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Quantifying the Impact of Trade on Wages: The Role of Nontraded Goods

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Quantifying the Impact of Trade on Wages: The Role of Nontraded Goods

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Abstract

This paper uses an applied general equilbrium model to decompose the effects of changes in trade and technology-related variables on wages of skilled and unskilled labor between 1982 and 1996 in the United States. The results indicate that trade-related variables (tariff cuts, improvement in the terms of trade, and the increase in the trade deficit) had little impact on the widening wage gap. Also, changes in total factor productivity had a small effect on relative wages. The major factor behind the rise in the skilled wage relative to the unskilled wage was differential rates of growth in skill-biased technical change across sectors. The paper also highlights the role that nontraded goods play in explaining the wage gap. Finally, the paper presents estimates of the effect of trade on wages by calculating what wage rates would be under autarky. The results show that expanding trade could actually reduce wage inequality, rather than increase it. The welfare costs to the U.S economy of moving to autarky (using 1996 as a base) are about 6 percent of GDP.

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I. Introduction

One development in the U.S. economy that has received considerable attention in the last decade is the rather pronounced widening of the wage gap between skilled and unskilled workers. For example, between 1982 and 1996, real wages of workers with less than12 years of education declined by about 25 percent, while real wages of those with more than12 years of education rose somewhat (Figure 1) (See Baldwin and Cain (1997) for a fuller discussion of wage developments).[2]

This widening wage gap has been the subject of active research by both labor and trade economists. While a natural subject for investigation by labor economists, trade economists have shown considerable interest in this subject since the widening of the wage gap in the United States has coincided with a fairly rapid expansion of imports from low-wage countries. In this context, the obvious question arises as to whether there is a causal link between these two developments. A number of economists have computed the labor content of imports and used this calculation to estimate the decline in labor demand as a result of higher imports. The effect of rising imports on wages can then be inferred from comparing the size of the reduction in demand for labor with changes in labor supply. Most of these types of studies find, little, if any, effect on wages arising from greater import penetration. (See Borjas, Freeman, and Katz (1992) and Katz and Murphy (1992) for examples).

Another possible channel through which international trade could affect wages is through changes in the prices of exports and imports. If import-competing goods are intensive in low-skill labor, then a decline in the relative price of imports could "explain" at least part of the observed relative decline in the wages of low-skilled labor through Stopler-Samuelson type effects. Bhagwati (1991) and Lawrence and Slaughter (1993) point out for example, that the relative price of imports actually increased over much of the period of observed rising wage inequality. Thus, this development seems to work against trade as an important factor that helps explain the widening wage gap.[3]

Most of the work done to date on trying to isolate the role of international trade in explaining wage inequality has been cast in models that focus on traded goods (exports and imports) and omit nontraded goods. This is surprising because value-added in the nontraded sector is quite large in many developed countries (almost 70 percent of GDP in the United States in 1982). By omitting nontraded goods, economists might be neglecting an important channel through which trade-related variables could affect wages. This paper seeks to shed

