TMD DISCUSSION PAPER NO. 96

TRADE AND THE SKILLED-UNSKILLED WAGE GAP IN A MODEL WITH DIFFERENTIATED GOODS

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July 2002

Abstract

There is a continuing debate about whether international trade is responsible for the observed skilled-unskilled wage gap. In this paper we present a general equilibrium trade model with differentiated goods. We begin with an analytical model and show how changes in relative factor returns can be decomposed into changes in commodity prices, changes in the trade balance, and changes in the factor endowment Then we use a computable general equilibrium (CGE) trade model calibrated to the U.S. economy in 1982 to analyze the effects of these shocks, as well as technology changes, observed in the U.S. in the 1980's.
(JEL F11,F14, F15)

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Trade and the Skilled-Unskilled Wage Gap in a Model with Differentiated Goods

By, Karen Thierfelder and Sherman Robinson[1]

There is a continuing debate about the role of changes in trade on the evolution of relative wages—particularly the skilled-unskilled wage gap. In the 1980's, the wage gap widened considerably in the United States, and there was an active literature on the roles of trade, technology, and changes in labor supplies, particularly due to migration and education, in explaining these changes. The empirical models used to analyze the links fall into two broad groups: (1) partial-equilibrium models of the labor market, focusing on changes in the supply and demand of labor by skill category, and (2) general equilibrium trade models linking domestic factor returns to changes in world prices and the composition of trade.[1]

Labor economists use "factor content" models to analyze how changes in the composition of demand for goods feeds back into domestic factor markets in a partial-equilibrium framework. Recent studies include Adrian Wood (1994, 1995, 1998), Jeffrey Sachs and Howard Shatz (1994), and George J. Borjas et al. (1992, 1996). These models start by assuming that unskilled-labor-intensive imports displace unskilled-labor-intensive domestic production. Using input-output data, they identify the shifts in labor demand arising from changes in the structure of demand for goods, which are then assumed to affect equilibrium wages in labor markets.[2] In this framework, labor economists find that any worsening of the U.S. trade deficit contributes to the widening wage gap because the increase in unskilled-labor-intensive imports relative to capital-intensive and skill-intensive exports will reduce the demand for unskilled labor.[3]

Trade economists, using the Heckscher-Ohlin-Samuelson (HOS) model, look for links between commodity prices and factor prices. From the Stolper-Samuelson Theorem, in a world with all goods tradable, one would expect changes in world commodity prices to generate large changes in domestic factor prices[4] The Factor-Price Equalization Theorem makes an even stronger statement: assuming identical tastes and technology in all countries, free trade in commodities will lead to identical factor prices internationally, regardless of differing factor endowments across countries —a result often cited by protectionist pressure groups in the North. Finally, the Rybczynski Theorem shows that, with unchanged commodity prices, changes in factor endowments will lead to a magnified change in the structure of production and trade, but no change in relative wages. Trade theory would thus tend to focus attention on commodity prices and trade rather than changes in the skill-composition of the domestic labor supply.[5]

There are serious theoretical problems in reconciling the labor-market and trade-theory approaches. J. David Richardson (1995, p.35) identifies the challenge: "In short, the work that needs to be done in this area will bridge the gap between international and labor economics." Some progress has been made in that direction. For example, Matthew J. Slaughter (1999) summarizes the differences between the two perspectives and describes the implications of each approach for the elasticity of labor demand. George Johnson and Frank Stafford (1999) describe what labor economists might find useful in trade theory.

In this paper, we present a theoretical model that can capture many of the differences between the approaches of trade and labor economists. We start with Ronald W. Jones (1974), who examines the role of non-traded goods in the HOS model. We extend Jones to include imperfect substitutability between traded and non-traded goods, and the links between product markets and factor markets. The model also includes the balance of trade and the real exchange rate, which supports analysis of how changes in the trade balance affect factor markets. We show that, in this model, changes in relative wages can be decomposed into effects arising from changes in: (1) relative factor supplies, (2) relative prices, and (3) the trade balance. In contrast to the “factor content” approach, we show that increases in the trade deficit should reduce the gap between skilled and unskilled wages in a developed country such as the U.S.

After describing the links between trade and wages in our theoretical model, we then use a CGE trade model calibrated to the U.S. economy in 1982 to analyze the links between changes in relative wages and changes in trade, technology, factor supplies, and the trade balance.[6] There are 15 sectors, with a focus on manufacturing sectors. This aggregation is useful to analyze the effect of trade on U.S. wages because relevant imports from developing countries are primarily in the unskilled-labor-intensive manufacturing sectors. There are four labor categories in the model. We use the model for two applications.[7] First, we show the importance of trade in affecting relative wages by simulating the counterfactual: what would U.S. wages be in the absence of trade with developing countries?[8] Second, we use the model to decompose the impact on relative wages of changes in international prices, the trade balance, and the supply of unskilled labor of the order of magnitude observed in the 1980's. We find that a small endowment change can generate a dramatic change in the wage gap and that a large change in international prices generates a small change in the wage gap. Our results are consistent with those from empirical trade models which use regression analysis and find that trade is not responsible for the observed widening of the wage gap between skilled and unskilled labor. We then consider the role of biased technological change, which can have large effects.

The remainder of the paper is organized as follows. First, we present the theoretical model and discuss its properties. We conclude with a decomposition equation showing that changes in relative wages arise from changes in relative prices, relative factor supplies, and the trade balance. We then use an empirical CGE model of the U.S. economy in 1982 to show how relative wages respond to changes in relative prices, relative factor supplies, and the trade balance of the order of magnitude observed in the 1980's. Our conclusions follow.

