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TRADE AND TRADABILITY: EXPORTS, IMPORTS, AND FACTOR MARKETS IN THE SALTER-SWAN MODEL

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Abstract

We extend the Salter-Swan model to include both factor markets and semi-traded goods. In our model, changes in relative factor prices depend on changes in world commodity prices, factor endowments, and the trade balance. In contrast, only changes in world commodity prices can affect factor prices in the neoclassical trade model. The inclusion of semi-traded goods weakens the magnification effect of both the Stolper-Samuelson and Rybczynski theorems. When imports and domestic goods are poor substitutes, a characteristic of some commodities in developing countries, the sign of the Stolper-Samuelson effect is reversed.

Key words: Semi-traded goods, two-way trade, Salter-Swan Model, Stolper-Samuelson Theorem
JEL codes: F11, F13, F15

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I. Introduction

In trade data, there is evidence of cross-hauling–countries import and export the same commodity, even for the most detailed commodity categories. This observation is inconsistent with neoclassical trade theory, in which goods are homogenous. According to the Heckscher-Ohlin Samuelson (HOS) model, a country imports its non-comparative advantage good and exports its comparative advantage good. There is no two-way trade at the commodity level.

Empirical trade models account for cross-hauling by using the Armington (1969) assumption that imports and domestic goods are imperfect substitutes in consumption.[1] There is a large class of single- and multi-country, applied, computable general equilibrium (CGE) trade models which incorporate the Armington assumption at the commodity level to accommodate observed trade patterns. CGE models have been used extensively to analyze the effect of free trade agreements as well as trade and domestic policy reform issues in both developed and developing countries.[2]

In this paper, we describe the theoretical properties of such trade models, focusing on factor markets. We extend the Salter-Swan model, in which there is both a traded and a non-traded good, and specify that imports and domestic good are imperfect substitutes in

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[1] Armington (1969) used this specification in estimating import demand functions. Many empirical studies support this specification. For example, Shiells and Reinert (1993) find low import substitution elasticities for the U.S., Canada, and Mexico, suggesting that it is important to characterize imported and domestic goods as semi-tradable.

[2] Many surveys of CGE trade models are available: NAFTA (Francois and Shiells, 1994), regional trade agreements and agriculture (Burfisher and Jones, 1998), and the Uruguay Round (Martin and Winters, 1996, Shoven and Whalley, 1992). Robinson (1989) and de Melo (1988) describe the application of these models to development issues.

consumption.[3] Rather than having a non-traded good, we have a semi-traded good. Similarly, exports and the domestic good are imperfect substitutes in production. As in the Salter-Swan model, we include both domestic and traded goods so the model includes the real exchange rate. We also draw upon Jones (1965) which includes factors, but not non-traded goods, and Jones (1974) which includes a non-traded good, but not factor markets. We incorporate both factor markets and semi-traded goods. In the extreme case, when imports and domestic goods are perfect substitutes, our model collapses to the neoclassical HOS model.

The Stolper-Samuelson and Rybczynski theorems describe the links between trade and factor markets. We show how these theorems operate in a model with semi-traded goods. We find that the magnification effect of both theorems is weaker. Furthermore, when imports and domestic goods are poor substitutes in consumption, a characteristic of some commodities in developing countries, the sign of the Stolper-Samuelson effect is reversed. We also provide a decomposition equation showing the effects of changes in relative commodity prices, changes in the relative endowment, and changes in the trade balance on changes in relative factor prices.[4]

II. The 1-2-2-3 Model

Our analytical model closely follows Jones (1974) who incorporates a non-traded good into the 2x2x2 HOS framework. We expand Jones (1974) by (1) exploring the factor market linkages, which he did not include in the model with a non-traded good; (2)

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[3]This model was first described in Salter (1959) and Swan (1960).

[4]Abrego and Whalley (2000) and Krugman (2000) use a stylized model to analyze changes in factor prices. They do not solve the model for an explicit decomposition equation, but rather use the model to simulate observed changes in factor prices and commodity prices.

treating the non-traded good as a semi-traded good which is an imperfect substitute in consumption for the imported good; and (3) adding the balance of trade. The result we call the 1-2-2-3 model—one country, two production activities, two inputs, and three commodities. A version of this model without factor markets, the 1-2-3 model (one country, two production activities, and three commodities), was first described in de Melo and Robinson (1989). They specified explicit functional forms for the aggregate utility function (constant elasticity of substitution, CES) and the production possibility frontier (constant elasticity of transformation, CET).[5]

The economy produces two goods, E and D. The good E is exported and is not consumed domestically. The good D is consumed domestically. Imports, M, represent a third commodity which is consumed, but not produced, domestically. The goods M and D are imperfect substitutes in demand. Aggregate absorption, Q, is given by:

$$Q = F(M, D; \sigma_Q) \qquad \textbf{(1)}$$

where σ_Q is the elasticity of substitution in demand. Absorption represents aggregate utility or welfare in this model. In the 1-2-3 model, F(•) was defined as a CES function. In the 1-2-2-3 model, we assume that the desired ratio of imports to domestic goods is given by:

$$\frac{M}{D} = k\left(\frac{P^D}{P^M}\right)^{\sigma_Q} \qquad \textbf{(2)}$$

[5]Devarajan, Lewis, and Robinson (1990, 1993) explore the properties of the model in detail, extending it to include tariffs and taxes, and also use the same basic framework to analyze issues concerning the appropriate definition of the equilibrium real exchange rate.

where k is constant for a CES function and approximately constant otherwise, and P^M and P^D are the prices of M and D respectively.[6]

Following Jones' notation, the technology for producing E and D is given by the coefficients matrix A:

$$A = \begin{bmatrix} A_{KE} & A_{KD} \\ A_{LE} & A_{LD} \end{bmatrix} \qquad \textbf{(3)}$$

where A_{ij} is the quantity of factor i required to produce a unit of good j. We do not assume that these coefficients are constant. When the coefficients are variables, however, they are assumed to depend only on relative factor prices —there is no technical change.[7] Given this technology, factor market clearing requires:

$$\begin{aligned} A_{KE}E + A_{KD}D &= K \\ A_{LE}E + A_{LD}D &= L \end{aligned} \qquad \textbf{(4)}$$

where K and L are aggregate supplies of capital and labor.

