

Jones, Ronald Winthrop

Working Paper

International trade, real wages and technical progress: The specific factors model

Diskussionsbeiträge - Serie II, No. 274

Provided in Cooperation with:

Department of Economics, University of Konstanz

Suggested Citation: Jones, Ronald Winthrop (1995) : International trade, real wages and technical progress: The specific factors model, Diskussionsbeiträge - Serie II, No. 274, Universität Konstanz, Sonderforschungsbereich 178 - Internationalisierung der Wirtschaft, Konstanz

This Version is available at:

<https://hdl.handle.net/10419/101455>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

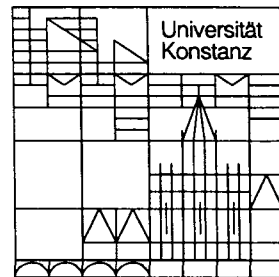
Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Sonderforschungsbereich 178
„Internationalisierung der Wirtschaft“

Diskussionsbeiträge



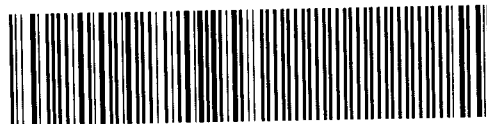
Juristische
Fakultät

Fakultät für Wirtschafts-
wissenschaften und Statistik

Ronald W. Jones

**International Trade, Real Wages
and Technical Progress:
The Specific-Factors Model**

W 113 (274)



25. JULI 1995 Weltwirtschaft
Kiel

W 113 (274) *mr. br sig gla*

**International Trade, Real Wages and
Technical Progress:
The Specific-Factors Model**

617828

Ronald W. Jones

Serie II - Nr. 274

Juli 1995

International Trade, Real Wages and Technical Progress:
The Specific-Factors Model

Ronald W. Jones^{*}
University of Rochester

It has been over fifty years since Stolper and Samuelson (1941) pointed out that whereas free trade may be beneficial to a country in aggregate terms, even a broad-based factor such as labor may be hurt by the price changes which trade brings about. In particular, a staple of Heckscher-Ohlin trade theory is that relatively capital-abundant countries tend to import commodities which are produced by labor-intensive techniques at home, and the competition which such trade engenders serves to depress real wages. Recent battles to obtain passage of the NAFTA accord and Uruguay Round of GATT agreements in the United States have focused on the overall gains which freer trade is likely to produce, and have suggested, perhaps only implicitly, that the gains are sufficient to compensate potential losers among the working class. Such compensation schemes, however, are rarely introduced, although certain sections of the economy may achieve exceptions to a move to more liberal trade.

Changes in the global trading scenario are taking place against a background of advances in technology. Technical progress in a country is generally expected to benefit most productive factors, but strict adherence to a narrow Heckscher-Ohlin interpretation suggests that if technical progress at home is centered in capital-intensive sectors, real wages will suffer, regardless of the capital-saving or labor-saving bias in technical change. Such a drop in real wages would be even more pronounced if simultaneously foreign countries are expanding the world output of labor-intensive

^{*} I am indebted to the Department of Decision Sciences and Managerial Economics of the Chinese University of Hong Kong for encouragement and support of this research.

products, both because of advances in foreign technology in these areas and, perhaps especially, because of the arrival of new labor-abundant countries into the world trading community. Elsewhere (Jones, 1995) I have argued that bias in technical progress and the possibility of variations in the bundles of commodities produced can play a role in letting Heckscher-Ohlin theory predict a richer and more realistic set of outcomes. The Heckscher-Ohlin model, however, is not the only model which can be used to analyze trade issues. In this paper I focus on the consequences of technical progress for real wages in a model in which labor is a mobile factor and sectors produce outputs by combining labor with human or physical capital that is tied to a particular industry, at least in the short run. Although the sector-specific model easily accommodates many sectors, for ease of exposition the analysis focusses on the two-commodity case.