I. The 1-2-2-3 Model

We present a general equilibrium trade model with non-traded goods which are imperfect substitutes with traded goods.[9] This theoretical model underlies a large class of single- and multi-country, applied, computable general equilibrium (CGE) trade models. Computable general equilibrium (CGE) models use the assumption, originally described in Paul S. Armington (1969), that goods are differentiated by country of origin and that imports and domestic goods are imperfect substitutes in demand.[10] Such 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.[11]

Our analytical model closely follows Jones (1974) who incorporates a non-traded good into the 2x2x2 HOS framework. We expand upon Jones by (1) exploring the factor market linkages, which he did not; (2) 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).[12]

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

$$Q = F(M, D; \sigma_Q)$$

demand. Aggregate absorption, Q, is given by:

where σ_Q is the elasticity of substitution in demand. Absorption represents aggregate utility 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

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

that the desired ratio of imports to domestic goods is given by:

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.[13]

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

$$A = \begin{bmatrix} A_{KE} & A_{KD} \\ A_{LE} & A_{LD} \end{bmatrix}$$

matrix A:

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.[14] Given this technology, factor market clearing requires:

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

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

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

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

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

In competitive equilibrium, unit costs will equal market prices:

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

$$P^M\ M = \Phi\ P^E\ E$$

balance of trade is given by:

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). We use Jones's (1965) notation to describe endowment shares ($\lambda_{ij,}$ the share of the total supply of factor i used in sector j) and value added shares (θ_{ij}, the share of factor i in total income generated in sector j). We assume that the export good is relatively capital intensive so the determinants of matrices of both $\lambda_{ij,}$ and θ_{ij}, denoted as $|\lambda|$ and $|\theta|$, are positive (and less than one). The elasticity of transformation between E and is given by Ω. It is a function of the endowment shares and the elasticities of substitution between labor and capital in production of goods E and D.[15]

The model reduces to four relationships in changes in relative prices, production, and demand. The first is the link between changes in relative prices and relative wages along the contract

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

curve underlying the production possibility frontier.

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.

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

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

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.[16]

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

$$\left(\hat{M} - \hat{D}\right) = -\sigma_Q\left(\hat{P}^M - \hat{P}^D\right)$$

equation 2 yields:

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

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

differentiating equation 6 yields:

The changes in relative prices of D and E can be expressed as a function of changes in

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

exogenous world prices, factor endowments, and the balance of trade:

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.[17] In the general case, there is effectively a different real exchange rate for imports and exports. Equation 11 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.

Changes in relative wages can be expressed in terms of changes in world prices, the balance

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

of trade, and factor endowments:

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, something the standard HOS model cannot. In our framework, factor-biased technological change operates like a change in the endowment and therefore affects relative wages.

II. Properties of the 1-2-2-3 Model

A. Implications 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 12 go to zero. In the limit, the remaining term in world prices reduces to:

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

which corresponds to equation 7 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.

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

When there is no change in factor supplies and the balance of trade, equation 12 reduces to:

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 Jaime de Melo and Sherman 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.[18] 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 11, 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 14, 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. In this case, an increase in the 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.

B. Implications 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 11). Substitute the resulting expression for $\hat{P}^E - \hat{P}^D$ into equation 8. 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

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

variables held constant:

As with the Stolper-Samuelson Theorem, this equation reduces to the HOS version (equation 8, 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 $\sigma_Q < 1$.

C. 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 et al. (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-1980's 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 12, 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 11, 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.[19] The production of E declines, D expands, and the relative wage gap narrows.[20]

III. Properties of the Decomposition Equation

Equation 12 can be used to decompose the relative contributions of changes in world prices, the balance of trade, and factor endowments to changes in relative factor returns. This decomposition is at the heart of the policy debate about the causes of the widening of the skilled-unskilled wage gap in the U.S. The 1-2-2-3 model can be used as the organizing framework for detailed empirical work, using both econometric analysis and simulation models. Here, we calibrate the parameters for the 1-2-2-3 model, using data for the U.S. in 1982, to show the magnitude of the coefficients in equation (21).[21] The aggregate data for the U.S. from the *Economic Report of the President* do not differentiate labor by skill category so we use the two inputs capital and labor. To include skilled-labor in this framework, one can assume that it is a complement to capital in production.

Value and endowment shares for the export and the domestic sector appear in table 1.[22] Note that the value share to capital in the export sector is greater than the value share to labor in that sector, indicating that the export sector is capital intensive. Likewise, the endowment share of capital in the export sector exceeds the endowment share of labor in the export sector. We assume the elasticity of substitution of factors in production (σ_E, σ_D) is 0.1.

Table 2 reports the elasticity of import substitution, (σ_Q), assumed to be 3.0. Using the assumed elasticities and the observed value and endowment shares, we compute the transformation elasticity. The resulting coefficients for the price, trade balance, and endowment terms in equation 21 are given in Table 2.

Note first that the Stolper-Samuelson magnification effect is nearly eliminated. The coefficient on the price term is 1.11, which implies that relative wages change only slightly more than relative prices. Second, the size of the coefficient for the endowment term, 5.51, is much larger. Not only do changes in endowments have a direct effect on relative wages, the effect is magnified. There is a large scope for factor-market and endowment effects in this type of trade model.