In competitive equilibrium, unit costs will equal market prices:

$$\begin{aligned} A_{KE}W_K + A_{LE}W_L &= P^E \\ A_{KD}W_K + A_{LD}W_L &= P^D \end{aligned} \qquad \textbf{(5)}$$

[6]In the general case, we ignore income effects and assume the absorption function is well behaved (*e.g.* homothetic, convex, and twice-differentiable).

[7]We also assume that both sectors use both factors in equilibrium, so there are no corner solutions.

where W_K and W_L are the "wages" of capital and labor and P^E and P^D are output prices. To close this model, we require an equation linking exports and imports. We assume that the balance of trade is given by:

$$P^M M = \Phi P^E E \tag{6}$$

where Φ is a parameter giving the ratio of import expenditures to export earnings. This specification extends the standard HOS model, allowing the balance of trade to affect consumption, production, and factor returns. When Φ is one, trade is balanced, with export earnings exactly equaling import costs —as in the usual HOS model. The trade balance (the value of exports minus imports in world prices) equals (1 - Φ) times export earnings. An increase in Φ implies a worsening of the trade balance.

Assuming that the country is "small" so that we can assume world prices, P^M and P^E, are fixed, the model is complete. There are seven equations for seven endogenous variables: Q, E, D, M, W_K, W_L, and P^D. Unlike the HOS model, one of the commodity prices is endogenous.

We demonstrate how the endogenous variables, particularly relative wages, change in response to changes in the prices of the traded goods (P^E and P^M), factor supplies (K and L), and the balance of trade (Φ). First, we define the share parameters and elasticities that are important to the linkages. Our notation again follows Jones (1965). Define λ_{ij} as the share of the total supply of factor i used in sector j:

$$\lambda_{KE} = \frac{A_{KE}\,E}{K}; \quad \lambda_{KD} = \frac{A_{KD}\,D}{K}$$

$$\lambda_{LE} = \frac{A_{LE}\,E}{L}; \quad \lambda_{LD} = \frac{A_{LD}\,D}{L} \tag{7}$$

Define θ_{ij} as the share of factor i in total income generated in sector j.

$$\theta_{ij} = \frac{A_{ij}\,W_i}{P^j} \tag{8}$$

Given that factors are fully employed and that income is fully allocated to factors (zero profit condition), it follows that:

$$\sum_j \lambda_{ij} = \sum_i \theta_{ij} = 1 \tag{9}$$

We will assume that E is the capital-intensive sector and that D is labor-intensive. Capital's value share in E must be greater than its value share in D, ($\theta_{KE} > \theta_{KD}$), and also the share of the total capital stock used in E must be greater than the share of the labor force used in E, ($\lambda_{KE} > \lambda_{LE}$). Define the following matrices:

$$\lambda = \begin{bmatrix} \lambda_{KE} & \lambda_{KD} \\ \lambda_{LE} & \lambda_{LD} \end{bmatrix} \tag{10}$$

$$\theta = \begin{bmatrix} \theta_{KE} & \theta_{LE} \\ \theta_{KD} & \theta_{LD} \end{bmatrix} \tag{11}$$

Given that the rows of each of these matrices sum to one, their determinants are given by:

$$|\lambda| = \lambda_{KE} - \lambda_{LE}\,; \quad |\theta| = \theta_{KE} - \theta_{KD} \tag{12}$$

Under the assumption that E is capital intensive, both determinants are positive (and less than one).

Use a (ˆ) to denote the relative change in a variable or parameter (or its log derivative). The elasticities of substitution between capital and labor in production in the two sectors E and D can be defined by:

$$\begin{aligned} \sigma_E &= \frac{\hat{A}_{LE} - \hat{A}_{KE}}{\hat{W}_K - \hat{W}_L} \\ \sigma_D &= \frac{\hat{A}_{LD} - \hat{A}_{KD}}{\hat{W}_K - \hat{W}_L} \end{aligned} \tag{13}$$

In addition, define two additional parameters:

$$\begin{aligned} \delta_K &= \lambda_{KE}\,\theta_{LE}\,\sigma_E + \lambda_{KD}\,\theta_{LD}\,\sigma_D \\ \delta_L &= \lambda_{LE}\,\theta_{KE}\,\sigma_E + \lambda_{LD}\,\theta_{KD}\,\sigma_D \end{aligned} \tag{14}$$

Quoting Jones (1965, p. 35): “In general, δ_L is the aggregate percentage saving in labor inputs at unchanged outputs associated with a 1% rise in the relative wage rate, the saving resulting from the adjustment to less labor-intensive techniques in both industries as relative wages rise.”

Finally, the elasticity of transformation between E and D (along the production possibility frontier) is given by:

$$\Omega = \frac{\left(\delta_K + \delta_L\right)}{|\lambda|\,|\theta|} \tag{15}$$

In the original 1-2-3 model, the production possibility frontier was defined as a CET function, with a constant Ω. In the 1-2-2-3 model, we only assume it to be approximately fixed when taking log derivatives.[8]

The model reduces to four relationships in changes in relative prices, production, and demand.[9] The first is the link between changes in relative prices and relative wages along the contract curve underlying the production possibility frontier.

$$\left(\hat{W}_K - \hat{W}_L\right) = \frac{1}{|\theta|}\left(\hat{P}^E - \hat{P}^D\right) \tag{16}$$

In the standard HOS model, where both goods are tradeable and their prices are set in world markets, this equation demonstrates the Stolper-Samuelson Theorem. Relative wages depend only on relative prices and, since $|\theta| < 1$, the change in relative wages is greater than the change in relative prices—the model incorporates the magnification effect.