1. Wage Rates, Prices, Endowment Changes and Technical Progress.

In the specific-factors framework suppose that labor is the mobile factor and each sector ($i = 1, 2$) uses a type of capital (physical or human) specific to that sector (K_i). The relationship between prices, endowment changes and the wage rate is well known (Jones, 1971 or Caves, Frankel and Jones, 1993):

$$(1) \quad \hat{w} = \beta_1 \hat{p}_1 + \beta_2 \hat{p}_2 - \frac{1}{\gamma_L} \left\{ \hat{L} - \left[\lambda_{L1} \hat{K}_1 + \lambda_{L2} \hat{K}_2 \right] \right\},$$

where coefficients $\beta_i = \frac{\lambda_{Li} \gamma_{Li}}{\gamma_L}$ sum to unity since γ_L , the economy's overall elasticity

of demand for labor, is the weighted average, $\sum_i \lambda_{Li} \gamma_{Li}$, of the elasticities of labor demand in each sector (γ_{Li}) (or the elasticity of the marginal product of labor schedule in each sector), the weights, λ_{Li} , denoting the fraction of the entire labor force (L)

allocated to the i^{th} sector. Two basic features of the specific-factors model are revealed by equation (1): (i) An increase in any commodity price raises the wage rate, but only by a fraction of the price rise, and (ii) Even if commodity prices are held constant, factor endowment changes have an independent effect on the wage rate. An expansion in labor supply depresses the wage rate whereas an increase in either type of capital supply causes the wage rate to rise. In more detail, any change in factor endowments is aggregated so that only the *net* increase in labor supply, defined as \hat{L} minus the λ_L -weighted average of capital supply changes, affects the labor market.

The change in labor's *real wage* is obtained by subtracting from \hat{w} the change in the cost-of-living index for labor, \hat{p}_L :

$$(2) \quad \hat{p}_L \equiv \alpha_1 \hat{p}_1 + \alpha_2 \hat{p}_2 ,$$

where the α_i represent labor's consumption share for the i^{th} commodity. Substituting into (1), the expression for the change in labor's real wage is given by:

$$(3) \quad \hat{w} - \hat{p}_L = (\beta_2 - \alpha_2)(\hat{p}_2 - \hat{p}_1) - \frac{1}{\gamma_L} \left\{ \hat{L} - [\lambda_{L1} \hat{K}_1 + \lambda_{L2} \hat{K}_2] \right\}$$

In Ruffin and Jones (1977) it was argued that real wages would tend to fall if a country levied a tariff on imports. The reasoning established a presumption, not a certainty, and rested on two assumptions: (i) Taste patterns for laborers were similar to that for the economy as a whole, and (ii) The imported good was produced locally with a degree of flexibility in labor demand and intensity of labor usage that were typical of the economy-wide average. A rewriting of β_i as in (4) lends precision to these phrases:

$$(4) \quad \beta_i = \theta_i \left(\frac{\lambda_{Li}}{\theta_i} \right) \left(\frac{\gamma_{Li}}{\gamma_L} \right)$$

Taking the three terms in (4) in reverse order, $\left(\frac{\gamma_{Li}}{\gamma_L}\right)$ compares the elasticity of sector i 's

demand for labor to the economy-wide average. The term $\left(\frac{\lambda_{Li}}{\theta_i}\right)$, where θ_i denotes

the fraction of the national income devoted to producing commodity i , indicates that sector i is labor-intensive if the term exceeds unity.¹ If sector i is "typical" of sectors

in the economy in these two respects, β_i will reflect the importance of commodity i in the country's production bundle, θ_i . If good i is imported, and if labor's tastes are

those of the population at large and the commodity is "typical" in its technology, α_i exceeds β_i (equal to θ_i) and a tariff-inspired increase in commodity i 's price would lower the real wage.