Finally, the trade balance (or Dutch disease) effect is smaller and of opposite sign than the price effect. The relative size of the trade balance effect is set by the choice of the import substitution elasticity. For a value of three, the effect is exactly half the value of the price effect. A given percent worsening of the trade balance will offset half of a comparable change in relative world prices. In the short run, one might well assume a lower import substitution elasticity, and so expect a larger offset.

Data for the changes in relative prices, the change in the trade balance, and the change in the relative supply of labor to capital also appear in table 2, calculated for the time periods 1980-1985 and 1986-1990. The trade balance shows the most dramatic changes over the two time periods. It increased 31 percent in the early 1980's and declined 21 percent from 1986 to 1990. Consistent with an increase in the trade deficit, the price of exports relative to the price of imports increased from 1980 to 1985. Using the computed coefficients for the decomposition equation and data for the U.S. in 1980-1990, we find that the return to capital relative to labor increased ten percent from 1980 to1985. It declined seven percent from 1986 to 1990. Despite the large increase in the trade deficit from 1980-1985, which has a negative coefficient in the decomposition equation, the wage gap increased over that period.

We find that the calculated coefficients in the decomposition equation are sensitive to parameter values. For example, when the import substitution parameter increases, the size of both the endowment and trade-balance effects decreases and the price effect increases. As expected, the model moves toward the standard HOS model as the import substitution elasticity increases, but contrary to the HOS model, the endowment term remains important. Even when the substitution elasticity reaches a value of 32, the coefficient on the endowment term is around one.

We also consider the sensitivity of the coefficients in the decomposition equation to initial trade shares. In the standard HOS model, the trade share is irrelevant —it matters only whether a good is tradable, not how much is traded. In the 1-2-2-3 model, the response of relative wages to changes in endowments is very sensitive to the trade share. The coefficients on the price and trade-balance terms level off as the trade share reaches 20 percent, while the coefficient on endowments falls steadily. At a trade share of 40 percent, the size of the endowment effect is close to the price effect. Labor economists and trade theorists share equal billing in countries with high trade shares.

Finally, we consider the sensitivity to the transformation elasticity, Ω, which is computed from the production elasticities, endowment shares, and value added shares (see equation 15). We find that as the transformation elasticity increases, the magnitudes of all three effects decrease. The endowment effect is relatively more important the lower is the transformation elasticity, but its coefficient remains significantly larger than the others for all values of Ω. Our sensitivity analysis suggests that the focus of labor economists on supply and demand in factor markets is well grounded, even in a trade-focused general equilibrium model.

IV. Multi-Sector Model of the U.S. Economy in 1982

To get a better perspective of the U.S. wage gap in the 1980's, we use a multi-sector version of the 1-2-2-3 model, calibrated to the U.S. economy in 1982.[23] There are 15 sectors in the computable general equilibrium (CGE) model, with an emphasis on manufacturing sectors which had high import shares of consumption during that time period (see table 3).[24]

There are four types of labor – professional, technical support, semi-skilled, and low-skilled. These categories are aggregates of the occupations defined by the Standard Occupation Classification in the U.S. Census (see table 4). The data matrices of employee compensation and the number of full time equivalents by both sector and occupation are constructed from two sources. The *March 1987 Current Population Survey* provides information on the share of income and the share of workers by occupation for each industry. The shares are used to distribute both the employee compensation and the number of full time equivalents for each industry as provided in the *Survey of Current Business.*[25]

Table 5 provides information on the structure of the U.S. economy in 1982. In general, the manufacturing sectors have a high share of imports in consumption, particularly sectors such as autos, consumer electronics, light manufacturing, and textiles. There is some evidence of two-way trade in sectors such as steel, autos, household appliances and consumer electronics for which both the share of exports in production and imports in consumption are high.

Value added shares (θ_{ij}) and endowment shares (λ_{ij}) are given in tables 6 and 7. Textiles, steel, autos, and light manufacturing have high value added shares for unskilled labor. These sectors also have high import shares in consumption.

In the multi-sector CGE model, goods are produced for both intermediate and final demand. Intermediate input demands are taken from the U.S. input-output table. Production requires primary factors (labor, land, and capital) with CES value-added functions and intermediate inputs with fixed input-output coefficients. With this production structure, we must account for both the direct factor use and the indirect factor use which arises through demand for intermediate inputs. In table 8, we report direct and indirect factor coefficients, measured as the share of the factor per unit of output.

We also report the factor content of the domestic good, imports, and exports. As a developed country, the unskilled-labor content of U.S. imports exceeds the unskilled labor content of U.S. exports. Likewise the skilled-labor content of U.S. exports (professional labor) exceeds the skilled-labor content of U.S. imports.[26]

The relationship between trade changes, production changes, and changes in factor returns are more complicated in the multi-sector model, compared to the analytical model in which only two goods are produced. At first glance, one may think that links in the decomposition equation (21) would break down in a multi-sector model because there are more goods than factors. However, we impose the structure of the analytical model sector-by-sector, with imperfect substitution in consumption between the imported and the domestic variety of each good (Armington elasticity) and imperfect substitution in production between the exported and the domestic variety (constant elasticity of transformation, CET, elasticity).

DeMelo and Robinson (1989) extend the 1-2-3 (one country, two production activities, and three goods) to the multi-sector model. Here, we discuss extensions that are relevant to factor market linkages in the 1-2-2-3 model, which they do not discuss. First, the multi-sector model, by construction, adds strong separability in production. The Armington and CET functions by sector allow some adjustment to price changes to take place within a sector–an increase in sectoral exports, for example, can be met by either a reduction in sales to the domestic market or by an increase in production. There is less need for output structure to change in the multi-sector model than in the analytical model, since the model allows both exports and imports in the same sector (two-way trade). As a result, factor intensity differences by sector matter less. The multi-sector model thus has a bias against finding a big trade effect because of separability by sector.[27] When the Armington and CET elasticities are low, the multi-sector model behaves more like the analytical model.

