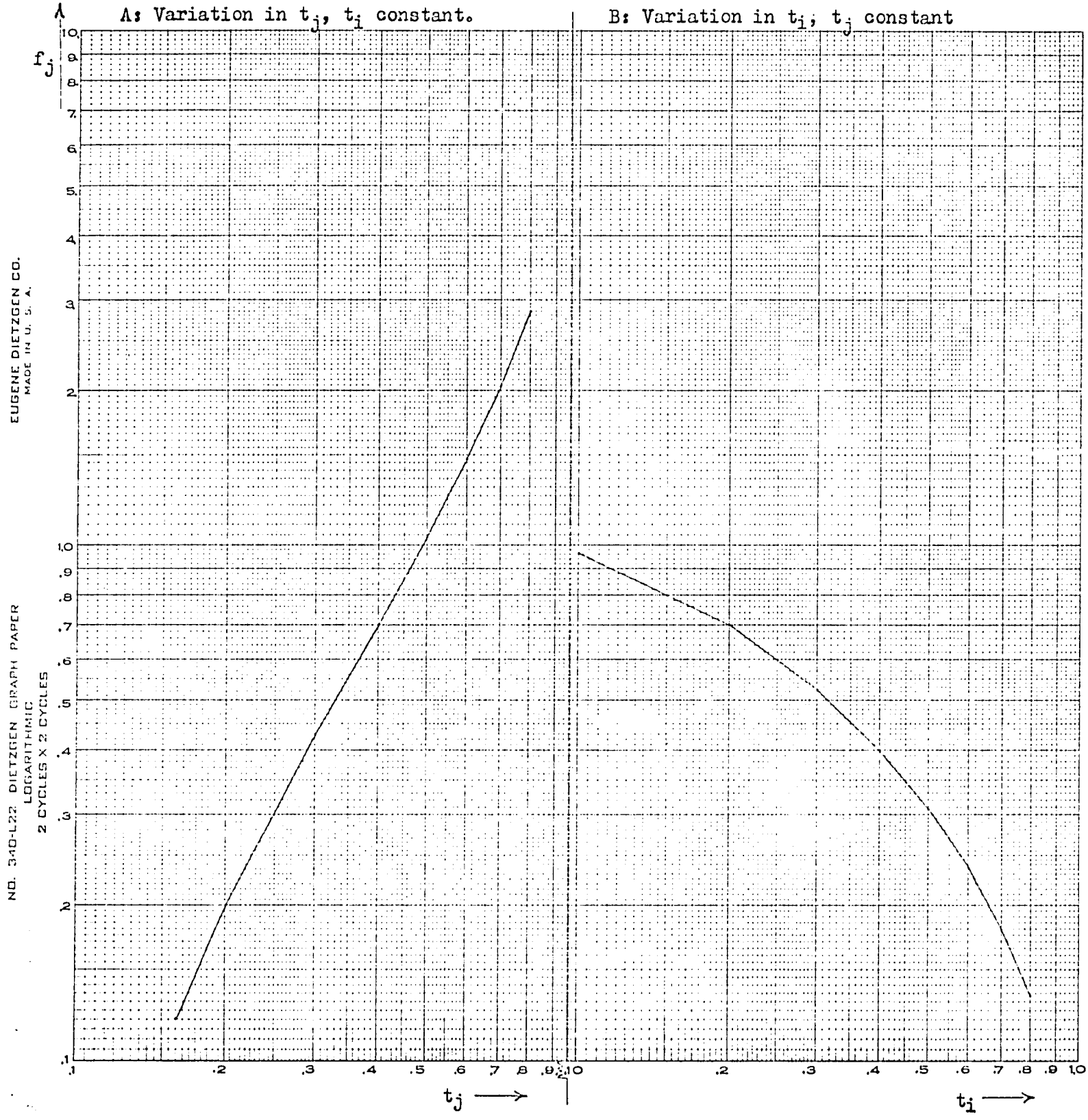

FIGURE III: Comparison of Effect of Variation in Nominal Tariff Rates Between World Value Coefficients (Curves I) and Domestic Value Coefficients (Curves II).

