Trade and Wages: A Deeper Investigation

Ronald W. Jones
University of Rochester

Roy J. Ruffin
University of Houston

When does international trade hurt workers? The classic answer provided by Wolfgang Stolper and Paul Samuelson (1941) presumed a Heckscher-Ohlin scenario in which only two commodities are produced with two productive factors completely mobile between sectors. The factor-intensity ranking of traded commodities told all, with real wages in the country importing the labor-intensive commodity unambiguously worsened if it should lower protective barriers to trade, while real wages in the exporting country would rise.[1] This answer has proved popular not only because it is simple, but it also has minimal data requirements (Edward Leamer, 1998). However, there is another simple model that emphasizes the distinction between factors that are specific to individual sectors and a more mobile factor like labor (Ronald Jones, 1971 and Samuelson, 1971), which provides a richer set of criteria for judging the effect of trade on wage rates. In the specific-factors model the crucial defining technological characteristic that points to the asymmetry between sectors is what we call the *intensity-elasticity nugget*. Here we investigate not only its role in determining how changes in the terms of trade affect real wages and the pattern of trade, but also how the size of this nugget itself may be affected by such price changes.

[1] This remark assumes that the same commodity is labor intensive in both importing and exporting countries. In the many-commodity case other outcomes are possible, even in the absence of technological factor-intensity reversals (Ronald Jones , 2002).

Specific factors are a pervasive phenomenon in production processes (e.g., Gene Grossman and James Levinson, 1989). Not only is capital specific in the short run in the form of equipment designed for particular products[2], there are many products for which factor specificity is a good first approximation. For example, oil fields, rice paddies, and coffee plantations may be converted to other uses only when the prices of those products fall to very low levels[3]. Any degree of heterogeneity in land, capital, or labor yields to those factors economic rents in particular industries and thus lends the flavor of factor specificity to a broad range of factors.[4] Common labor is perhaps the least specific of all factors, and so it seems appropriate to apply the specific-factors model (with labor mobile) to the impact of trade on a significant fraction of a nation's workers.[5]

In this specific factors model labor's nominal wage will be raised by an increase in either commodity price, but proportionally not by as much. Since the cost of living to workers would also increase, there emerges a *neoclassical ambiguity* about the effect of commodity price changes on the *real* wage rate. It was in this setting that over twenty-five years ago Ruffin and Jones (1977) argued that there is a *presumption* that labor stands to gain in real terms by more open trade *regardless of the trade pattern*. However, a recent paper by James Melvin and Robert Waschik (2001) supplies a valuable computer-generated example in the specific-factors context that suggests that when elasticities of substitution in production are sufficiently low, mobile labor's real wage is

[2] See Wolfgang Mayer (1974), Michael Mussa (1974) and J. Peter Neary (1978) for an analysis of short-run specificity of capital.
[3] Gottfried Haberler (1936, p. 194) points out that there is long-run factor specificity mainly in extractive industries.
[4] See Roy Ruffin (2001) for an analysis of quasi-specificity in a model with features both of the Heckscher-Ohlin and the specific-factors model.
[5] Both Ruffin (1981) and Jones and Stephen Easton (1983) show that the mobile factor in the specific-factors model may share many of the properties of a "middle" factor in the general three-factor, two-commodity model.

depressed by *any* movement away from autarky.[6] The effect of trade on real wages is obviously an important issue. Admittedly, the specific-factors model with a single type of labor is not well suited to analyze the effect of trade or technical progress on the *wage premium* that skilled workers receive over the unskilled, a currently fashionable topic.[7] However, here we concentrate on a more fundamental issue – what is the link between the terms of trade and average real wages? We show that the specific factors model gives an empirically interesting answer to this question, one that even allows for a lowering of world prices of "capital-intensive" exportables to harm workers. In Mexico, for instance, from 1980 to 1999, the price of their highly capital-intensive oil exports tumbled from a yearly average of $31 a barrel to $16 a barrel while hourly wages fell from $2.21 to $2.12.[8] Under Stolper-Samuelson, worker real income should have improved!

Although our analysis is conducted for two sectors, it generalizes in simple fashion to any number of sectors. This research is important because it suggests some promising empirical studies as well as policies that might be followed to ameliorate any losses workers might sustain from trade.

Section 1 reviews the foundations for studying the elasticity of the nominal wage rate with respect to a change in commodity prices. Section 2 shows that the gains to labor can be broken down into potentially measurable "terms of trade" and "production bias" effects, both of which can be represented geometrically. Section 3 analyzes in

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[6] Of course it has often been suggested that low elasticities of substitution in production may be detrimental to labor (for a survey see William Tyler, 1974), primarily if there is a promotion of capital-intensive import-competing activity. Note that in the Stolper-Samuelson model such elasticities do not count – only factor intensities matter.

[7] Of course one of the specific factors could be singled out as skilled labor, e.g. used only in the export sector. Alternatively, an extension of the specific-factors model could be investigated, such as in Ruffin (2001) or Jones and Sugata Marjit (2003). These models allow both types of wage rates to rise or fall together, along with changes (in either direction) in the wage premium.

detail how, with constant elasticities of substitution, changes in commodity prices or factor endowments affect wage gains, and Section 4 concentrates on scenarios in which trade is damaging to workers. Section 5 allows world prices to be determined endogenously and shows that a result reminiscent of the Heckscher-Ohlin model extends to the specific factors model: If trade is caused by labor being the abundant factor, then labor will gain from trade. But if trade is caused by other factors, such as technology differences, trade may prove hazardous for labor under limited circumstances. Section 6 summarizes and makes some concluding remarks on future research.

1. Labor Intensity and Technological Flexibility with Specific Factors

A deeper study of the specific-factors model can benefit from a reprise of what is already known (Jones, 1971; Mussa, 1974). Commodities are labeled *1* and *2*, and L denotes mobile labor, K_1 and K_2 the factors specific to each sector, a_{ij} the input-output coefficients, w and r_j the nominal wage and rent in the j^{th} sector, and p_j the j^{th} commodity price. The requirement that labor be fully employed is shown in equation (1):

(1) $$a_{L1}x_1 + a_{L2}x_2 = L$$

Techniques are sufficiently flexible so that specific capitals are also fully employed:

(2) $$a_{Kj}x_j = K_j$$

Each input-output coefficient depends upon the ratio of the wage rate to the return to the type of specific factor used in that sector. Indeed, the definition of the elasticity of substitution in a sector is provided by (3), where a “hat” over a variable indicates the relative change in that variable:

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[8] Of course, there may be complicated institutional factors outside the competitive market-clearing model

(3) $$\sigma_j \equiv -\frac{(\hat{a}_{Lj} - \hat{a}_{Kj})}{(\hat{w} - \hat{r}_j)}$$

In the competitive profit relations, costs for each x_j are driven down to price:

(4) $$a_{Lj}w + a_{Kj}r_j = p_j$$

The input-output coefficients along the unit isoquant are selected so as to minimize unit costs of production at given factor prices, requiring:

(5) $$\theta_{Lj}\hat{a}_{Lj} + \theta_{Kj}\hat{a}_{Kj} = 0,$$

with the θ_{ij} denoting factor *i*'s distributive share in industry *j*. Differentiating the competitive profit conditions, (4), and making use of (5):

(6) $$\theta_{Lj}\hat{w} + \theta_{Kj}\hat{r}_j = \hat{p}_j$$

Finally, the relative change in each input-output coefficient can be obtained by combining equation (5) with the definition of the elasticity of substitution in each sector given by equation (3):

(7) $$\hat{a}_{Lj} = -\theta_{Kj}\sigma_j(\hat{w} - \hat{r}_j); \qquad \hat{a}_{Kj} = \theta_{Lj}\sigma_j(\hat{w} - \hat{r}_j)$$

Return, now, to the full-employment condition (1). Output changes are obtained by differentiating (2) (yielding $\hat{x}_j = \hat{K}_j - \hat{a}_{Kj}$), and a substitution into the differentiated form of equation (1) (with λ_{Lj} denoting the fraction of labor used in industry *j*), yields:

(8) $$\lambda_{L1}(\hat{a}_{L1} - \hat{a}_{K1}) + \lambda_{L2}(\hat{a}_{L2} - \hat{a}_{K2}) = \hat{L} - [\lambda_{L1}\hat{K}_1 + \lambda_{L2}\hat{K}_2].$$

Substituting in the definition of the elasticity of substitution from (3):

(9) $$\lambda_{L1}\sigma_1(\hat{w} - \hat{r}_1) + \lambda_{L2}\sigma_2(\hat{w} - \hat{r}_2) = -\{\hat{L} - [\lambda_{L1}\hat{K}_1 + \lambda_{L2}\hat{K}_2]\}$$

The competitive profit equations of change, (6), can be re-arranged:

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that account for this apparent anomaly.

(10) $\theta_{Kj}(\hat{w}-\hat{r}_j)=(\hat{w}-\hat{p}_j)$.

This relationship between changes in wage/rent ratio and wage/price ratios is useful in considering how the *elasticity of demand for labor* in the jth sector, denoted by γ_{Lj} and defined as (minus) the relative change in the labor/capital ratio with respect to a relative change in the wage/price ratio, is related to the *elasticity of substitution* in that sector. Thus combining equations (3) and (10):

(11) $\gamma_{Lj} = \sigma_j/\theta_{Kj}$

In what follows the relationship shown by equation (11) is crucial. It reveals that *even if elasticities of substitution are constant, the elasticities of demand for labor and the factor-intensity ranking will in general* not *be constant if factor prices change, with the comparison of the σ's with unity indicating in which direction distributive shares move.*

Solutions for Wage Rate and Relative Output Changes:

Throughout the paper we let the second commodity serve as numeraire, so that substituting back into equation (9) generates the final solution for the effect of a price change and endowment changes on the wage rate:

(12) $$\hat{w}=\beta_1\hat{p}_1+(\frac{1}{\gamma_L})\hat{V}.$$

where $\beta_j \equiv \frac{\lambda_{Lj}\gamma_{Lj}}{\gamma_L}$; $\gamma_L \equiv \lambda_{L1}\gamma_{L1} + \lambda_{L2}\gamma_{L2}$; and $\hat{V}\equiv\left[(\lambda_{L1}\hat{K}_1+\lambda_{L2}\hat{K}_2)-\hat{L}\right]$.

Thus the effect of an increase in the price of the first commodity on the nominal wage rate is a fraction, β_1, of the commodity price change. γ_L represents the average elasticity of demand for labor in the economy and $\hat{V}$ changes in capital relative to labor. Clearly, $\beta_1 + \beta_2 = 1$; a doubling of all commodity prices would double all factor returns.

Turning to relative output changes, $(\hat{x}_1 - \hat{x}_2)$, when commodity prices are held constant but endowments change, clearly if either type of specific capital increases, so will the output using that type of capital. And the other output falls as it loses labor to the expanding sector.[9] Of more interest are the output changes associated with a rise in labor endowment (or a fall in *V*). In such a case taking relative changes (for fixed capital) in equation (2) and subtracting,

(13) $$(\hat{x}_1 - \hat{x}_2) = \hat{a}_{K2} - \hat{a}_{K1}$$

Making use of the solutions in (7) and the relations given by (10) and (11), with commodity prices fixed[10],

(14) $$(\hat{x}_1 - \hat{x}_2) = \{\theta_{L2}\gamma_{L2} - \theta_{L1}\gamma_{L1}\}\,\hat{w}$$

Finally, the wage change in this case equals $-\left(\frac{1}{\gamma_L}\right)\hat{L}$, so that

(15) $$(\hat{x}_1 - \hat{x}_2) = \{\theta_{L1}\gamma_{L1} - \theta_{L2}\gamma_{L2}\}\left(\frac{1}{\gamma_L}\right)\hat{L}$$

A comparison both of labor intensities and labor demand elasticities is involved in determining which output expands relatively more when the labor force grows.

[9] However, a Rybczynski-like result (1955) for the 2x2 model, whereby the favored output expands relatively more than the intensive (specific) factor, does not hold.

The Intensity-Elasticity Nugget:

It is especially useful to rewrite the fraction, β_1, in a form that reveals the role of factor intensities and factor demand elasticities, on the one hand, and the output share of the first commodity, on the other. As is easy to show, β_1 can be expressed as the product of three parameters.[11]

(16) $\beta_1 = [i_1 \, s_1] \, \theta_1$

Taking these in reverse order:

(i) θ_1 is the share in national income represented by output in the first sector.

(ii) s_1 denotes the *relative* elasticity of demand for labor in the first industry, which is γ_{L1}/γ_L. If there are only two sectors in the economy, this expression exceeds unity only if the elasticity of demand for labor in the first sector exceeds a comparable expression for the second. A rough way of referring to a situation in which s_1 exceeds unity is to say that sector *1* has the more *flexible* technology.

(iii) i_1 denotes the *relative* labor intensity in the first industry, indicated by the expression λ_{L1}/θ_1. An intensity definition for labor involves a comparison of labor's distributive shares in the two sectors. It is easy to show that the term λ_{L1}/θ_1 is the same as the expression θ_{L1}/θ_L, a comparison of labor's distributive share in the first sector to the average for the economy, θ_L.[12] Such an expression in the 2-sector case exceeds unity only if labor's share in sector *1* is larger than in sector *2*.

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[10] This result is found in Jones (1971), eq. (1.14). It could also be derived by making use of the duality relations between commodity and factor prices, on the one hand, and endowments and outputs, on the other.

[11] See Jones (1989) or Richard Caves, Jeffrey Frankel and Jones (2002), p. S-21.

[12] Let Y denote the value of output. Then $\lambda_{L1}/\theta_1 = (X_1 a_{L1} Y)/(X_1 L p_1) = (w a_{L1} Y)/(w L p_1) = \theta_{L1}/\theta_L$.