Suppose, now, that endowments do not change but that each sector exhibits technical progress. Following the treatment in Jones (1965) the relative change in each input-output coefficient, \hat{a}_{ij} , can be decomposed into two parts, \hat{c}_{ij} and \hat{b}_{ij} :

$$(5) \quad \hat{a}_{ij} = \hat{c}_{ij} - \hat{b}_{ij}$$

The \hat{c}_{ij} represent alterations in techniques that are induced by changes in factor price ratios, $\frac{r_i}{w}$, as of a given technology, whereas \hat{b}_{ij} represents the relative *reduction* in the

use of factor i to produce commodity j as of a given set of factor prices. Thus

$(\theta_{L1}\hat{b}_1 + \theta_{K1}\hat{b}_{K1})$ represents π_1 , the Hicksian measure of the rate of technical progress

¹ The term also equals $\frac{\theta_{Li}}{\theta_L}$, a comparison of labor's distributive share in sector i to labor's overall share in the national income.

in the first industry, and the term $(\hat{b}_{L1} - \hat{b}_{K1})$ captures the Hicksian bias in technical progress; if this is positive, technical progress has been labor-saving in the first sector.

With this general characterization of technical progress in hand it is possible to develop expressions for changes in nominal wage rates or real wage rates that parallel (1) and (3) for the case of endowment changes. The key relationship is the labor-market clearing condition (6) where x_i is output of the i^{th} sector:

$$(6) \quad a_{L1}x_1 + a_{L2}x_2 = L$$

As of fixed factor endowments, but allowing for technical progress, rates of change are shown in (7):

$$(7) \quad \lambda_{L1}(\hat{a}_{L1} + \hat{x}_1) + \lambda_{L2}(\hat{a}_{L2} + \hat{x}_2) = 0$$

Output changes are restricted by fixed endowments of capital ($a_i x_i$ equals K_i), so that

$$(8) \quad \hat{x}_i = -\hat{a}_{Ki}$$

Substitution into (7), making use of the decomposition given by (5), yields:

$$(9) \quad \sum_i \lambda_{Li}(\hat{c}_{Li} - \hat{c}_{Ki}) = \sum_i \lambda_{Li}(\hat{b}_{Li} - \hat{b}_{Ki})$$

By definition each $(\hat{c}_{Li} - \hat{c}_{Ki})$ is linked to the elasticity of substitution, σ_i . Thus:

$$(10) \quad (\hat{c}_{Li} - \hat{c}_{Ki}) \equiv -\sigma_i(\hat{w} - \hat{r}_i)$$

By the competitive profit equations of change in sector i :²

$$(11) \quad \theta_{Li}\hat{w} + \theta_{Ki}\hat{r}_i = \hat{p}_i + \pi_i$$

Subtracting \hat{w} from both sides yields:

$$(12) \quad \theta_{Ki}(\hat{r}_i - \hat{w}) = (\hat{p}_i - \hat{w}) + \pi_i,$$

² Since $\sum \theta_{ij}(\hat{a}_{ij} + \hat{w}_i) = \hat{p}_j$, and $\sum \theta_{ij}\hat{a}_{ij} = \sum \theta_{ij}\hat{c}_{ij} - \sum \theta_{ij}\hat{b}_{ij}$, and since $\sum_i \theta_{ij}\hat{c}_{ij} = 0$

by cost minimization, equation (11) follows, with π_i , defined as $\theta_{Li}\hat{b}_{Li} + \theta_{Ki}\hat{b}_{Ki}$. The θ_{ij} are distributive shares.

and substitution into (10) reveals that

$$(13) \quad (\hat{c}_{Li} - \hat{c}_{Ki}) = -\frac{\sigma_i}{\theta_{Ki}}(\hat{w} - \hat{p}_i - \pi_i)$$

But the term $\left(\frac{\sigma_i}{\theta_{Ki}}\right)$ is equivalent to the elasticity of labor demand in sector i , γ_{Li} , so that substitution into (9) results in a solution for the nominal wage rate change that parallels equation (1):

$$(14) \quad \hat{w} = \beta_1(\hat{p}_1 + \pi_1) + \beta_2(\hat{p}_2 + \pi_2) - \frac{1}{\gamma_L} \left\{ \pi_L - [\lambda_{L1}\hat{b}_{K1} + \lambda_{L2}\hat{b}_{K2}] \right\},$$

where π_L is defined as $\sum \lambda_{Li}\hat{b}_{Li}$, the average degree of saving in labor-usage as of given factor prices. For future reference define \hat{B}_L as the labor-saving bias in technology:

$$(15) \quad \hat{B}_L \equiv \pi_L - [\lambda_{L1}\hat{b}_{K1} + \lambda_{L2}\hat{b}_{K2}]$$