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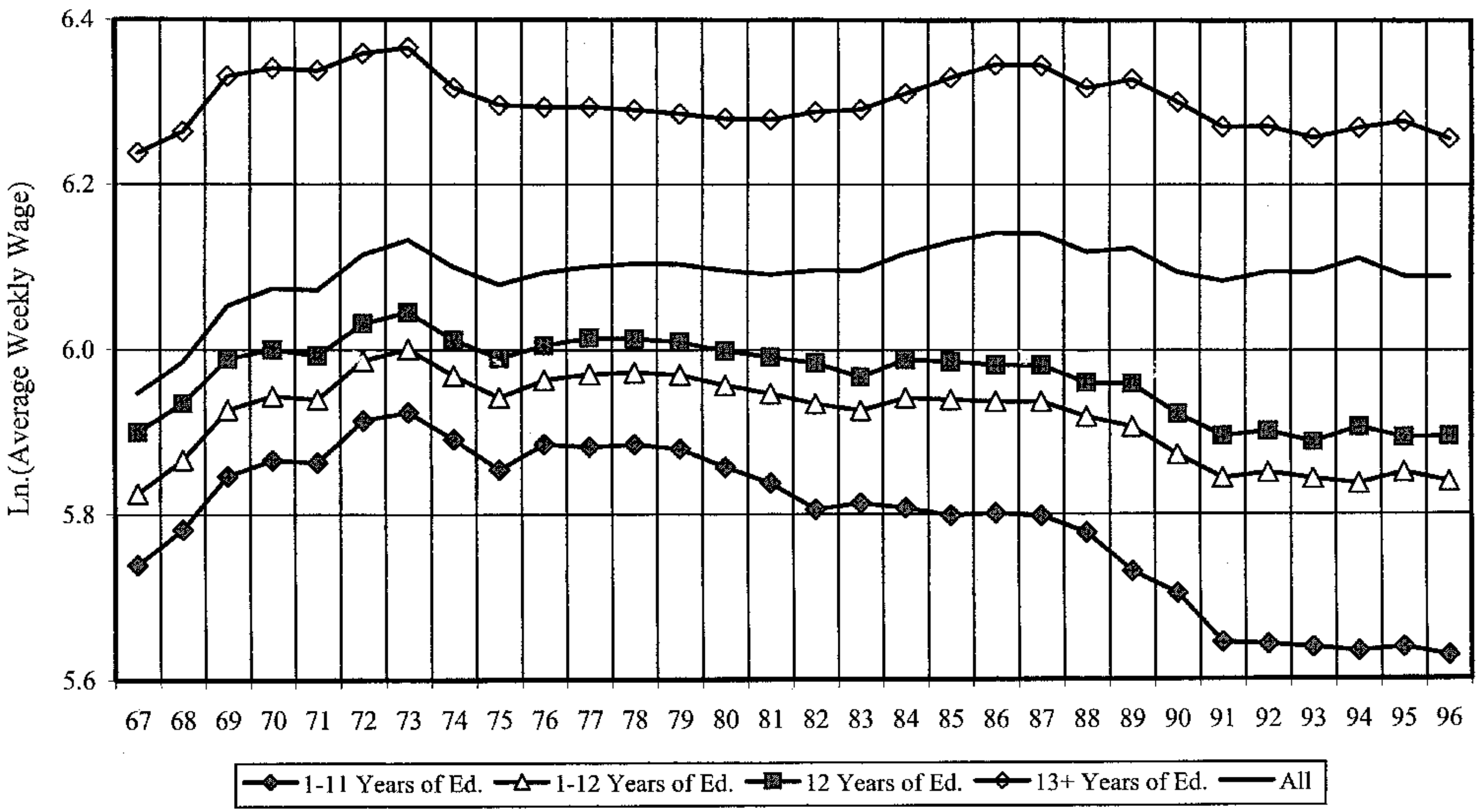
[2] These data were compiled from the Bureau of Labor Statistics and were made available by Glen Cain.

[3] The results of nine product-price studies are surveyed in Slaughter (1998).

Figure 1. Log of U.S. Real Wages by Educational Group, 1967–96



Source: Baldwin and Cain (1997)

some light on the role that nontraded goods have played in explaining the widening wage gap in the United States between 1982 and 1996.

Cassing and Cassing (1996) point out a number of different ways in which international trade could influence relative wages through interactions with the nontraded goods market. For example, they point out that in the context of a model with two traded goods, one nontraded good, two mobile factors, and a sector-specific factor in the export sector, greater international borrowing, perhaps to finance a larger budget deficit, could push up the price of nontraded goods if they are normal in consumption.[4] This would lead to effects on relative wages, depending on elasticities of substitution between labor types, and capital-labor ratios. Greater foreign borrowing would not have any wage effects in the standard two-by-two trade model of a small open economy because prices of goods are determined in international markets. Thus, nontraded goods provide an additional channel through which changes in trade-related variables could affect relative wages. Cassing and Cassing (1996) try to determine the sign of wage changes that result from various changes in exogenous variables (e.g. changes in the terms of trade), but do not provide quantitative estimates of the effects of these changes on wages in the United States using actual data. Robinson and Thierfelder (1996) make some of the same points as Cassing and Cassing (1996), particularly the effects that greater foreign borrowing might have on the nontraded goods market—"Dutch Disease" effects—and relative wages. They develop an applied general equilibrium model of the U.S. economy and use it to assess the effects of changes in factor endowments, the balance of trade, and world prices on wages, but they claim that their results are largely "suggestive" of the types of results one could expect.