The intuition behind this product formulation is simple: the response of the wage rate to a price change is larger the more important the good in total output, the more labor-intensive the good, and the more elastic the demand for labor used in the good.[13] We call the product of the relative labor intensity and relative elasticity of demand for labor in the first sector, i_1s_1, the *intensity-elasticity nugget.* This nugget is the defining technological characteristic of the specific factors model. Does its value exceed or fall short of unity? The answer to this query reveals whether the nominal wage rate rises by more or less than the share of the first commodity in national income (or even falls) as p_1 rises. It plays much the same role as the labor-intensity ranking in 2x2 models.

In particular, the intensity-elasticity nugget is crucial not only in relating wage responses to price changes, but also in relating output changes (at constant prices) to changes in the labor supply. Clearly with the new terminology equation (15) can be rewritten as (15'):

(15') $$(\hat{x}_1 - \hat{x}_2) = \theta_L \left\{ i_1 s_1 - i_2 s_2 \right\} \hat{L}$$

This serves to contrast the nugget for the first sector with that of the second. They are related. Indeed, since $\beta_1 + \beta_2 = 1$, equation (13) implies:

(17) $$\theta_1(i_1s_1) + \theta_2(i_2s_2) = 1$$

Solving for the (i_2s_2) term and substituting into (15') yields:[14]

(18) $$(\hat{x}_1 - \hat{x}_2) = \left[\frac{\theta_L}{\theta_2} \right] \left\{ i_1 s_1 - 1 \right\} \hat{L}$$

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[13] The more elastic demand for labor implies that the marginal productivity of labor falls more slowly, so the wage rate rises by more as the price of the good increases.

[14] This equation can be alternatively derived by Samuelson (1953) reciprocity, i.e., $\partial x_i/\partial L = \partial w/\partial p_i$**.** Thus, (16) and (18) reflect the fundamental duality between endowment effects on output**s** and price effects on the nominal wage rate.

This expression emphasizes the crucial role for the value of the intensity-elasticity nugget compared with unity, and is utilized in Section 5's discussion of two-country trade. And, given the interest that traditional trade theory accords the factor-intensity ranking, we shall on occasion assume that the intensity ranking dominates in determining whether or not the size of the nugget exceeds unity.

2. Real Wages and the Beta Function

The *real* wage rate received by labor will be improved by an increase in the price of the first commodity if and only if the relative increase in the nominal wage rate, captured by the fraction, β_1, exceeds the increase in labor's cost of living, indicated by the share that the consumption of commodity *1* takes in labor's income. Call this share δ_1. Thus the *real wage* increases if and only if as p_1 rises, β_1 exceeds δ_1 or, if p_1 falls, β_1 falls short of δ_1 so that the cost of living falls more than the nominal wage rate.

Without further restrictions on the taste pattern of laborers we are left with what has been termed the *neoclassical ambiguity*, the fact that changes in the terms of trade do not necessarily improve or lower the *real* wage rate. To help simplify matters, we now make an important assumption common to empirical trade models: *Workers share the same homothetic taste pattern as possessed by all other agents in the economy*. In our diagrams we assume an even more strict taste pattern for labor.

Given that an increase in the relative price of the first commodity improves the real wage rate if and only if $(\beta_1 - \delta_1)$ is positive, it proves useful to decompose this term into two measurable quantities:

$$(\beta_1-\delta_1) \equiv (\theta_1-\delta_1) + (\beta_1-\theta_1) \qquad (19)$$

The first term on the right-hand side represents the *terms-of-trade effect*. A positive value, revealing an excess of production of commodity *1* over consumption, implies that the country exports the first commodity and therefore benefits by an increase in its price. The terms-of-trade effect *always* operates to improve the real return to labor, given our assumption about labor's taste pattern. The second term has special significance for workers because it compares the increase in the nominal wage rate with the importance of the first commodity in overall production; $(\beta_1 - \theta_1)$ is what we call the *production bias effect*, and it can be rewritten as $(i_1 s_1 - 1)\theta_1$. If the value of the nugget, $i_1 s_1$, exceeds unity, we shall refer to the first commodity as being "biased towards labor," thus taking into account both labor intensities and labor demand elasticities.[15]

We have argued that the comparison of the value of the nugget with unity plays much the same role in the specific-factors model as does the labor-intensity ranking in the 2x2 Heckscher-Ohlin model. However, as equation (19) reveals, there is a crucial difference. In the 2x2 case an increase in p_1 raises the real wage if the first commodity is labor intensive, regardless of whether the price change reflects an improvement or deterioration in the terms of trade. In the specific-factors model the *country's* gain if the terms of trade improve spills over to reflect a bias in favor of the real return to the mobile factor, labor. Ruffin and Jones (1977) argued that there was a *presumption* that the real wage of workers would be improved by a rise in the price of exportables, so that mobile labor would be supportive of free trade. Our presumption was based on the fact that if exports were "typical" or "neutral" in terms both of labor-intensity and the elasticity of demand for labor by sector (that is both i_1 and s_1 were unity, or at least the nugget was),

[15] This explicit formulation is implicit in Ruffin and Jones (1977).

the bias term would disappear so that β_1 becomes θ_1 and the real wage would increase by moving to free trade because there is always a positive terms-of-trade effect. However, if the country does export the first commodity, but the nugget, $(i_1 s_1)$, is sufficiently smaller than unity, the bias effect might outweigh the favorable terms-of-trade effect, and increases in the relative price of exportables would hurt labor.

To simplify the subsequent diagrammatic discussion, let us assume that labor and indeed all agents consuming in the economy possess Cobb-Douglas utility functions so that the consumption share for the first commodity, δ_1, is a constant. As we proceed, we indicate how our qualitative conclusions would need to be modified for more general homothetic tastes. Turn, now, to the upper diagram in Figure 1. Recall that throughout we are holding constant the absolute price of the second commodity. The Cobb-Douglas assumption underlies the horizontal δ_1 line. The production share θ_1 curve must rise monotonically with p_1. The intersection of these two loci, where local demand and production are in balance (point *A*), establishes the price of the first commodity in autarky, p_1^A. It is the β_1 curve whose shape may be much less regular. For purely illustrative purposes the Beta function in Figure 1 rises for low prices and then turns down to intersect the θ_1 curve at point *B* and the δ_1 line at point *E* (and earlier at point *C*).

The lower diagram in Figure 1 explicitly shows the dependence of the real wage rate on relative commodity prices. As drawn, the β_1-curve lies above the θ_1-curve at the autarky price. By equation (16) this means that for prices near autarky the value of the intensity-elasticity nugget, $(i_1 s_1)$, exceeds unity, so that some exports of the first commodity unambiguously favor labor, which would lose if the country imports small amounts of commodity one. Suppose world p_1 is greater than the autarky price. At point

B the bias term vanishes, and then works against labor for higher values of p_1. Between points *B* and *E* the terms-of-trade effect, $(\theta_1-\delta_1)$, outweighs the negative bias term, $(\beta_1-\theta_1)$ or $(i_1s_1-1)\theta_1$, so that the real wage still rises with increases in the export price. This is the basis for the presumption argument that labor gains from trade – in this range it gains because of the favorable terms-of-trade effect despite the bias of exports against labor.

