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Raveendra Batra

Francisco R. Casas

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TRADED AND NON-TRADED INTERMEDIATE INPUTS
EFFECTIVE PROTECTION AND REAL WAGES *

by

Raveendra N. Batra
and
Francisco R. Casas

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Traded And Non-Traded Intermediate Inputs, Effective Protection, And Real Wages

Introduction

Following the pioneering theoretical contributions of Johnson [17] and Corden [10], a rich literature has evolved concerning the implications of effective tariff rates, as distinguished from the nominal rates, for the allocation of resources usually in a small country which in its trading relations with the rest of the world takes the international prices as given. The effective rate of protection (ERP) for an importable commodity takes into account not only its nominal tariff, which tends to raise its output, but also tariffs on intermediate inputs which, by raising the cost of production, tend to lower its output. The final result, which is the outcome of these two opposing forces, is that unless the nominal tariff rates on the final and intermediate inputs are identical, the ERP on the final commodity differs from its nominal rate and may even be negative. It is then possible that a commodity may be nominally protected but "effectively" unprotected.¹

The bulk of the earlier ERP literature has been cast in the partial equilibrium, fixed coefficients mould, ² and in this sense at least, the development of the new theory of protection constitutes a surprising departure from most other recent developments in trade theory where the analytical ingredients have been provided by and large by the well known Heckscher-Ohlin, general equilibrium model. More recently, however, trade theorists have begun to take stock of the deficiencies in the earlier ERP literature by introducing variable production coefficients in the general equilibrium models. Jones [18] has introduced an imported input in the usual two-commodity,
two-factor model and derived sufficient conditions under which the ERP concept can be used in ranking an industry in terms of the level of its effective tariff. This is a very useful and important extension of the ERP analysis, but unlike several partial equilibrium studies which consider both non-traded and traded inputs, Jones ignores the consequences arising from the presence of non-traded material inputs.

One purpose of this paper is to generalize Jones' results to a model that incorporates both the traded and non-traded intermediate inputs. The major result in this connection is to show that the substitution possibilities between traded and non-traded material inputs are significant determinants of the movement of resources between different commodities. It may be argued that the imported inputs, say oil, coal, etc., are better substitutes of non-traded material inputs, like, say, electricity, gas, etc., than of the non-traded primary factors. To this extent then the neglect of non-traded material inputs would introduce a bias in the results.

The customary literature in trade theory abounds in the studies of the effects of protection on real factor rewards, the unambiguous analysis of which was first provided by Stolper and Samuelson [26]. However, Stolper and Samuelson and others who have extended their results consider only the nominal tariffs. Another purpose of this paper then is to explore the implications of the ERP for the real wages of the primary factors.
I. Development of the Model and Its Structural Relations

It is assumed that there are three domestically produced commodities: \( X_1 \), the importable good, \( X_2 \), the exportable good, and \( M \), the non-traded intermediate product which is produced solely to be used as an input in the production of the importable good. A fourth commodity, \( Q \), is imported from abroad and used as an input again in \( X_1 \) but not \( X_2 \). The material inputs could also be utilized in \( X_2 \), but this would unnecessarily complicate the analysis without adding anything to the exposition. There is perfect competition in all markets, production functions exhibit constant returns to scale and two primary factors, labor (\( L \)) and capital (\( K \)), are inelastically supplied and fully employed. World prices of all traded commodities are constant, but domestic prices of the importables as well as the non-traded input may be altered due to the imposition of tariffs.

The three production functions are given by:

\[
X_1 = F_1(L_1, K_1, M, Q),
\]

\[
X_2 = F_2(L_2, K_2), \text{ and}
\]

\[
M = F_M(L_M, K_M),
\]

where \( L_j \) and \( K_j \) denote respectively the labor and capital inputs used in the production of the \( j^{th} \) commodity (\( j = 1, 2, M \)). With linearly homogeneous production functions, the entire information concerning the production surface can be summed up in the unit isoquant which denotes one unit of output. The production functions can then be expressed as

\[
F_1\left(\frac{L_1}{X_1}, \frac{K_1}{X_1}, \frac{M}{X_1}, \frac{Q}{X_1}\right) = F_1(a_{L1}, a_{K1}, a_{M1}, a_{Q1}) = 1,
\]

\[
F_2\left(\frac{L_2}{X_2}, \frac{K_2}{X_2}\right) = F_2(a_{L2}, a_{K2}) = 1, \text{ and}
\]

\[
F_M\left(\frac{L_M}{X_M}, \frac{K_M}{X_M}\right) = F_M(a_{L_M}, a_{K_M}) = 1.
\]
where \( a_{ij} \) represents the amount of the \( i^{th} \) factor per unit of the \( j^{th} \) product (\( i = L, K, M, Q; \) and \( j = 1, 2, M \)). With full employment,

\[
a_{L1} x_1 + a_{L2} x_2 + a_{LM} M = L
\]

and

\[
a_{K1} x_1 + a_{K2} x_2 + a_{KM} M = K
\]

Since \( M = a_{M1} x_1 \), these two equations can be written as

\[
(a_{L1} + a_{LM} a_{M1}) x_1 + a_{L2} x_2 = L
\]

and

\[
(a_{K1} + a_{KM} a_{M1}) x_1 + a_{K2} x_2 = K
\]

With perfect competition in product markets, unit costs reflect product prices. Let \( r \) stand for the reward of capital, \( w \) for the wage rate and \( P_j \) for the price of the \( j^{th} \) commodity (\( j = 1, 2, M, Q \)). Then

\[
a_{L1} w + a_{K1} r + a_{M1} P + a_{Q1} P = P_1
\]

and

\[
a_{L2} w + a_{K2} r = P_2
\]

If production coefficients are fixed, (1.1)-(1.5) describe the production side of the system. However, in the general case of variable coefficients, additional equations must be introduced in order to determine the input-output coefficients (\( a_{ij} \)'s). These are determined by the requirement that with linearly homogeneous production functions, each \( a_{ij} \) is itself a linear homogeneous function of input prices. In general, we may write

\[
a_{i1} = a_{i1}(w, r, P_M, P_Q)
\]

and

\[
a_{i2} = a_{i2}(w, r)
\]
\[ a_{iM} = a_{iM}(w, r). \]  

(1.8)

The solution of the production side of the model described by the system of equations (1.1)-(1.8) proceeds as follows: First, the three equations (1.3)-(1.5) containing three parameters, \( P_1 \), \( P_2 \) and \( P_Q \), can be solved to obtain three unknowns, \( w \), \( r \) and \( P_M \), in terms of the international prices of the traded goods and the input/output coefficients. We assume that this solution is unique.\(^5\) With \( w \), \( r \), \( P_M \) so determined and with \( P_Q \) exogenously given, \( a_{ij} \)'s can be solved from (1.6)-(1.8). These values in turn can be plugged in (1.1a) and (1.2a) to derive expressions for \( X_1 \) and \( X_2 \) in terms of the given supplies of K and L; finally \( a_{M1} \) and \( X_1 \) can be used to obtain \( M \). Hence the set of equations (1.1)-(1.8) specify a completely determinate production side of the model. The demand side will not be presented since the focus of the paper is on resource allocation and factor price changes brought about by changes in the domestic prices of the two importables, \( X_1 \) and \( Q \), through the imposition of tariffs.