This paper attempts to take the work of these previous papers a step further in three different ways. First, this paper uses an applied general equilibrium model of the U.S. economy, calibrated to data for 1982, to assess the importance of trade-related and technology-related variables on relative wages. The changes that took place in factor endowments, tariffs, the terms of trade, the balance of trade, total factor productivity, and factor-biased technical change between 1982 and 1996 are imposed on the model and it is used to decompose the effects of changes in each of these variables individually on relative wages that took place over the period. This exercise is similar to the one undertaken for the United Kingdom by Abrego and Whalley (2000), except that Abrego and Whalley do not include nontraded goods in their model. This paper differs from that of Robinson and Thierfelder (1996) in that it considers the effects of changes in trade policy and changes in total factor productivity and factor-biased technical change on a sectoral basis on relative wages.[5]

[4] Without the specific factor in the export sector, the price of nontraded goods would be determined from the supply side because the international prices of the traded goods determine the returns to the two mobile factors.

[5] Thierfelder and Robinson (2002) calculate the changes in technology-related variables (factor-biased technical change and total factor productivity) needed to be consistent with the observed wage gap. They do not, however, provide detailed estimates of these changes on a sectoral basis.

Second, this paper quantifies the role that nontraded goods play in affecting relative wages by using an applied general equilibrium model to calculate the wage effects of changes in exogenous variables with and without adjustment in the nontraded goods market. A series of experiments are performed using the base model (where the nontraded sector can adjust to shocks) and a version of the model in which the nontraded sector cannot adjust (This version of the model mirrors the behavior of the traditional Hecksher-Ohlin model, in which all goods are tradeable). In this way, it is possible to isolate the role that nontraded goods play in affecting wages.

Finally, the question: "What is the effect of trade on wages?" has generated a lot of discussion about how to isolate the precise role that trade plays in influencing wage movements. How exactly can trade affect wages when trade flows and wage rates are both endogenous variables simultaneously determined in a general equilibrium system? Krugman (2000) and Deardorff and Hakura (1994), among others, suggest that the question of how trade affects wages should really be posed in a "but for" sense. That is, what would wages be "but for" trade? This paper attempts to provide some answer to this question by using the applied model to calculate what factor prices would be in the absence of trade. By comparing wage rates when the economy is open to trade with wage rates when the economy is closed, it is possible to isolate the effect of trade on wages.

The remainder of the paper is organized as follows. The next section describes the applied general equilibrium model and data used in the paper. The third section describes the methodology and results from the experiments performed. Section four contains the conclusions.

II. Model, Data, and Calibration

This paper uses a three-sector applied general equilibrium model of the U.S. economy calibrated to data for 1982. The sectors include exportables, importables, and nontraded goods. Each of these sectors uses three factors of production: skilled labor, unskilled labor, and capital. Both skilled and unskilled labor are mobile across all three sectors, while capital is sector specific. Total income available for spending is the sum of factor income, tariff revenue, and capital inflows. A representative consumer maximizes a Stone-Geary utility function, subject to a budget constraint, which gives rise to demand functions for each of the three goods. The terms of trade are given, and the world price of the importable good is taken to be the numeraire. Given values for all of the exogenous variables and the parameters, the model solves for the price of nontraded goods that is consistent with equilibrium in factor and goods markets, that is, quantity demanded equals quantity supplied in all markets.