We have assumed that the free-trade price is at p_1^T. Labor clearly gains by free trade. Does this mean that labor would necessarily vote against protection? No. A reduction in price to p_1^E would achieve a local maximum for the real wage rate. These two questions are often confused. Labor can benefit by trade but still want protection.

Now consider the opposite trade pattern (p_1^T lower than p_1^A) so that the country would import good *1*. In the neighborhood of the autarky price the bias term indicates that labor would prefer the country to export the first commodity. Therefore price reductions down to p_1^C would lower the real wage; the bias effect outweighs the favorable terms-of-trade effect so that the reduction in the nominal wage rate is more severe than the drop in the cost of living. At even lower prices, however, the fall in p_1 leads to a terms-of-trade improvement (the country *imports* the first good) that becomes sufficiently powerful to outweigh the adverse effect of a positive value for $(i_1s_1-1)\theta_1$ when p_1 falls. Point *C* represents a minimum for the real wage.

Point *B* is special, because there the value of the intensity-elasticity nugget is unity. An interesting special case would have the comparison of the nugget with unity depend only upon the labor-intensity ranking, i_1. (Later we focus on how the intensity and elasticity terms are related). For example, it is easy to show that such dominance by the intensity term would follow if elasticities of substitution were equal in the two sectors. In such a case to the left of point *B* the *first* commodity is relatively labor intensive, while the ranking changes to the right of point *B*, where the *second* commodity becomes labor intensive (i_1 becomes smaller than unity). Such a *factor-intensity reversal* for price changes for an economy with given endowments cannot take place in the Heckscher-Ohlin 2x2 setting, but easily can in the specific-factors model.

Two aspects of the β_1 (Beta) function in Figure 1 should be emphasized –the height of the curve, and its shape. First of all, because at autarky the nugget, i_1s_1, exceeds unity, labor's interests are biased towards having the country export the first commodity. That is, a basic *asymmetry* between the two sectors of the economy in autarky has been assumed, an asymmetry reflecting either sector *1* being labor intensive or having a more flexible technology, or a combination of the two. Secondly, as drawn, the extent of this bias *changes* with price increases. For prices higher than at *B*, the product, i_1s_1, becomes smaller than one.

To focus on this second feature, in Figure 2 we assume an absence of factor bias in autarky, implying that the β_1 curve passes through the autarky intersection of the θ_1 and δ_1 curves. (That is, the value of the nugget, i_1s_1, is unity at the autarky point). However, note that endogenous asymmetry is created with movements in price away from autarky. The value of the nugget increases systematically with increases in p_1 in the β_1' curve, decreases systematically (but not too severely) in the β_1'' curve, and decreases so sharply in the β_1''' curve that the curve actually becomes negatively sloped. In more detail:

(i) The β_1' curve**:** Labor unambiguously gains from trade *regardless* of the pattern of trade because the nugget steadily rises from its value of unity in autarky. What is the role of labor intensity? It is only one part of the i_1s_1 term that is monotonically increasing with p_1. Now suppose we (arbitrarily) invoke the "strong labor-intensity" assumption, *viz.*, that the size of the product ($i_1 s_1$) exceeds unity if and only if the relative labor-intensity term for the first sector, i_1, is itself greater than unity. This stacks the deck, as it were, in making the role of factor-intensity dominant, but makes comparisons with the 2x2 model easier. Consider the result along the β_1' curve: *Under the strong labor-intensity assumption, the country always exports its labor-intensive commodity, and labor always experiences an increase in its real wage from trade.* The connection between real wages and labor intensity provided by this case is even stronger than in Stolper-Samuelson because here the country *always* exports its labor-intensive commodity.

(ii) The β_1'' curve**:** This is positively sloped but flatter than the θ_1 curve. The value of the nugget falls as the price of good 1 rises, but not by enough to offset the rise in θ_1. Good 1 is becoming less labor-intensive and/or has a progressively lower elasticity of demand for labor as p_1 rises. The strong labor-intensity assumption now implies that the first commodity is capital intensive for p_1 above the autarky price and labor intensive for prices below autarky. If we maintain our assumption that tastes are Cobb-Douglas, then once again labor gains in real terms if the country exports the first commodity. What happens if the first commodity is imported, instead? Labor still gains in real terms since the nominal wage would fall by less than labor's cost of living. However, note that regardless of the trade pattern the country always *imports* its labor-intensive commodity. The result: *Under the strong labor-intensity assumption, the positive link between labor gains and labor intensity of exports is completely disrupted.* And by assumption the blame cannot be laid at the feet of asymmetric substitution terms. This case reveals the importance of the terms-of-trade effect, since it outweighs the anti-labor bias provided by the labor-intensity ranking (i.e. value of the nugget less than unity).[16]

(iii) The β_1''' curve**:** Here the decline in the size of the nugget, $i_1 s_1$, as p_1 increases is so severe that the Beta function is negatively sloped. If tastes are Cobb-Douglas, labor must lose by trade, regardless of the trade pattern. *If the strong labor-intensity assumption is once again invoked, protection would always be applauded by labor since imports are always labor intensive.* This is even stronger than Stolper-Samuelson.[17]

Note that it is only in the intermediate case (ii) that factor intensities or, more generally, the intensity-elasticity nugget, provide a false lead as to the behavior of real wages with trade. And it is this possibility that supports our *presumption* that labor gains from trade – the favorable terms-of-trade effect outweighs the bias term against labor. In the Stolper-Samuelson scenario in the 2x2 case the favorable terms-of-trade effect for the economy as a whole has no bearing on whether labor gains or loses with trade. As we now show, these three cases are distinguished by the *size* of the elasticities of substitution in production in the two sectors. The β_1' curve is associated with elasticities of substitution greater than unity, the β_1'' curve with elasticities smaller than unity but greater than some value that is less than ½, while the negatively sloped β_1''' curve is associated with substitution elasticities even smaller.

[16] In this case labor might lose instead of gain *if* we remove the assumption of Cobb-Douglas tastes and assume, instead, that demand curves for commodities are *inelastic*. The δ_1 curve would become upward sloping, and might lie above the β_1 curve for some prices. Case (i) does not face this problem if we assume that there is a unique equilibrium point in autarky, because then these two curves intersect only once.

[17] If consumer tastes lead to *elastic* commodity demands, however, the δ_1 curve also becomes negatively sloped, opening up the possibility that labor might actually gain by trade.

3. The Case of Constant Elasticities of Substitution in Production

The structure of the specific-factors model suggests that the adoption of the popular constant-elasticity-of substitution production function specification (CES) can aid in the analysis both of the slope (or elasticity) of the Beta function and how changes in factor endowments cause the function to shift.

The benchmark case is the one in which the β_1-curve and the positively-sloped θ_1-curve coincide: Production in each sector exhibits Cobb-Douglas technology with identical distributive shares for labor that remain constant with any change in relative commodity prices. Thus the bias term always vanishes, which implies that the real wage *always* increases away from autarky.[18] Furthermore, the strong symmetry between sectors suggests that neither an expansion of the labor force nor a balanced growth of sector-specific capitals would shift the Beta function because outputs would both expand at the same rate.

