AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

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Batch 68

1. SUBJECT CLASSIFICATION	A. PRIMARY Development and economics	DK00-0000-0000
	B. SECONDARY Trade and commerce	

2. TITLE AND SUBTITLE
Non-traded inputs and substitution in calculating the effective protective rate

3. AUTHOR(S)
Leith,J.C.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1967	37p.	ARC 382.L533b

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Wis.

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Economic interdependence in southeast Asia project. Publication)

9. ABSTRACT

10. CONTROL NUMBER PN-AAE-400	11. PRICE OF DOCUMENT
12. DESCRIPTORS Allocations, Economic analysis, Economic integratic., Import substitution, Protection, Regional planning, Taiwan, Tariffs	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-355 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

NON-TRADED INPUTS AND SUBSTITUTION IN CALCULATING THE EFFECTIVE PROTECTIVE RATE

by

J. CLARK LEITH

AID-University of Wisconsin
Research Project on "Economic
Interdependence in Southeast
Asia"
Draft of a Research Paper
June, 1967

Preface

This paper is concerned with the general problem of how the imposition or elimination of trade barriers affects resource allocation. The analysis demonstrates, by spelling out and correcting two major short-comings, that the existing "theory of effective protection" does not adequately measure the resource allocation effects of a tariff structure.

Particular policy problems to which this analysis might be applied include the evaluation of import substitution and regional economic integration programs. In each it is clearly crucial to know what impact a given change in the structure of trade restrictions would have on resource allocation. Without a clear understanding of the theoretical issues developed in this paper, miscalculations are likely.

Of additional interest to the policy-oriented reader are some tentative estimates of effective protecitve rates of Taiwan. Although there are a number of shortcomings in the basic data (in common with most other empirical work in the field), the results indicate the biases found in the Taiwan tariff structure.

Non-Traded Inputs and Substitution in Calculating the Effective Protective Rate

J. Clark Leith*

Introduction

In the past few years the topic of "effective" rates of protection has been the object of considerable attention, both theoretically and empirically, among international economists.[1] The basic point of the analysis, that one must take into account tariffs on material inputs as well as the tariff on the output in order to discover the resource allocation effect, was made simply and clearly by a strategic choice of assumptions. Either implicitly or explicitly, the initial writers made the following assumptions:[2]

(a) The tariff rate represents the rate of divergence between the free trade and protected prices of a tradable.[3]

(b) The production function is linearly homogeneous.

(c) The physical interindustry relationships are fixed.

(d) The elasticities of foreign demand for exports and foreign supply of imports are infinite.

(e) The elasticity of supply of domestic non-tradable inputs is infinite.

(f) The elasticity of supply of factor inputs to the domestic industry is less than infinite.

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*This paper is based on an unpublished doctoral dissertation, University of Wisconsin, June, 1967, and was supported financially by the the AID/University of Wisconsin Research Project on "Economic Interdependence in Southeast Asia". Several members of the project, particularly, P.T. Ellsworth, R.E. Baldwin, T. Morgan, and S. Naya provided valuable suggestions. Sole responsibility for the research, however, remains with the author.

(h) Trade and production in protected industries exist both before and after the introduction of protection.

This paper extends the theoretical analysis to allow relaxation of two of these: assumptions (c) and (e). The other assumptions will be retained throughout. In addition, to simplify the discussion it is convenient to assume that the ith good is the only material input and that factor f is the only primary factor used in the production of good j.

In Section I we summarize the existing analysis of the effective protective rate and introduce a simple graphical approach for handling the analysis. We show in Sections II and III respectively that: (a) Under conditions of less than infinitely elastic supplies of non-traded inputs, part of the protection of a tariff on imports of a final good is passed on to the non-traded input, and part applied to the primary factor; the proportions depending on their relative supply elasticities. (b) Substitutability between the primary factor and the material inputs permits economizing in production, yielding a greater increase in the effective protective rate than under conditions of fixed physical coefficients of production. In both of these Sections we deal with the question of how to define the effective protective rate in light of the purposes of the concept, and given the modified assumptions. In Section IV we demonstrate that the effective protective rate is highly sensitive to these modifications, with tentative estimates for sixteen import-competing sectors of Taiwan. Section V contains our concluding remarks.

I. Summary of Existing Analysis

The impact of protection under the assumed conditions can be illustrated by means of Figure I. In Figure I a corner unit isoquant,

$q_j = 1$, represents the entire Leontief-type production function which is linearly homogeneous and has a zero elasticity of substitution. This is sufficient to describe the entire production function of good j, for it shows the combinations of material input i and primary factor f required to produce one unit of good j, or any multiple thereof. Under free trade the per unit prices of j and i, given from abroad, together yield the vertical intercept (Ob) of the unit isocost curve. Since we are concerned with output costs per unit of j, we also know point a on the unit isocost curve. Points a and b together define the position and slope of the unit isocost curve b a c. The introduction of protection changes domestic prices of goods j and i, changing the equilibrium solution in Figure I. A tariff on good j of, say, 20% with no tariff on good i results in a 20% increase in the per unit outlay on good j, shifting the vertical intercept of the per unit isocost curve upward by 20% to point d, permitting the horizontal intercept to drop to point e. This provides us with sufficient information to determine the proportionate change in per unit value added: i.e., the effective protective rate.

Figure I, however, provides no indication of the resource allocation effects that the effective protective rate is designed to indicate.[4] For this one must consider what happens to production when protection is introduced and what it is that, despite the linearly homogeneous production function, limits the expansion of production when protection is introduced.

There are two extreme cases, a vertical supply curve, and a horizontal supply curve, neither of which satisfactorily describes the usual situation. At the one extreme, protection yields no change in production, with the entire protection being absorbed by the pre-existing producers in the form of a quasi-rent. However, for this solution to remain as a long-run equilibrium there would have to be some mechanism whereby the quasi-rent could be retained, for otherwise production would expand as new producers enter the market, competing away the quasi-rent. At the other extreme, disturbance of the free trade equilibrium results in an expansion of production at constant costs, limited only by the extent of the market. Thus, there would be zero imports in any protected industry.

Clearly, neither extreme case yields much insight into the resource allocation pulls that we want to measure. Instead, consider the intermediate situation of an upward-sloping supply curve: the greater the degree of protection, the greater the pull of resources into the industry to expand production. The upward-sloping supply curve is possible despite the linearly homogeneous production function because the primary factor is available only at increasing costs to the user industry. As production expands, the industry must attract the primary factor from alternative occupations (including leisure) by paying a successively higher and higher price.

This approach is illustrated in Figure II. Under the assumption of fixed physical input coefficients, the domestic supply curve of good j (S_j^1) is the vertical summation of the supply curves (to industry j) of input i (S_i^2) and factor f (S_f), where the quantity axes are all reduced to the same scale, and the superscripts 1 and 2 represent domestic and foreign suppliers respectively. In Figure II domestic free trade production takes place at point d. The introduction of tariffs changes domestic prices of goods j and i, changing the equilibrium solution, just as in Figure I. In Figure II S_j^2 (the foreign supply curve of good j) is raised