A. Model Structure

Production structure

The production structure of the model consists of two stages. At the first stage, an aggregate labor input is combined with sector specific capital to produce output. At the second stage, given the aggregate labor input, firms determine the amounts of skilled and unskilled labor that satisfy the aggregate labor input, as well as minimize total labor costs. Specifically, output of each of the three goods X_j is produced by combining an aggregate labor input L_j, with sector specific capital K_j according to a constant elasticity of substitution (CES) production function:

$$X_j = AX_j[\delta_j L_j^{-\Omega_j} + (1-\delta_j)K_j^{-\Omega_j}]^{(-1/\Omega_j)} \tag{1}$$

where AX_j and δ_j are constants, and $\Omega_j = (1 - \varphi_j)/\varphi_j$, where φ_j is the elasticity of substitution between capital and labor in the production of good j. Growth in total factor productivity is introduced through changes in AX_j and δ_j measures the "bias" of labor in the production function. The aggregate labor input is determined where the value of the marginal product of labor equals the aggregate wage rate:

$$W_j = (\partial X_j / \partial L_j) PX_j \tag{2}$$

where PX_j is the producer price of the jth good and W_j is the aggregate wage in the jth sector. Since capital is sector specific, its return, R_j, is a residual after labor is paid the value of its marginal product:

$$PX_j X_j = W_j L_j + R_j K_j \tag{3}$$

At the second stage, firms determine the optimal mix of skilled and unskilled labor by minimizing total labor costs subject to a labor aggregation function. Specifically, the labor aggregation function is:

$$L_j = A0_j\,[\alpha_j UL_j^{-\rho_j} + (1-\alpha_j)SL_j^{-\rho_j}]^{(-1/\rho_j)} \tag{4}$$

where UL_j is the amount of unskilled labor used in sector j, SL_j is the amount of skilled labor used in sector j, and $\rho_j = (1 - \sigma_j)/\sigma_j$, with σ_j denoting the elasticity of substitution between skilled and unskilled labor. Changes in the total labor input not accounted for by changes in the quantities of labor skill types are captured by changes in the parameter $A0_j$, while α_j measures the "bias" of unskilled labor in the aggregate. Changes in skill-biased technical change imply a lower value for α_j, thus giving more weight to skilled labor and less weight to unskilled labor in the aggregation function. Total labor costs are given by:

$$W_j L_j = W_U UL_j + W_S SL_j \tag{5}$$

where W_U and W_S are unskilled and skilled wages respectively. Minimizing (5) subject to (4) gives the optimal mix of unskilled to skilled labor as:

$$\frac{UL_j}{SL_j} = \left(\frac{W_S}{W_U}\right)^{\frac{1}{(\rho_j+1)}} \left(\frac{\alpha_j}{1-\alpha_j}\right)^{\frac{1}{(\rho_j+1)}} \quad (6)$$

Note that both W_S and W_U are not subscripted by sector j, as skilled and unskilled labor are mobile across all sectors and must earn the same return in all sectors. Both types of labor must be fully employed, so total labor demand must equal the endowments of both unskilled and skilled labor respectively:

$$\sum_j UL_j = ULAB \quad (7)$$

and

$$\sum_j SL_j = SLAB \quad (8)$$

where *ULAB* and *SLAB* are the fixed endowments of unskilled and skilled labor.[6] Since capital is immobile, stocks are fixed by sector:

$$K_j = \overline{K_j} \quad (9)$$

As pointed out in Abrego and Whalley (2000), using a model in which all factors of production are mobile across sectors and where the number of goods equals the number of factors generates a production possibilities frontier that is nearly flat. Adding sector specific factors—capital in this case—introduces curvature to the production frontier and avoids the problem of specialization. Robinson and Thierfelder (1996) avoid this problem by introducing imperfect substitutability on the demand side between imports and the nontraded good, and through imperfect substitutability in production between exports and the nontraded good.

Aggregate income and demand

Aggregate income available for spending is the sum of all factor income, tariff revenue, and borrowing from abroad.[7] Borrowing is taken to be fixed, in terms of the numeraire. Accordingly, spendable income Y, is given by:

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[6] The model used here does not allow for unemployment, which would be determined in the context of a macroeconomic model. Davis (1998) discusses the implications of moving from autarky to free trade in the context of a model where one country (the United States) has a flexible wage and the other (Europe) maintains a rigid wage. He finds that U.S wages rise to the European level and entry of the "unskilled" south raises European unempolyment, while the United States is fully insulated from the shock.