A final important difference between the multi-sector and the analytical model is that consumer preferences differ by sector. For example, in the U.S. model, the highest consumer expenditure shares are on high-wage services, low-wage services, and food. These sectors have different factor intensities and trade shares so, a priori, it is not clear how a change in income will affect factor returns. In the analytical model, when income increased, consumption of both imports and domestic goods increased, increasing the production of the domestic good and the return to unskilled labor, which the domestic good is assumed to use intensively.

First, we use the CGE model to consider the question, "what would the structure of U.S. wages be, but for imported manufactured goods from developing countries?" We simulate a 50 percent reduction in the quantity of manufactured imports.[28] Consistent with other empirical studies of the links between trade and wages, we find a very small impact on wages. In the base model, the ratio of the professional wage to the unskilled wage is 1.60. That ratio reduces slightly to 1.59 following a 50 percent reduction in manufactured imports in the central elasticity case. A negligible change, given the magnitude of the import shock.

Next, we use the model for three comparative static simulations based on the decomposition equation (21). The magnitudes of the shocks are constructed to reflect changes observed in the U.S. in the 1980's. We consider a 50 percent reduction in the world prices of imports, an increase in the trade balance by \$200 billion (from essentially zero), and a 5 percent decrease in the supply of unskilled labor. [29] We also consider the sensitivity of our results to the elasticity of substitution between imports and domestic goods in consumption. In our discussion of the Stolper-Samuelson theorem we note that the sign on the link between trade price shocks and the wage gap depends upon whether or not the elasticity of substitution is greater or less than one.

In the central case, we find that the price and labor market changes in the multi-sector model are consistent with the changes predicted in the analytical model. A 50 percent decline in the price of imported manufactured goods increases the wage gap between professional (skilled) and unskilled workers. However, the change is small given the magnitude of the price shock: the ratio of professional wages to unskilled wages is 1.60 in the base and 1.61 following the reduction of import prices. When imports and domestic goods are poor substitutes, the wage ratio declines slightly, to1.59. As shown in the discussion of the Stolper-Samuelson results for the analytical model, when the elasticity of substitution between imports and domestic goods is less than one, the sign on the link between commodity prices and factor returns changes. When imports and domestic goods are highly substitutable, so it is easier for imports to displace domestic goods in consumption, the wage ratio increases further to 1.63.[30]

In all scenarios, an increase in the trade deficit has only a slight impact on the wage ratio, the highest value being 1.61 in the high Armington elasticities case. However, the analytical model predicts that when the trade deficit worsens, there is an increase in absorption, and the wage gap narrows. In that model, consumers spend more on the imported good (M) and the domestic good (D). As production of D increases, demand for unskilled labor increases. In the multi-sector model, the same mechanism is at work, but the links are more complicated because there are 15 different goods to consume, each with different factor intensities. The consumer has the highest expenditure shares for low-wage services, high-wage services, and processed food. The high-wage service sector has a very high direct and indirect professional labor coefficient (table 8) suggesting that when it expands, it puts upward pressure on the professional wages, increasing the wage gap.

Finally, a reduction in the supply of unskilled labor reduces the wage substantially, to 1.54, regardless of the Armington elasticity. This change is consistent with predictions from the analytical model. The change is in the correct direction and is large, given that the labor supply only contracted 5 percent. In contrast, a 50 percent reduction in the price of imports has a much smaller impact on relative wages. The model suggests that endowment changes have a dramatic effect on the wage gap.

In contrast, an endowment change does not affect factor prices in the HOS model, where only price changes and sector-biased technical change can influence the wage gap. 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." In our framework, factor-biased technological change will affect the wage gap because it operates like an endowment change. Trade can have a big effect on wages when it induces factor-biased technological change. Wood (1994,1995) makes this argument, noting that 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.

Next, we cumulate the effects of the three shocks to provide a historical decomposition of the wage gap for the U.S. in the 1980's. The trade deficit, coupled with the import price shock, widens the wage ratio to from 1.61, with the import price shock alone, to 1.62. However, the net effect of the import price shock, the change in the trade deficit, and the change in the supply of unskilled labor, reduces he wage ratio to 1.56. This result is consistent with our earlier discussion of the effects of each shock individually. However, it is not consistent with the observed data. For example, James Harrigan and Rita A. Balaban (1999, figure 2) report that the in the U.S., the ratio of college graduate to high school graduate average weekly wage went from 1.52 in 1980 to 1.7 in 1985. Similarly, Robert E. Baldwin and Glen Cain (1999, table 1) report the ratio of workers with 13 or more years of education to workers with 12 or fewer years of education with respect to wages rose from 1.38 in 1980 to 1.50 in 1987.

The contrast between our simulated wage ratio and the actual wage ratio suggests that our model omits another shock which affected the relative wage in the U.S. during the 1980s. Many researchers attribute the increase in the wage gap to technological change.[31] In our simulation model, one can compute the technology shock needed to generate the observed wage gap, given the observed price, trade balance, and endowment shock. One can incorporate sector-biased total factor productivity growth, consistent with the approach that Lisandro Abrego and John Whalley (2000) and others who follow the HOS model use. Or, one can find the factor-biased productivity shock, similar to the change Wood (1998) describes, that is consistent with the observed wage ratio and other shocks. In our model, we can accommodate either type of technology shock. This is in contrast to the HOS model in which factor-biased technological progress operates like an endowment shock and has no effect on factor prices when commodity prices are determined in large world markets.