Figure I

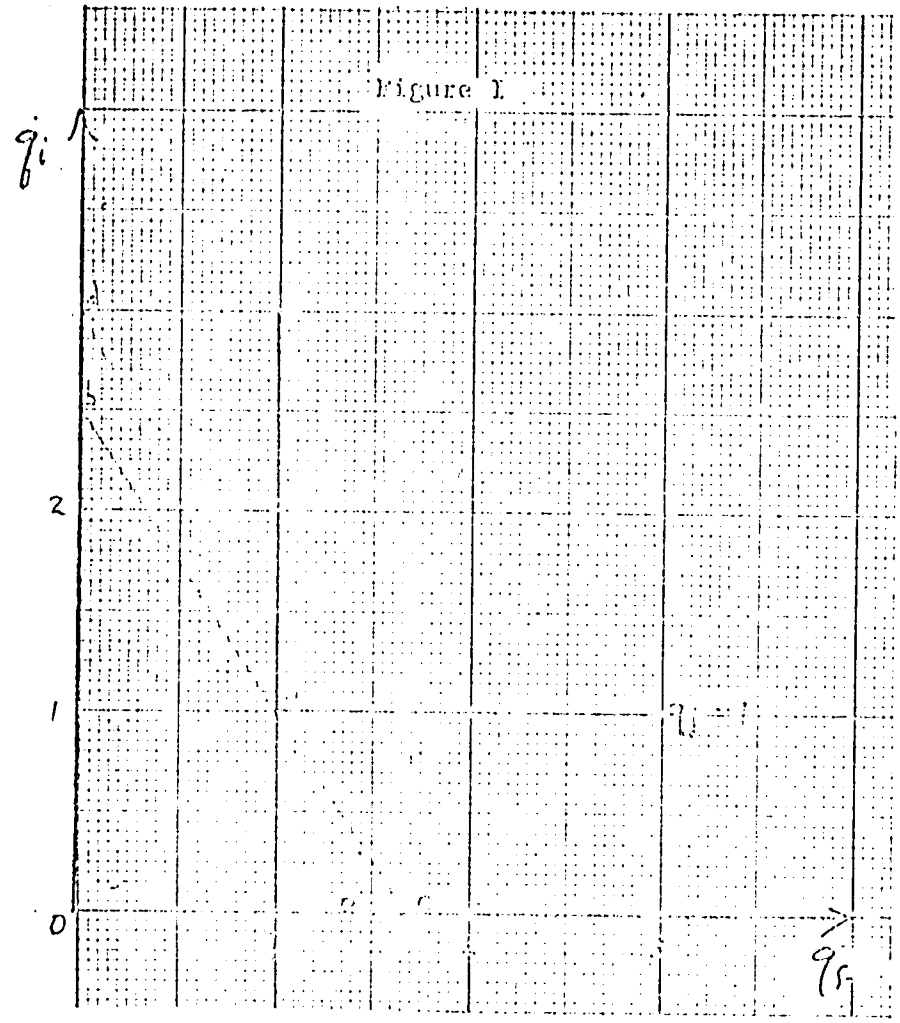
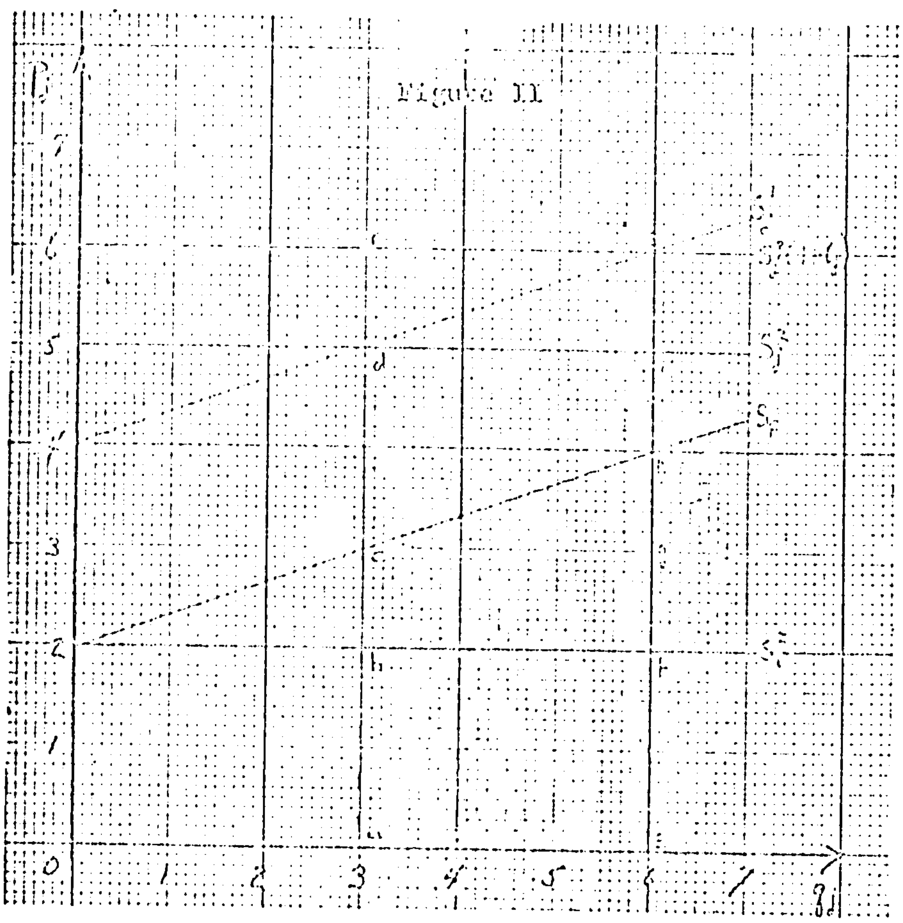


Figure II



vertically by the amount of the tariff, but S_i^2 (the foreign supply curve of good i) remains constant. The new equilibrium production point at s involves the total increase in per unit outlay on good j going to value added with no change in the value of the material input i per unit of j.

The gross value input-output relationships of Figure II are described by the following relationships:

Under free trade

$$X_j = V_j + X_{ij}$$

where:

X_j = the value of total domestic output of industry j at free trade prices,
V_j = the value added by the primary factor in the production of good j, at free trade prices, and
X_{ij} = the value of inputs from the ith industry to industry j, at free trade prices.

With the introduction of tariffs, however,

$$X_j(1 + t_j)\left[1 + (t_j - t_i)e_j\right] = V_j(1 + f_j)\left[1 + (t_j - t_i)e_j\right] + X_{ij}(1 + t_i)\left[1 + (t_j - t_i)e_j\right]$$

where:

t_j = the tariff rate on imports of good j,

t_i = the tariff rate on imports of good i,

f_j = the effective rate of protection, and

e_j = the elasticity of domestic supply of good j.

Solving for f_j,

$$f_j = \frac{X_j t_j - X_{ij} t_i}{V_j}.$$

Alternatively, working from the protected position

$$X_j' = V_j' + X_{ij}',$$

where the primed symbols indicate value at protected prices. Deflating to free trade values, and solving for f_j,

$$f_j = \frac{V_j'}{\frac{X_j}{1+t_j} - \frac{X_{ij}}{1+t_i}} - 1.$$

These relationships can also be expressed in the unit value terms of Figure I, yielding

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

and

$$(2) \qquad f_j = \frac{v_j'}{\frac{1}{1+t_j} - \frac{a_{ij}}{1+t_i}} - 1$$

where:

a_{ij} = the coefficient of value of input from industry i per unit value of output of industry j, at free trade prices, and

v_j = the coefficient of value added per unit value of output of industry j, at free trade prices,

and the primed symbols continue to indicate value at protected prices.

There are clearly two alternative, but equivalent, ways of regarding f_j under these conditions:

$$(3) \qquad f_j = \frac{v_j' - v_j}{v_j}, \text{ or}$$

$$(3^*) \qquad f_j = \frac{p_f' - p_f}{p_f}.$$

In other words, the effective rate of protection amounts of either the proportionate change in the value added per unit of the original output, or the proportionate change in the price of the primary factor.[5]

In conclusion, the simplicity of this analysis contributes substantially to a clear understanding of the issue. While recognising this, one can also see that in the form just presented, it is essentially a limited partial equilibrium analysis, relying on infinite supply and zero substitution elasticities to yield its uncomplicated results.

The present research is aimed at removing these limitations while retaining the original partial equilibrium approach. In what follows we will continue to focus on the degree of protection granted a particular industry, without taking into account general equilibrium repercussions. The reasons for proceeding in this manner are twofold. First, we are attempting to retain sufficient manageability to permit empirical estimation of a scale of rates. General equilibrium models allowing for intermediate goods, such as Travis's[6] or McKinnon's,[7] are very useful in understanding the overall impact of differentiated tariff structures. However, there remains a substantial gap between their analyses and that of detailed industry-by-industry analysis. The approach adopted here is to close the gap by improving the industry-by-industry analysis. Second, it is possible to introduce certain general equilibrium repercussions after one has developed the scale of partial rates. This is how Corden proceeds,[8] and the present work is entirely compatible with his general equilibrium considerations. What we are concerned with here is the initial derivation of individual rates.

II. Non-Traded Inputs

The analysis of Section I was conducted on the assumption that input i is a tradable, or that if it is a non-traded good, it is available to the protected industry at constant costs. The purpose of this Section is to relax that assumption, and examine the consequences of doing so.