[7] Note that spendable income Y is not the same as GDP or GNP.

$$Y = W_U ULAB + W_S SLAB + \sum_j R_j K_j + TARIFF + CAPINF \tag{10}$$

where *TARIFF* is tariff revenue on imports and *CAPINF* is exogenous capital inflows. Tariff revenue on imports is given by:

$$TARIFF = t_M PW_M (DD_M - X_M) \tag{11}$$

where t_M is the ad-valorem tariff rate and DD_M is domestic demand for the importable good. The difference between domestic demand and production equals imports.

The domestic demand functions for the three goods are determined by maximizing a Stone-Geary utility function:

$$U = (DD_X - \lambda_X)^{\beta_X} (DD_M - \lambda_M)^{\beta_M} (DD_N - \lambda_N)^{\beta_N} \tag{12}$$

where λ_j denotes the minimum or "subsistence" level of consumption of good j, and β_j are the marginal budget shares. Maximization of (12) subject to (10) gives demand functions of the following form:

$$DD_j = \lambda_j + (\frac{\beta_j}{PD_j})[Y - \sum_j PD_j \lambda_j] \tag{13}$$

where PD_j is the price paid by the consumer for good j. The prices paid by the consumer (*PD*) for both the exportable and nontraded good are the same as the producer prices (*PX*), since there are no taxes or subsidies on these goods, but the consumer price of the importable good differs from the producer price (world price) because of the tariff:

$$PD_M = PW_M (1 + t_M) \tag{14}$$

Equilibrium

Equilibrium in the model is achieved when a set of relative prices is found such that the demand for all factors of production equals their endowments and when a set of goods prices is found that clears commodity markets. In this model, since the terms of trade are exogenous, the price of nontraded goods, P_N, adjusts to bring about equilibrium in the nontraded goods market:

$$X_N = DD_N \tag{15}$$

The terms of trade are exogenous:

$$\frac{PW_X}{PW_M} = TOT = \overline{TOT} \tag{16}$$

Since there is no money in the model, it can only determine relative prices, rather than absolute prices. All demand and supply functions are homogeneous of degree zero in prices, so any price may be chosen as numeraire. The world price of importables, PW_M, is taken to be the numeraire, so its price is fixed at one. The model also satisfies Walras' Law.

B. Data and Calibration

Data

The model is benchmarked to data for the U.S. economy in 1982. The changes that have occurred between 1982 and 1996 in factor supplies, technological progress, tariffs, the terms of trade, and the balance of trade are then imposed on the model and parameters are adjusted so that the model replicates the structure of the economy in 1996. Data on exports, imports, and GDP were taken from the National Income and Product Account (NIPA) tables produced by the U.S. Department of Commerce. The average tariff rate on imports in 1982 and 1996 is calculated by dividing total tariff revenue by the value of imports of goods and services from the national accounts data. Data on the terms of trade are taken from the price deflators for exports and imports of goods and services from the NIPA tables. Data on the breakdown between earnings of skilled and unskilled workers are broadly based on data from the Bureau of Labor Statistics, Current Population Surveys and Baldwin and Cain (1997).

Calibration

The technique of calibration, described in Mansur and Whalley (1984), is used to obtain values for the unknown parameters. Calibration entails using data on exogenous and endogenous variables in the base year to "solve for" unknown parameter values. Because of this technique, the model will replicate the base year data exactly, that is, the model will produce values for all the endogenous variables that match the observed values.

Elasticities

The model requires a number of elasticity values that are exogenous to the model. In production, the elasticity of substitution between labor and capital in production is assumed to be 0.5 in all sectors. The elasticity of substitution between skilled and unskilled labor is assumed to be 1.25 in all sectors, which is in the range of values used by Cline (1997). Sensitivity tests are performed on this elasticity.