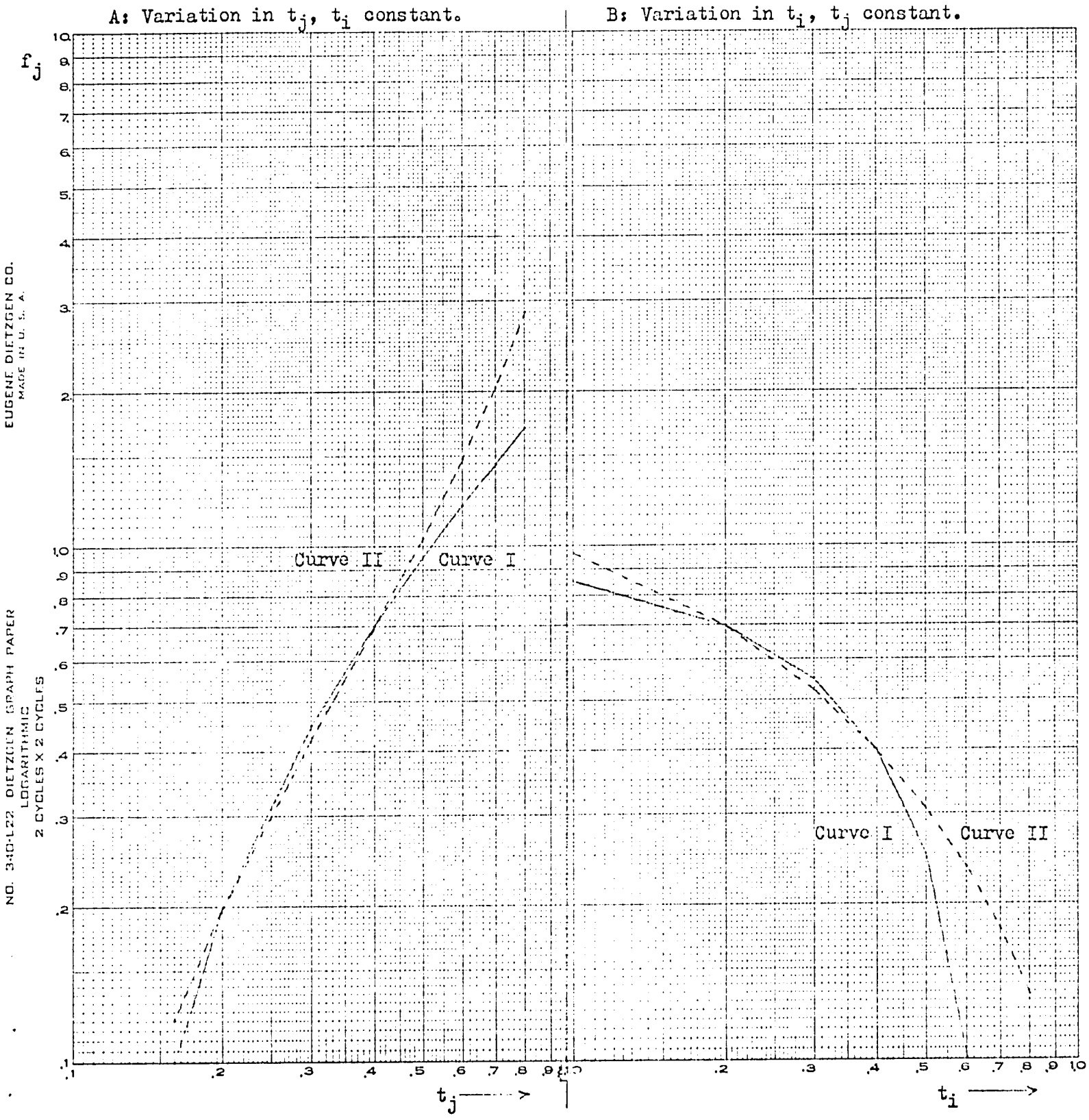

TABLE II: Effect of Variation in t_j or t_i: Domestic Values Formula

t_j	f_j	t_i	f_j
0.16	0.1205	0.1	0.968
0.2	0.2	0.2	0.7
0.3	0.4258	0.3	0.5241
0.4	0.7	0.4	0.4
0.5	1.04	0.5	0.3077
0.6	1.4727	0.6	0.2364
0.7	2.0421	0.7	0.1796
0.8	2.825	0.8	0.1333

formulas will yield the true f_j for the correct values of t_j and t_i. The second identity is due to the fact that in both formulas where $t_j = t_i$ then $t_j = t_i = f_j$[11]. It is between these two points of coincidence that the relative sensitivity to error between using world value coefficients and domestic value coefficients changes: in this example where $t_j = t_i = 0.3$.

For variation of t_j up to the point where $t_j = 0.3$ Curve II (domestic value coefficients) is less steep than Curve I (world value coefficients), and thus f_j is <u>less</u> sensitive to errors in t_j where domestic value coefficients are used. As t_j increases beyond the value of 0.3, Curve II

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[11] This may be seen from the following two rearrangements of the original formulas:

$$(2'') \qquad f_j = t_j + \frac{(t_j - t_i)\sum_i a_{ij}}{v_j}$$

$$(3'') \qquad v'_j \left(\frac{1 + t_j}{1 + f_j}\right) = 1 - \sum_i a'_{ij}\left(\frac{1 + t_j}{1 + t_i}\right)$$

Thus, in both cases, where $t_j = t_i$, then $f_j = t_j = t_i$. It is also interesting to note that where $t_j > t_i$, then $f_j > t_j > t_i$ and where $t_j < t_i$ then $f_j < t_j < t_i$.

is steeper than curve I, indicating that f_j is more sensitive to errors in t_j when domestic value coefficients are employed. The reverse situation occurs for variation of t_i: Curve II is steeper than Curve I up to the point $t_i = 0.3$, and for values of $t_i > 0.3$, Curve II is less steep than Curve I.

III. SPECIFICATION OF NOMINAL TARIFF RATES:

From the previous section it is clear that misstatements of nominal tariff rates may lead to substantial errors in the estimated rates of effective protection. However, accurate specification of nominal tariff rates may be very difficult. The following are some of the more important problems that must be dealt with:[12]

A. C.I.F. Adjustment:

The nominal tariff rates should be expressed as a precentage of C.I.F. value. This requires s conversion of any specific duties to their *ad valorem* equivalents. It may also necessitate conversion of the *ad valorem* tariff schedule from, say, an F.O.B. basis to a C.I.F. basis, where the tariff is not levied on the C.I.F. value. To do this one should multiply each *ad valorem* tariff rate by the ratio of the F.O.B. to the C.I.F. price of the good in question. For example, if the C.I.F.

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[12] In addition to nominal tariff rates the researcher, of course, requires data on the inputs used and value added by primary factors. Two potential published sources of this information, (which may or may not have an acceptable degree of accuracy), are: (1) an input-output table and (2) a census of industry. The major weakness of the former is that the sectors may be so broad and heterogeneous as to be meaningless for several industrial classifications. The latter, however, may fall short of the ideal as well, for the source of substantial material inputs may be unspecified.

price of a good is $100, while the F.O.B. price is $90, a 20% ad valorem tariff rate on the F.O.B. value yields a domestic price of $100 plus 20% of $90, which is $118. Thus, to obtain the appropriate expression of the rate of divergence between domestic and international values in this case, take 90% of 20% which is 18% of the C.I.F. value.