Factor-intensities in the final products are defined by columns of the matrix A which is formed by incorporating the \( a_{ij} \)'s spanning the full employment equations (1.1a) - (1.2a):

\[
A = \begin{bmatrix}
a_{L1} + a_{LM} a_{M1} & a_{L2} \\
 a_{K1} + a_{KM} a_{M1} & a_{K2}
\end{bmatrix}
\]

As regards the price equations (1.3) - (1.5), the factor-intensities are specified by the rows of the A matrix, even though it does not contain \( a_{Q1} \); the reason for this asymmetry is attributable to the fact that although \( a_{Q1} \) enters into the determination of \( P_1 \) it absorbs no proportion of domestic primary factors, because \( Q \) is produced abroad. Since it is the proportion of the domestic primary factors used in the production of each commodity that determines its factor-intensity, the use of \( Q \) by \( X_1 \) entails no modification to the factor-intensities.
At this stage a distinction must be drawn between the net and the
gross capital/labor ratio in the first commodity, for \( X_1 \) is using not
only \( K_1 \) and \( L_1 \) directly but by utilizing \( M \) as an input, it is also using,
although indirectly, \( K_M \) and \( L_M \) embodied in the production of \( M \). Let \( k_n \)
denote the net capital/labor ratio and \( k_g \) the gross capital/labor ratio
in the first commodity. Then

\[
k_n = \frac{K_1}{L_1}
\]

and

\[
k_g = \frac{K_1 + K_M}{L_1 + L_M} = \frac{K_1}{L_1} + \frac{K_M}{L_M} \cdot \frac{M}{X_1} = \frac{a_{K1} + a_{KM}M}{a_{L1} + a_{LM}M}.
\]

Note that no distinction between the gross and the net capital/labor ratio
need be made in the case of the second commodity. It may now be observed
that the determinant of \( A \) is positive if \( X_2 \) is capital-intensive relative to
\( X_1 \) in the gross sense, that is, \( k_2 > k_n \), where \( k_2 = a_{K2}/a_{L2} \) is the capital/labor
ratio in the second commodity, because

\[
|A| = (a_{L1} + a_{LM}M)k_2 - (a_{K1} + a_{KM}M)k_2 > 0
\]

if

\[
\frac{a_{K2}}{a_{L2}} = k_2 > \frac{a_{K1} + a_{KM}M}{a_{L1} + a_{LM}M} = k_n.
\]

Without loss of generality, we assume hereafter that \( X_2 \) is the capital-intensive
commodity and \( X_1 \) the labor-intensive commodity in the gross or the "true"
sense, so that \( |A| > 0 \). However, this assumption does not rule out the possi-
ability that \( X_2 \) may be actually labor-intensive relative to \( X_1 \) in the net
sense, that is, \( k_2 \) may be less than \( k_n \) even if \( k_2 > k_g \), for \( |A| \) can be
written as:
\[ |A| = a_{L2} \left[ a_{L1} (k_2 - k_n) + a_{M1} a_{LM} (k_2 - k_M) \right], \]  

(1.9)

where \( k_M = K_M / L_M \). Clearly \( |A| \) may be positive, which implies \( k_2 > k_n \), even if \( k_2 < k_n \), provided \( k_2 > k_M \). In other words, factor-intensities defined in the gross sense need not be identical to those defined in the net sense. A sufficient condition for the gross and the net factor-intensity rankings to be identical is that \( x_2 \) is the most capital-intensive of all domestically produced goods.

This possibility of a conflict between the net and gross factor-intensity rankings constitutes one of the basic differences between our model incorporating both non-traded and imported intermediate inputs and Jones' [18] model which allows for the presence of imported inputs only. As must be evident by now, the presence of imported inputs makes no difference to the ranking of commodities, but the presence of non-traded material inputs does. In the absence of the latter, the possibility of the alleged conflict vanishes as may be observed from the technology matrix by setting \( a_{M1} \) equal to zero.

The Structural Relations: The next step in facilitating the exposition is to derive expressions portraying the structural relations in the model. Let an asterisk denote the relative rate of change in a variable, i.e., \( x_1^* = dX_1 / X_1 \), etc. Differentiating (1.1a) and (1.2a), we obtain:

\[ (\lambda_{L1} + \lambda_{LM} \lambda_{M1}) x_1^* + \lambda_{L2} x_2^* = - (\lambda_{L1} a_{L1}^* + \lambda_{L2} a_{L2}^* + \lambda_{LM} a_{LM}^* + \lambda_{LM} \lambda_{M1} \lambda_{M1} a_{M1}^*) \]  

(1.10)

\[ (\lambda_{K1} + \lambda_{KM} \lambda_{M1}) x_1^* + \lambda_{K2} x_2^* = - (\lambda_{K1} a_{K1}^* + \lambda_{K2} a_{K2}^* + \lambda_{KM} a_{KM}^* + \lambda_{KM} \lambda_{M1} \lambda_{M1} a_{M1}^*) \]  

(1.11)

where \( \lambda_{ij} \) equals the proportion of the supply of the \( i^{th} \) factor used in the production of the \( j^{th} \) commodity. For example, \( \lambda_{L1} = a_{L1} x_1 / L = L_1 / L \) is the proportion
of labor used directly in the production of $X_1$. Differentiating (1.3)-(1.5), we get:

$$\theta_{L1}^* w_k^* + \theta_{K1}^* r_k^* + \theta_{M1}^* p_{M1}^* = p_1^* - \theta_{Q1}^* p_{Q1}^* ,$$  
(1.12)

$$\theta_{L2}^* w_k^* + \theta_{K2}^* r_k^* = 0 ,$$  
(1.13)

$$\theta_{LM}^* w_k^* + \theta_{KM}^* r_k^* = p_{M1}^* ,$$  
(1.14)

where each $\theta$ indicates the distributive share of the relevant primary or material input in each commodity. For instance, $\theta_{L1}^* = a_{L1}^*/p_{1}^*$ is the share of labor used directly in the production of the first commodity. In obtaining (1.12)-(1.14), use has been made of the cost minimization condition which requires that in each industry the factor-share weighted average of relative changes in input-output coefficients be zero. For example, in the first commodity

$$\theta_{L1}^* a_{L1}^* + \theta_{K1}^* a_{K1}^* + \theta_{M1}^* a_{M1}^* + \theta_{Q1}^* a_{Q1}^* = 0 .$$

Substituting (1.13) in (1.12) yields

$$(\theta_{L1}^* + \theta_{LM}^* \theta_{M1}^*) w_k^* + (\theta_{K1}^* + \theta_{KM}^* \theta_{M1}^*) r_k^* = p_{M1}^* - \theta_{Q1}^* p_{Q1}^* .$$  
(1.15)

Let $\lambda$ indicate the matrix of coefficients shown on the left-hand sides of (1.10) and (1.11) and let $\theta$ be the corresponding matrix for (1.15) and (1.13).

Then remembering that $\lambda_{M1}^* = 1$,

$$\lambda = \begin{bmatrix} \lambda_{L1} + \lambda_{LM} & \lambda_{L2} \\ \lambda_{K1} + \lambda_{KM} & \lambda_{K2} \end{bmatrix} , \text{ and}$$

$$\theta = \begin{bmatrix} \theta_{L1} + \theta_{LM} \theta_{M1} & \theta_{K1} + \theta_{KM} \theta_{M1} \\ \theta_{L2} & \theta_{K2} \end{bmatrix} .$$
where the determinants of $\lambda$ and $\theta$ are given by

$$|\lambda| = \lambda_k^2 (\lambda_{L1} + \lambda_{LM}) - \lambda_{L2} (\lambda_{K1} + \lambda_{KM})$$

$$= \frac{a_{K2}X_2}{KL} \left( \frac{a_{L1}X_1}{L} + \frac{a_{LM}X_1}{M} \cdot \frac{a_{M1}X_1}{M} \right) - \frac{a_{L2}X_2}{KL} \left( \frac{a_{K1}X_1}{K} + \frac{a_{KM}X_1}{K} \cdot \frac{a_{M1}X_1}{M} \right)$$

$$= \frac{X_1X_2}{KL} \left[ a_{K2} (a_{L1} + a_{LM} a_{M1}) - a_{L2} (a_{K1} + a_{KM} a_{M1}) \right]$$