Values for unknown parameters in domestic demand functions (λ_j and β_j in equation (13)) are determined by solving a set of simultaneous equations that satisfy the demand functions given by equation 13 and that generate the elasticity values given in Table 1. Since there are three goods, there are three income elasticities of demand, a (3x3) matrix of compensated demand elasticities, and a corresponding (3x3) matrix of uncompensated demand elasticities. To determine these elasticities, values for the income elasticity of demand for exportables and the nontraded good were specified exogenously. The remaining income elasticity—for importable goods—was determined by the Engel aggregation condition, since only two of the three elasticities are independent:

$$s_M \eta_M + s_X \eta_X + s_N \eta_N = 1 \qquad \textbf{(17)}$$

where s_j is the budget share of good *j*. This procedure determines each β_j, since from equation (13), the income elasticity of demand for good *j* takes the form:

$$\eta_j = \frac{\beta_j}{S_j} \qquad \textbf{(18)}$$

Thus, each β_j determines the income elasticity of demand for good *j* in the initial equilibrium, along with the expenditure share. The values chosen for λ_j must satisfy each demand function. To determine each λ_j, the demand functions are used together with the expression for the uncompensated own-price elasticity of demand for the nontraded good, which is given by:

$$\varepsilon_{NN} = -1 + (\frac{P_N \lambda_N}{P_N DD_N})(1 - \beta_N) \qquad \textbf{(19)}$$

The value chosen for ε_{NN} is –1.6. Thus, using this equation for ε_{NN}, together with the demand functions for the two traded goods and the values of β_X and β_N determined by the chosen income elasticities, it is possible to solve for λ_X, λ_M, λ_N, and β_M. Once all values for λ_j and β_j are determined, all the income and uncompensated elasticities are known, which are then used to compute the compensated elasticities using the Slutsky equation. The complete elasticity matrices shown in Table 1 satisfy all of the necessary restrictions from consumer theory. For example, the demand functions are homogeneous of degree zero in prices, so the row sum of the compensated demand elasticities is zero.

A key parameter in the decomposition analysis is α_j, which is a measure of the "bias" of unskilled labor in the labor aggregation function. A larger value for α_j implies that unskilled labor will have more "weight" in the labor aggregation function. In the decomposition performed here, α_j declines, which suggests that more weight is placed on skilled labor. Solving equation 6 for α_j gives:

$$\alpha_j = \frac{1}{(\frac{W_S SL_j^{(1+\rho_j)}}{W_U UL_j^{(1+\rho_j)}}) + 1} \qquad \textbf{(20)}$$

Table 1. Base Case Elasticity Values[1]

Compensated Demand Elasticities:

	Imports	Exports	Nontraded
Imports	-2.1	0.1	2.0
Exports	0.3	-1.2	0.9
Nontraded	0.8	0.1	-0.9

Uncompensated Demand Elasticities

	Imports	Exports	Nontraded
Imports	-2.4	0.0	1.4
Exports	0.2	-1.2	0.6
Nontraded	0.5	0.0	-1.6

	Imports	Exports	Nontraded
Income Elasticities	0.9	0.4	1.1

[1] Each value reported for the compensated and uncompensated elasticity is the percentage change in the quantity demanded of the good listed in the row with respect to a 1 percent change in the price of the good listed in the column.

Values for the remaining parameters in the production function (AX_j, $A0_j$, and δ_j) are determined that are consistent with the observed data on employment and output by sector, as well as satisfy the conditions for cost minimization in 1982 and 1996. In other words, parameters values are chosen such that the model replicates the structure of the U.S. economy in 1982 and 1996.

III. Methodology and Results

The model described above is used to conduct three sets of experiments. In the first set, the changes that took place in trade and technology-related variables between 1982 and 1996 in the U.S. economy, given in Table 2, are imposed on the model and it is used to decompose the effect of changes in each of these variables on the observed change in wages between 1982 and 1996. Exogenous variables for which there are no reliable data, such as sectoral capital stocks, are adjusted so that the model produces values for all the endogenous variables that match their 1996 values as closely as possible.[8] Given this procedure, it is then possible to decompose the overall change in relative wages given by the model—a 6.7 percent rise in the skilled wage relative to the unskilled wage—into the individual contribution of each variable. Results from this decomposition exercise are given in tables 3 through 5.