We find that, given the observed price, trade balance, factor endowment, and relative wage changes, factor-biased technological change in which skilled labor becomes more productive must have increased by 40 percent in the U.S. in the 1980s. Similarly, total factor productivity in the sectors that use unskilled labor relatively intensively would have had to increase by 64 percent, given the observed price, trade balance, factor endowment and relative wage changes.

Alternatively, it may be that the labor market is segmented. Many studies of the skilled-unskilled wage gap in the U.S. focus on manufacturing sectors. In the short term, the unskilled workers in the manufacturing sectors may be unable to move into the services sectors which have a much higher share of domestic goods in consumption than the other sectors in the economy (see table 5) and therefore are less vulnerable to trade shocks. We consider the implications of this view of the labor market and find that trade shocks have a much stronger effect on wages when the labor markets are segmented. For example, when the import price of manufactured goods falls 50 percent, the ratio of the payment to skilled workers to unskilled workers in the non-services sectors increases from 1.5 to 1.62 (see table 9). A combined shock of the price decline and the trade deficit increase the ratio to 1.76 and both the trade and labor supply shocks generate a wage gap of 1.69. These results suggest that in the short term, when it may be difficult for unskilled workers to move out of manufacturing sectors, trade shocks can have a strong impact on the wage ratio.

V. Conclusions

The debate about the impact of changes in world prices and trade on relative wages in developed countries has been strongly influenced by neoclassical trade theory, especially the Heckscher-Ohlin-Samuelson (HOS) model. In this general-equilibrium model, changes in factor supplies do not affect relative wages. We extend the analytic HOS model to include semi-tradable goods, thus capturing the fact that imports and domestic goods are imperfect substitutes in production.

Our extended analytic model incorporates the theoretical properties of a large body of empirical CGE models used for trade policy analysis. We show that in this class of models, 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 both factor endowments and the balance of trade. Our model provides a unifying framework for the trade-wage debate.

Analysis with an archetype model, patterned after the U.S. in 1982, indicates that changes in relative wages are more sensitive to changes in factor endowments than to changes in world prices or the trade balance. Not only is there room for labor economists, they have a prominent role. However, Stolper-Samuelson effects become more important as the trade share increases, which brings trade economists back into the picture. This result from the 1-2-2-3 model is intuitively appealing and contrary to the standard HOS model, where trade shares are irrelevant. Finally, changes in the trade balance do affect relative wages, but in the opposite direction from that derived from factor-content analysis, which assumes increased imports displace domestic production. The 1-2-2-3 model captures the general-equilibrium feedback from increasing aggregate absorption, which is ignored in the partial-equilibrium approach.

The results from the empirical multi-sector model are consistent with other studies of the links between trade and wages. Increased trade, which reduces the price of unskilled-labor-intensive import goods in developed countries, is responsible for very little of the observed wage gap. When we simulate a reduction in imports, we find only a slight reduction in the wage gap. Conversely, when we reduce the price of imported manufactured goods in the U.S. by approximately the change observed during the 1980"s, the wage gap increases slightly. In addition, changes in the trade balance, and hence changes in absorption, also only have a small effect on the wage gap, despite the observed large increase in the trade deficit during the 1980's. However, endowment changes do have large effects on the wage gap. Our results suggest an indirect route for trade to influence wages. When trade encourages factor-biased technological trade, it will dramatically influence the wage gap.

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1. See J. David Richardson (1995), Richard B. Freeman (1995), Matthew J. Slaughter (2000), and Robert C. Feenstra and Gordon H. Hanson (2001) for surveys of the models. Gary Burtless (1995) and Jeffrey G. Williamson (1995) provide historical overviews.

2. Trade economists also have views about the factor content model. Alan Deardorff (2000) and Alan Deardorff and Robert W. Staiger (1988), using an analytical trade model, find that the factor content of trade can be used to indicate the effects of trade on relative factor prices. Paul R. Krugman (2000) notes that trade theorists were wrong to reject the factor content approach. In contrast, Edward E. Leamer (1996) argues that the link between factor contents and factor returns is ambiguous.

3.George J. Borjas et al. (1992, p.214), not 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."

4.As Leamer (1998, pp.146-147) notes, neoclassical trade theory implies that "prices are set on the margin. ... What matters is whether or not the marginal unskilled worker is employed in the apparel sector, sewing the same garments as a Chinese worker whose wages are one-twentieth of the U.S. level."

5.See Leamer (1998), Robert E. Baldwin and Glenn Cain (2000), and James Harrigan and Rita A. Balaban (1999) for regression analysis of trade relationships derived from a general equilibrium trade model. In general, trade economists find that the links between trade and wages are small empirically. Leamer (1998) notes that the 1970s was the Stolper-Samuelson decade, and that there was a 4 percent mandated reduction per year in unskilled-wages.

6.Rod Tyers and Yongzheng Yang (1997) also use an applied general equilibrium model to examine the effects of East Asian openness and growth on developed-country factor markets. Harringan and Balaban (1999) use a regression model to analyze wage inequality in the U.S.

7. We provide one "complete general equilibrium story" that Krugman (1995, p.344) notes "has been absent from the debate." He presents a stylized general equilibrium model with a "set of ballpark parameters" (p. 329) to evaluate the impact of trade with Newly Industrializing Economies (NIE) on wages in developed countries. He finds that trade the observed increase in trade with NIE countries can be associated with fairly small wage changes. We use a CGE model calibrated to actual U.S. data to answer similar questions.