$$= \frac{X_1X_2}{KL} |A| ;$$

$$|\theta| = \theta_k^2 (\theta_{L1} + \theta_{LM} \theta_{M1}) - \theta_{L2} (\theta_{K1} + \theta_{KM} \theta_{M1})$$

$$= \frac{a_{K2} \cdot a_{L1} \cdot a_{LM} \cdot a_{M1}}{P_2} \left( \frac{a_{L1} \cdot a_{LM} \cdot a_{M1}}{P_1} \right) - \frac{a_{L2} \cdot a_{K1} \cdot a_{KM} \cdot a_{M1}}{P_2} \left( \frac{a_{K1} \cdot a_{KM} \cdot a_{M1}}{P_1} \right)$$

$$= \frac{w_k}{P_1 P_2} |A| .$$

It is clear that the signs of $|\lambda|$ and $|\theta|$ are the same as the sign of $|A|$. In other words, if $X_2$ is capital-intensive relative to $X_1$ in the gross sense which makes $|A|$ positive, each of $|\lambda|$ and $|\theta|$ is positive. The determinant of $\theta$ can be written in yet another manner which highlights the role played by the imported input. Let $\rho_{L1} = \theta_{L1} + \theta_{LM} \theta_{M1}$ be the gross share of labor in the first industry and $\rho_{K1} = \theta_{K1} + \theta_{KM} \theta_{M1}$ be the gross share of capital in the first industry. Since factor shares in any industry add up to unity,

$$\rho_{L1} + \rho_{K1} = \theta_{L1} + \theta_{K1} + \theta_{M1} (\theta_{LM} + \theta_{KM}) = 1 - \theta_{Q1} .$$
Since \( \theta_{L2} + \theta_{K2} = 1 \),

\[
|\theta| = \theta_{K2} \rho_{L1} - (1 - \theta_{K2}) \rho_{K1} = \left[ (1 - \theta_{Q1}) \theta_{K2} - \rho_{K1} \right]
\]  

(1.16)

or

\[
|\theta| = \left[ \rho_{L1} - \theta_{L2} (1 - \theta_{Q1}) \right].
\]  

(1.17)

If \( Q \) were not imported to be used as an input in \( X_1 \), \( X_2 \) would be capital-intensive relative to \( X_1 \) in the gross sense if \( \theta_{K2} > \rho_{K1} \) from (1.16) or \( \rho_{L1} > \theta_{L2} \) from (1.17). The presence of payments for the services of the imported input, however, causes a decline in the gross share of labor and capital in the first industry. Here \( X_2 \) is capital-intensive in the gross sense only if

\( \theta_{K2} > \rho_{K1} / (1 - \theta_{Q1}) \), or \( \rho_{L1} > \theta_{L2} (1 - \theta_{Q1}) \). Since \( (1 - \theta_{Q1}) < 1 \), \( |\theta| > 0 \) only if \( \theta_{K2} > \rho_{K1} \), but \( \rho_{L1} \) need not exceed \( \theta_{L2} \). These remarks will be useful in facilitating the exposition of the subsequent sections.
II. Effective Protection and Real Wages

Some of the structural relations presented in the preceding section may now be solved to derive the implications of the ERP for real rewards of the primary factors. According to the Stolper-Samuelson theorem, nominal protection raises the real reward of the primary factor employed intensively by the importable commodity and lowers the real reward of the factor employed intensively by the exportable commodity. We now examine the impact of the ERP on real wages of the factors and see under what conditions the primary factor employed intensively by the importable good stands to benefit from effective protection.

Equations (1.13) and (1.15) may be solved to obtain

\[ w^* = \frac{\theta_{K2}}{|\theta|} (P_1^* - \theta_{Q1} P_Q^*), \]  
(2.1)

and

\[ r^* = -\frac{\theta_{L2}}{|\theta|} (P_1^* - \theta_{Q1} P_Q^*). \]  
(2.2)

The sign of \((P_1^* - \theta_{Q1} P_Q^*)\) reflects the change in \(X_1\)'s ERP. If this is positive, \(X_1\)'s ERP has increased; if negative, \(X_1\)'s ERP has declined. One glance at (2.1) and (2.2) is sufficient to reveal that \(w\) is positively and \(r\) negatively related to the ERP on \(X_1\). Since

\[ \frac{\theta_{K2}}{|\theta|} = \frac{\theta_{K2}}{\theta_{K2} (1 - \theta_{Q1}) - \rho_{K1}} > 1, \]

the proportionate rise in the wage rate exceeds the ERP. However, although a positive \((P_1^* - \theta_{Q1} P_Q^*)\) causes a decline in \(r\), it is by no means certain that the proportionate decline in \(r\) exceeds the ERP, for \(\theta_{L2}/|\theta|\), although positive, need not exceed unity. Furthermore, although the introduction of the ERP on \(X_1\) causes a rise in \(w\) and a decline in \(r\), does it also result in a rise in the real wage rate and a decline in the real reward of capital.
in terms of the two final commodities? Since $P_2$ is constant, a rise in $w$ and a decline in $r$ amount to a rise in the real wage rate and a decline in the real reward of capital in terms of the second commodity. Whether this is also true in terms of the first commodity depends on the sign of $(w^* - P_1^*)$ and $(r^* - P_1^*)$. Subtracting $P_1^*$ from both sides of (2.1) and (2.2), and using (1.16) and (1.17), we obtain

$$w^* - P_1^* = \frac{\theta K_2 \theta Q_1 + \rho K_1}{|\theta|} P_1^* - \frac{\theta K_2 \theta Q_1}{|\theta|} P_1^*$$

(2.3)

$$r^* - P_1^* = \frac{\theta L_2 \theta Q_1 P_Q}{|\theta|} - \frac{(\rho L_1 + \theta L_2 \theta Q_1)}{|\theta|} P_1^*$$

(2.4)

With $|\theta| > 0$, $w^* - P_1^* > 0$ if

$$\frac{P_1^*}{P_Q} > \frac{\theta K_2 \theta Q_1}{\theta K_2 \theta Q_1 + \rho K_1}$$

(2.5)

and $r^* - P_1^* < 0$ if

$$\frac{P_1^*}{P_Q} > \frac{\theta L_2 \theta Q_1}{\theta L_2 \theta Q_1 + \rho L_1}$$

(2.6)

Since the right hand side of both (2.5) and (2.6) is less than unity, a sufficient condition for the real wage to rise and the real reward of capital to decline as a result of the imposition of tariffs on the final and intermediate imported products is that $P_1^* > P_Q^*$. In other words, if the nominal tariff on the final product, $X_1$, exceeds or equals that on the intermediate product, $Q$, the ERP leads to a rise in the real wage rate and a decline in the real reward of capital in terms of both final commodities. Even if the tariff on $X_1$ is less than that on the imported input, the real wage may rise and the real reward of capital may decline unambiguously, provided the
share of the non-traded material input in the first industry is sufficiently large to confer high values to $\rho_{K1}$ and $\rho_{L1}$. 12

How does all this fit with the Stolper-Samuelson theorem? The answer lies in how we define the factor-intensities between the final commodities. If $X_1$ and $X_2$ are ranked according to the capital/labor ratios in the gross sense, then clearly $P_1^* \geq P_Q^*$ is a sufficient condition for the validity of the Stolper-Samuelson theorem in terms of the ERP. For then with $X_1$ labor-intensive in the gross sense, the effective protection of the first commodity (so that $P_1^* \theta_1 P_Q^*$) causes an unambiguous rise in the real reward of labor, the factor employed intensively by the importable commodity ($X_1$) and an unambiguous decline in the real reward of capital, the factor employed intensively by the exportable commodity, $X_2$. However, if one insists on looking at the factor-intensity ranking in the net sense, and if the latter runs into conflict with the gross factor-intensity ranking, then the Stolper-Samuelson theorem does not hold even if $P_1^* \geq P_Q^*$. This, of course, would be true even with the conventional view of the Stolper-Samuelson theorem which considers the nominal rather than the effective tariff. This can be most clearly seen by equating $P_Q^*$ to zero and observing that with $|\theta| > 0$, $(w^* - P_1^*) > 0$ and $(r^* - P_1^*) < 0$. But evidently this alone does not ensure the validity of the Stolper-Samuelson theorem when factor-intensity rankings are specified in terms of the net capital/labor ratio. By contrast, the existence of the imported inputs makes no difference to the validity of the traditional Stolper-Samuelson theorem. All this discussion leads to the following theorems:

**Theorem 1:** In the presence of a nominal tariff on the imports of the final product alone, the Stolper-Samuelson theorem continues to be valid if commodities are ranked in terms of their gross capital/labor ratios. However,
if the ranking is in terms of the net capital/labor ratios, the theorem may not hold. The presence of the imported input necessitates no modification to this result so long as it is not taxed.