The accompanying Figure III is drawn in the same manner as Figure II above, except that the excess supply curve of good i to industry j is solely domestic and is less than infinitely elastic. The slope of the domestic supply curve of good j is now the sum of the slopes of the supply curves of input i and factor f rather than of factor f alone. Given the foreign price of j by S_j^2, there is an equilibrium level of domestic production at $\underline{f}$ which in turn yields a free trade equilibrium material input cost per unit of output, and a value added per unit of output or, what amounts to the same thing, equilibrium prices of good i and factor f to user industry j.

The introduction of a tariff on imports of good j means that, under the assumption of infinitely elastic foreign supplies of tradables, the domestic price of j is increased by the amount of the tariff. However, it is also clear that domestic production in industry j does not expand as much as would have occurred had input i been available at constant costs.

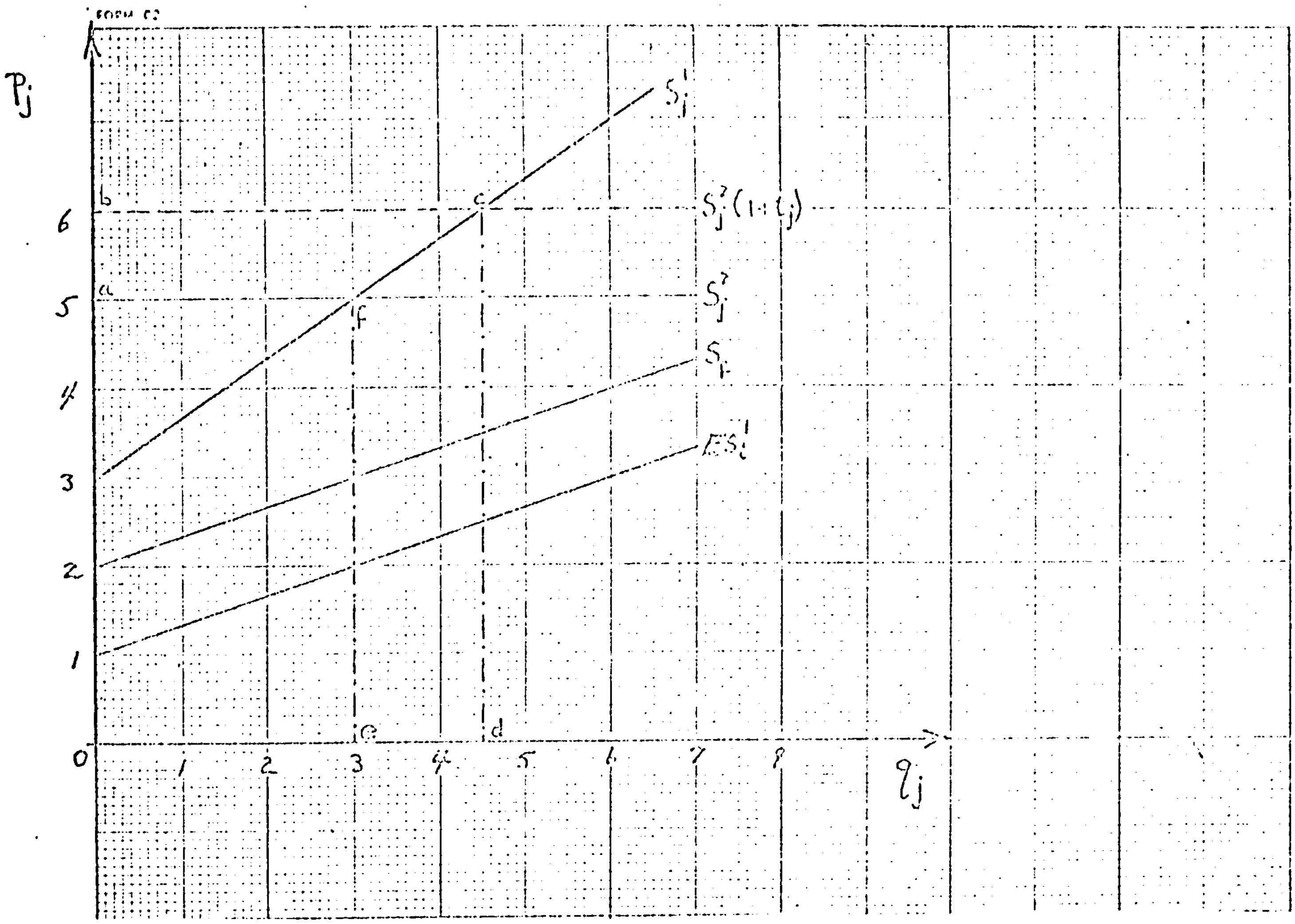
The important question that must be dealt with now is how to define the effective rate of protection when non-traded inputs are available only at increasing costs. Balassa[9] and Basevi[10] treated non-tradables in the same way as any other material input, but with a zero tariff, thus in this case implicitly defining the effective rate to be the absolute size of the output price change as a per cent of the initial value added per unit of output.

Corden argues that:

> "Unless there are two inputs only and one is in infinitely elastic supply so that its price does not rise when the price of the output rises, it is impossible to distinguish the effective protective rate for different inputs. For each product one can talk only about a single effective rate for all those inputs combined that are not in infinitely elastic supply to the industry."[11]

Under this definition the effective rate of protection in Figure III would

Figure III



equal the tariff rate.[12] This approach, while certainly superior to the overstatements of f_j in the pioneering works of Balassa and Basevi, is still unsatisfactory. The very useful distinction between industries is blurred, and even more important, certain resource allocation effects cannot be distinguished.

Consider the following example. Goods A and B both have the same free trade value added proportions; both use a single material input which is non-traded (but which is different between A and B); both are protected by identical nominal tariff rates; and both have the same elasticity of supply of the primary factor to their industry. Now if the elasticity of supply of the non-traded input used by good A exceeds that of the non-traded input used by good B, then the elasticity of supply of good A exceeds that of good B. Hence, output of good A expands more than output of good B. In terms of resource allocation effects, A is clearly more protected than B in such a case, yet Corden's measurement would suggest that A and B are equally protected. In our view, the measure that most clearly indicates the direction of resource allocation effects and also retains the distinction between industries is still the value added per unit of output or, what amounts to the same thing under the fixed input coefficient assumption, the price of the primary factor.

Apparently one of the major reasons by Corden recommended his approach was because "the effects on the primary factor and non-traded inputs cannot be separated out."[13] Clearly one is no further ahead if one cannot derive a formula for determining the increase in value added per unit of output. We proceed with the derivation in the following manner.

The introduction of a tariff on good j imports increases the value of domestic production from X_j (free trade value) to X'_j (protected value)

$$X'_j = X_j(1 + t_j)(1 + e_j t_j).$$

Similarly, under the assumption of fixed physical input coefficients,

$$X'_{ij} = X_{ij}(1 + e_j/e_{ij} \cdot t_j)(1 + e_j t_j),$$

where e_{ij} is the elasticity of (excess) supply of good i to industry j, and

$$V'_j = V_j(1 + f_j)(1 + e_j t_j).$$

From these equations the formulas for f_j corresponding to equations (1) and (2) above are: from free trade

(4) $$f_j = \frac{t_j - a_{ij}(e_j/e_{ij})t_j}{v_j},$$

and from the protected situation

(5) $$f_j = \frac{v'_j}{\frac{1}{1 + t_j} - \frac{a_{ij}}{1 + (e_j/e_{ij})t_j}} - 1.$$

The conclusion is clear. The presence of non-traded inputs available at less than infinitely elastic supply results in a sharing of the protection between the material input and the primary factor. Such cases blur the neat concept implied by the formulas presented in Section I. However, by separating the impact of protection on the material input from its impact on the primary factor, one is able to retain the original definition of the effective protective rate: the proportionate change in value added per unit of output, which is identical with the proportionate change in the price of the primary factor under the fixed physical input coefficient assumption. Furthermore, the distinction of resource pulls between industries is retained. Unfortunately, however, we have added to our information needs for empirical estimation.

III. Substitution

In the foregoing we have assumed fixed physical input coefficients, ignoring any possibility of substitution between the primary factor and material input. We now turn to the task of relaxing that assumption to allow for any elasticity of substitution between f and i.