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[8]It is well known that the transformation elasticity is close to linear when technology is either Cobb-Douglas or CES (with high elasticities), as shown in Johnson (1966). See also Abrego and Whalley (2000) for a more recent discussion.

[9]Details of the derivations are given in Robinson and Thierfelder (1996).

Second, movements along the production possibility frontier are determined both by changes in relative prices and changes in relative factor endowments.

$$\left(\hat{E} - \hat{D}\right) = \frac{1}{|\lambda|}\left(\hat{K} - \hat{L}\right) + \Omega\left(\hat{P}^{E} - \hat{P}^{D}\right) \qquad \textbf{(17)}$$

This equation demonstrates the Rybczynski Theorem. Since $|\lambda| < 1$, with unchanged prices, changes in relative factor endowments will have a magnified effect on relative production.[10]

The demand side of the model involves D and M rather than D and E. Log differentiating equation 2 yields:

$$\left(\hat{M} - \hat{D}\right) = -\sigma_{Q}\left(\hat{P}^{M} - \hat{P}^{D}\right) \qquad \textbf{(18)}$$

This equation shows how relative demand for M and D changes with changes in relative prices.

Finally, the supply and demand sides are linked through the balance-of-trade equation. Log differentiating equation 6 yields:

$$\left(\hat{E} - \hat{M}\right) = \hat{P}^{M} - \hat{P}^{E} - \hat{\Phi} \qquad \textbf{(19)}$$

The changes in relative prices of D and E can be expressed as a function of changes in exogenous world prices, factor endowments, and the balance of trade:

[10] Equations 16 and 17 present results for relative wages and production. When only one price changes, one can show that one wage goes up while the other falls (Stolper-Samuelson). Similarly, one can show that, with a change in one factor endowment, one output goes up while the other falls (Rybczynski).

$$\left(\hat{P}^{E} - \hat{P}^{D}\right) = \frac{1}{\left(\sigma_{Q} + \Omega\right)}\left[(\sigma_{Q} - 1)(\hat{P}^{E} - \hat{P}^{M}) - \hat{\Phi} + \frac{1}{|\lambda|}\left(\hat{L} - \hat{K}\right)\right] \qquad \textbf{(20)}$$

In this model, when world prices are fixed, $\hat{P}^{D}$ is the relative price of nontraded (semi-tradable) goods to traded goods, and represents the real exchange rate.[11] In the general case, there is effectively a different real exchange rate for imports and exports. Equation 20 refers to domestically produced goods supplied to domestic and world markets, and describes how the economy moves along the production possibility frontier as a function of changes in world prices, the balance of trade, and factor endowments.

Substituting (20) into (16), changes in relative wages can be expressed in terms of changes in world prices, the balance of trade, and factor endowments:

$$\left(\hat{W}_{K} - \hat{W}_{L}\right) = \frac{1}{|\theta|\left(\sigma_{Q} + \Omega\right)}\left[(\sigma_{Q} - 1)(\hat{P}^{E} - \hat{P}^{M}) - \hat{\Phi} + \frac{1}{|\lambda|}\left(\hat{L} - \hat{K}\right)\right] \qquad \textbf{(21)}$$

This is the fundamental result from the 1-2-2-3 model. In contrast to the HOS model, when nontraded goods are included, changes in relative wages depend not only on changes in world prices, but also on changes in factor endowments and the balance of trade. Furthermore, the model can accommodate factor-biased technological change, which in the standard HOS model has no impact on relative wages. In our framework, factor-biased technological change operates like a change in the endowment and therefore

[11] This equation is equivalent to the equation for the equilibrium real exchange rate in the 1-2-3 model derived in Devarajan, Lewis, and Robinson (1993), with the addition of a term for changes in factor endowments.

affects relative wages.

III. Implications of Tradability for the Stolper-Samuelson Theorem

As the elasticity of substitution in consumption, σ_Q, goes to infinity, the last two terms in brackets in equation 21 go to zero. In the limit, the remaining term in world prices reduces to:

$$\left(\hat{W}_K - \hat{W}_L\right) = \frac{1}{|\theta|}\left(\hat{P}^E - \hat{P}^M\right) \tag{22}$$

which corresponds to equation 16 with $\hat{P}^D = \hat{P}^M$ since D and M are now perfect substitutes. This is exactly the HOS model, with changes in relative wages depending only on changes in world prices, and the Stolper-Samuelson Theorem again applies. The HOS model can thus be seen as a special case of the 1-2-2-3 model when imports and domestic goods are perfect substitutes.

When there is no change in factor supplies and the balance of trade, equation 21 reduces to:

$$\left(\hat{W}_K - \hat{W}_L\right) = \frac{1}{|\theta|}\left[\frac{\left(\sigma_Q - 1\right)}{\left(\sigma_Q + \Omega\right)}\right](\hat{P}^E - \hat{P}^M) \tag{23}$$

Since Ω is positive, the second term in this expression is always less than one. The result is that the magnification effect in the Stolper-Samuelson Theorem is reduced. The larger is the transformation elasticity Ω and the closer is the elasticity of substitution in demand to one, the weaker is the link between changes in prices and changes in relative wages.