The expression for the change in the real wage rate, parallel to (3), can thus be written as (16):

$$(16) \quad \hat{w} - \hat{p}_L = (\beta_2 - \alpha_2)(\hat{p}_2 - \hat{p}_1) + \sum_i \beta_i \pi_i - \frac{1}{\gamma_L} \hat{B}_L$$

For a country engaged in free trade and facing given world commodity prices, technological progress at home affects real wages in a manner that should be compared with the Heckscher-Ohlin model. First, if technical progress is Hicksian neutral and at the same rate in both sectors, real wages will rise by that same relative amount in either model. If technical change is Hicksian neutral but at different rates in the two sectors, in the specific-factors model, as (16) shows, labor gains at least to some extent - the term,

$\sum_i \beta_i \pi_i$, is positive. But in the Heckscher-Ohlin model everything depends on a factor intensity comparison between the sector with greater progress and the other sector. Indeed, if progress occurs significantly more rapidly in the capital-intensive sector, real wages could suffer.³ Finally, the point that is worth emphasizing is that the factor *bias* of technical progress is of no consequence for real wages in the Heckscher-Ohlin model unless the production bundle changes in composition. Bias in the specific-factors model, by contrast, is of first-order importance.

2. Endogenous Price Response in a Closed Economy

If technical progress takes place in a closed economy the relative commodity price ratio must adjust to clear commodity markets. To analyze this issue consider, first, the effect of technical progress on the ratio of outputs produced, $(\hat{x}_2 - \hat{x}_1)$. As will be shown, this parallels the effect of factor endowment changes on outputs.

With fixed endowments of K_1 and K_2 , eq. (8) suggests that

$$(17) \quad (\hat{x}_2 - \hat{x}_1) = \hat{a}_{K1} - \hat{a}_{K2} = (\hat{c}_{K1} - \hat{c}_{K2}) + (\hat{b}_{K2} - \hat{b}_{K1})$$

The \hat{c}_{Kj} depends upon the elasticity of the demand for labor and the degree of technical progress in the j^{th} sector. Thus equation (13), showing $(\hat{c}_{L1} - \hat{c}_{K1})$, can be combined with the statement that cost minimization requires $(\theta_{L1} \hat{c}_{L1} + \theta_{K1} \hat{c}_{K1})$ to vanish:

³ As of fixed prices the solution for the wage change in the Heckscher-Ohlin model is

$\hat{w} = \frac{1}{|\theta|} \{ \theta_{K2} \pi_1 - \theta_{K1} \pi_2 \}$ where $|\theta|$ equals $(\theta_{K2} - \theta_{K1})$. For details see Jones (1965).

$$(18) \quad \begin{aligned} \theta_{L1} \hat{c}_{L1} + \theta_{K1} \hat{c}_{K1} &= 0 \\ -\hat{c}_{L1} + \hat{c}_{K1} &= \gamma_{L1} (\hat{w} - \hat{p}_1 - \pi_1) \end{aligned}$$

This pair of equations leads, in particular, to solutions for \hat{c}_{Ki} :

$$(19) \quad \hat{c}_{Ki} = \theta_{Li} \gamma_{Li} (\hat{w} - \hat{p}_i - \pi_i),$$

implying that, from (17),

$$(20) \quad (\hat{x}_2 - \hat{x}_1) = (\hat{b}_{K2} - \hat{b}_{K1}) + \theta_{L1} \gamma_{L1} (\hat{w} - \hat{p}_1 - \pi_1) - \theta_{L2} \gamma_{L2} (\hat{w} - \hat{p}_2 - \pi_2)$$