The linearly homogeneous production function represented by a unit isoquant in Figure I was a special case of zero elasticity of substitution. For elasticities of greater than zero, the unit isoquant is curved as in Figure IV. The determination of equilibria under free trade and protection, however, remains the same. Thus, the free trade per unit prices of the product and material input determine the vertical intercept of the unit isocost curve <u>Ob</u>, and the tangency solution at point <u>a</u> in turn defines the horizontal intercept <u>Oc</u>, and the price of factor f.

The introduction of protection under conditions of substitutability between i and f means that for any $t_j \neq t_i$ the point of tangency moves away from point <u>a</u>. For some $t_j > t_i$ that yields the vertical intercept <u>Od</u>, the tangency point moves along the isoquant to point <u>g</u>. Equilibrium at <u>g</u> involves a greater increase in the price of factor f, and the use of <u>less</u> f and <u>more</u> i per unit of j produced than if no substitution had been allowed. This means that the proportionate increase in the price of f is greater than the proportionate increase in value added per unit of output. For $t_j < t_i$, the vertical intercept of the unit isocost curve is lowered to, say, <u>Or</u>, yielding a tangency solution at <u>h</u>. Again, protected equilibrium under conditions of substitution permits a price of factor f that is higher than had there been no substitution. But, in this case the use of factor f has increased, and that of input i decreased per unit of output. Consequently, the proportionate change in value added per unit of output in this case will be larger than the proportionate change in the price of factor f. These results are summarized in Table I.

Figure IV

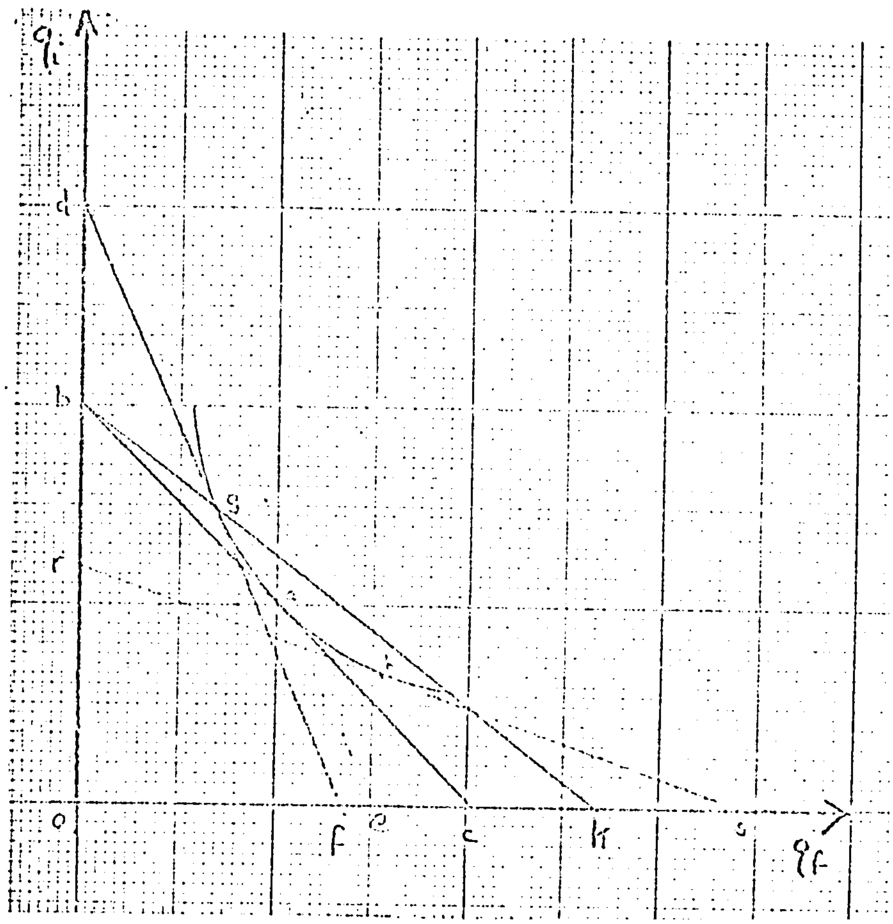


Table I: Proportionate Changes in the Primary Factor Price and Per Unit Value Added

Substitution Elasticity	$t_j > t_i$	$t_j = t_i$	$t_j < t_i$
Zero	$\frac{dP_f}{P_f} = \frac{dv_j}{v_j}$	$\frac{dP_f}{P_f} = \frac{dv_j}{v_j}$	$\frac{dP_f}{P_f} = \frac{dv_j}{v_j}$
Positive	$\frac{dP_f}{P_f} > \frac{dv_j}{v_j}$	$\frac{dP_f}{P_f} = \frac{dv_j}{v_j}$	$\frac{dP_f}{P_f} < \frac{dv_j}{v_j}$

Let f_j be the proportionate change in the price of the primary factor, and let z_j be the proportionate change in value added per unit of output. Clearly, if for one case $f_j > z_j$, while for another $f_j < z_j$, the identity between the two that existed under conditions of fixed physical input coefficients has broken down. We must, therefore, reexamine our definition of the effective rate of protection. We will consider the impact of protection on each of f_j and z_j, and then turn to the problem of definition.

To simplify the analysis we have chosen to work with a constant elasticity of substitution production function relating inputs of material i and factor f to the output of good j.[14] In this way we avoid complications that would arise from variation in the elasticity of substitution as the relative prices change.[15] Consider the following form for domestic production

$$S_j = \left(\alpha_{ij} S_{ij}^{-\beta} + \alpha_{fj} S_{fj}^{-\beta}\right)^{-\frac{1}{\beta}}$$

where the S's represent the same quantitites as before, but with the country superscripts omitted to avoid confusion with the exponents, the α's represent "distribution parameters,"[16] and β is a substitution parameter related to the elasticity of substitution (σ) between the two inputs in the following way:

$$\sigma = \frac{1}{1 + \beta}$$

By way of illustration Figure V contains a family of such functions with the α's set at 1/2, and various selected values of σ from zero to infinity.[17]

From the production function it is possible to derive input demand functions[18]

$$S_{ij} = \frac{P_j^{\sigma} S_j \alpha_{ij}^{\sigma}}{P_i^{\sigma}}$$

$$S_{fj} = \frac{P_j^{\sigma} S_j \alpha_{fj}^{\sigma}}{P_f^{\sigma}}$$

With some manipulation

$$\alpha_{ij}^{\sigma} = \frac{S_{ij} P_i^{\sigma}}{S_j P_j^{\sigma}}$$

$$\alpha_{fj}^{\sigma} = \frac{S_{fj} P_f^{\sigma}}{S_j P_j^{\sigma}}$$

Clearly, the right hand sides are the value coefficients from an input output table. These may be in either protected or free trade prices.