In discussing more general cases note that a change in commodity price ratios has an effect on factor price ratios that is uniquely *different* to that found in the Heckscher-Ohlin model – labor becomes relatively cheaper compared with the specific factor in one sector, but more expensive in the other. The effect on distributive factor shares and thus on the value of the intensity-elasticity nugget depends sensitively on whether the elasticity of substitution in each sector exceeds or falls short of unity. The defining technological characteristic in the specific-factors model, the intensity-elasticity nugget, provides the intuition for the shape of the Beta function.

[18] As a slight variation, suppose both sectors exhibit Cobb-Douglas production functions but the first sector is labor intensive. The β_1-curve would always lie above the θ_1-curve. Labor would benefit by trade if the first commodity is exported, and even benefit if it is imported if the price fall from autarky is sufficiently great.

First, suppose both σ_1 and σ_2 are larger than one. An increase in p_1 (with p_2 always constant) must lower the relative wage but raise labor's share in sector *1* and raise the relative wage but lower labor's share in the second sector. Thus unambiguously i_1 would increase. But so would the substitution term, s_1, in the CES case. The link between the elasticity of substitution and the elasticity of a sector's demand for labor is shown in equation (11), so that if the σ's are constant, a drop in θ_{K1} and an increase in θ_{K2} must serve to raise the relative elasticity of demand for labor in the first sector, s_1. (Incidentally, the values of the elasticities of substitution need not be the same between sectors). The consequence: The size of the nugget, i_1s_1, must be increasing as the price of the first commodity goes up. (In Figure 2 this is reflected in the β_1'curve, rising from autarky above and away from the θ_1 curve.) High σ's imply that a rising export price serves increasingly to improve net benefits for labor.

A quite different scenario for the elasticity of the Beta function emerges when both elasticities of substitution are smaller than unity. An increase in sector 1's price, once again lowering the wage/rental ratio in sector *1*, now causes θ_{L1} to decline. By equation (11), a constant σ_1 now gets translated into a smaller value for the elasticity of demand for labor.[19] With opposite changes taking place in sector two, both s_1 and i_1 fall, explaining either the β_1" curve or the β_1'" curve in Figure 2. With small enough elasticities of substitution, the value of the nugget falls so much that the Beta function can be downward-sloping.

[19] Strictly speaking it is not necessary to assume CES functions. A glance at equation (11) reveals that as long as the elasticity of substitution does not change as much and in the same direction as the capital share, the same qualitative results will hold.

If the elasticity of substitution in one sector exceeds unity and in the other falls short of it, the *relative* values that are captured by both i_1 and s_1 might not change much so that any gap between the β_1 and θ_1 curves would remain relatively unaltered.

The β_1 curve could be negatively sloped, and a further bit of algebra helps to reveal the necessary conditions.[20] As well, the effects of endowment changes in altering the value of β_1 can be shown.

Differentiating the expression for β_1 in equation (12) leads to:

$$(20) \qquad \hat{\beta}_1 = \beta_2\{(\hat{\lambda}_{L1} - \hat{\lambda}_{L2}) + (\hat{\gamma}_{L1} - \hat{\gamma}_{L2})\}$$

The first term in brackets is clearly positive if p_1 rises, since labor will be transferred to the first industry. Using our earlier algebra, the explicit solution for this first term is:

$$(21) \qquad (\hat{\lambda}_{L1} - \hat{\lambda}_{L2}) = \left\{\beta_1\gamma_{L2} + \beta_2\gamma_{L1}\right\} \hat{p}_1 + (s_2 - s_1)\hat{V} + (\hat{K}_1 - \hat{K}_2)$$

The dependence of the second term on relative labor demand elasticities is easily explicable. Suppose the labor endowment rises at given commodity prices (thus lowering *V*). This lowers the wage rate and new labor is channeled to both sectors, but especially to the sector with the more flexible technology. If, instead, both capital supplies were to be increased in the same proportion, the wage rate would rise in both sectors, and labor would be drawn away from the more flexible sector. The role of the third term is obvious; a greater relative increase in the type of capital specific to the first sector would directly help to reallocate labor towards the first sector.

With CES functions assumed, the second term in brackets in (20) is given by $(\hat{\theta}_{K2} - \hat{\theta}_{K1})$, which leads to:

[20] This possibility emerges clearly in extreme cases without using algebra (Ruffin and Jones, 2003).

$$(22) \qquad (\hat{\theta}_{K2} - \hat{\theta}_{K1}) = \left\{ \beta_1 (\frac{\theta_{L2}}{\theta_{K2}})(\sigma_2 - 1) + \beta_2 (\frac{\theta_{L1}}{\theta_{K1}})(\sigma_1 - 1) \right\} \hat{p}$$

$$+ \frac{1}{\gamma_L} \left\{ (\frac{\theta_{L2}}{\theta_{K2}})(\sigma_2 - 1) \ - \ (\frac{\theta_{L1}}{\theta_{K1}})(\sigma_1 - 1) \right\} \hat{V}$$

Here the important role of the σ's versus unity in determining the direction in which distributive shares change is confirmed. With a price change, the wage/rental ratio falls in one sector and rises in the other. Therefore if both elasticities exceed unity (or both fall short of unity), capital's distributive shares move in opposite directions in the two sectors, thus *enhancing* the difference in their changes. If the labor endowment rises instead, at constant prices this lowers the wage rate in *both* sectors, thus changing capital shares in the same direction if both σ's are either greater or less than unity.

Combining (21) and (22) into (20) yields the result we need:

$$(23) \qquad \hat{\beta}_1 = \beta_2 \left\{ \beta_1 \frac{(1+\theta_{L2})}{\theta_{K2}} \left[\sigma_2 - \frac{\theta_{L2}}{(1+\theta_{L2})} \right] + \beta_2 \frac{(1+\theta_{L1})}{\theta_{K1}} \left[\sigma_1 - \frac{\theta_{L1}}{(1+\theta_{L1})} \right] \right\} \hat{p}_1$$

$$+ \frac{\beta_2}{\gamma_L} \left\{ \frac{(1+\theta_{L2})}{\theta_{K2}} \left[\sigma_2 - \frac{\theta_{L2}}{(1+\theta_{L2})} \right] \ - \ \frac{(1+\theta_{L1})}{\theta_{K1}} \left[\sigma_1 - \frac{\theta_{L1}}{(1+\theta_{L1})} \right] \right\} \hat{V}$$

$$+ \beta_2 (\hat{K}_1 - \hat{K}_2)$$

The form of the coefficients is striking both in the similarities and differences between price and endowment changes already noted in equation (22) and in the crucial comparison of each sector's elasticity of substitution with a fraction that could never exceed ½.[21] Thus for changes in commodity prices, a *sufficient* condition for the β_1 schedule to be positively sloped is that elasticities of substitution in production exceed one-half.[22] In the coefficient of the $\hat{V}$ term, we notice that since the wage/rental rate moves in the same direction in the two sectors, the *shift* in the Beta function, whether up or down, might be small even if both σ's are greater than, or less than, unity. (Recall that there is no shift in the Beta function if the σ's and labor shares are equal.)