Equation (14) provides solutions for $(\hat{w} - \hat{p}_i - \pi_i)$, and substitution reveals:

$$(21) \quad (\hat{x}_2 - \hat{x}_1) = (\hat{b}_{K2} - \hat{b}_{K1}) + \{\theta_{L1} \gamma_{L1} \beta_2 + \theta_{L2} \gamma_{L2} \beta_1\} \{(\hat{p}_2 - \hat{p}_1) + (\pi_2 - \pi_1)\} \\ + \left\{ \frac{\theta_{L2} \gamma_{L2} - \theta_{L1} \gamma_{L1}}{\gamma_L} \right\} \hat{B}_L$$

The coefficient of $(\hat{p}_2 - \hat{p}_1)$ is, by definition, the elasticity of relative supply along the transformation schedule, σ_S . This term can be simplified as:⁴

⁴ As explained in Jones (1979, Ch. 7), if an assumption of symmetry is made such that γ_{L1} and γ_{L2} are equal and, as well, labor intensities, θ_{L1} and θ_{L2} are equal, the expression for σ_S reduces to $\frac{1 - \theta_K}{\theta_K} \cdot \sigma_i$, where σ_i is the common value of the elasticity of substitution between sectors. These

symmetry assumptions are made to allow a comparison with the σ_S term in a 2-sector Heckscher-Ohlin model. There factor intensity differences are paramount, and a symmetry assumption is made about the degree of immobility of capital between sectors - capital is completely mobile in and out of both. If, furthermore, each sector has a common elasticity of substitution, σ_i , the expression for σ_S

reduces to $\frac{1 - |\lambda||\theta|}{|\lambda||\theta|} \sigma_i$, where $|\lambda||\theta|$, a positive fraction, indicates the degree of factor-intensity difference between sectors.

$$(22) \quad \sigma_s = \frac{\gamma_{L1}\gamma_{L2}}{\gamma_L} [\lambda_{L1}\theta_{L2} + \lambda_{L2}\theta_{L1}]$$

With this simplification in hand, the change in relative outputs when prices may alter and technical progress takes place is shown in (23):

(23)

$$(\hat{x}_2 - \hat{x}_1) = \sigma_s(\hat{p}_2 - \hat{p}_1) + \sigma_s(\pi_2 - \pi_1) + (\hat{b}_{K2} - \hat{b}_{K1}) + \left\{ \frac{\theta_{L2}\gamma_{L2} - \theta_{L1}\gamma_{L1}}{\gamma_L} \right\} \hat{B}_L$$

The meaning of this expression can be appreciated by comparing it with the analogous expression for relative output changes when technology is kept constant but factor endowments change (see Jones, 1971):

$$(24) \quad (\hat{x}_2 - \hat{x}_1) = \sigma_s(\hat{p}_2 - \hat{p}_1) + (\hat{K}_2 - \hat{K}_1) + \left\{ \frac{\theta_{L2}\gamma_{L2} - \theta_{L1}\gamma_{L1}}{\gamma_L} \right\} \left[\hat{L} - (\lambda_{L1}\hat{K}_1 + \lambda_{L2}\hat{K}_2) \right]$$

The coefficient of price changes is the same in (23) and (24), but with technical progress the *effective* price change to producers in sector i is $(\hat{p}_i + \pi_i)$. With changes in capital supplies there are concomitant changes in outputs as of given prices; the same remark can be made for the $(\hat{b}_{K2} - \hat{b}_{K1})$ term in (23). Finally, note that the coefficient of \hat{B}_L in (23) is also the coefficient for the *net* increase in labor supply in (24), and reveals how an increase in labor supply (or net labor-saving bias in technical progress) affects relative outputs. The sign of this coefficient is positive if, for sector 2, an index of the relative

degree of flexibility in labor demand $\left(\frac{\gamma_{L2}}{\gamma_L}\right)$ times an index of the intensity with which labor is utilized in the second sector (θ_{L2}) exceeds the comparable product in sector 1. Thus the effect on outputs of an increase in net labor supply or an aggregate labor-saving bias in technology depends both upon a factor-intensity ranking and a comparison of the ease of factor substitution. This joint dependence on both aspects of technology is one of the hall-marks of the specific-factors model that distinguish it from the Heckscher-Ohlin model.