When the elasticity of substitution equals one, the right-hand side goes to zero and changes in world prices have no effect on relative wages. One way to see what is going on is to consider the country's offer curve, which shows the relationship between exports (on the horizontal axis) and imports (on the vertical axis) as world prices change. As de Melo and Robinson (1989) show, when $\sigma_Q = 1$ the country's offer curve becomes vertical. In that case, as the world price of imports changes, expenditure on imports remains fixed nominally and hence, with a fixed export price, real exports do not change.[12] Hence, there is no movement along the production possibility frontier, and relative wages do not change. The link between changes in world prices and changes in relative wages is completely broken.

When $\sigma_Q > 1$, from equation 20, an increase in the price of imports leads to an increase in the price of D, which corresponds to an appreciation of the real exchange rate. The offer curve slopes upwards. When imports become more expensive, it is worthwhile to produce more of the domestic substitute, moving resources away from the production of exports. The volume of trade declines and, from equation 23, the relative wage of capital falls. Such a situation might characterize a developed country when the price of its imports rise on world markets. The sign of the results is the same as in the HOS model, but the magnification effect is weakened or eliminated.

When $\sigma_Q < 1$, M and D are weak substitutes.[13] In this case, an increase in the

[12]The model is characterized by Lerner symmetry. It does not matter whether world export or import prices change. In the cases discussed below, for expositional convenience, we will start from a change in the world price of imports, assuming export prices are fixed.

[13]Bhattarai, Ghosh, and Whalley (1999) assert that when the Armington elasticity is less than one, a country's offer curve is "perverse." We would argue that they are not perverse, but rather describe commodities such as capital goods, for which imports are poor substitutes for the domestic good in developing countries. All standard trade theory texts show the offer curves as having an upward sloping, a vertical, and a backward bending

world price of M leads to a decrease in the price of D relative to E, which is a depreciation of the real exchange rate. Production of D declines and exports increase. In effect, the country depreciates in order to shift resources into exports, increasing export earnings in order to pay for the more expensive, but essential, imports. The offer curve is backward bending. This situation is characteristic of developing countries which have to undergo a structural adjustment program in the face of an adverse terms-of-trade shock (for example, a large increase in the price of oil). In this case, changing a commodity price has the opposite effect on wages than would be predicted by the HOS model. In a developing country exporting labor-intensive goods, where $|\theta| < 0$, an increase in the price of imports will lead to an increase in the wage of labor relative to capital, while the HOS model would predict a decrease. The 1-2-2-3 model seems much more realistic in this case.

IV. Implications of Tradability for the Rybczynski Theorem

To consider the application of the Rybczynski Theorem in the 1-2-2-3 model, consider the relationship between the change in domestic relative prices as factor endowments change when world prices and the balance of trade do not change (equation 20). Substitute the resulting expression for $\hat{P}^E$ & $\hat{P}^D$ into equation 17. The result is an expression relating the change in the structure of production as a function of the change in factor endowments, all other exogenous variables held constant:

segment.

$$\left(\hat{E} - \hat{D}\right) = \frac{1}{|\lambda|}\left[\frac{\sigma_Q}{\left(\sigma_Q + \Omega\right)}\right]\left(\hat{K} - \hat{L}\right) \qquad \textbf{(24)}$$

As with the Stolper-Samuelson Theorem, this equation reduces to the HOS version (equation 17, the Rybczynski Theorem) as a special case in the limit when the elasticity of substitution (σ_Q) goes to infinity. In general, however, the magnification effect in the Rybczynski Theorem is ameliorated. Since Ω is greater than zero, the term in brackets is less than one. The greater is Ω and the lower is σ_Q, the weaker is the link between changes in factor endowments and changes in the structure of production. Unlike the Stolper-Samuelson Theorem, there is no sign reversal when $\sigma_Q < 1$.

V. Trade Balance Effects

One view of the effect of changes in the balance of trade on relative wages is that a worsening in the trade balance (increasing Φ) leads to increased imports which displace domestic production of low-skill, labor-intensive goods (D), and hence should widen the wage gap. Borjas, Freeman, and Katz (1992), using the factor-content approach, compute the net implicit contribution of the trade deficit to the supply of labor by different skill categories. They conclude (p. 214): "The annual increase in implicit labor supply due to the mid- and late-1980s trade deficit in manufactures was on the order of 1.5 percent for the economy as a whole and 6 percent for the manufacturing sector." They then analyze the impact of these shifts on wages in a partial-equilibrium analysis of the labor markets, concluding that ". . . from 15 to 25 percent of the 11 percentage point rise in the earnings of college graduates relative to high school graduates from 1980 to 1985 can be attributed to the massive increase in the trade deficit over the same period."

In equation 21, however, an increase in Φ will lead to a narrowing of the wage gap, since the sign of the coefficient on $\hat{\Phi}$ is negative. There is a serious conflict between the 1-2-2-3 model and the labor-market approach. The problem is a conflict between partial- and general-equilibrium models. The labor-market approach assumes that increased imports due to the worsening of the balance of trade will "displace" domestic production of labor-intensive goods. However, increasing Φ implies that absorption will rise since the worsening trade balance shifts the consumption possibility frontier out, even though the production possibility frontier stays the same. Consumers have more to spend and, since *D* is a normal good, they will demand more *D* as well as more *M*. The effect will be to increase the relative price of *D*, as shown in equation 20, shifting resources away from *E* to produce more *D*. The increase in P^D represents an appreciation of the real exchange rate and the model demonstrates the Dutch disease.[14] The production of *E* declines, *D* expands, and the relative wage gap narrows.[15]

VI. Conclusions

We extend the Salter-Swan and Jones models to include semi-tradable goods, rather than a pure non-traded good, and also explicitly include factor markets. In this

[14]The Dutch disease occurs when an increase in availability of foreign exchange (arising, say, from the discovery of oil in the North Sea) worsens the trade balance and generates a real appreciation of the exchange rate, increasing imports, and reducing production of tradables.