Theorem 2: In the absence of the non-traded intermediate product, the Stolper-Samuelson theorem necessarily holds in terms of the ERP concept, provided the tariff on the imports of the final product is at least as large as the tariff on the imported input. If the non-traded good also exists, then this condition is sufficient for the validity of the theorem when factor-intensities are defined in the gross sense. Otherwise, the remarks made in theorem 1 apply.

Theorem 3: If effective protection is provided to the first commodity by means of lowering the input tariff alone (or by giving a trade subsidy to the imported input), so that $P^*_1 = 0$ and $P^*_Q < 0$, inequalities (2.5) and (2.6) are automatically satisfied, and the Stolper-Samuelson theorem continues to be valid, provided the net and the gross factor-intensity rankings are identical.

Theorem 4: In the presence of a nominal tariff on the imports of the final product, the Stolper-Samuelson theorem may not hold if the imported input is also taxed, provided the output tariff is less than the input tariff, even though the ERP on the final product itself is positive. This result is valid irrespective of whether factor-intensities are defined in the gross or the net sense.

The discussion presented above also suggests that effective protection always raises the relative reward of the factor utilized intensively—in the gross sense—by the importable commodity, for from (2.1) and (2.2)

$$w^* - r^* = \frac{P^*_1 - \theta_0 Q P^*_Q}{\theta}$$
is always positive if $|\theta|$ and $(P^*_1 - \theta Q_1 P^*_Q)$ are positive; however, it may not unambiguously raise the real reward of the relevant factor in terms of both final products. Thus we are back in the pre-Stolper-Samuelson world, for the main contribution of Stolper and Samuelson was to demonstrate that (nominal) protection moved the real and the relative rewards of a factor in the same direction: however, with effective protection, as we have established above, this may no longer be true, and we confront the same index number problem which, prior to the Stolper-Samuelson contribution, was believed to have stood in the way of reaching definite conclusions concerning the effects of protection on income distribution.

III. The ERP and Resource Allocation

We have shown in the foregoing section that effective protection conferred on the labor-intensive commodity, $X_1$, raises the wage rate (though not necessarily the real wage rate) and lowers the reward of capital. If there were no imported inputs, with given supplies of labor and capital, this would ensure a rise in the output of $X_1$ and a decline in the output of $X_2$ even when intermediate products are domestically produced. The output of $X_1$ relative to $X_2$, i.e., $X_1/X_2$, would then necessarily rise. However, when a material input is imported, the factor supplies are no longer constant, for even if $K$ and $L$ are given, the supply of the imported input does vary with the imposition of effective protection, especially when substitution between the domestic and the imported inputs is permitted. It is then possible that $X_1/X_2$ may actually decline even though effective protection was provided to $X_1$. This section is devoted to the examination of conditions under which such a "perverse" possibility can be shown to exist.

With this purpose in mind, it is natural for us to revert to (1.10)
and (1.11) in Section I. However, these two equations cannot be solved to derive meaningful results, unless the expressions for $a^*_{LM}$ etc. are obtained, which in turn may be accomplished by totally differentiating (1.6) - (1.8) to yield:

$$
a^*_{L1} = \theta_{L1} \sigma_{LL}^1 w^* + \theta_{K1} \sigma_{LK}^1 r^* + \theta_{M1} \sigma_{LM}^1 p^* + \theta_{Q1} \sigma_{LQ}^1 p^*
$$

$$
a^*_{K1} = \theta_{L1} \sigma_{LK}^1 w^* + \theta_{K1} \sigma_{KK}^1 r^* + \theta_{M1} \sigma_{KM}^1 p^* + \theta_{Q1} \sigma_{KQ}^1 p^*
$$

$$
a^*_{M1} = \theta_{L1} \sigma_{LM}^1 w^* + \theta_{K1} \sigma_{KM}^1 r^* + \theta_{M1} \sigma_{MM}^1 p^* + \theta_{Q1} \sigma_{MQ}^1 p^*
$$

$$
a^*_{L2} = \theta_{L2} \sigma_{LL}^2 w^* + \theta_{K2} \sigma_{LK}^2 r^*
$$

$$
a^*_{K2} = \theta_{L2} \sigma_{LK}^2 w^* + \theta_{K2} \sigma_{KK}^2 r^*
$$

$$
a^*_{LM} = \theta_{LM} \sigma_{LL}^M w^* + \theta_{KM} \sigma_{LK}^M r^*
$$

$$
a^*_{KM} = \theta_{LM} \sigma_{LK}^M w^* + \theta_{KM} \sigma_{KK}^M r^*,
$$

where $\theta$'s are as defined before and $\sigma_{ij}^v$ is the partial elasticity of substitution between factors $i$ and $j$ in the $v^{th}$ industry. Substituting these in (1.10), we obtain

$$(\lambda_{L1} + \lambda_{LM} \lambda_1) x^*_{1} + \lambda_{L2} x^*_{2} = \beta_L (w^*-r^*) + \beta_{Q1}(w^*-p^*) + \beta_{Q2}(r^*-p^*), (3.1)$$

where

$$\beta_L = \lambda_{L1} \theta_{K1} \sigma_{LK}^1 + \lambda_{L2} \theta_{K2} \sigma_{LK}^2 + \lambda_{LM} \theta_{KM} \sigma_{LM}^M + \lambda_{L1} \theta_{M1} \theta_{KM} \sigma_{LM}^2 + \lambda_{KM} \theta_{K1} \theta_{LM} \sigma_{KM}^1$$

$$\beta_{Q1} = \lambda_{LM} \theta_{Q1} \sigma_{LQ}^1 + \lambda_{LM} \theta_{Q1} \sigma_{MQ}^1, \text{ and}$$

$$\beta_{Q2} = \lambda_{LM} \theta_{KM} \theta_{Q1} \sigma_{MQ}^1.$$

Performing analogous substitutions in (1.11) yields:

$$(\lambda_{K1} + \lambda_{KM} \lambda_1) x^*_{1} + \lambda_{K2} x^*_{2} = -\beta_K (w^*-r^*) + \beta_{Q3}(w^*-p^*) + \beta_{Q4}(r^*-p^*), (3.2)$$
where
\[ \beta_k = \lambda_k \theta_1 \sigma_{Lk}^1 + \lambda_k \theta_2 \sigma_{Lk}^2 + \lambda \theta_{LM} \sigma_{LM}^1 + \lambda \theta_{KL} \sigma_{KL}^1 + \lambda \theta_{LM} \sigma_{LM}^2, \]
\[ \beta_4 = \lambda \theta_{LM} \sigma_{MQ}^1, \] and
\[ \beta_3 = \lambda \theta_{LM} \sigma_{MQ}^1. \]