4. Possible Adverse Effects of Trade on Workers

We started this paper by asking when international trade hurts workers. Now we have the necessary ingredients for the answer. Let the world price of the first commodity on world markets be higher than in autarky, with expectations that such a relative price will rise even more in the future, further encouraging greater globalization in the form of expanded exports of the first commodity. Labor must gain by the terms-of-trade effect, so that it can be hurt by trade only if the bias effect, $(i_1 s_1 - 1)\theta_1$, becomes sufficiently negative. A (damaging) small value for the intensity-elasticity nugget suggests some combination of relative labor intensity in the import-competing sector and relatively inflexible technology in the export sector. Furthermore, equation (23) reveals that if technological flexibility throughout the economy is severely limited (very small values for both σ_1 and σ_2), any further stimulus to exports given by a rising price can make matters even worse for labor. Although the economy would gain by such an

[21] In the Melvin and Waschik (2001) paper, an example is provided where each sector's σ has the same value of 0.4 and the same labor shares in autarky. This example is like Figure 2's β"' curve, downward sloping and passing through the consumption share δ_1 line at the autarky price.
[22] A question about the effects of technical progress on real wages that leads to somewhat similar conclusions was raised in Jones (1996).

improvement in the terms of trade, labor would be left out – real wages would fall. Such low elasticities convert an improvement in the terms of trade into significant reductions in the value of the nugget, dragging the value of the price elasticity of wages, β_1, even lower.

Could an expansion of the economy's capital stock improve the prospects of such expanded trade for labor? The good news for labor is that at given terms of trade *any* increase in the stock of capital must serve to raise the wage rate. But what effect would it have on the position of the Beta function? Would this be shifted upwards, thus enhancing the effect of any further export price rise on the nominal wage rate? Clearly the composition of the increased capital stock makes a difference (see especially equation (21)); the more this favors the first sector the more apt is the β_1 curve to shift upwards (especially because of the positive effect on the share in production of the exportable sector, θ_1). Neglecting this effect (by having a balanced expansion of capital in both sectors), the answer depends on the sign of the coefficient of $\hat{V}$ in equation (23) and two special cases can be considered.

First suppose labor intensities are (initially) the same between sectors, so that the sign of the coefficient for balanced increases in capital in (23) is positive if and only if export sector-1 has a *lower* elasticity of substitution in production, implying that the export sector is *not* biased towards labor. That is, it is precisely in the case in which improvements in the terms of trade spell potential danger for labor that balanced capital expansion serves to help by shifting the Beta function upwards. A balanced expansion of capital stocks causes wages to rise, thus increasing, relatively, the distributive share for labor in the relatively inflexible export sector.

In the second case, suppose that the size of the nugget is smaller than unity because it is the import-competing sector that is relatively labor intensive and the two sectors share the same value for the elasticity of substitution. The criterion for the β_1-curve to shift upwards with a proportional increase in capital stocks becomes:

(24) $$(\theta_{L2} - \theta_{L1})(\sigma - ½) > 0.$$

In this case as well a balanced increase in capital stocks shifts the Beta function upwards despite a less than unit value for the nugget as long as the common elasticity of substitution exceeds ½. Once again the importance to labor of having overall sufficient flexibility in production techniques is illustrated.

There is a further cause for labor optimism when export prices rise: Rents to the specific factor in the export sector are increased by expansion in trade, and this sends out a signal to increase the supply of the specific factor, if possible, or to encourage technological change that will raise labor's productivity in the export sector. The so-called "green revolution" in agriculture provides an example in which a fixed supply of land can nonetheless yield expanding outputs without requiring sharp drops in labor's marginal productivity. And the large volumes of trade in raw materials, which may serve as specific inputs in export sectors, also serve as responses to the signal of higher local rents. Although expanded trade may at first lead to concentrations in production and short-run gains to non-labor inputs that are temporarily rigid in their availability, such increases in rents signal supply changes over time that will work to benefit labor. The specific-factors setting need not imply that such factors cannot expand endogenously in response to changes in rents.

5. Two-Country Trade

Trade theorists may have noticed something odd about our preceding explanation of how trade or protection affects real wages, *viz*. nothing was said about the *causes* of international trade. The trading position depended only upon whether the *exogenously-given* world relative price of commodity *1* was higher or lower than the price ruling in autarky. If higher, the country exported the first commodity. In this section we first analyze the case in which only two trading economies exist, and they share the same technology and endowments of specific factors. World prices are *endogenously* determined. If the endowment of labor abroad is smaller than it is at home, the home country can be considered to be the labor-abundant country.

Our earlier analysis in Section 1 (equation (18)) revealed how the value of the nugget compared with unity determined whether the production ratio, x_1/x_2, would rise or fall as the labor force expands and commodity prices are kept constant. We no longer need to assume a CES technology. Thus if the foreign country has a smaller labor force, the ratio of its production of the first commodity to that of the second will fall if, and only if, the bias term favors labor for increases in p_1. If it does, *i.e*. if β_1 exceeds θ_1, abroad the autarky relative price of the first commodity will be higher than it is at home, and the resulting equilibrium world price, p_1^T, will also exceed the home autarky price. Instead, if the nugget is smaller than unity, the autarky price of the first commodity abroad would be lower than that at home; with trade the home country would import commodity 1.

These ideas are illustrated in Figure 3. We have deliberatively drawn the β_1 curve downward sloping in order to represent the Melvin-Waschik finding that very low elasticities of substitution in production could spell trouble for real wages with trade.

Home and foreign countries share the same technology and the same endowments of specific factors. Now consider autarky prices in the two countries with two alternative demand constellations (both Cobb-Douglas) represented by the $\delta_1^{(1)}$ line and the $\delta_1^{(2)}$ lines, common to both countries. If tastes support the upper $\delta_1^{(1)}$ line, the home autarky price is shown by $H^{(1)}$. With β_1 smaller than θ_1, the foreign country, with a smaller labor endowment, will have an autarky price, $F^{(1)}$, lower than at home. The free trade price lies between the two autarky prices, the home country imports the first commodity, and as a consequence its nominal wage rate is reduced by less than its cost of living so that real wages increase with trade. If tastes are shown by the $\delta_1^{(2)}$ line, the autarky home price is $H^{(2)}$. Because β_1 exceeds θ_1, as the foreign country loses labor, the relative supply of the first commodity abroad is reduced and the foreign autarky price is higher than at home. The home country now becomes an exporter of the first commodity and, with β_1 exceeding θ_1, the wage rate increase exceeds the rise in labor's cost of living. Once again home real wages would rise (and those abroad would fall). These favorable outcomes for home real wages (and unfavorable outcomes for the capital abundant foreign country's real wages) can be seen to hold as well if the β_1 curve is positively sloped.

The conclusion of this reasoning is that in the two-country case with countries differing only in their labor endowments, *the labor-abundant home country's real wage rate must rise with free international trade.* This is a strong result, because the labor-abundant home country might export its capital-intensive commodity. As well, the value of the nugget was not specified. Furthermore, it does not depend upon the *size* of elasticities of substitution. The basic notion that *trade benefits the abundant factor* is broader than the Stolper-Samuelson theorem and is impervious to the Melvin and Waschik critique.