[15]Bhagwati and Dehejia (1994) also criticize Borjas, Freeman, and Katz, but from the perspective of the HOS model, arguing that changes in endowments should have no effect on relative wages. Leamer (1996, pp. 11-12) considers a model with nontradables and notes that: "An external deficit raises the demand for nontradables and may or may not affect wages." In a footnote, he worries about different causes of a change in the deficit, and how they might affect relative wages.

model, we show that the change in relative factor prices depends not only on changes in commodity prices, as explained in the Stolper-Samuelson theorem, but also on changes in factor endowments and in the balance of trade. We find that imperfect substitutability between the import and domestic goods dampens the magnification effects in the Stolper-Samuelson and Rybczynski theorems. When imports and domestic goods are poor substitutes, the sign of the Stolper-Samuelson result is opposite of what the neoclassical trade model predicts. We also find that the trade balance effect on relative factor returns is the opposite of what factor content studies predict. In a general equilibrium framework, we capture the absorption effect of a deterioration of the trade balance, as well as the changes in the structure of production. Factor content analysis, using a partial equilibrium framework, only accounts for the latter effect.

There are a number of implications for policy analysis of including semi-traded goods in the model. For example, empirical models based on the 1-2-2-3 model can provide a unifying framework for the trade-wage debate, in which labor and trade economists have different approaches to explain the widening gap between skilled and unskilled wages in developed countries observed in the 1980s. Labor economists generally use partial equilibrium models measuring the factor content of traded goods.[16] Imports displace domestic production and, in effect, shift the demand for labor. Trade economists, using the Heckscher-Ohlin-Samuelson (HOS) model, look for links between

[16]Recent studies include Wood (1994), Sachs and Shatz (1994), and Borjas, Freeman, and Katz (1992, 1996).

commodity prices and factor prices.[17] The 1-2-2-3 model can accommodate both trade balance and world price shocks.

The 1-2-2-3 also can be used to evaluate the effects of technological progress on factor returns, another aspect of the trade-wage debate.[18] According to the HOS model, only sector-biased technological progress can affect wages. As Richardson (1995, p. 42) notes,

> "The [trade-wage] debate increasingly and properly isolates trade prices and sectoral total factor productivity differences as the causes of long-run factor-price movements. Trade volumes are correspondingly treated endogenously. Neutral and factor-augmenting technological change is seen to be just like factor-supply change, with innocuous impacts on factor prices."

Other economists, notably Wood (1994, 1995, 1998), argue that trade can have a big effect on wages when it induces factor-biased technological change. According to Wood, imports of unskilled-labor-intensive goods from developing countries induce "defensive innovation" by firms in developed countries as they use new production methods that economize on unskilled labor. The 1-2-2-3 model can accommodate both types of technological change. Factor-biased technological change will affect the wage gap because it operates like an endowment change, which does affect wages in the 1-2-2-3

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[17]See Leamer (1998), Baldwin and Cain (2000), and Harrigan and Baliban (1999) for regression analysis of trade relationships derived from a general equilibrium trade model. Slaughter (2000) provides an overview of such commodity price studies.

[18]For a discussion of the role of technological progress in the trade-wage debate, see Krugman (2000), Baldwin and Cain (2000), Leamer (1998), Francois and Nelson (1998) and Wood (1998).

model.

Finally, a model with semi-traded goods and factor markets is important for analysis of structural adjustment programs in developing countries. When imports and the domestic good are poor substitutes, as is the case for many commodities that developing countries import, a commodity price shock will have the opposite effect on factor returns than that predicted using a neoclassical trade model. This linkage matters for poverty analysis which looks at the effects of prices shocks on income.

References

Abrego, Lisandro and John Whalley (2000). "The Choice of Structural Model in Trade-Wage Decompositions," *Review of International Economics*, Vol. 8 no. 3, pp. 462-477.

Armington, Paul S. (1969). "A Theory of Demand for Products Distinguished by Place of Production." *IMF Staff Papers*, Vol. 16, pp. 159-178.

Baldwin, Robert E. and Glen Cain (2000). "Shifts in Relative U.S. Wages: The Role of Trade, Technology and Factor Endowments," *Review of Economics and Statistics*, Vol. 82, no. 4, pp. 580-595.

Bhagwati, Jagdish and Vivek H. Dehejia (1994). "Freer Trade and Wages of the Unskilled —Is Marx Striking Again?" In Bhagwati and Kosters, editors, *Trade and Wages*, Washington, D.C.: American Enterprise Institute.

Bhatarai, Keshab, Madanmohan Ghost, and John Whalley (1999). "More on Trade Closure." In Gustav Ranis and Lakshmi K. Raut, editors, *Trade Growth and Development, Essays in Honor of Professor T.N. Srinivasan.* New York: Elsevier Press.

Borjas, George J., Richard B. Freeman, and Lawrence F. Katz (1996). "Searching for the Effect of Immigration on the Labor Market." Unpublished, Harvard University and NBER, presented to the American Economic Association Meetings, January 5-7, 1996, San Francisco, California.

Borjas, George J,. Richard B. Freeman, and Lawrence F. Katz (1992). "On the Labor Market Effects of Immigration and Trade" In G. Borjas and R. Freeman, eds., *Immigration and the Work Force.* Chicago: University of Chicago and NBER, pp. 245-69.

Burfisher, Mary E. and Elizabeth A. Jones, eds. (1998). *Regional Trade Agreements and U.S. Agriculture*, Economic Research Service, AER No. 771. Washington, DC: U.S. Department of Agriculture.

Devarajan, Shantayanan, Jeffrey D. Lewis, and Sherman Robinson (1993). "External Shocks, Purchasing Power Parity, and the Equilibrium Real Exchange Rate." *World Bank Economic Review*, Vol. 7., No. 1 (January), pp. 45-63.