8. Krugman (2000) and Alan Deardorff and Dalia Hakura (1994) note that this is the appropriate counterfactual when looking at the effect of trade on wages.

9.The model is an extension of the Salter-Swan model in which the non-traded good is not substitutable with the traded good. See Wilfred Salter (1959) and T. Swan (1960) for the original model.

10. Paul S. Armington (1969) used this specification in estimating import demand functions. Many empirical studies support this specification. For example, Clinton R. Shiells and Kenneth 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.

11.Many surveys of CGE trade models are available: NAFTA (Joseph F. Francois and Clinton R. Shiells, 1994), regional trade agreements and agriculture (Mary E. Burfisher and Elizabeth A. Jones, 1998), and the Uruguay Round (Will Martin and L. Alan Winters, 1996). Sherman Robinson (1989) and Jaime de Melo (1988) describe the application of these models to development issues.

12.Shantayanan Devarajan et al. (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.

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

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

15.An appendix with the formal derivation is available from the authors upon request.

16.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).

17.This equation is equivalent to the equation for the real exchange rate in the 1-2-3 model derived in Devarajan et al. (1993), with the addition of a term for changes in factor endowments.

18.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.

19.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.

20.Jagdish Bhagwati andVivek H. Dehejia (1994) also criticize Borjas et al. 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.

21.Lisandro Abrego and John Whalley (2000) use a similar empirical approach and calibrate a two sector, two factor general equilibrium model for the UK in 1990. They use data on the observed changes in wages and prices to solve for the sector-biased technological change consistent with the data. This simulation allows them to decompose the effects of trade and technology on wage changes. We first derive the decomposition equation from the analytical model and use the data to determine the magnitude of the coefficients in the decomposition equation. We then use a much more detailed CGE model calibrated to the U.S. in 1982 to simulate the effects of the observed changes in relative prices, the trade balance and the relative endowment on changes in relative wages.

22.Production and trade data are from the U.S. National Income and Product Accounts. To aggregate sectors, we treat all sectors which are net exports as the export sector. Those remaining sectors which are net imports are aggregated into the domestic sector.

23.Krugman (2000) argues that there is a need for a computable general equilibrium model, calibrated for the U.S. economy with commodity detail, to better explore the general equilibrium linkages. He presents a stylized model, in which both goods are traded, calibrated to "ball park parameters," similar to our approach in section III.

24.A detailed description of the model and data is available from the authors upon request.

25.The *Survey of Current Business* is a better source of data on income because it provides information on employee compensation which indicates the factor cost from the producer's perspective. Likewise, the number of full time equivalents, found in the *Survey of Current Business,* is a better indication of factor use than the labor data in the *Current Population Survey*. As a result, only the occupation detail is taken from the *Current Population Survey*.

26.We find there is no Leontief paradox in the data.

27.This separability implies the need for disaggregation in the multi-sector model. Then, there will tend to be more specialization, with less observed two-way trade by sector.

28.Since we use constant elasticity of substitution (CES) import demand equations, it is not possible for imports to equal zero. Instead we reduce imports dramatically.

29.Data for the change in the relative price of imports are from Harrigan and Balaban (1999, figure 5) in which they report a 45 percent decline in the price of unskilled-labor-intensive tradable goods. This is an upper bound on the price change; at the other extreme, studies report that there is little evidence of a reduction in the prices of unskilled-labor intensive goods in the U.S. (for example, Robert Z. Lawrence and Matthew J. Slaughter, 1993). Harriagan and Balaban (1999, table 2) report a 12 percent decline in the supply of workers with 11 or fewer years of education for the 1980-1990 period; and Baldwin and Cain (2001, table 1) report the average annual percentage decline for this group to be 2.3 percent from 1980-87. Based on this data, we consider the effects of a 5 percent decline in the supply of unskilled labor. The trade balance is taken directly from data reported in the *Economic Report of the President*. It represents 75percent of the value of exports in the base model and 6.4percent of real GNP.

30.The wage response to price shocks is sensitive to the elasticity of substitution among inputs in production. In the scenarios reported here, we assume an elasticity of 1.5 in all sectors. Sensitivity analysis shows that for lower elasticities of substitution, which adds curvature to the transformation frontier, the magnitude of the change in the wage gap for the given price shocks is bigger.

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

Table 1- Archetype data and parameters for U.S.

	Exports (E)	Domestic (D)	Sum
Output	10	90	100
Capital (K)	8	47	55
Labor (L)	2	43	45
Value shares (θ)			
K	0.80	0.52	
L	0.20	0.48	
Factor shares (λ)			
K	0.15	0.85	1.00
L	0.04	0.96	1.00

K/L substitution elasticity (σ_E, σ_D)	0.10	0.10

The archetype data are based on data for the U.S. economy in the 1980s from the *Economic Report of the President, 2000*. GDP is normalized at 100, output and factor prices are normalized to one. Nominal exports were approximately 10% of the value of nominal GDP during the 1980s.