If trade is caused by differences in technology, such as is typical between advanced and developing countries, the array of possibilities shown earlier when the world price ratio was exogenously given now also applies. And these results indicate that labor may indeed suffer with expansions of trade if substitution elasticities in production are relatively small in the export sector. For example, now both countries could in autarky be at a neutral position ($i_1 s_1 = 1$) but at different autarky prices. Opening trade would thus hurt labor in *both* countries if the β_1–curve is downward-sloping and help labor in *both* if upward-sloping, just as in Figure 2's β_1''' and β_1' curves, respectively.[23]

6. Concluding Remarks

The question of the effect of trade-related changes in commodity prices on the distribution of income, especially as regards the rewards to labor, has received prime attention both from trade theorists and from labor economists (*e.g.* Sue Collins, 1998). In this paper we shift attention away from the classic Stolper-Samuelson finding that a factor-intensity ranking tells all about trade and real wages and, instead, concentrate on investigating more thoroughly what the specific-factors model tells us about the possibilities of gains or losses to labor, considered to be mobile between sectors of the economy. Whereas the defining technological characteristic in the Stolper-Samuelson case is the labor-intensity ranking, in the specific-factors model it is the *intensity-elasticity nugget*, which gives the relative elasticity of demand for labor in exportables equal importance with relative labor intensity. However, there is a further important difference between the two models and their implication for real wages. In both it is clear that an improvement in the terms of trade signals gains for the overall economy, but only in the specific-factors setting (with labor the mobile factor) will such gains *also* work to improve the real wage rate.

As the recent article by Melvin and Waschik (2001) reveals, presumption is not certainty, and they provide an example in which workers are hurt by trade, regardless of which commodity the country exports. The key to this result is the possible extremely low elasticity of substitution in each of the sectors of the economy. The implication is that as a country's terms of trade improve, calling forth greater activity in its export sector, exportables become less and less labor intensive and, relative to the import-competing sector, exhibit lower and lower flexibility in their labor demand. Such an endogenously-created asymmetry between sectors can lead to a lowering of the real wage rate as a consequence of greater globalization. However, if world terms of trade are endogenously determined between two countries differing only in overall capital/labor endowment proportions, trade must lead to an improvement in real wages in the relatively labor-abundant country. As well, even if overall low elasticities lead to an asymmetric low value of the intensity-elasticity nugget in the exportable sector, changes in rents to specific factors may signal increases in their supplies or induce technical progress that converts temporary losses in real wages into longer-term gains.

There may be a lesson in all this for empirically-minded trade economists: Devote more study to the estimates of elasticities of substitution in various industries and in

[23] Ruffin and Jones (2003) analyze technology differences in the simplified case in which production functions exhibit zero or infinite substitution elasticities, reaching the same conclusions.

different countries. There are a number of countries that export primary products. What are the production functions for those goods? Are they really Cobb-Douglas? (If so, the specific factors model says that it is the labor-intensity ranking that matters.) As for values of these elasticities, there seems to be little agreement. In a careful study Alan Woodland (1975) argues for low elasticities in Canada. In Kenneth Arrow, *et. al.* (1961), elasticities were relatively high. More recently, Edward Balistreri, *et. al.* (2002), examine the possibility of Cobb-Douglas values in 28 industries, and find support in 20 of them. Since there is evidence of a broad range of estimates among industries, the asymmetries emphasized here may be very important.[24] A systematic survey of techniques, countries and results would appear to be useful.

There is a dramatic example from Thailand where real wages suffered while the terms of trade improved. From 1857 to World War II, rice production and exports increased more than twenty-fold. The terms of trade generally improved, but real wages fell while agricultural rents rose over the century (David Feeny, 1979). The specific factors model suggests that such cases should be rare because, according to Arrow, *et. al.* (1961, p. 239), agricultural and mining exhibit relatively high elasticities of substitution. As noted in the introduction, Mexico provides another example: the terms of trade fell from 1980 onwards. Even though the main export (oil) is extremely capital-intensive, real wages fell. This could suggest the power of the terms-of-trade effect on real wages found in the specific-factors model.

Worker dissatisfaction with open markets can place political impediments in the transition to free trade. Since free trade is generally beneficial and over long periods

[24] The ratio of highest to lowest elasticity was about 4 in Arrow, *et. al*. (1961), 6 in Tyler (1974), and 19 in Woodland (1975).

appears to generate sizeable gains from learning and scale effects (David Gould and Ruffin, 1995), economists interested in promoting free trade need to pay attention to the possible problems arising from factor specificity and to the policies (fostering investments in specific factors in the export sectors rather than import sectors) that could be followed to overcome them. The paper suggests that these problems could be rather limited in scope, but that is for future empirical research to determine.

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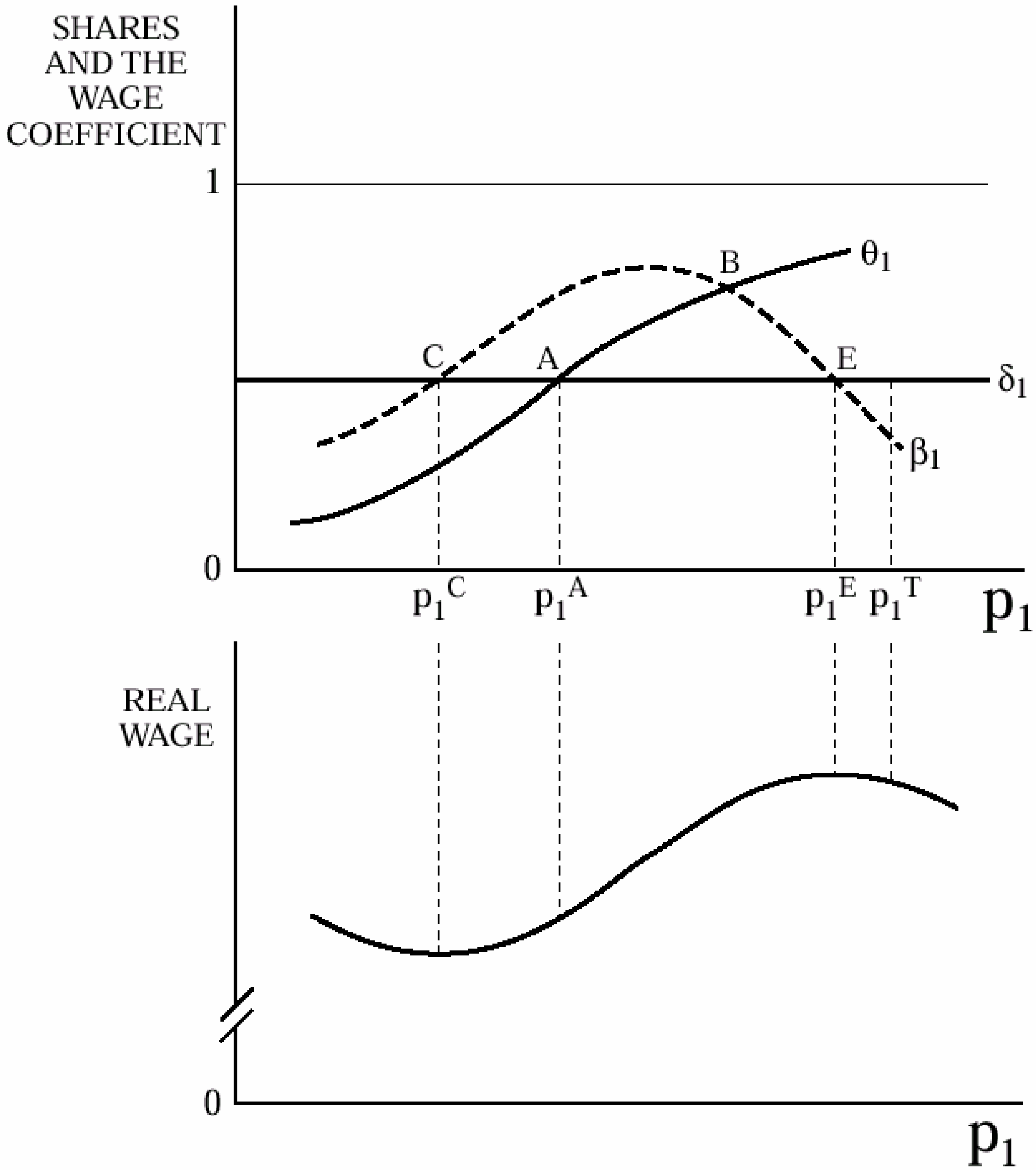