In the second set of experiments, the importance of nontraded goods is highlighted by performing a number of experiments using two versions of the model: one where the nontraded sector can adjust to exogenous changes (base model) and one where it cannot. To prevent adjustment in the nontraded goods market, the own-price and income elasticity of demand for nontraded goods are set to zero. This procedure effectively renders the cross-price elasticities of demand for exportables and importables with respect to the price of the nontraded good zero as well, through the relevant adding-up restrictions from consumer theory. On the supply side, the employment levels of both unskilled and skilled labor in the nontraded sector are fixed at their 1982 levels. Together with a fixed stock of capital in the nontraded sector, this procedure keeps the output of the nontraded good constant at its 1982 level. Table 7 reports the effects of the changes in trade-related variables on wage rates using both versions of the model. Tables 8 through 10 report wage elasticities with respect to changes in factor supplies, technology-related variables, and productivity measures, both individually and jointly.

In the third set of experiments, both versions of the model are used to explore the effects on wage rates of moving to autarky. Table 11 presents the effects on wages, prices, outputs, and aggregate welfare, as measured by the equivalent variation.

[8] In some cases, this procedure necessitated altering data on the sectoral capital stocks so that the model replicated the structure of the economy in 1996 as closely as possible with respect to trade flows, GDP, and the sectoral shares of value added. The model also had to be amended to allow for growth in foreign income, so that export flows would match actual data.

Table 2. Structure of the U.S. Economy and Changes in Key Variables Between 1982 and 1996

	1982	1996
Structure of Production/Capital-Labor Ratios		
Exportables	0.8	0.8
Importables	1.2	1.3
Nontraded	1.1	1.0
Skill-Intensity of Production		
(Ratio of employment of skilled to unskilled labor)		
Exportables	0.5	1.0
Importables	0.4	0.7
Nontraded	0.9	1.5
Distribution of Labor Force (in percent of total)		
Unskilled	60.0	44.1
Skilled	40.0	55.9
Growth in Factor Endowments		
(Average percentage growth per year between 1982–96)		
Unskilled labor	n.a.	1.1
Skilled labor	n.a.	5.4
Terms of Trade Index		
(Price of exports of goods and services relative to		
Imports of goods and services)	98.0	100.0
Percentage change		2.5
Average Tariff rate on Imports (in percent)	2.8	2.0
Trade Balance (Billions of dollars)	-20.6	-88.9
Percent of GDP	0.6	1.1
Imports/GDP	9.3	12.3
Sectoral Output shares of GDP (in percent):		
Exportables	15.7	15.5
Importables	16.1	13.5
Nontraded	68.2	71.0
GDP (billions of current dollars)	3,259.2	7,813.2

Sources: National Income and Product Accounts, U.S. Bureau of Economic Analysis; and Current Population Surveys, U. S. Bureau of Labor Statistics.

Table 3. Effects of Changes in Trade-Related Variables and Factor Supplies on Wages Between 1982 and 1996