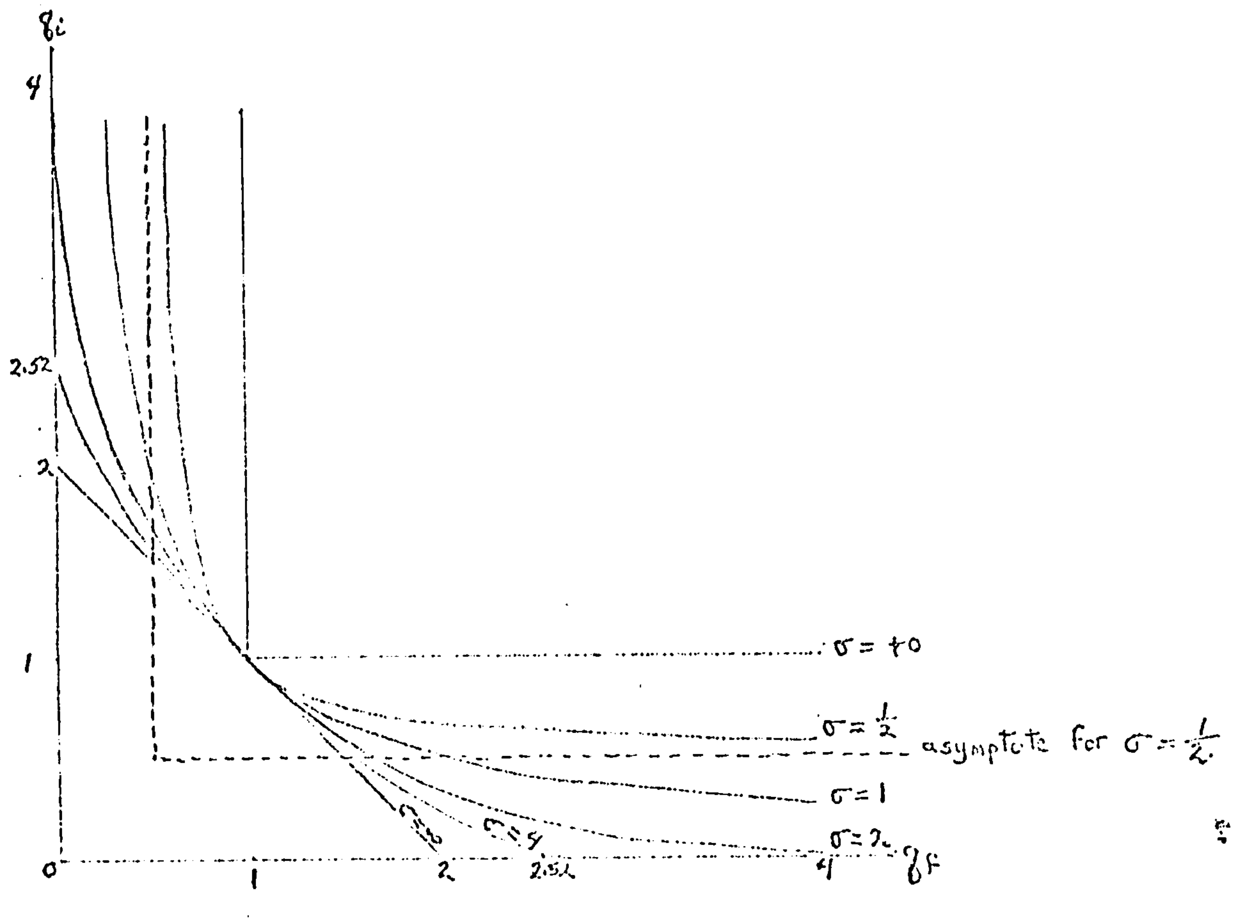
From the production function it is also possible to derive the minimum unit cost function as a function of the distribution parameter , the input prices, and the elasticity of substitution.[19] Setting the minimum unit cost function equal to the unit price, we have

$$P_j = \left[\alpha_{ij}^{\sigma} P_i^{1-\sigma} + \alpha_{fj}^{\sigma} P_f^{1-\sigma}\right]^{\frac{1}{1-\sigma}} .$$

Substituting the input-output value ratios for the appropriate distribution parameters we have under free trade

$$P_j = P_j = \left[a_{ij} P_i^{1-\sigma} + v_j P_f^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Figure V



and under protection

$$P_j = \left[a'_{ij}P_i^{1-\sigma} + v'_j P_f^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

Now, since our concern is with relative price changes, set each price equal to unity. Then under free trade

$$(1)^{1-\sigma} = a_{ij}(1)^{1-\sigma} + v_j(1)^{1-\sigma}$$

Inflating to protected prices

$$(1+t_j)^{1-\sigma} = a_{ij}(1+t_i)^{1-\sigma} + v_j(1+f_j)^{1-\sigma}$$

and solving for f_j

(6) $$f_j = \left[\frac{(1+t_j)^{1-\sigma} - a_{ij}(1+t_i)^{1-\sigma}}{v_j}\right]^{\frac{1}{1-\sigma}} - 1.$$

Under protection

$$(1)^{1-\sigma} = a'_{ij}(1)^{1-\sigma} + v'_j(1)^{1-\sigma}$$

and deflating to free trade prices

$$\left[\frac{1}{(1+t_j)}\right]^{1-\sigma} = a'_{ij}\left[\frac{1}{(1+t_i)}\right]^{1-\sigma} + v'_j\left[\frac{1}{(1+f_j)}\right]^{1-\sigma}$$

and again solving for f_j, we obtain

(7) $$f_j = \frac{1}{\left[\frac{\left\{\frac{1}{(1+t_j)}\right\}^{1-\sigma} - a'_{ij}\left\{\frac{1}{(1+t_i)}\right\}^{1-\sigma}}{v'_j}\right]^{\frac{1}{1-\sigma}}} - 1.$$

To visualize the significance of substitution when protection is imposed, consider any set of tariff rates t_j and t_i. Together they yield a new vertical intercept of the isocost curve in Figure V. For $\sigma = 0$, the vertical intercept and the "corner" of the isoquant yield a horizontal intercept which involves a certain f_j. As σ increases from zero the tangency solution moves farther away from the original "corner" and the horizontal intercept becomes smaller and smaller while f_j becomes larger and larger. In other words, the greater σ, the greater f_j for any set of $t_j \neq t_i$.

If one is working from protected prices, however, failure to allow for substitution yields an overstatement of f_j. This may be seen by reference to Figure IV. From the protected equilibrium at point g, if one does not allow for the substitution that has already taken place, the free trade unit isocost curve that would be calculated under the assumption of fixed physical input coefficients would be hk, not the true free trade isocost curve hc. Acceptance of hk rather than hc implies that protection reduced the horizontal intercept from Ok to Of, when in fact protection only reduced it from Oc to Of. Thus, the fixed physical input coefficient assumption yields an overstatement of f_j when protected data are used.[20]

We turn now to the impact of protection on z_j under conditions of substitutability. The elasticity of substitution, together with the relative rates of t_j and t_i, determines whether the relative share of factor f increases or decreases. The various possibilities are summarized in Table II.

To show the size of z_j the relationship between V_j'/X_j' and V_j/X_j must be specified. We know that at world prices

$$1 = \frac{V_j}{X_j} + \frac{X_{ij}}{X_j} .$$

Protection increases the per unit price of good j at the rate t_j. At the same time, it changes the value of the primary factor per unit of the original output at the rate z_j, and changes the value of the material

Table II: Relative Shares of the Primary Factor

Substitution Elasticity	$t_j > t_i$	$t_j = t_i$	$t_j < t_i$
$\sigma = 0$	$\frac{V_j'}{X_j'} > \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} < \frac{V_j}{X_j}$
$0 < \sigma < 1$	$\frac{V_j'}{X_j'} > \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} < \frac{V_j}{X_j}$
$\sigma = 1$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$
$1 < \sigma < \infty$	$\frac{V_j'}{X_j'} < \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} = \frac{V_j}{X_j}$	$\frac{V_j'}{X_j'} > \frac{V_j}{X_j}$

input, again per unit of the original output, at the rate w_i. Thus

$$1(1 + t_j) = \frac{V_j}{X_j}(1 + z_j) + \frac{X_{ij}}{X_j}(1 + w_i),$$

and calculating the protected shares per unit of the protected situation

$$1 = \frac{V_j}{X_j}\frac{(1 + z_j)}{(1 + t_j)} + \frac{X_{ij}}{X_j}\frac{(1 + w_i)}{(1 + t_j)} .$$

In the protected situationthe relative shares are

$$1 = \frac{V_j'}{X_j'} + \frac{X_{ij}'}{X_j'} .$$

Hence, the relationship between the shares of the primary factor in the free trade and protected situations is

$$\text{(8)} \qquad \frac{V_j'}{X_j'} = \frac{V_j}{X_j}\frac{(1 + z_j)}{(1 + t_j)} \quad \text{or} \quad \frac{V_j'/X_j'}{V_j/X_j} = \frac{1 + z_j}{1 + t_j}$$

Equation (8), together with Table II, enables us to specify the relationships between z_j and t_j that are contained in Table III.

Table III. Proportionate Changes in Per Unit Value Added

Substitution Elasticity	$t_j > t_i$	$t_j = t_i$	$t_j < t_i$
$\sigma = 0$	$z_j > t_j > t_i$	$z_j = t_j = t_i$	$z_j < t_j < t_i$
$0 < \sigma < 1$	$z_j > t_j > t_i$	$z_j = t_j = t_i$	$z_j < t_j < t_i$
$\sigma = 1$	$z_j = t_j > t_i$	$z_j = t_j = t_i$	$z_j = t_j < t_i$
$1 < \sigma < \infty$	$z_j < t_j > t_i$	$z_j = t_j = t_i$	$z_j > t_j < t_i$

The first row of Table III contains the original relationships of the Johnson and Corden analysis. In the second row the same general relationships hold, (but further analysis would be necessary to specify the size of z_j where $t_j \neq t_i$ as between the two degrees of substitution). The third row contains the most startling result of all: if the effective rate of protection is defined as the proportionate change in value added per unit of output, for $\sigma = 1$, z_j always equals t_j. If this were the general case, we could simply revert to considering the nominal tariff rates as indicating the resource allocation effects of a tariff structure. Finally, for $\sigma > 1$, results opposite to the case of $0 \leq \sigma < 1$ are found.