Subtracting (3.2) from (3.1) using the definition of \( |\lambda| \) and performing some manipulations, we derive
\[
|\lambda| (x_1^* - x_2^*) = (\beta_L + \beta_K)(w^* - r^*)
+ \lambda \theta_{Q1} \sigma_{LQ}^1 (w^* - p_Q^*)
+ \lambda \theta_{Q1} \sigma_{KQ}^1 (p_Q^* - r^*)
+ \theta_{Q1} (\lambda_{LM} - \lambda_{KN}) \sigma_{MQ}^1 (p_M^* - p_Q^*).
\]

Using (2.1) and (2.2), (1.16) and (1.17), we derive
\[
w^* - r^* = \frac{P_1^* - \theta_{Q1} P_Q^*}{|\theta|} \quad \text{(3.4)}
\]
\[
w^* - p_Q^* = \frac{\theta_{K2} P_1^* - (\theta_{K2} - \theta_{K1}) P_Q^*}{|\theta|} \quad \text{(3.5)}
\]
\[
p_Q^* - r^* = \frac{\theta_{L2} P_1^* - (\theta_{L2} - \theta_{L1}) P_Q^*}{|\theta|} \quad \text{(3.6)}
\]

Subtracting \( P_Q^* \) from both sides of (1.14) and using (3.5) and (3.6) we obtain
\[
P_M^* - P_Q^* = \frac{(\theta_{LM} \theta_{K2} - \theta_{KN} \theta_{L2}) P_1^* - [(\theta_{LM} \theta_{K2} - \theta_{KN} \theta_{L2}) - (\theta_{LM} \theta_{K1} - \theta_{KN} \theta_{L1})] P_Q^*}{|\theta|} \quad \text{(3.7)}
\]

With this last equation, we have collected all the ingredients necessary to examine the implications of effective protection for the relative outputs of the two final commodities. One of the basic differences between the effective
protection and the nominal protection model is that, unlike with the latter, there are several ways of conferring protection on a final commodity when tariffs on imported inputs are permitted; for example, $X_1$ can be protected either by imposing an output tariff, or by lowering the input tariff (or by subsidizing the imports of the input), or by any combination of the two such that $(p_1^* - \theta Q_1 p_Q^*) > 0$. To begin with, we consider the two polar cases which involve the imposition of the output or the input tariff. In a model where only imported intermediate goods are allowed to exist, Jones has demonstrated that when protection is conferred purely through output tariffs, the relative output of the protected commodity must rise even when substitution is allowed between primary factors and imported intermediate inputs; if protection is provided through the other extreme way of lowering the input tariff, the relative output of the protected good may or may not rise, depending on whether or not the imported input is a better substitute of one primary factor than of the other. We will now examine these results in the context of our model which allows for the existence of two intermediate inputs, one non-traded and the other imported from abroad.

Consider first the case where $p_Q^*$ is zero but $p_1^* > 0$, so that protection is provided by the simplest way of the output tariff. Actually this case is no different from the conventional model of nominal protection without the presence of intermediate inputs. First, we have to determine the signs of $\beta_L$ and $\beta_K$ in (3.3). Following Jones we assume that all factors are substitutes so that the cross elasticities are positive, that is, $\sigma_{ij}^V > 0$ ($i \neq j$). It follows then that $\beta_L$ and $\beta_K$ are both positive. Let us now examine (3.3) and the signs of the four terms that make up the equation to determine the sign of $(X_1^* - X_2^*)$. For analytical convenience, we continue to assume that $X_1$ is labor-intensive.
relative to $X_2$ in the gross sense, so that $|\lambda|$ and $|\theta|$ are positive. With $P^*_Q = 0$, we know that $(w^*-r^*) > 0$, $w^* > 0$ and $r^* < 0$. All this follows from the discussion in the previous section. This means that the first three terms on the right-hand side of (3.3) are all positive, whereas the fourth term may be positive or negative, depending on the signs of $(\lambda_{LM} - \lambda_{KM})$ and $P^*_M$. From (3.7) $P^*_M \geq 0$ if $k_2 \geq k_M$ on the other hand

$$\lambda_{LM} - \lambda_{KM} = \frac{I_M}{K} (k-k_M) \geq 0 \text{ if } k \geq k_M,$$

where $k = K/L$ is the overall capital/labor ratio in the economy. In other words, if both $k_2$ and $k$ are either greater or less than $k_M$, the fourth term is positive, in which case $(X^*_1 - X^*_2) > 0$, so that the output-tariff alone leads unambiguously to a rise in the relative output of $X_1$. However, if $k_M$ lies between $k_2$ and $k$, the fourth term in (3.3) is negative, in which case it is no longer clear that $(X^*_1 - X^*_2) > 0$. The imposition of the output tariff alone may then lead to the paradox of a decline in the relative output of the protected commodity. Note that this possibility cannot arise if i) there is no non-traded intermediate input, ii) there is no substitution possibility between the non-traded and the traded inputs, so that $\sigma_M = 0$, or iii) the capital/labor ratio in the domestically produced input equals the overall capital/labor ratio. These are sufficient conditions, and obviously none of them is necessary to avoid the perverse possibility of a decline in the relative output of the protected commodity as a result of the introduction of the nominal (output) tariff. The necessary and sufficient condition for the paradoxical result can be derived by substituting (3.4)-(3.7) in the general equation (3.3) to obtain
\[ \lambda |(X_1^* - X_2^*) = \left[ (\beta_L + \beta_K) + (\lambda_{L1} \theta_{K2} \sigma_{LQ}^1 + \lambda_{K1} \theta_{L2} \sigma_{KQ}^1) \theta_{Q1} \right] \frac{P_1^* - \theta_{Q1} P_Q^*}{|\theta|} \]

\[ + \theta_{Q1} (\lambda_{LM} - \lambda_{KM})(\theta_{K2} - \theta_{KM}) \sigma_{MQ}^1 \left( \frac{P_1^* - \theta_{Q1} P_Q^*}{|\theta|} \right) \]

\[ + \theta_{Q1} \left[ (\lambda_{K1} \sigma_{KQ}^1 - \lambda_{L1} \sigma_{LQ}^1) - (\lambda_{LM} - \lambda_{KM}) \sigma_{MQ}^1 \right] P_Q^* \cdot \]

It can be seen that raising \( P_1^* \) alone can lead to the lowering of the relative output of \( X_1 \) if

\[ \frac{(\beta_L + \beta_K)}{\theta_{Q1}} + \lambda_{L1} \theta_{K2} \sigma_{LQ}^1 + \lambda_{K1} \theta_{L2} \sigma_{KQ}^1 < (\lambda_{KM} - \lambda_{LM})(\theta_{K2} - \theta_{KM}) \sigma_{MQ}^1 \] (3.8)

Since the left-hand side of inequality (3.8) is positive, it is clear that the necessary condition for (3.8) to be satisfied and the paradox to occur is that the two terms within the parentheses of the right-hand side of (3.8) have the same sign, which in turn implies that \( k_M \) lies between \( k_2 \) and \( k \). The likelihood of this paradox increases if, ceteris paribus, \( \sigma_{LQ}^1 \) and \( \sigma_{KQ}^1 \) are close to zero and \( \sigma_{MQ}^1 \) is sufficiently large, that is to say, if the imported input is more substitutive with the domestically produced input than it is with the primary factors. All this discussion gives rise to the following general theorem:

Theorem 5: When protection is provided by means of an output tariff alone, the necessary condition for the relative output of the protected commodity to decline is that the capital/labor ratio of the non-traded intermediate product lies between the capital/labor of the unprotected commodity and the overall capital/labor ratio in the economy.