For a closed economy relative commodity prices adjust to balance changes in supply with demand responses induced by price changes. If tastes are homothetic, the elasticity of substitution in demand, σ_D , can be defined as in (25):

$$(25) \quad (\hat{x}_2 - \hat{x}_1) = -\sigma_D(\hat{p}_2 - \hat{p}_1)$$

Equating the supply changes shown in (23) for the case of fixed endowments and technical progress to induced demand changes shown by (25) yields (26) as the solution for relative commodity price changes in a closed economy:

$$(26) \quad (\hat{p}_2 - \hat{p}_1) = \frac{-1}{(\sigma_S + \sigma_D)} \left\{ \sigma_S(\pi_2 - \pi_1) + (\hat{b}_{K2} - \hat{b}_{K1}) + \left[\frac{\theta_{L2}\gamma_{L2} - \theta_{L1}\gamma_{L1}}{\gamma_L} \right] \hat{B}_L \right\}$$

The remaining task in ascertaining how technical progress affects the real wage rate in a closed economy requires a substitution of these price changes into equation (16):

$$(27) \quad \hat{w} - \hat{p}_L = \frac{(\alpha_2 - \beta_2)}{(\sigma_s + \sigma_D)} \left\{ \sigma_s (\pi_2 - \pi_1) + (\hat{b}_{K2} - \hat{b}_{K1}) + \left[\frac{\theta_{L2} \gamma_{L2} - \theta_{L1} \gamma_{L1}}{\gamma_L} \right] \hat{B}_L \right\} \\ + \sum \beta_i \pi_i - \frac{1}{\gamma_L} \hat{B}_L$$

Understanding is clearly enhanced if, at this stage, special simplifying cases are considered. First, note the importance of the comparison between labor's stance as a demander of, say, the second commodity (α_2) and the effect of a relative price change on nominal wages (β_2). In the most symmetric case in which labor's taste patterns are shared by the community,⁵ and in which the imported commodity (say x_2) is "typical" in the intensity and substitutability aspects of technology, a reduction in the relative price of importables would not only signal a terms-of-trade improvement for the community, but an increase in the real wage. Technical progress biased in the direction of the second commodity aids in bringing about such a price change.

For special types of technical progress more can be said. As previously noted, Hicksian neutral technical progress at the same rate in both sectors leaves relative prices unaltered and improves the real wage by the same relative amount. Hicksian neutral progress at different rates in the two industries is more subtle in its effect on real wages. Such neutrality, even at different rates, implies that \hat{B}_L equals zero and that $\hat{b}_{Ki} = \pi_i$. Thus (27) reduces to (27'):

⁵ This assumption helps to support the demand expression shown in (25), since it implies that a redistribution of income does not affect relative demands. Without this, the solution for relative price changes in a closed economy becomes more complicated.

$$(27') \quad (\hat{w} - \hat{p}_L) = (\alpha_2 - \beta_2) \frac{(\sigma_s + 1)}{\sigma_s + \sigma_D} (\pi_2 - \pi_1) + \sum \beta_i \pi_i$$

The role of the elasticity of substitution in demand, σ_D , is apparent from (27') and (26). Technical progress favoring industry 2 causes a relative fall in X_2 's price. By (26) it becomes clear that in the Hicksian neutral case with progress at a greater rate in sector 2 the price ratio falls by more than the relative improvement in technology if and only if σ_D falls short of unity.

In his argument that technical progress could benefit real wages in a closed economy, Batra (1992) made the further assumptions (i) that good 1 represented services, which were the only goods consumed by labor ($\alpha_2 = 0$) and (ii) that (Hicks-neutral) technical progress took place only in manufactures ($\pi_1 = 0$). In such a case expression (27') reduces to (27''):

$$(27'') \quad (\hat{w} - \hat{p}_L) = \frac{\sigma_D - 1}{\sigma_s + \sigma_D} \beta_2 \pi_2$$

Therefore if σ_D exceeds unity in a closed economy, labor would gain in real terms. At issue is the conflict between labor's gain from the productivity improvement if commodity prices were unchanged, $(\beta_2 \pi_2)$, and the deleterious effect of the price drop for commodity 2 on the nominal wage, $\left(\frac{\sigma_s + 1}{\sigma_s + \sigma_D} \right) \cdot \beta_2 \pi_2$. Elastic demand serves to cushion such a price fall. Note that the Batra assumption on labor's taste patterns makes it impossible for labor to achieve any gain as consumers from the effect of the price drop for commodity 2.