If the C.I.F. conversion is not carried out, the nominal tariff rate for both inputs and outputs will be overstated. This will yield an overstatement of the effective rate of protection unless there is a compensating difference in the incidence of transport costs in the value of inputs vis-a-vus the value of the output. For example, transport costs may represent a sufficiently higher proportion of input value than of output value to overcome the effect of equal overstatements of t_j and t_i.

B. Weighting of Tariff Items:

The tariff schedule is generally expressed in considerably more detail than is given in published industry data. Consequently, one faces the problem of how to combine several tariff items to obtain a single rate for each input or final good.

The ideal weighting procedure is to weight each nominal tariff item by the proportion of output which the corresponding subsector represents in the total output of the sector. The proportions used should be derived from world values, not domestic values. For example, suppose there are two nominal tariff classifications included in the accompanying hypthetical sector 1, for which the value of output at domestic prices is $126. Unless one knows the proportion of output contributed by each subsector, the appropriate tariff rate for the sector as a whole cannot be determined. However, if this information is available, the rate of

divergence between domestic and international values for the sector can be determined. Deflating the value of output in each subsector by its

Table III: Output and Tariffs: Hypothetical Sector 1

	Subsector 1.A	Subsector 1.B	Sector 1 Total
1. Output--domestic prices	$22	$104	$126
2. Nominal Tariff	10%	30%	
3. Output--world prices	$20	$ 80	$100

tariff rate, one can determine the value of output for each subsector at world prices, the sum of which is the value of output for the sector as a whole at world prices. It is then evident that the rate of divergence between domestic values and world values for the sector as a whole amounts to 26%.

The same result could be obtained by multiplying each tariff rate by the production weight (at world prices), and summing the products. Thus:

$$t_j = \left(\frac{X_{j \cdot A}}{X_j}\right) t_{j \cdot A} + \left(\frac{X_{j \cdot B}}{X_j}\right) t_{j \cdot B} + \dots + \left(\frac{X_{j \cdot N}}{X_j}\right) t_j \tag{4}$$

where:

X_j = output of sector j at world prices

$X_{j \cdot A}$=output of subsector j·A at world prices

$t_{j \cdot B}$=tariff rate on subsector j·B

t_j = tariff rate on sector j.

To carry out this weighting procedure one needs a complete breakdown of the input-output table showing the composition of output corresponding to the tariff schedule for each sector. Such data are hard to come by, but none of the alternatives is entirely satisfactory. Weighting

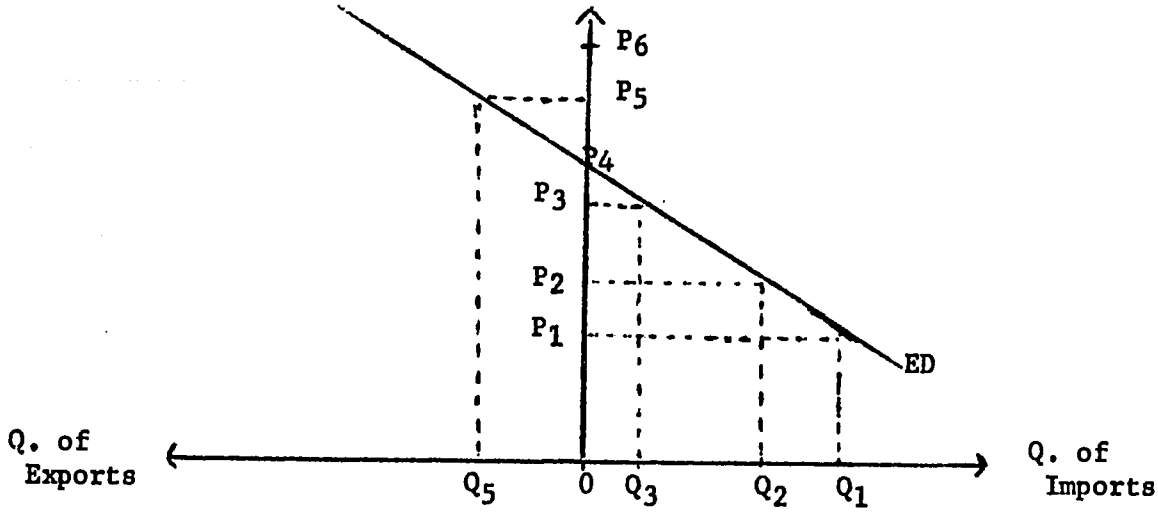
by value of domestic imports gives misleading results because the composition of imports is biased toward low duty items. Similarly, weighting by the value of world trade introduces a low duty bias, although offsetting differences between countries may tend to reduce the error. Simple unweighted averages, sometimes used to overcome the weighting problem in measuring the over-all height of national tariffs, would also be misleading in many cases since the "law of large numbers" on which this approach relies does not apply when the number of rates to be averaged becomes small.