Next consider the other polar case where protection is granted to the first commodity by subsidizing imports of the intermediate input \( Q \), so that
$P^*_1 = 0$ and $P^*_Q < 0$. The first two terms in (3.3) are again positive, but the last two terms may not be. With $P^*_Q < 0$, the third term is positive if $P^*_Q - r^* > 0$, which requires that $\rho_{L1} < \theta_{L2}$; however from (1.15) we know that $\rho_{L1}$ may be less or greater than $\theta_{L2}$ for $|\theta| > 0$, which introduces the possibility that $(P^*_Q - r^*)$ may be negative.

Thus even if the fourth term is zero or even positive, $(X^*_1 - X^*_2)$ may be negative. This is the result derived by Jones, and as we have shown the existence of the non-traded input may weaken or reinforce this result. The necessary condition for Jones' result can be obtained as a special case by equating $P^*_{1}$ and $\sigma^1_{MQ}$ to zero in (3.3a) and using (1.16) and (1.17), so that $(X^*_1 - X^*_2) < 0$ only if

$$- \theta_{Q1} P^*_Q \left[ (\beta_L + \rho_K^*) - \lambda_{L1} \xi_{LQ}(\theta_{K2} - \rho_{K1}) + \lambda_{K1} \xi_{KQ}(\theta_{L2} - \rho_{L1}) \right] < 0,$$

which, with $P^*_Q < 0$ and $\theta_{K2} > \rho_{K1}$ from (1.14), requires that $\rho_{L1} > \theta_{L2}$. If the non-traded input does not exist, $\rho_{L1}$ reduces to $\theta_{L1}$; hence the necessary condition for the 'perverse' possibility to arise is that the relative share of labor in the first industry exceeds that in the second industry, which, of course, is not necessary for $|\theta|$ to be positive. Now $\theta_{L1} > \theta_{L2}$ implies that factor-intensities in the two industries are sufficiently disparate.

When a non-traded material input is introduced, but $\sigma^1_{MQ} = 0$, then the necessary condition involves the comparison between the gross share of labor ($\rho_{L1}$) in the first industry using the non-traded input with the share of labor in the second industry which does not utilize the non-traded material input. This discussion leads to the following generalized theorem which applies to Jones' results as well as ours.

**Theorem 6**: Given that the substitution between the non-traded and imported material inputs is not permitted, the necessary condition for the relative output of the protected final commodity to decline, when protection is
granted by subsidizing imports of the intermediate input, is that the (gross) relative share of the primary factor employed intensively by the protected commodity exceeds the relative share of the same factor in the other commodity, provided, of course, the primary factors and the imported inputs are substitutes.

When substitution between the non-traded and imported material inputs is allowed, theorem 6 continues to be valid if \( k = k_m \), so that the fourth term in (3.3) goes to zero; if the fourth term is non-zero, evidently \( \rho_{L1} > \theta_{L2} \) may no longer be a necessary condition for \( X_1/X_2 \) to decline.

### Output and Input Tariffs Combined

In the general case where protection is granted by some combination of the output and the input tariff, \( P^*_1, P^*_Q \geq 0 \) and \( (P^*_1 - \theta_Q P^*_Q) \) is positive. The analysis here is much more involved and no simple answer is possible. To comprehend the causality of resource movements between final products, it is necessary to see how effective protection affects input prices. To clarify the issues involved, let us rewrite the full employment equations presented in Section I:

\[
\begin{align*}
\text{(1.1a)} & \\
& a_{Lg} X_1 + a_{L2} X_2 = L \\
& a_{Kg} X_1 + a_{K2} X_2 = K, \\
& \text{(1.2a)}
\end{align*}
\]

where \( a_{Lg} = a_{L1} + a_{Lm} m_1 \) and \( a_{Kg} = a_{K1} + a_{Km} m_1 \).

Let us commence with the simplest two-good, two-factor model where both \( a_{M1} \) and \( a_{Q1} \) (which does not enter the full employment equations) are zero and (1.1a) and (1.2a) reduce to

\[
\begin{align*}
\text{(1.1b)} & \\
& a_{L1} X_1 + a_{L2} X_2 = L \\
& a_{K1} X_1 + a_{K2} X_2 = K. \\
& \text{(1.2b)}
\end{align*}
\]

As a result of a rise in the price of the labor-intensive commodity \( X_1 \),
w rises and r declines, so that \( a_{L1} \) and \( a_{L2} \) decline and \( a_{K1} \) and \( a_{K2} \) rise. A decline in both \( a_{L1} \) and \( a_{L2} \) implies, with \( L \) constant, that \( X_1 \) and/or \( X_2 \) must rise in order to maintain the balance in (1.1b); however, with \( a_{K1} \) and \( a_{K2} \) both rising, it is clear from (1.2b) that both \( X_1 \) and \( X_2 \) cannot rise if \( K \) is to remain unchanged; therefore if the balance is to be maintained simultaneously in (1.1b) and (1.2b), it is necessary that the two outputs move in the opposite direction. Now a general decline in the labor/output coefficients and a rise in the capital/output coefficients give rise to a disequilibrium situation of excess supply for labor and excess demand for capital, which in turn can be corrected by a rise in the output of the labor-intensive commodity \( X_1 \) and a decline in the output of the capital-intensive commodity \( X_2 \). This is how a rise in the price of \( X_1 \) eventually leads to a rise in the output of \( X_1 \) and a decline in the output of \( X_2 \) such that (1.1b) and (1.2b) are satisfied.

Let us now see how the picture changes when, following Jones, we introduce an imported input into the model. The full employment equations are unchanged, but not the factors that influence the input-output coefficients, which are now determined by \( w, r \) and \( P_Q \). If effective protection is introduced simply by imposing the output tariff alone (so that \( P_Q^* = 0 \)), the input-output coefficients change in exactly the same manner as they do in the simple two-factor model, which in turn implies that the relative output of the first commodity necessarily rises. On the other hand, if protection is introduced by either lowering the input tariff or by introducing the output and the input tariff such that \( (P_1^* - \theta Q_1 P_Q^*) > 0 \), the results depend on the change in \( P_Q \) relative to the changes in \( w \) and \( r \). We know that \( w^* > 0 \) and \( r^* < 0 \); therefore if \( P_Q^* > 0 \), \( P_Q^* > r^* \). All this ensures a decline in \( a_{L2} \) and a rise in \( a_{K2} \), as was the case in the simple two-factor model. As regards the input coefficients in the first industry,
the answer depends on the relative magnitudes of \( w^* \) and \( P^*_Q \). If \( w^* > P^*_Q \ (r^*) \), substitution takes place against labor and in favor of capital, so that \( a^*_{L1} \) declines and \( a^*_{K1} \) rises, which in turn guarantees the rise in the relative output of the first commodity. However, if \( r^* < w^* < P^*_Q \), substitution in the first industry may occur in favor of labor and against the imported input, and if this substitution is 'sufficiently' pronounced, the relative output of \( X_1 \) will actually decline to maintain the balance in equations (1.1b) and (1.2b). Thus if \( P^*_Q \) lies between \( w^* \) and \( r^* \) in Jones' framework, the paradoxical decline in the relative output of the first commodity cannot occur.