To determine which of f_j or z_j is the appropriate measure of the effective rate of protection, consider a simple case in which the only difference is the elasticity of substitution between i and f. There is domestic free trade production of three tradable goods, A, B, and C, all of which have the same value added coefficients. Their material inputs are available at constant costs, and the elasticity of supply of factor f to each is identical. Finally, assume the elasticity of substitution between the primary factor and the material input in domestic production of good A is zero; in B it is one; and in C it is greater than one. Suppose now that equal tariff rates are imposed on imports of A,B, and C. If the effective rate of protection is defined as z_j, we would say that the scale of protective rates in ascending order is C,B, A.[21] If, on the other hand, we define the effective rate of protection as f_j, we would say that the scale of protective rates ascends A,B,C.

Recall that the purpose of the concept of effective protection is "to shed light on the direction of the resource allocation effects of a protective structure,"[22] and that the limitation on expansion of production is the elasticity of supply of factor f to the industry in the case where $e_{ij} = \infty$. Clearly, then, the scale of expansion of production is A,B,C, in ascending order, for production of good A is able to increase the price it can pay to the primary factor less then B can, and both are less than C. This occurs because the greater the economizing by substitution, the greater the expansion of production for a given outputtariff. We may conclude, therefore, that f_j (the proportionate change in the price of the primary factor) is the appropriate definition of the effective rate of protection.[23]

IV. Sensitivity

The crucial test of any theoretical refinement is the extent to which it alters the results that otherwise would be obtained. Recall that the purpose of the analysis is to derive a scale of effective protective rates. The scale tells us the relative magnitudes and the direction of the resource pulls instituted by the tariff structure. Consequently, if the relative magnitudes or if the positions on the scale of rates are significantly changed by taking into account the refinements we have introduced here, we may conclude that they are important.

We have made some tentative calculations of effective protective rates for sixteen import-competing manufacturing sectors of Taiwan using available tariff and production data, and assuming various supply and substitution elasticities.[24] The estimating formula was equation (7) in which the $a'_{ij}(1/1 - t_i)^{1-\sigma}$ was summed over all supplying industries. The elasticity of substitution was set successively at 0, 1/2, and 2.[25] The supply elasticity of non-traded inputs was set initially at infinity, which from (5) meant that dp_i/p_i of a non-traded input equals zero, and then set equal to the supply elasticity of the output.[26] In the former case this amounts to $t_i = 0$, and in the latter to $t_i = t_j$ whenever i is a non-traded good in (7).

The results, contained in Table IV, demonstrate that these two modifications do in fact work considerable changes on the magnitudes and rankings of the effective rates of protection.

Consider first a comparison of the nominal rates with the effective protective rates calculated under the usual assumptions of zero elasticity of substitution and infinitely elastic supplies of all non-factor inputs (columns 1 and 2). The usual results are present, generally higher effective protective rates than nominal rates (some spectacularly so), but some lower, with even one negative rate, and several ranking changes. This is usually as far as the analysis is taken. The implicit assumption is that although the rates of column 2 may not correspond exactly to the true effective rates, any differences that might arise from failure to consider matters such as substitution and non-traded inputs are not significant enough to change the conclusions. We will consider the impact of

Table IV. Estimated Nominal and Effective Protective Rates and Rankings by Protective Rates
(Ranks in Ascending Order, Protective Rates in Percentage)

	1		2		3		4		5		6		7	
Sector #	Rank	Rate	Rank	Rate	Rank	Rate	Rank	Rate	Rank	Rate	Rank	Rate	Rank	Rate
16.	9	30.2	12	74.2	12	68.1	10	37.3	10	42.3	11	55.2	10	35.1
17.	16	43.9	11	66.0	11	62.2	11	53.5	11	51.6	12	58.7	12	51.6
18.	13	39.2	14	137.9	14	113.9	15	98.4	15	88.2	14	82.3	15	70.7
19.	1	5.0	1	-2.3	1	-2.9	1	-4.3	1	-5.0	1	-4.9	1	-7.2
20.	6	24.8	6	43.6	6	41.4	5	20.5	5	20.2	6	35.5	5	18.8
21.	12	35.0	16	570.0	16	240.6	12	57.7	12	55.3	16	118.1	13	52.6
22.	7	26.6	9	56.0	9	51.4	6	21.1	6	20.4	8	42.5	6	19.1
23.	11	31.9	10	64.1	10	60.4	13	57.9	12	55.3	10	54.4	11	51.2
25.	15	41.7	13	89.9	13	102.9	14	64.2	14	62.6	13	69.6	14	58.0
27.	10	30.6	8	53.8	8	51.3	8	33.6	8	33.4	9	45.7	8	32.8
26.	8	27.5	7	44.2	7	43.0	9	36.9	9	36.5	7	39.2	9	34.5
28.	3	19.9	3	19.5	3	19.3	4	14.9	4	14.8	3	18.1	4	14.0
29.	2	17.3	2	5.7	2	4.5	2	1.7	2	0.5	2	2.3	2	-2.0
30.	5	24.3	5	36.9	5	34.7	7	21.6	7	20.6	5	33.2	7	21.8
31.	4	20.4	4	23.9	4	22.4	3	12.1	3	11.2	4	19.6	3	9.3
32.	14	39.4	15	193.9	15	146.4	16	140.4	16	120.7	15	92.7	16	84.0

Note: Column and row identification on following page.

Table IV Notes:

Column 1 - nominal rate.
Column 2 - effective rate with zero substitution and non-traded $dp/p = 0$.
Column 3 - effective rate with substitution elasticity = 0.5 and non-traded $dp/p = 0$.
Column 4 - effective rate with zero substitution and non-traded $dp/p = t_j$.
Column 5 - effective rate with substitution elasticity = 0.5 and non-traded $dp/p = t_j$.
Column 6 - effective rate with substitution elasticity = 2 and non-traded $dp/p = 0$.
Column 7 - effective rate with substitution elasticity = 2 and non-traded $dp/p = t_j$.

Sectors:

16. Pulp and paper and products thereof.
17. Leather and products thereof.
18. Rubber and products thereof.
19. Chemical fertilizer.
20. Drugs and medicines.
21. Plastic and products thereof.
22. Miscellaneous chemical products.
23. Petroleum products.
25. Miscellaneous non-metallic products.
26. Iron and steel.
27. Aluminum and products thereof.
28. Miscellaneous metal products.
29. Machinery.
30. Electrical machinery and appliances.
31. Transportation equipment.
32. Miscellaneous manufactures.

each separately, then the two together.

The impact of permitting substitution can be seen by comparing column 2 with 3, and 2 with 6 in Table IV. Changing the substitution elasticity from zero to 0.5 reduced all rates, but did not change any of the rankings. The high rates of sectors 18, 21, and 32 were reduced substantially more than the others, however, yielding a different impression of the relative degrees of protection. Thus, to take an extreme example, under zero substitution one would say that the rate at which industry 21 is protected is 100 times the rate at which industry 29 is protected. Yet, for a substitution elasticity of 0.5, the relative rate of protection between the two industries was cut almost in half.

A substitution elasticity of 2 reduced all rates more, and even changed some of the rankings. Under the traditional assumption of zero elasticity of substitution one would say that industry 22 is more protected than industry 27. Yet, if both industries have an elasticity of substitution of 2 between the material inputs and the primary factor, industry 27 is more protected than industry 22. Similarly, the rankings of industries 16 and 17 were changed by a substitution elasticity of 2. Clearly, then, the failure to consider substitution in the conventional manner of estimation could lead to erroneous conclusions about the relative magnitudes of the protective rates, and possibly even the rankings.

The effect of allowing for less than infinitely elastic supplies of non-traded material inputs can be seen by comparing column 2 with 4. Again, all the rates were reduced, and the reductions were such as to yield conclusions substantially different from those that would be drawn from effective protective rates calculated in the traditional manner. Not only are the relative magnitudes of protection different, but there are twelve industries which changed rank, six of which changed more than one position. An extreme case in industry 21: under the conventional procedure it is the most protected industry (rank 16), but by allowing for less than infinitely elastic supplies of non-traded material inputs, industry 21 became the twelfth most protected industry. This and other changes are tabulated in Table V.