Devarajan, Shantayanan, Jeffrey D. Lewis, and Sherman Robinson (1990). "Policy Lessons from Trade-Focused Two-Sector Models." *Journal of Policy Modeling*, Vol 12., No. 4, pp. 625-657.

Francois, Joseph F. and Clinton R. Shiells, eds. (1994). *Modeling Trade Policy: Applied General Equilibrium Assessments of North American Free Trade.* Cambridge: Cambridge University Press.

Francois, Joseph F. and Doulas Nelson (1998). "Trade, Technology, and Wages: General Equilibrium Mechanics," *Economic Journal*, vol. 108, pp. 1483-1499.

Harrigan, James and Rita A. Balban (1999). "U.S. Wage Effects in General Equilibrium: The Effects of Prices, Technology, and Factor Supplies, 1963-1991." NBER Working Paper No. 6981.

Johnson, Harry G. (1966). "Factor Market Distortions and the Shape of the Transformation Frontier," *Econometrica,* Vol. 34, p. 686-98.

Jones, Ronald W. (1974). "Trade with Non-Traded Goods: The Anatomy of Interconnected markets." *Economica*, Vol. 41 (May), pp. 121-138.

Jones, Ronald W. (1965). "The Structure of Simple General Equilibrium Models." *Journal of Political Economy,* Vol. 73, No. 6, pp. 557-72.

Krugman, Paul R. (2000). "Technology, Trade and Factor Prices," *Journal of International Economics*, Vol. 50., pp.51-71.

Leamer, Edward E., (1998). "In Search of Stolper-Samuelson Linkages between International Trade and Lower Wages," in Susan M. Collins, ed., *Imports, Exports and the American Worker*, Washington D.C.:Brookings Institution Press, pp. 141-203.

Leamer, Edward E., (1996). "What's the Use of Factor Contents?" *NBER Working Paper No. 5448,* Cambridge, MA.

Martin, Will and L. Alan Winters, eds. (1996). *The Uruguay Round and the Developing Countries*, Cambridge: Cambridge University Press.

Melo, Jaime de (1988). "Computable General Equilibrium Models for Trade Policy Analysis in Developing Countries: A Survey." *Journal of Policy Modeling*, Vol. 10, pp. 469-503.

Melo, Jaime de, and Sherman Robinson (1989). "Product Differentiation and the Treatment of Trade in Computable General Equilibrium Models of Small Countries." *Journal of International Economics*, Vol. 7, No. 1, pp. 45-63.

Richardson, J. David (1995). "Income Inequality and Trade: How to Think, What to Conclude." *Journal of Economic Perspectives,* Vol. 9, No. 3, pp. 33-55.

Robinson, Sherman (1989). "Multisectoral Models." In H. Chenery and T.N. Srinivasan, eds., *Handbook of Development Economics, Volume 2*. Amsterdam: Elsevier Science Publishers.

Robinson, Sherman and Karen Thierfelder (1996). "The Trade-Wage Debate in a Model with Nontraded Goods: Making Room for Labor Economists in Trade Theory." International Food Policy Research Institute, Trade and Macroeconomics Division, Discussion paper no. 9.

Sachs, Jeffrey and Howard Shatz (1994). "Trade and Jobs in U.S. Manufacturing." *Brookings Papers on Economic Activity,* Vol. 1, pp. 1-84.

Salter, Wilfred (1959). "Internal and External Balance: The Role of Price and Expenditure Effects." *Economic Record*, Vol. 35, pp. 226-38.

Shiells, Clinton R. and Kenneth Reinert (1993). "Armington Models and Terms of Trade Effects: Some Econometric Evidence for North America." Canadian Journal of Economics, Vol 26, pp. 299-316.

Shoven, John B. and John Whalley (1992). *Applying General Equilibruim.* Cambridge: Cambridge University Press.

Slaughter, Matthew J. (2000). "What are the Results of Product-Price Studies and What Can We Learn from Their Differences?" in Robert C. Feenstra, ed., *The Impact of International Trade on Wages*, "Chicago: University of Chicago Press, pp. 129-170.

Swan, T. (1960). "Economic Control in a Dependent Economy." *Economic Record*, Vol. 36, pp. 51-66.

Wood, Adrian (1998). "Globalisation and the Rise in Labour Market Inequalities," *Economic Journal*, Vol. 108, pp. 1463-1482.

Wood, Adrian (1995). "How Trade Hurt Unskilled Workers." *Journal of Economic Perspectives,* Vol. 9, No. 3, pp. 57-80.

Wood, Adrian (1994). *North-South Trade, Employment, and Inequality*. Oxford: Clarendon Press.

Appendix

Derivation of the wage decomposition equation in the 1-2-2-3 model

Following Jones (1965), we consider two production goods, E, the export good, and D, the good sold on the domestic market. There are two inputs, labor (L) and capital (K). Assume that the export good is capital intensive and the domestic good is labor intensive. There is constant returns to scale technology described by the input coefficient A_{ij} which indicates the quantity of factor i needed to produce one unit of commodity j. The input coefficients depend only on factor prices. In equilibrium, full employment and zero profit conditions hold:

$$A_{KE}\,E + A_{KD}\,D = K \tag{1}$$

$$A_{LE}\,E + A_{LD}\,D = L \tag{2}$$

$$A_{KE}W_K + A_{LE}W_L = P^E \tag{3}$$

$$A_{KD}W_K + A_{LD}W_L = P^D \tag{4}$$

Totally differentiating the full employment conditions and dividing through by the appropriate forms of one and the endowment of either labor or capital, we find:

$$\lambda_{KE}\,\hat{E} + \lambda_{KD}\,\hat{D} = \hat{K} - [\lambda_{KE}\,\hat{A}_{KE} + \lambda_{KD}\,\hat{A}_{KD}] \tag{5}$$

$$\lambda_{LE}\,\hat{E} + \lambda_{LD}\,\hat{D} = \hat{L} - [\lambda_{LE}\,\hat{A}_{LE} + \lambda_{LD}\,\hat{A}_{LD}] \tag{6}$$