The analysis becomes more complicated when a non-traded material input is introduced in addition to the imported input. Here \( P^*_M \) plays the same role as \( P^*_Q \) with one difference, namely, the change in \( P^*_M \), unlike \( P^*_Q \), is endogenous, so that even when \( P^*_Q = 0 \), as is the case in the presence of the output tariff alone, a change in \( P^*_M \) resulting from a rise in \( P^*_1 \) could cause the same complications as the change in \( P^*_Q \) does in Jones' model. For normal results, we now need that \( a^*_{LQ} \) and \( a^*_{L2} \) decline and \( a^*_{KQ} \) and \( a^*_{K2} \) rise when \( w, P^*_M \) and \( r \) are altered as a result of the rise in \( P^*_1 \) alone. As usual \( a^*_{K2} \) rises and \( a^*_{L2} \) declines, because \( P^*_M \) does not influence the input choice in the second industry. For the same reason, \( a^*_{KM} \) rises and \( a^*_{LM} \) declines. Since \( P^*_M \) from (1.1) is a weighted average of \( w^* \) and \( r^* \), \( w^* > P^*_M > r^* \), which means that \( a^*_{L1} \) falls and \( a^*_{K1} \) rises. These changes serve to lower \( a^*_{LQ} = a^*_{L1} + a^*_{LM} \) and to raise \( a^*_{KQ} = a^*_{K1} + a^*_{KM} \), as is required for the normal results. Now suppose that \( P^*_M < 0 \), such that \( a^*_{LM} \) rises. This factor tends to raise both \( a^*_{LQ} \) and \( a^*_{KQ} \) and if its effect is sufficiently pronounced, \( a^*_{LQ} \) may actually rise, thereby creating the "perverse" possibility of a decline in the relative
output of the first commodity. Even if $P^*_M > 0$ and $a^*_M$ declined, the "perverse" result could still occur, because this factor tends to lower $a_{kg}$, and if its impact was sufficiently large, $a_{kg}$ could actually fall, which would again run into conflict with the conditions sufficient to rule out the paradox. Hence in the presence of the non-traded material input, there is no simple sufficient condition that would ensure the occurrence of the "normal" result, except that the change in $a^*_M$ is not large enough to reverse the "regular" signs of $a^*_K$ and $a^*_L$, which latter condition is perhaps satisfied if $k_2$ and $k$ are both greater than $k_M$.

When protection is granted by means of output as well as input tariffs, the picture becomes more blurred, but the explanations advanced above still apply. Specifically, the introduction of non-traded material inputs may weaken or reinforce the results derived in their absence. It is worth pointing out here that the responsibility for the paradoxical results always rests with the presence of the imported input which makes the effective factor supply variables, irrespective of the existence or the non-existence of the non-traded material inputs. To obtain a clear demonstration of this point, set $\theta_{Q1}$ to zero, so that (3.3a) reduces to

$$|\lambda| (x^*_1 - x^*_2) = \frac{(\beta_L + \beta_K) P^*_1}{|\theta|} > 0,$$

because both $\beta_L$ and $\beta_K$, which include elements of the non-traded material input, are positive. Hence to attain "perverse" results, the presence of imported inputs is indispensable.

IV. Conclusions

Introducing a non-traded and an imported material input in the traditional two-good, two-factor constant returns to scale model, we have
examined in the foregoing the effects of effective protection on real wages of primary factors and the allocation of resources between the final products. The following results are of particular interest:

(1) The existence of imported inputs entails no modification to the factor-intensity rankings of the commodities, but the introduction of non-traded material inputs does. In the presence of the non-traded material input, a distinction needs to be drawn between the net and the gross capital/labor ratio in the commodity using that input. Under these conditions, the ranking of a commodity in terms of its net and gross capital/labor ratios may differ which gives rise to the question as to which factor-intensity ranking should be adopted to conduct the analysis. If factor-intensities are defined in terms of the net, or the 'apparent' capital/labor ratios, the Stolper-Samuelson theorem may never be valid. If they are specified in terms of the gross, or the 'true,' capital/labor ratios, the theorem is valid, provided the output tariff is at least as large as the input tariff. In the contrary case where the output tariff falls short of the input tariff, the theorem may not be valid in the sense that effective protection may not result in a categorical rise in the real reward of the primary factor employed intensively by the protected commodity, although, as it turns out, it always leads to a rise in the relative reward of the relevant factor. This indeterminacy creates the same index number problem which, prior to the Stolper-Samuelson contribution, has been alleged to have hindered the derivation of unambiguous results concerning the implications of protection (nominal) on the real and relative factor rewards.

(2) The main conclusion concerning the allocation of resources is that the presence of non-traded material inputs in addition to the imported input can cause a "perverse" decline in the output of the protected commodity relative to that of the unprotected commodity, even though effective protection is
provided by means of the simplest way of imposing the output tariff alone. The necessary condition for the occurrence of this paradox is that the capital/labor ratio of the intermediate product is itself intermediate in relation to the capital/labor ratio of the unprotected commodity and the overall capital/labor ratio (i.e., factor endowments of the primary factors) in the economy. Once this condition is satisfied, the likelihood for the emergence of the paradox increases with i) the increase in the elasticity of substitution between the non-traded and imported material inputs, ii) the increase in the relative share of the imported input in the total cost of the protected commodity, and iii) the decrease in the substitution elasticities between the primary factors and the imported inputs.

(3) If protection is granted by means of lowering the input tariff alone, then the necessary condition for the paradoxical lowering of the relative output of the imported commodity is that the relative share (gross) of the primary factor utilized intensively by the protected commodity exceeds its relative share in the unprotected commodity, provided i) there are no substitution possibilities between the non-traded material input, or (ii) the capital/labor ratio of the non-traded material input is the same as the overall capital/labor ratio of the economy. This is the condition implicit in Jones' results, but is not explicitly recognized by him.

(4) When protection is granted by means of some combination of output and input tariffs, the results become more complex and no simple and meaningful conditions, necessary for the paradox or sufficient to avoid it, can be derived. However, Jones' general conclusion, that if protection is conferred primarily by a large increase in the output tariff accompanied by a sufficiently small rise in the input tariff, the relative output of the protected commodity will rise, is no longer valid when a non-traded material input is incorporated in his model. We need only refer to conclusion 2 for the validity of this result.
Finally, we state that the analysis of the present paper, like most recent general equilibrium studies that have attempted to evaluate the ERP concept in terms of its predictable effects on resource allocation, is far from encouraging to the use of effective tariffs.

The villain, as suggested before, is not the non-traded material input, not even the concept of effective tariff, but the imported input, whose presence makes the effective factor supply variable when it is substitutable with the domestic inputs. Jones has provided some basis for salvaging the ERP concept; our analysis destroys even that little hope, especially when it is realized that the possibility of paradoxical resource allocational effects in our model, unlike in Ramaswami-Srinivasan impossibility theorem [23] or in Corden's framework [10], does not crucially depend on the biases in substitution elasticities. Witness here the fact that in (3.8), even if

\[ \sigma_{LQ}^1 = \sigma_{KQ}^1 = \sigma_{MQ}^1 , \]

so that there is no such bias, the inequality (3.8) could be satisfied to produce the paradoxical result.
Footnotes

1 See, for example, Corden [10, p. 222].

2 See, for example, the earlier empirical contributions by Barber [3], Balassa [2], Basevi [4] and the recent theoretical as well as empirical studies by Corden [11], Leith [21], [22], Guisinger [15], Travis [27], Naya and Anderson [23], Finger [13], Humphrey and Tsukahara [16], and Grubel and Lloyd [14]. To be sure some of these contributions, especially the recent ones, do analyze the implications of substitution between the domestic primary and non-primary factors and the imported inputs, although the basic underlying framework is couched in the partial equilibrium terms.

3 Other general equilibrium contributions have been made by Corden [11], Ruffin [25], Ramaswami and Srinivasan [24], and Bhagwati and Srinivasan [8]. For a recent empirical study using the general equilibrium framework, see Evans [12].

4 Since the appearance of the original contribution by Stolper and Samuelson, various extensions and modifications to their results have been provided by Bhagwati [7], Kemp [19], Batra [5], and Batra and Casas [6]. The present paper is yet another attempt to extend the Stolper-Samuelson theorem by considering the ERP rather than the nominal protection examined by Stolper and Samuelson.