Table V. Changes in Ranking of Industries from Less than Infinitely Elastic Supplies of Non-Traded Inputs

Industry #	Direction of Change	Original Rank	New Rank
16	down	12	10
18	up	14	15
20	down	6	5
21	down	16	12
22	down	9	6
23	up	10	13
25	up	13	14
26	up	7	9
28	up	3	4
30	up	5	7
31	down	4	3
32	up	15	16

Four industries (numbers 20, 22, 30, and 31) whose effective rates exceeded their nominal rates in the conventional analysis had their rates reduced to less than their nominal rates as a consequence of allowing for less than infinitely elastic supplies of non-traded inputs.

Generally, allowance for non-traded inputs reduced the effective protective rates more than allowance for substitution. For an elasticity of substitution of 0.5 only in the case of industry 32 was the reduction due to substitution greater, but for a substitution elasticity of 2, industries 18, 19, and 23 were also affected more by substitution than by non-traded inputs.

Finally, consider the result of simultaneously allowing for substitution and non-traded inputs. The net effect of the two influences combined can be seen by comparing column 2 with 5, and 2 with 7. Again, the effective protective rates are all substantially lower, and several rankings are different. Further, they are all lower than the rates obtained from either modification individually. However, because the increase in the price of non-traded inputs reduced the extent of substitution, the net rates in column 5 or column 7 are not substantially lower than the rates in column 4, except in the cases of very high initial effective protective rates.

VII. Conclusion

The conclusion is clear. Allowing for less than infinitely elastic supplies of non-traded inputs and substitution between material inputs and the primary factor substantially alters the estimated effective protective rate, and the alteration in many cases is likely to be sufficient to change the conclusions that one would draw from the scale of rates.

These advances, however, have not been achieved without a substantial augmentation of data needs for empirical estimation. At least two additional questions must now be answered before one proceeds with empirical work. Does the supply elasticity of a non-traded input differ significantly from the supply elasticity of the final good? Is there some one elasticity of substitution that is the general case, or does it differ significantly between industries?

Finally, there are important aspects of the impact of protection that remain to be explored, both theoretically and empirically. Matters such as the disaggregation of the "primary factor" to distinguish among, say, land, labor, and capital, the implications of abandoning the linearly homogeneous production function, and the dynamic characteristics of how equilibrium is reached, are all important to our more complete understanding of how a protective structure affects resource allocation.

Footnotes:

1. The initial contributions include: C.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); and Swedish Customs Tariff Commission, Revision of the Swedish Customs Tariff (Stockholm, 1957). Later works of a theoretical nature include W.M. Corden, "The Structure of a Tariff System and the Effective Protective Rate," Journal of Political Economy (June 1966); H.G. Johnson, "Tariffs and Economic Development," Journal of Development Studies (October 1964); H.G. Johnson, "The Theory of Tariff Structure with Special Reference to World Trade and Development," in H.G. Johnson and P.B. Kenen, Trade and Development (Geneva: Librairie Droz, 1965); R.I. McKinnon, "Intermediate Products and Differential Tariffs: A Generalization of Lerner's Symmetry Theorem," Quarterly Journal of Economics (November 1966); and W.P. Travis, The Theory of Trade and Protection (Cambridge: Harvard University Press, 1964). Empirical estimates have been prepared and published by B. Balassa, "Tariff Protection in Industrial Countries: An Evaluation," Journal of Political Economy (December 1965); 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 (May 1966); John H. Power, "Import Substitution as an Industrialization Strategy," Philippine Economic Journal (forthcoming); and R. Soligo and J.J. Stern, "Tariff Protection, Import Substitution and Investment Efficiency," Pakistan Development Review (Summer 1965).

2. One assumption that is not necessary is the absence of monopoly in the domestic market. An attempt by a monopolist to restrict output in order to raise his price would be met with failure. Foreign supplies would make up the contraction at the constant foreign price (plus tariff if any). Hence, the net domestic demand curve facing the monopolist is horizontal at the competitive domestic price.

3. Under certain assumptions differentiation of domestic and foreign products will not affect this condition, for it can be shown that the price paid to the domestic producer will rise by the proportion of the tariff rate. Assuming that the domestic product sells at some constant percentage discount from the price of the foreign good, then $p_j^d = p_j^f(1 - d_j)$ where the superscripts d and f represent domestic and foreign products respectively, and d_j is the rate of discount at which the domestic product sells. The tariff raises the price of the foreign product: $p_j^{f'} = p_j^f(1 + t_j)$, and in turn $p_j^{d'} = p_j^{f'}(1 - d_j)$. Then $p_j^{d'} = p_j^f(1 + t_j)(1 - d_j)$, and therefore $p_j^d(1 + t_j) = p_j^{d'}$. I.e., the proportionate increase in the price of the domestic product equals the per unit tariff rate.

4. See W.M. Corden, 1966, op. cit., particularly p. 222.

5. The geometry of Figures I and II may also be used to demonstrate another characteristic of the basic model. As several writers, including Johnson, 1965, op. cit., and Corden, 1966, op. cit., have pointed out, if $t_j = a_{ij}t_i$, then $f_j = 0$, and if $t_j < a_{ij}t_i$, then $f_j < 0$. A zero or negative effective protective rate means the production would not change in the jth industry, or would decline, respectively. Thus, in Figures I and II if in addition to the tariff $t_j = 0.2$ we introduce a tariff rate on good i sufficient to make $t_j = a_{ij}t_i$, (i.e., $t_i = 0.5$), the intercept on the i axis in Figure I falls by the proportion t_j, yielding an unchanged p_f. In Figure II the same reaction is seen when the absolute size of the upward shift in S_j^2 due to t_i yields an upward shift in S_j^1 which equals the absolute size of the per unit tariff on imports of j. The tariffs on i and j just offset each other in both cases, and there is no change in the quantity of good j produced domestically. If, however, $t_j < a_{ij}t_i$, then in Figure I the intercept on the i axis falls by more than t_j, resulting in a decrease in p_f. In Figure II, the new production point would be to the left of x.

6. W.P. Travis, op. cit.

7. R.I. McKinnon, op. cit.

8. W.M. Corden, 1966, op. cit.

9. B. Balassa, op. cit., p. 578.

10. G. Basevi, op. cit.

11. W.M. Corden, 1966, op. cit., p. 228.

12. Similarly, R.I. McKinnon, op. cit., p. 612, employs "vertical integration to the extent of eliminating domestic non-tradable intermediate inputs" by assigning the non-tradables content to value added.

13. W.M. Corden, 1966, op. cit., p. 228.

14. For a convenient summary of the CES production function see J.S. Chipman, "A Survey of the Theory of International Trade: Part 3, The Modern Theory," Econometrica (January 1966), pp. 58 ff.

15. It should be noted that a particular characteristic of the CES production function may place a limit on the size of f_j. In Figure V, for example, if $\sigma = 4$, and should t_j be sufficiently large relative to t_i to raise the vertical intercept of the isocost curve above 2.52, the value of f_j would be negative. Thus, for some $\sigma > 1$, the unit isoquant intersects the axes, limiting the extent of substitution and hence the size of f_j.

16. Cf. J.S. Chipman, op. cit., p. 59.

17. Figure V is adapted from ibid., Figure 3.11, p. 58.

18. Ibid., pp. 59-60.

19. The derivation may be found in ibid., p. 59.

20. This is the same conclusion reached by W.M. Corden, 1966, op. cit., p. 235, although by a different route, and conforms with the possibility, suggested by Basevi, op. cit., p. 150, that in extreme cases one obtains absurd results of negative rates from the fixed physical coefficient assumption. For some set of $t_i > t_j$ in Figure IV the vertical intercept Od would rise sufficiently to yield a protected equilibrium point g that is higher than the free trade vertical intercept Ob. The line bg in such a case would have a positive slope, implying a negative free trade price of factor f, and hence a negative value added at free trade prices: clearly an absurd result.