Totally differentiating the zero profit conditions and dividing by the appropriate forms of one and the price term, we find:

$$\theta_{LE}\,\hat{W}_L + \theta_{KE}\,\hat{W}_K = \hat{P}^E - [\theta_{LE}\,\hat{A}_{LE} + \theta_{KE}\,\hat{A}_{KE}] \qquad \textbf{(7)}$$

$$\theta_{LD}\hat{W}_L + \theta_{KD}\hat{W}_K = \hat{P}^D - [\theta_{LD}\hat{A}_{LD} + \theta_{KD}\hat{A}_{KF}] \qquad \textbf{(8)}$$

For variable input coefficients, we need additional conditions. Take the derivative of the unit cost equations, holding factor and output prices constant. Rearranging terms, we find:

$$\theta_{LE}\hat{A}_{LE} + \theta_{KE}\hat{A}_{KE} = 0 \qquad \textbf{(9)}$$

$$\theta_{LD}\hat{A}_{LD} + \theta_{KD}\hat{A}_{KD} = 0 \qquad \textbf{(10)}$$

These equations indicates a movement along an isoquant. Note that the input coefficients are functions only of relative prices, there is no technical change.

The λ_{ij}'s and the θ_{ij}'s embody the technology coefficients when relative changes are shown. The λ_{ij} term is the share of the total supply of factor i used in sector j. For example, for capital:

$$\lambda_{KE} = \frac{A_{KE}\,E}{K}; \quad \lambda_{KD} = \frac{A_{KD}\,D}{K} \qquad \textbf{(11)}$$

We define θ_{ij} as the share of factor i in total income generated in sector j.

$$\theta_{ij} = \frac{A_{ij}\,W_i}{P^j} \qquad \textbf{(12)}$$

Given that factors are fully employed and income is fully allocated to factors, it follows that :

$$\sum_j \lambda_{ij} = \sum_i \theta_{ij} = 1 \qquad \textbf{(13)}$$

We will assume that E is the capital-intensive sector and that D is labor-intensive. Capital's value share in E must be greater than its value share in D ($\theta_{KE} > \theta_{KD}$). The share of the total capital stock used in E must be greater than the share of the labor force used in E, ($\lambda_{KE} > \lambda_{LE}$).

We define the following matrices:

$$\lambda = \begin{bmatrix} \lambda_{KE} & \lambda_{KD} \\ \lambda_{LE} & \lambda_{LD} \end{bmatrix} \qquad \textbf{(14)}$$

$$\theta = \begin{bmatrix} \theta_{KE} & \theta_{LE} \\ \theta_{KD} & \theta_{LD} \end{bmatrix} \qquad \textbf{(15)}$$

Note that the determinants of the matrices are:

$$\begin{aligned} |\lambda| &= \lambda_{KE}\lambda_{LD} - \lambda_{LE}\lambda_{KD} \\ |\lambda| &= \lambda_{KE} - \lambda_{LE} \\ |\lambda| &= \lambda_{LD} - \lambda_{KD} \end{aligned} \qquad \textbf{(16)}$$

and

$$\begin{aligned} |\theta| &= \theta_{KE}\theta_{LD} - \theta_{KD}\theta_{LE} \\ |\theta| &= \theta_{LD} - \theta_{LE} \\ |\theta| &= \theta_{KE} - \theta_{KD} \end{aligned} \qquad \textbf{(17)}$$

The elasticity of substitution for factors of production in each industry is:

$$\sigma_E = \frac{(\hat{A}_{LE} - \hat{A}_{KE})}{(\hat{W}_K - \hat{W}_L)} \qquad \textbf{(18)}$$

$$\sigma_D = \frac{(\hat{A}_{LD} - \hat{A}_{KD})}{(\hat{W}_K - \hat{W}_L)} \tag{19}$$

Combining equations (9) and (18), we find:

$$(\hat{W}_K - \hat{W}_L)\sigma_E = -\frac{\theta_{KE}}{\theta_{LE}}\hat{A}_{KE} - \hat{A}_{KE} \tag{20}$$

or:

$$\hat{A}_{KE} = -\theta_{LE}(\hat{W}_K - \hat{W}_L)\sigma_E \tag{21}$$

and

$$\hat{A}_{LE} = \theta_{KE}(\hat{W}_K - \hat{W}_L)\sigma_E \tag{22}$$

Likewise, combining equations (10) and (19) we find:

$$\hat{A}_{KD} = -\theta_{LD}(\hat{W}_K - \hat{W}_L)\sigma_D \tag{23}$$

$$\hat{A}_{LD} = \theta_{KD}(\hat{W}_K - \hat{W}_L)\sigma_D \tag{24}$$

Substituting equations (21) and (23) into equation (5):

$$\lambda_{KE}\hat{E} + \lambda_{KD}\hat{D} = \hat{K} - [-\lambda_{KE}\theta_{LE}(\hat{W}_K - \hat{W}_L)\sigma_E - \lambda_{KD}\theta_{LD}(\hat{W}_K - \hat{W}_L)\sigma_D] \tag{25}$$

or,

$$\lambda_{KE}\,\hat{E} + \lambda_{KD}\,\hat{D} = \hat{K} + \delta_K\,(\hat{W}_K - \hat{W}_L) \tag{26}$$

Likewise, substituting equations (22) and (24) into equation (6):

$$\lambda_{LE}\hat{E} + \lambda_{LD}\hat{D} = \hat{L} - \delta_L(\hat{W}_K - \hat{W}_L) \qquad \textbf{(27)}$$

where:

$$\delta_K = \lambda_{KE}\theta_{LE}\sigma_E + \lambda_{KD}\theta_{LD}\sigma_D \qquad \textbf{(28)}$$

$$\delta_L = \lambda_{LE}\theta_{KE}\sigma_E + \lambda_{LD}\theta_{KD}\sigma_D \qquad \textbf{(29)}$$