Figure 1: Free Trade, Protection and Real Wages

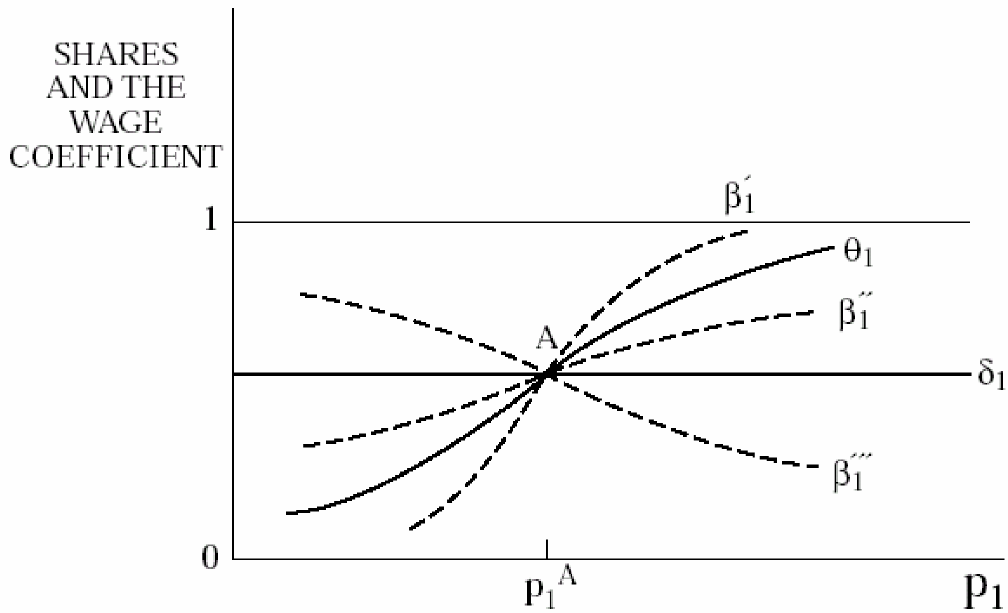

Figure 2: Alternative Wage Responses

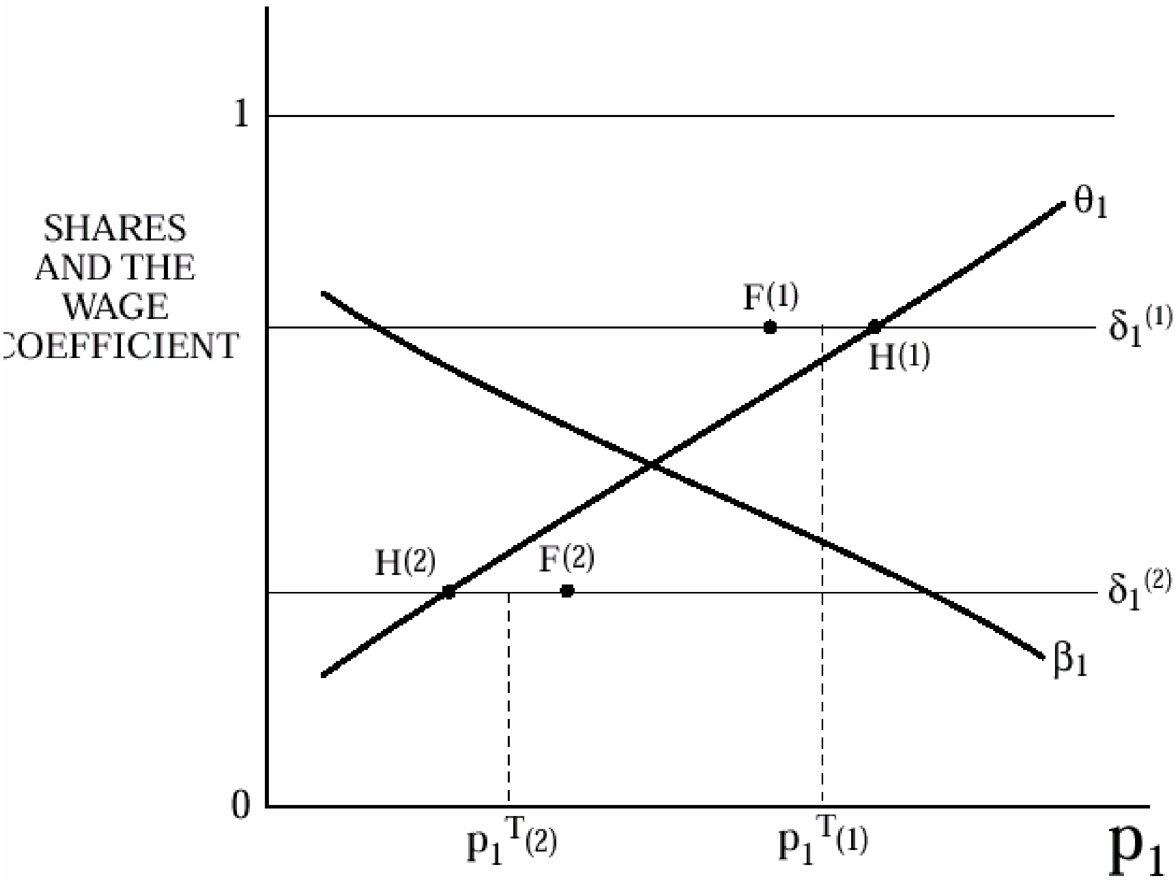

Figure 3: Two-Country Trade