Table 2 - Relative wage change equation

Coefficients	Value
Import substitution elasticity (σ_Q)	3.00
Transformation elasticity (Ω)	3.46
Determinant $\lvert\theta\rvert$	0.28
Determinant $\lvert\lambda\rvert$	0.11

Relative wage change equation:

$$\left(\hat{W}_K - \hat{W}_L\right) = 1.11(\hat{P}^E - \hat{P}^D) - 0.56\,\hat{\Phi} + 5.51(\hat{L} - \hat{K})$$

Decomposition of relative wage changes

	1980-1985	1986-1990
$(\hat{P}^E - \hat{P}^M)$	0.22	-0.07
$\hat{\Phi}$	0.31	-0.21
$(\hat{L} - \hat{K})$	0.01	-0.02
$(\hat{W}_K - \hat{W}_L)$	0.10	-0.07

Sources: Data for nominal and real GDP are from *Economic Report of the President, 1996* (Tables B-1 and B-2). The export (import) price index is constructed as the ratio of nominal to real exports (imports). The trade balance is computed as the ratio of nominal imports to nominal exports. Data for percent change in the supply of labor are from the *Economic Report of the President 1996* (Table B-34). Data for percent change in the supply of capital are calculated from data on capital stock Thierfelder (1992), adjusted for changes in gross fixed real investment (from Table B-2, *Economic Report of the President, 1996*) and an assumed depreciation rate of 8 percent per year. When computing the percent change in relative wages, $(\hat{P}^E - \hat{P}^M)$ is substituted for $(\hat{P}^E - \hat{P}^D)$. The percent change in relative factor returns is an upper bound, when imports and the domestic good are perfects substitutes.

Table 3 - Sector aggregation and magnitude in the base data

Sector	SIC Code	Share of output
Agriculture, forestry, and fisheries	1,2,7,8,9	3.3
Mining	10,12,13,14	3.3
Tobacco manufacturing	21	0.4
Food processing	20	4.6
Textiles and apparel	22, 23	1.8
Chemicals and allied products	28	2.7
Steel and steel products	33, 34, 35	7.0
Autos	371	1.9
Transportation equipment	37 except 371	1.4
Household appliances and instruments	363,38	1.0
Other electronics	361,362, 364-367, 369	2.3
Light manufacturing	25, 26, 31, 27, 39	3.8
Intermediate goods	24, 29, 30, 32	6.0

Low-wage services	52-59, 70-79, 65, 15-17	29.9
High-wage services:	40-49, 50, 51, 60-64, 67, 80, 82-87, 89, 90-97	30.6

Source: Author's calculations using US 1982 input-output table.

Table 4 - Occupation categories in CGE model and share of labor supply and labor value added

Labor type	Occupation number	Employment share	Labor value added share
Professional labor		0.252	0.333
Executives, administration, and managerial	1		
Professional specialty	2		
Technical labor		0.256	0.232
Technical and related support	3		
Sales	4		
Administration support (including clerical)	5		
Semi-skilled labor		0.262	0.243
Private household services	6		
Protective services	7		
Other services	8		
Precision production, crafts, and repair	10		

Unskilled labor		0.230	0.191
Farming, forestry, and fisheries	9		
Machine operators, assemblers, and inspectors	11		
Transportation and material moving equipment	12		
Handlers, equipment cleaners, and laborers	13		

Source: Occupation categories are from the March 1987 Current Population Survey. Shares are computed from U.S. 1982 input-output data and employment data.

Table 5 - Structure U.S. economy, 1982

	Structure (percent):		Compositional shares of (percent)			
	Export/ Production	Import/ Consumption	Value added	Domestic consumption	Exports	Imports
Agriculture	10.4	3	2.2	3.1	7.4	1.8
Mining	4	20.4	3.9	3.3	2.9	15.7
Tobacco	12.6	3.3	0.3	0.3	1	0.2
Food processing	4.4	4.1	2.2	4.6	4.4	3.7
Textiles	3.7	12.8	1.1	1.8	1.5	5
Chemicals	11.1	6.3	1.8	2.6	6.6	3.1
Steel	13	10.7	5.3	6.4	19.8	14.2
Autos	14.5	32.4	1	1.7	6	15
Household Appliances	13.5	12.5	0.9	0.9	2.8	2.3
Electronics	16.2	28.2	2	2	8.2	14.9
Light manufacturing	4.8	13.5	2.9	3.8	4	11
Intermediates	6.7	8.6	2.4	5.8	8.6	10.1
Low-wage services	0.8	0	36.1	31.1	5.2	0

High-wage services	2.3	0.2	37.2	31.3	15.3	1.3
Transportation equipment	21.4	7.6	0.7	1.1	6.3	1.7
Total	4.6	5.1	100	100	100	100

Source: Author's calculations using US 1982 input-output table.

Table 6 - Endowment shares

	Capital	Land	Labor			
			Professional	Technical	Semi-skilled	Unskilled
Agriculture	3.1	100.0	0.5	0.4	0.2	3.9
Mining	4.5	0.0	1.3	0.8	1.9	1.3
Tobacco	0.1	0.0	0.0	0.1	0.1	0.3
Food processing	1.0	0.0	1.3	1.1	2.0	4.2
Textiles	0.4	0.0	0.8	0.9	0.9	4.0
Chemicals	1.5	0.0	2.2	1.7	1.3	1.8
Steel	3.6	0.0	6.2	4.6	7.0	11.0
Autos	0.8	0.0	0.7	0.7	1.4	3.0
Household Appliances	0.3	0.0	1.1	1.0	0.6	1.2
Electronics	0.6	0.0	3.6	2.4	2.3	2.3
Light manufacturing	1.4	0.0	3.0	2.9	2.1	6.2
Intermediates	1.9	0.0	1.8	1.6	2.1	5.9
Low-wage services	60.4	0.0	11.2	18.5	48.9	34.4
High-wage services	20.1	0.0	64.8	62.7	28.2	19.7
Transportation equipment	0.4	0.0	1.3	0.7	1.0	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Author's calculations using U.S. 1982 CGE input-output table and *March 1987 Current Population Survey.*