Substituting equations (9) and (10) into equations (7) and (8), we find:

$$\theta_{LE}\hat{W}_L + \theta_{KE}\hat{W}_K = \hat{P}^E \qquad \textbf{(30)}$$

$$\theta_{LD}\hat{W}_L + \theta_{KD}\hat{W}_K = \hat{P}^D \qquad \textbf{(31)}$$

Subtracting the endowment changes, equation (27) from equation (26) we find:

$$(\lambda_{LE} - \lambda_{KE})\hat{E} + (\lambda_{LD} - \lambda_{KD})\hat{D} = (\hat{L} - \hat{K}) - (\delta_L + \delta_K)(\hat{W}_K - \hat{W}_L) \qquad \textbf{(32)}$$

and equation (16) implies:

$$-|\lambda|(\hat{E} - \hat{D}) = (\hat{L} - \hat{K}) - (\delta_L + \delta_K)(\hat{W}_K - \hat{W}_L) \qquad \textbf{(33)}$$

$$(\hat{E} - \hat{D}) = -\frac{1}{|\lambda|}(\hat{L} - \hat{K}) + \frac{(\delta_L + \delta_K)}{|\lambda|}(\hat{W}_K - \hat{W}_L) \qquad \textbf{(34)}$$

Subtracting the zero profit conditions, equation (31) from equation (30) we find:

$$(\theta_{LE} - \theta_{LD})\ \hat{W}_L + (\theta_{KE} - \theta_{KD})\ \hat{W}_K = (\hat{P}^E - \hat{P}^D) \tag{35}$$

and equation (17) implies:

$$(\hat{W}_K - \hat{W}_L) = \frac{1}{|\theta|}(\hat{P}^E - \hat{P}^D) \tag{36}$$

Substituting equation (36) into equation (34), we find an expression for the production possibilities frontier:

$$(\hat{E} - \hat{D}) = -\frac{1}{|\lambda|}(\hat{L} - \hat{K}) + \Omega(\hat{P}^E - \hat{P}^D) \tag{37}$$

where,

$$\Omega = \frac{(\delta_K + \delta_L)}{|\lambda||\theta|} \tag{38}$$

Building on Jones' description of production, there are four key equation in the 1-2-2-3 model, expressed in log differentiated form:

Contract curve:

$$(\hat{W}_K - \hat{W}_L) = \frac{1}{|\theta|}\ (\hat{P}^E - \hat{P}^D) \tag{39}$$

Supply:

$$(\hat{E} - \hat{D}) = -\frac{1}{|\lambda|}(\hat{L} - \hat{K}) + \Omega\ (\hat{P}^E - \hat{P}^D) \tag{40}$$

Demand:

$$(\hat{M} - \hat{D}) = -\sigma_Q(\hat{P}^M - \hat{P}^D) \tag{41}$$

Balance of Trade:

$$(\hat{E} - \hat{M}) = \hat{P}^M - \hat{P}^E - \hat{\Phi} \tag{42}$$

Rearranging equation (40), the supply equation, we find:

$$\hat{D} = \hat{E} + \frac{1}{|\lambda|}(\hat{L} - \hat{K}) - \Omega\,(\hat{P}^E - \hat{P}^D) \tag{43}$$

Likewise, rearranging equation (41), the demand equation, we find:

$$\hat{D} = \hat{M} + \sigma_Q(\hat{P}^M - \hat{P}^D) \tag{44}$$

Combining equations (43) and (44):

$$(\hat{E} - \hat{M}) = -\frac{1}{|\lambda|}(\hat{L} - \hat{K}) + \Omega\,(\hat{P}^E - \hat{P}^D) + \sigma_Q(\hat{P}^M - \hat{P}^D) \tag{45}$$

or,

$$(\hat{P}^E - \hat{P}^D) = [(\hat{E} - \hat{M}) + \frac{1}{|\lambda|}(\hat{L} - \hat{K}) - \sigma_Q(\hat{P}^M - \hat{P}^D)]\frac{1}{\Omega} \tag{46}$$

Combining this with the balance of trade equation (42):

$$(\hat{P}^E - \hat{P}^D) = \frac{1}{\Omega}\,[(\hat{P}^M - \hat{P}^E - \hat{\Phi}) + \frac{1}{|\lambda|}(\hat{L} - \hat{K}) - \sigma_Q(\hat{P}^M - \hat{P}^D)] \tag{47}$$

$$\hat{P}^E - \hat{P}^D) = \frac{1}{\Omega}\,[(1-\sigma_q)(\hat{P}^M - \hat{P}^E) - \hat{\Phi} + \frac{1}{|\lambda|}(\hat{L} - \hat{K}) - \sigma_Q(\hat{P}^E - \hat{P}^D \tag{48}$$

$$(\hat{P}^E - \hat{P}^D) = \frac{1}{(\sigma_Q + \Omega)}\,[(\sigma_Q - 1)(\hat{P}^E - \hat{P}^M) - \hat{\Phi} + \frac{1}{|\lambda|}(\hat{L} - \hat{K})] \tag{49}$$

Substituting equation (49) for the price term in the contract curve, equation (39), we find:

$$(\hat{W}_K - \hat{W}_L) = \frac{1}{|\theta|}\,\frac{1}{(\sigma_Q + \Omega)}\,[(\sigma_Q - 1)(\hat{P}^E - \hat{P}^M) - \hat{\Phi} + \frac{1}{|\lambda|}(\hat{L} - \hat{K})] \tag{50}$$

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