21. For good A, $z = t/v$; for B, $z = t$; for C, $z < t$.

22. W.M. Corden, 1966, op. cit., p. 227.

23. The basic idea is found in R.I. McKinnon, op. cit., p. 614, but not elaborated. The reader will note also that, despite the selection of f_j as the appropriate indicator of the production allocation effects of a tariff structure, z_j may nevertheless be a useful measure for other purposes, particularly to determine whether or not net activity in a particular process has been stimulated.

24. A description of the data sources and estimating procedure is contained in an Appendix available on request from the author.

25. These elasticity coefficients were selected primarily to facilitate computation of the rates. Another elasticity coefficient that could have been selected was unity. Unfortunately this is a special case, and turns out to be much more difficult computationally. Thus, in (7), for $\sigma = 1$, f_j has no meaning. But, since the case of $\sigma = 1$ is the Cobb-Douglas type, we can work directly from a Cobb-Douglas production function in which a_{ij} and v_j are the (constant) exponents. Setting the unit cost function (see J.M. Henderson and R.E. Quandt, *Microeconomic Theory* (New York: McGraw-Hill Book Co., 1958), pp. 66-67 for the derivation) equal to p_j.

$$p_j = \frac{p_i^{a_{ij}} \cdot p_f^{v_j}}{k}$$

where $k = A \cdot a_{ij}^{a_{ij}} \cdot v_j^{v_j}$, which is a constant, or

$$p_j \cdot k = p_i^{a_{ij}} \cdot p_f^{v_j}.$$

Since we are concerned with relative price changes, set $p_j k = 1$, $p_i = 1$, and $p_f = 1$. Then, deflating to free trade prices,

$$\frac{1}{1 + t_j} = \left[\frac{1}{1 + t_i}\right]^{a_{ij}} \cdot \left[\frac{1}{1 + f_j}\right]^{v_j}$$

and solving for f_j,

$$f_j = \frac{1}{\left[\left(\frac{1}{1 + t_j}\right) \div \left(\frac{1}{1 + t_i}\right)^{a_{ij}}\right]^{1/v_j}} - 1.$$

26. When $e_j = e_{ij}$, $t_j = f_j = dp_i/p_i$, and thus the protection is shared equally between the primary factor and the non-traded input. This is similar to an approach first used by J.S. Mill and recommended by Viner: "Cf. J.S. Mill's treatment of the division of gain from international trade where the same problem of the *a priori* probabilities arises: 'The advantage will probably be divided equally oftener than in any one unequal ratio that can be named; though the division will be much oftener, on the whole, unequal than equal.' (On some unsettled questions, 1844, p. 14.)" J. Viner, Studies in the Theory of International Trade (London: Allen and Unwin, Ltd., reprinted 1960), p. 326n.

Appendix: Data Sources and Estimating Procedures

1. Production Data

The production data ideally should include prices and quantities of output and inputs for each process whose product is tradable. Such data are seldom recorded for anything more than a small subset of processes in even the advanced countries, and further, their collection is generally beyond the reach of the non-governmental researcher. The production data that are available have been subjected to aggregation, sometimes a substantial amount. Consequently, we are confined to a consideration of processes which have been aggregated on a value basis.

For Taiwan the 1961 input-output table[1] provided us with input-output coefficients in value terms for the 36 producing sectors distinguished. Unfortunately, the classification is on the basis of type of material produced rather than on the level of fabrication. For example, sector 18, "Rubber Products," includes both natural and synthetic rubber used as raw materials, and final goods such as rubber tires, gloves, and footwear. Further, the table does not distinguish between competitive and non-competitive imports, so we have had to utilize the coefficients that exclude all imports. And, finally, for each sector there is a row of unallocated inputs whose source is not identified. Since for those there is no known tariff rate, we had to adopt some arbitrary procedure: we assigned the unallocated input the weighted average tariff rate on all the other inputs used by the sector.

2. Tariff Data

National tariff schedules generally classify goods on the level of detail at which goods move in international trade, and the Taiwan schedule[2] is no exception. The classification of import commodities contains almost 800 sections, many of which are subdivided two or more times. This is obviously much more detailed than the industry classification, raising the problem of how to combine several tariff items to obtain a single rate for each input-output sector. None of the various weighting procedures is entirely satisfactory. Weighting by value of domestic imports yields a low-duty bias because of the relative stimulus given to the import of low duty items. Weighting by domestic production yields an opposite bias. Weighting by the value of world trade introduces a low-duty bias, although offsetting inter-country differences may tend to reduce the bias. A procedure that I have suggested elsewhere,[3] weighting each nominal tariff item by the proportion (at world prices) of domestic production plus imports which the corresponding subsector represents in the total output of the sector, yields an offsetting of the biases of import and production weights. This, however, is clearly impractical for the non-governmental researcher. It would require a complete breakdown of the input-output table, showing the composition of production plus imports at the level of detail found in the tariff schedule. Finally, simple unweighted averaging of the tariff rates in each sector, which relies on the "law of large numbers" to overcome whatever biases may be present, assigns equal weight to each classification in the tariff schedule that happens to fall within a particular sector.

For the purposes of illustrating the impact of our modifications on the traditional estimates of effective protective rates we used simple unweighted averages of tariff rates on the grounds that limitations in the other data used did not justify a more refined weighting procedure.

Selection of an averaging procedure does not solve all the problems of specifying the appropriate nominal tariff rates.[4] In addition there may be a number of cases in which the tariff rate does not represent the true impact of the tariff structure on the domestic price. Overstatement of the impact may arise from: (a) scheduled tariffs on export goods which are identical in price domestically and internationally, (neglecting transport costs and in the absence of price discrimination between domestic and foreign markets); (b) "excessive" tariffs rates that are more than enough to eliminate imports; and (c) price control. In the other direction, quantitative restrictions on either the goods or money side may limit imports to less than would be the case if the tariff alone were operating, yielding an understatement of the price-raising effect of the trade barrier.

Unfortunately not all of these are identifiable at the aggregated level of the Taiwan input-output table. Practically every sector contains some items for which one or more of the above over or under-statements might be found. We were unable to devise any meaningful way of taking into account quantitative restrictions, price control, or "excessive" tariff rate at this aggregate level, for in no sector does any appear to have a differential impact.

Export goods, however, do seem to be concentrated in a few sectors. But, since it was impossible to define unambiguously an export sector, we arbitrarily selected as export sectors (and therefore assigned a zero tariff rate) those in which the net export balance constitutes 10% or more of the domestic production. Under this definition the following industries were considered export industries in the calculations:

#10. Sugar

#11. Canned Food

#14. Textiles

#15. Lumber and Plywood

#24. Cement and Cement Products

These sectors account for almost 50% of total exports, while exports of all the remaining sectors that showed a positive export balance totalled less than 5% of exports.

Finally, the theory assumes that the tariff rates are expressed as a percentage of the C.I.F. value. However, the value on which the Taiwan tariff is levied is defined as:[5]

$$\text{dutiable value} = \frac{\text{wholesale market value}}{1 + \text{tariff rate} + 0.14} .$$

As this probably approximates the C.I.F. value, we made no attempt to adjust the calculations.

3. Non-Traded Inputs

There are three supplying service sectors in the Taiwan input-output table that are clearly non-traded: #34, Electricity Supply; #35, Water Supply; #36, Transportation, Communication, and Miscellaneous Services. Of the material inputs used, the high degree of aggregation hides all but #2, Sugar Cane. In the calculations these industries were treated as non-traded.

4. Substitution Elasticities

For Taiwan we have no information about the magnitude of the substitution elasticities between each material input and the primary factor. However, to demonstrate the importance of a non-zero substitution elasticity we calculated the effective protective rates under the traditional assumption of zero substitution elasticities, and then arbitrarily selected two alternative substitution elasticities of 0.5 and 2, and recalculated the effective protective rates under each.

Appendix Footnotes

1. Republic of China, Council for International Economic Cooperation and Development, Executive Yuan, "Taiwan's Interindustry Relations Table for 1961 (37 Sectors)," Taipei, September 1964. Unfortunately a more refined table now under construction will not be available for several months.

2. Republic of China, Customs Import and Export Tariff of the Republic of China, (Taipei: Taiwan Trading Book Store, 1966).

3. J. Clark Leith, "The Specification of Nominal Tariff Rates in Effective Protection Estimates," Philippine Economic Journal (forthcoming).

4. See ibid.

5. U.S. Department of Commerce, Overseas Business Reports, 64-89, "Foreign Trade Regulations of Taiwan," (September 1964), p. 1.