The preceding scenario does not reveal the potential role for a labor-saving bias in technical progress. From (26) it is clear that a labor-saving bias in technical progress anywhere in the economy tends to reduce by more the relative price of the commodity which would expand at constant prices if the labor force expanded. This is the commodity with the higher product of labor intensity (θ_{Li}) , and relative technological flexibility $\left(\frac{\gamma_{Li}}{\gamma_2}\right)$. If α_2 and β_2 should be equal, real wages are unaffected by changes in relative commodity prices but a labor-saving bias in technical progress serves as a drag on real wages and may eventuate in a real loss to labor.

As equation (27) reveals, the term, T :

$$(28) \quad T \equiv \sum \beta_i \pi_i - \frac{1}{\gamma_L} \hat{B}_L$$

is crucial in assessing the impact of biased technical progress on real wages either when relative price changes by themselves do not affect the real wage (because α_2 approximately equals β_2) or when the country is a small price-taker in the world economy and technical progress only takes place at home. To illustrate the role of bias, consider the case in which technological progress in each sector takes the form of a reduction in the labor-input requirement at given factor prices of the same relative amount in the two sectors, with no change in the capital-input requirement; that is, $\hat{b}_{Li} = \pi_L$, and $\hat{b}_{Ki} = 0$ for $(i = 1, 2)$. This kind of change stacks the decks, as it were, against labor. The expression for T in (28) reduces to (28'):

$$(28') \quad T = \left\{ \sum \beta_i (\theta_{Li}) \right\} \pi_L - \left(\frac{1}{\gamma_L} \right) \pi_L$$

Since the economy-wide elasticity of demand for labor, γ_L , appears in the denominator of each β_i , and since γ_{L_i} equals $\frac{\sigma_i}{\theta_{K_i}}$, the condition for T to be positive in this special case is that:

$$(29) \quad \sum \lambda_{L_i} \sigma_i > \sum \lambda_{L_i} \left(\frac{\theta_{K_i}}{\theta_{L_i}} \right)$$

That is, if on average the elasticity of substitution in each sector exceeds the ratio of distributive shares of capital to labor in that sector, the real wage will rise. If, in most sectors, labor's distributive share exceeds that of capital, this condition could well be met. Other special cases could be considered, but a general result emerges:

Even if relative commodity price changes do not affect real wages or are determined in world markets, productivity improvements that are primarily (Hicksian) labor-saving in character will nonetheless raise real wages if elasticities of substitution in production are sufficiently high (exceeding the ratio of capital shares to labor shares).

3. Real Wage Changes in an Open Economy: Further Remarks

When an economy is open to trade, local supply shocks which are brought about as a consequence of technical progress or factor endowment growth need not lead to relative price adjustments equating local demand and supply. Although expressions such as (23) or (24) for relative output changes are still valid, the extent of price changes depends upon the relative size of the country as well as upon the possible existence of supply shocks which are originating elsewhere in the global economy.

A scenario that may not bode well for real wages in a country is one in which technical progress at home is less pronounced than abroad. At the extreme, suppose no technical progress characterizes home technology. By equation (16) it is clear that the real wage depends exclusively on the impact of foreign changes on the terms of trade and whether labor's average propensity to consume the commodity which has fallen in price (α_i) exceeds or falls short of its importance for the nominal wage (β_i). In the discussion about taste patterns for American labor there is a wide range of opinion. Batra (1992) asserts a low value for labor's propensity to consume manufactures which have fallen in price in consequence of technical improvements abroad. By contrast, in a recent paper Leamer (1995) suggests a biased taste pattern on the part of labor in favor of commodities such as textiles and apparel in which increased foreign production has recently been most pronounced.⁶ As well, most laborers possess TV sets and perhaps VCR's made abroad. Of course taste patterns are just one side of the picture. To the extent that American production of these imported goods has fallen, the associated production weight on nominal wage rates (β_i) will tend to be small, making it more likely that future price drops will increase real wages.