The bias introduced into the estimates of effective protection by inadequate weighting procedures cannot be determined a priori. Each case has to be examined individually.

C. Misstatement of Actual Nominal Tariff Rates:

Another thorny problem concerns nominal tariff rates that do not represent the actual divergence between domestic and international values. The assumption that the world price plus tariff equals the domestic price for each good excludes from the analysis tariffs on export goods, "excessive" tariff rates, and other sources of divergence between domestic and international prices such as non-tariff barriers. For example, in Figure V, the curve ED represents the domestic excess demand for a given good at various domestic prices. First, suppose the world price equals OP_5, in which case the country would export OQ_5 of the good per period. Even if the tariff schedule lists a rate of P_5P_6/OP_5, the domestic price remains OP_5. Although it is not at all uncommon to find substantial tariff rates listed in the schedule for goods that a country exports, one must exclude such rates. Neglecting transport costs,

Figure V:



and in the absence of price discrimination between the domestic and foreign markets, the world price equals the domestic price, and there is, therefore, no divergence between domestic and international values.

Second, if the world price equals OP_1, the country imports OQ_1 per period in the absence of a tariff. With a tariff of, say, P_1P_2/OP_1 imports are limited to OQ_2. However, "excessive" tariff rates, which are more than enough to eliminate imports, such as P_1P_5/OP_1, are commonly found in tariff schedules. The operative tariff rate to use in such a case is P_1P_4/OP_1. The unwitting use of the former instead of the latter rate of course overstates the nominal tariff rate.

Third, if the world price equals OP_1 and there is a tariff rate of P_1P_2/OP_1 combined with a quantitative restriction of OQ_3, the domestic price exceeds the duty-paid price by P_2P_3, and the published tariff rate is meaningless, for the operative tariff rate is P_1P_3/OP_1.

To deal with such cases of non-equivalence one must determine the amount by which the domestic price of an input or output differs from the world price, and express this as a proportion of the world price to

obtain the actual nominal tariff rate on the good. In other words, equation (2) becomes

$$(2''') \qquad f_j = \frac{p_j - \sum_i a_{ij} p_i}{v_j}$$

and equation (3) becomes

$$(3''') \qquad f_j = \frac{v_j}{\frac{1}{1+p_j} - \sum_i \frac{a_{ij}}{1+p_i}} - 1$$

where:

p_j = the proportion by which the domestic price exceeds the world price of good j (output),

p_i = the proportion by which the domestic price exceeds the world price of good i (input).