5 An interesting feature of our model is that the non-reversal of factor-intensities between final products is not a necessary condition to obtain the unique solution. An examination of the production coefficients in (1.1a) and (1.2a) suggests that even if the sign of \( \frac{a_{K2}/a_{L2}}{a_{K1}/a_{L1}} \) is not unique, the sign of \( \frac{(a_{K2}/a_{L2}) - (a_{K1}/a_{L1})}{(a_{K1}/a_{L1})} \) may still be. See footnote 6 for further details.

6 It is clear that even if the sign of \( (k_2 - k_n) \) is reversed as a result of changes in the wage/rental ratio so that factor-intensities are reversible, \(|A|\) may still be positive at all factor prices. Hence the stipulation that factor-intensities in the final products be non-reversible is no longer necessary for the unique sign of \(|A|\), which is all we need to ensure a unique solution in the model. For relevance of this footnote, see footnote 5 and for further details on the net and gross factor-intensities, see Batra and Casas [6].

7 An alternative and perhaps easier way of deriving (1.9) and (1.10) would be to first differentiate (1.1) and (1.2) and then substitute the derivative of \( M = a_{M1}X_1 \). It may be pointed out here that \( \lambda_{M1} = a_{M1}X_1/M = 1 \). Therefore, in what follows, we eliminate \( \lambda_{M1} \) wherever it occurs in order to reduce the length of equations.

8 The original Stolper-Samuelson presentation emphasized the effects of protection on the real reward of the scarce factor. This brings into relevance
the question of the validity of the Heckscher-Ohlin theorem which states that the relatively scarce factor is intensively used by the importable good. In our model, however, the Heckscher-Ohlin theorem may not be valid; that is why we have stated the Stolper-Samuelson theorem as one predicting the effects of protection of the real reward of the factor intensively employed by the importable good. This is how Lancaster [20] and Bhagwati [7] present the Stolper-Samuelson theorem. For details on the conditions that ensure the validity of the Heckscher-Ohlin theorem in the presence of the non-traded material input, see Batra and Casas [6].

\[ t_1^* = \frac{p_1^*(1+t_1) - p_1^*}{p_1^*} = t_1, \quad \text{and} \]
\[ t_Q^* = \frac{p_Q^*(1+t_Q) - p_Q^*}{p_Q^*} = t_Q. \]

Now the effective tariff formula used by Corden among others is

\[ \text{ERP} = \frac{t_1^* - \theta_{Q1}t_Q^*}{1 - \theta_{Q1}} = \frac{p_1^* - \theta_{Q1}p_Q^*}{1 - \theta_{Q1}}. \]

Since \( \theta_{Q1} < 1 \), the sign of \( (p_1^* - \theta_{Q1}p_Q^*) \) alone is indicative of whether or not a commodity has been protected.

\[ \theta_{L2}/|\theta| \] from (1.15) is given by

\[ \frac{\theta_{L2}}{|\theta|} = \frac{\theta_{L2}}{\rho_{L1} - \theta_{L2}(1-\theta_{Q1})}. \]

Now \( |\theta| > 0 \) if \( \rho_{L1} > \theta_{L2} - \theta_{L2} \theta_{Q1} \). However, if \( \rho_{L1} < \theta_{L2}, \theta_{L2}/|\theta| > 1 \); otherwise, the latter is less than one.

This follows from the fact that, as shown in footnote 9, \( t_1 = p_1^* \) and \( t_Q = p_Q^* \).

12. This is because both \( \rho_{K1} \) and \( \rho_{L1} \) tend to be higher the higher is the level of \( \theta_{M1} \), which in turn tends to lower the expressions on the right hand side of (2.5) and (2.6), and thus raise the likelihood of these inequalities being satisfied when \( p_1^*/p_Q^* < 1 \).

13. For further details on \( c_{ij}^V \) see Allen [1, Chap. 19], and for its use in the context of trade theory, see Kemp [19, Chap. 7] and Casas [9]. It may be pointed out here that if all input prices change in the same proportion, \( a^V_{ij} = 0 \), which for, say, \( a^V_{11} \) implies that

\[ \theta_{L1} \sigma_{LL} + \theta_{K1} \sigma_{LK} + \theta_{M1} \sigma_{LM} + \theta_{Q1} \sigma_{LQ} = 0 \]

By using the relationships which imply \( a^V_{ij} = 0, c^V_{ij} \) (i=j) can be eliminated from the expression for \( a^V_{ij} \).
As Jones points out, the possibility of complementarity can be discussed without any difficulty, but the results are less elegant.

Actually this assumption is not at all crucial, because from (3.4) - (3.7) it can be observed that the four terms on the right hand side of (3.3) all contain $|\theta|$ in the denominator. Since $|\lambda|$ and $|\theta|$ always possess the same sign, the assumption that $X_1$ is the labor-intensive commodity in the gross sense does not influence the movement of resources in any way.

Note that $k_M$ lying between $k_2$ and $k$ does not conflict with $|\theta| > 0$ because

$$k = \frac{L_1}{L} k_n + \frac{L_2}{L} k_2 + \frac{L_M}{L} k_M, \quad \text{or}$$

$$k - k_M = \frac{L_1}{L} (k_n - k_M) + \frac{L_2}{L} (k_2 - k_M).$$

Now if $k_2 > k_M$, $k_M > k$, only if $k_n < k_M$. However, $k_n < k_M$ does not prevent $|A|$ or $|\theta|$ from being positive. See the expression for $|A|$ in Section 1.

Equation (3.3a) is obtained by substituting for $w^*$ and $r^*$ in (3.3) from (2.1) and (2.2), and substituting for $p^*_M$ from (1.14), (2.1), and (2.2).

As established earlier

$$\frac{a_M^*}{M} = \frac{\theta_1}{L} w^* + \frac{\theta_1}{K_1} r^* + \frac{\theta_{M_1}}{\sigma_{MM}^*} P^*_M + \frac{\theta_1}{Q_1} \sigma_{MQ}^* Q^*.\phantom{\text{nil}}$$

Since

$$-\frac{\theta_{M_1}}{\sigma_{MM}^*} = \frac{\theta_1}{L} \sigma_{LM}^* + \frac{\theta_1}{K_1} \sigma_{KM}^* + \frac{\theta_1}{Q_1} \sigma_{MQ}^* Q^*$$

from the fact that $a_{ij}^* = 0$ if all input prices change in the same proportion,

$$\frac{a_M^*}{M} = \frac{\theta_1}{L} \sigma_{LM}^* (w^* - p^*_M) + \frac{\theta_1}{K_1} \sigma_{KM}^* (r^* - p^*_M) + \frac{\theta_1}{Q_1} \sigma_{MQ}^* (Q^* - p^*_M).$$

With $p^*_Q = 0$, $p^*_M < 0$, and $w^* > p^*_M > r^*$, $a_{M_1}^* > 0$ if the positive first and the last terms outweigh the negative second term. However, the assumption of $a_{M_1}^* > 0$ is by no means crucial to the demonstration of the paradox when $p^*_M$ along is positive. This latter point is made clear in the subsequent discussion.

This condition is equivalent to the requirement that the capital-labor ratio of the domestic intermediate input lies between the net ratios for the two final commodities. This is because if both $k_2$ and $k_M$ are greater (smaller) than $k$ as is the case when $k_2 \gtrless k_M \gtrless k_1$, then $k_1$ must be less (greater) than $k$, since $k$ is a weighted average of the $k_i$'s. Hence $k_2 \gtrless k_M \gtrless k_1$.

This point can be demonstrated without much ado. The paradox of a decline in $X_1/X_2$ consequent upon a rise in $p_1$ alone requires that inequality (3.8) be satisfied. For large values of $\theta_{Q_1}$, $\beta_L^2 - \beta_K^2/\theta_{Q_1}$ tends to be small, which in turn augments the chances of (3.8) being satisfied.
References