Table 7 - Value added shares

	Capital	Land	Labor				Total
			Professional	Technical	Semi-skilled	Unskilled	
Agriculture	25.9	44.8	4.5	2.5	1.5	20.7	100.0
Mining	75.0	0.0	8.3	3.3	8.8	4.5	100.0
Tobacco	65.7	0.0	0.6	5.7	11.5	16.5	100.0
Food processing	38.9	0.0	13.6	7.7	15.7	24.2	100.0
Textiles	20.6	0.0	14.7	11.7	12.2	40.8	100.0
Chemicals	37.8	0.0	25.5	13.8	11.1	11.9	100.0
Steel	17.2	0.0	24.9	12.8	20.8	24.4	100.0
Autos	12.8	0.0	16.0	10.5	23.4	37.3	100.0
Household Appliances	33.9	0.0	25.2	15.7	10.2	15.0	100.0
Electronics	14.8	0.0	37.5	17.1	17.6	13.1	100.0
Light manufacturing	26.4	0.0	21.7	15.0	11.6	25.3	100.0
Intermediates	26.8	0.0	17.1	10.6	14.7	30.8	100.0
Low-wage services	49.0	0.0	7.2	8.3	23.3	12.3	100.0
High-wage services	19.0	0.0	37.4	25.2	12.1	6.3	100.0
Transportation equipment	12.8	0.0	37.6	13.7	21.9	14.0	100.0

Source: Author's calculations using U.S. 1982 input output table and *March 1987 Survey of Current Business.*

Table 8 - Direct and indirect labor coefficients per thousand dollars of output

	Capital	Land	Labor			
			Professional	Technical	Semi-skilled	Unskilled
Agriculture	23.0	26.0	46.0	45.0	41.0	141.0
Mining	23.0	0.1	28.0	27.0	39.0	30.0
Tobacco	13.0	5.0	36.0	43.0	41.0	73.0
Food processing	17.0	9.0	57.0	55.0	58.0	107.0
Textiles	12.0	1.0	63.0	75.0	69.0	220.0
Chemicals	18.0	0.4	68.0	64.0	53.0	59.0
Steel	15.0	0.1	70.0	63.0	73.0	88.0
Autos	16.0	0.2	60.0	55.0	67.0	94.0
Household appliances	12.0	0.1	76.0	71.0	62.0	82.0
Electronics	11.0	0.1	86.0	70.0	79.0	70.0

Light manufacturing	14.0	0.2	75.0	76.0	61.0	106.0
Intermediate goods	19.0	0.6	52.0	50.0	53.0	72.0
Low-wage services	29.0	0.4	41.0	55.0	101.0	76.0
High-wage services	14.0	0.2	125.0	116.0	72.0	46.0
Transportation Equip.	15.0	0.2	95.0	72.0	86.0	79.0
			Factor content of:			
Domestic goods	20.0	1.0	75.0	75.0	76.0	72.0
Imports	16.0	1.0	63.0	58.0	62.0	83.0
Exports	17.0	3.0	74.0	68.0	67.0	81.0

Source: Author's calculations using U.S. 1982 CGE model. The direct and indirect factor coefficients are calculated as: $L \bullet (I - A)^{-1}$ where L is a matrix of factor use per unit of output, I is the identity matrix, and A is the matrix of input-output coefficients. The factor contents of domestic (import, export) demand are calculated as the vector of each sector's share of the value of domestic goods (imports, exports) times the matrix of direct and indirect factor requirements per unit of output.

Table 9 - Return to professional labor/Return to unskilled labor

Scenarios	Low trade elasticities: For sectors with high import shares in consumption Armington elasticity = 0.8	Central case: For sectors with high import shares in consumption Armington elasticity = 3.0	High trade elasticities: For sectors with high import shares in consumption Armington elasticity = 7.0	Segmented Labor Market: Central case elasticites; unskilled labor is segmented into services and non-services sectors
Base	1.60	1.60	1.60	1.50
Reduce imports of manufactured goods by 50 percent	1.61	1.59	1.59	1.46

Effects of the individual components of the decomposition equation:				
Reduce the world price of imports of manufactured goods by 50 percent	1.59	1.61	1.63	1.62
Increase the trade deficit to $200 billion	1.60	1.60	1.61	1.59
Reduce the supply of unskilled labor by 5 percent	1.54	1.54	1.54	1.44
Cumulative effects of trade and endowment changes described above:				
Reduce world price of imports & increase the trade deficit	1.59	1.62	1.65	1.76
Reduce world price of imports, increase the trade deficit, and reduce the supply of unskilled labor	1.54	1.56	1.59	1.69

Source: Model simulations from U.S. 1982 CGE model. The base data includes taxes by sector, factor productivity differences by sector, and other distortions, so the simulations are done in a second best environment. Sectors with high import shares in consumption are, mining, textiles, steel, autos, household appliances, consumer electronics, and light manufacturing**.** The CET elasticity in those sectors equals 0.2; sensitivity to the Armington elasticity is noted in the table. The Armington and CET elasticities for all other sectors are 1.5. The elasticity of substitution among in puts in the CES production function is 1.5. For the segmented labor market case, the wage ratio is the ratio of the payment to skilled labor relative to the payment to unskilled non-service labor.

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