The amount of data needed to develop such price estimates is staggering, particularly in LDC's where "excessive" protection (in the sense used here) and non-tariff barriers are used extensively.[13]

To the extent that nominal tariff rates fail to represent the actual divergence between domestic and international prices, estimates of effective protection based on uncorrected nominal tariff rates will be in error. The direction and magnitude of that error will depend on the relative incidence of misstatement between inputs and outputs, and on whether world-value or domestic-value coefficients are used. For example, if "excessive" protection is confined to a given final good, without occurring on any of its inputs, there will be an overstatement of effective protection if the nominal tariff rate is left uncorrected. Also, the failure to correct for "excessive" protection will yield greater errors if domestic value coefficients rather than world value coefficients are

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[13] This is not to suggest that similar situations are not to be found in the DC's, but merely that they are more prevalent in the LDC's.

used.[14] If the former are used the error increases at a faster rate, and may be so great as to yield the absurd result of negative value added at world prices.[15] In the other direction, if an export good is used as an input, the effective level of protection pertaining to the output will be understated if a nominal tariff rate on the export good is introduced into the calculations. The different in the magnitude of the error between using world value and domestic value coefficients will depend on the degree to which the input tariff is overstated.[14] For other types of inappropriate nominal tariff data one is able to evaluate the bias introduced into the effective protection estimates in a similar manner.

IV. SUMMARY:

Policy makers require accurate estimates of effective protection in order to assess the impact of the national protective structure on resource allocation. In providing this information economists should realize that the analysis rests on certain restrictive assumptions, and that the estimates are sensitive to errors in the specification of actual nominal tariff rates. The sources of potential error in nominal tariff data are numerous, and contrary to first appearances, substantial data not ordinarily available are needed.

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[14] Assuming that the nominal tariff rate on the output exceeds the nominal tariff rate on the input. See p. 8 above.

[15] A priori it is impossible to determine if a value of $f_j < -1$, which implies $v_j < 0$, is due to: (a) absolute inefficiency as suggested by Soligo and Stern, op. cit., (b) the use of fixed coefficients as Basevi maintains, op. cit., or (c) a misstatement of t_j when domestic value coefficients are used.

APPENDIX: DERIVATION OF FORMULAS

1. World Values

In an input-output system,

(A.1) $$X_j = V_j + \sum_i X_{ij}$$

where:

X_j = the value of total output of industry j at world prices,

V_j = the value added by primary factors in the production of the jth good at world prices,

X_{ij} = the value of inputs from the ith industry at world prices.

Dividing by X_j, (A.1) becomes

(A.2) $$1 = v_j + \sum_i a_{ij}$$

In domestic production, however, equation (A.2) must be modified to take into account the divergence between domestic and international values. Thus:

(A.3) $$1(1 + t_j) = v_j(1 + f_j) + \sum_i a_{ij}(1 + t_i)$$

where:

t_j = the rate of divergence between world prices and domestic prices on the output of industry j,

t_i = the rate of divergence between world prices and domestic prices on the output of the ith industry,

f_j = the rate of divergence between world prices and domestic prices on the value added in industry j.

Since equation (A.2) holds, it is possible to subtract 1 from each side of (A.3), yielding

$$t_j = v_j f_j + \sum_i a_{ij} t_i$$

or $$v_j f_j = t_j - \sum_i a_{ij} t_i$$

then

(A.4) $$f_j = \frac{t_j - \sum_i a_{ij} t_i}{v_j}$$

2. Domestic Values

Using the same symbols as above, but priming the input-output symbols to indicate value at domestic prices

(A.5) $$X'_j = V'_j + \sum_i X'_{ij}$$

and dividing by X'_j

(A.6) $$1 = v'_j + \sum_i a'_{ij}$$

Deflating domestic values to world values

(A.7) $$\frac{1}{1 + t_j} = \frac{v'_j}{1 + f_j} + \sum_i \frac{a'_{ij}}{1 + t_i}$$

and rearranging

$$\frac{v'_j}{1 + f_j} = \frac{1}{1 + t_j} - \sum_i \frac{a'_{ij}}{1 + t_i}$$

or $$1 + f_j = \frac{v'_j}{\frac{1}{1 + t_j} - \sum_i \frac{a'_{ij}}{1 + t_i}}$$

then

(A.8) $$f_j = \frac{v'_j}{\frac{1}{1 + t_j} - \sum_i \frac{a'_{ij}}{1 + t_i}} - 1$$