4. Concluding Remarks

Most small-scale models of international trade tend to downplay an important characteristic of trade - that it cuts the one-to-one dependence of the consumption bundle on the production bundle. A country may produce only a narrow band of products for the world market while consuming a much wider variety of products available through trade. The multi-commodity Heckscher-Ohlin model (e.g. see Jones,

⁶ However, account must taken of high and/or increasing degrees of protection for such commodities in the United States.

1974) makes good use of this high degree of concentration in production to suggest how increased foreign production of goods that are highly labor-intensive can benefit home laborers, who have progressed to produce more capital-intensive commodities. Somewhat similar analysis can be developed for a multi-commodity specific-factors model, even if some production remains of commodities which are primarily produced abroad and imported. If labor is mobile between sectors, the real wage will tend to rise when prices of such commodities fall since the position of laborers as consumers will outweigh their role as competing producers.

In this paper I have focused on the role of technical progress at home in affecting wage rates. For a closed economy, the supply changes induced by technology shocks serve to alter commodity prices, and these changes as well affect real wages. The changes in supply reflect not only inter-sectoral differences in the rate of technical change but also the labor-saving or capital-saving bias. The two sector Heckscher-Ohlin model shares this characteristic for a closed economy. However, if an economy is a price-taker on world markets, and if changes originating at home are the primary cause of technical progress, in the simple Heckscher-Ohlin model such factor bias has no independent role to play in determining real wages, parallel to the result that endowment changes have no influence on factor prices if commodity prices are unchanged. It is in this regard that the specific-factors model suggests what may appear as a more realistic outcome: labor-saving technical progress has a tendency to depress the real wage rate even without working through a change in commodity prices. As was emphasized in Section 2's discussion, however, and as is evident from equation (16), improvements in technology at home that are primarily labor-saving in character will nonetheless serve to raise real wages if technology exhibits the kind of flexibility that is captured in high-

elasticities of substitution or elasticities of derived demand for labor. This effect is independent of the well-recognized dampening of commodity prices which high elasticities provide.

Some types of labor do not possess the degree of mobility assumed in this model. As was recognized long before the landmark contribution of Stolper and Samuelson, a type of labor that is specifically employed in one industry will unambiguously have its real wage lowered by foreign competition in this sector. A comparable result follows if technical progress obviates the need to employ such a factor. The Stolper-Samuelson contribution, and recent concerns about trade liberalization in the United States, deal with the fate of real wages of broad classes of labor. The specific-factors model with labor the mobile factor may suggest a more optimistic outcome for real wages for economies importing commodities from more labor-abundant countries and facing price changes induced by expansion abroad and technical progress at home.

References:

- Batra, R. (1992): "The Fallacy of Free Trade," Review of International Economics.
- Caves, R.E., J. Frankel and R.W. Jones (1993): World Trade and Payments, 6th edition, (Harper-Collins).
- Jones, R.W. (1965): "The Structure of Simple General Equilibrium Models," Journal of Political Economy.
- Jones, R.W. (1971): "A Three-Factor Model in Theory, Trade and History," Ch. 1 in Bhagwati (et al); Trade, Balance of Payments and Growth (Elsevier)
- Jones, R.W. (1974): "The Small Country in a Many Commodity World," Australian Economic Papers.
- Jones, R.W. (1979): International Trade: Essays in Theory (North-Holland).
- Jones, R.W. (1995): "Trade and Wages: Comments on Theoretical Issues," unpublished Brookings Conference proceedings.
- Leamer, E. (1995): "A Trade Economist's View of U.S. Wages and Globalization," unpublished Brookings Conference proceedings.
- Ruffin, R. and R.W. Jones (1977): "Protection and Real Wages: The Neo-Classical Ambiguity," Journal of Economic Theory.
- Stolper, W. and P. Samuelson (1941): "Protection and Real Wages," the Review of Economic Studies.