	Percent Change in (W_S/W_U)	Percent Change in Skilled Wage	Percent Change in Unskilled Wage	Percent Change in Price of Non-Traded Goods	Percent Change in Output of Non-Traded Goods
All Exogenous changes	**6.7**	**52.5**	**42.9**	**77.1**	**40.9**
Changes in Trade-Related Variables					
σ_j = 1.25	0.2	2.1	1.9	2.4	0.2
σ_j = 0.75	0.3	2.1	1.8	2.4	0.2
Exports skill intensive	0.2	2.1	1.8	2.4	0.2
Increase in Trade Deficit					
σ_j = 1.25	0.3	1.7	1.4	2.3	0.4
σ_j = 0.75	0.5	1.8	1.3	2.3	0.4
Exports skill intensive	-0.1	1.4	1.6	2.3	0.4
Reduction in Import Tariff					
σ_j = 1.25	0.0	-0.6	-0.5	-0.7	-0.1
σ_j = 0.75	-0.1	-0.6	-0.5	-0.7	-0.1
Exports skill intensive	0.1	-0.5	-0.6	-0.7	-0.1
Improvement in Terms of Trade					
σ_j = 1.25	-0.1	1.0	1.0	0.7	-0.1
σ_j = 0.75	-0.1	0.9	1.0	0.7	-0.1
Exports skill intensive	0.3	1.2	0.9	0.7	-0.1
Effects of Changes in all Factor Supplies					
σ_j = 1.25	-38.7	-27.6	18.0	-2.5	55.5
σ_j = 0.75	-55.3	-40.7	32.8	-3.6	54.7
Exports skill intensive	-37.3	-24.4	20.6	-0.3	52.3
Change in Supply of Unskilled Labor					
σ_j = 1.25	12.3	-1.3	-12.1	0.9	3.8
σ_j = 0.75	21.1	3.4	-14.6	1.1	3.6
Exports skill intensive	12.5	-1.6	-12.5	0.5	4.2
Change in Supply of Skilled Labor					
σ_j = 1.25	-46.3	-50.8	-8.4	0.8	16.5
σ_j = 0.75	-64.1	-61.6	7.0	-0.3	15.5
Exports skill intensive	-44.7	-48.4	-6.7	2.8	14.2
Change in Supply of Capital					
σ_j = 1.25	1.6	39.9	37.7	-3.7	24.5
σ_j = 0.75	2.6	40.8	37.2	-3.6	24.5
Exports skill intensive	0.3	38.7	38.3	-3.8	24.6

Source: Author's calculations.

A. Results of Decomposition Exercise

As shown in table 3, the percentage change in the ratio of skilled to unskilled wages rose by about 7 percent between 1982 and 1996, which is the value used by Baldwin and Cain (1997), drawing on data from current population surveys. Baldwin and Cain divide the labor force into two categories: the portion that is unskilled, defined as a high-school graduate or less; and the portion which is skilled: defined as those with a college degree or more. Using this definition, the ratio of wages of skilled to unskilled rose by 6.7 percent between 1982 and 1996. Unskilled labor suffered a real-wage decline of about 22 percent, while real wages of skilled workers rose slightly over this period. Tables 3 through 5 present the effects of changes in trade and technology-related variables on relative wages for different values of the elasticity of subsitution between skilled and unskilled labor, as well as different assumptions about skill intensity (exports are intensive in skilled labor, rather than nontraded goods).

Trade-related variables taken together (changes in the trade deficit, import tariffs, and the terms of trade) raised the skilled wage, relative to the unskilled wage, by about 0.2 percentage points. This general finding that trade-related variables had little effect on wages is broadly consistent with empirical econometric studies, such as Harrigan (1998), Slaughter and Swagel (1998), and Hakura (1997). The greatest effect on wages arose from the larger trade deficit (and higher capital inflows), which pushed up the price of nontraded goods and the skilled wage, since nontraded goods are the most skill intensive sector. While the U.S. trade deficit did widen between 1982 and 1996 (by about ½ of a percentage point of GDP), this magnitude was not large enough to produce significant wage effects.[9]

The reduction in the average import tariff between 1982 and 1996 had only a very small effect on relative wages (Table 3) and this result is consistent with the findings of Haskel and Slaughter (2000).[10] Slaughter and Swagel (1998) and Hakura (1997) found that changes in import prices (which would occur as a result of a change in the import tariff) did not have large effects on wages in the United States. In the model used in this paper, the tariff cut lowered the skilled wage by slightly more than the unskilled wage, so reducing the tariff lessened wage inequality (see the section below for a fuller discussion of this result). A shortcoming of this analysis is that it only considers a reduction in an aggregate measure of trade policy, the tariff. Changes in non-tariff barriers (NTBs) that occurred between 1982 and 1996 (particularly NTBs in textiles, automobiles, and steel) were ignored. This omission almost certainly biased the wage effects downward. To assess the importance of the initial tariff rate, the calculation was repeated

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[9] It is possible that increased trade flows over the period 1982 and 1996 endogenously increased the demand for skilled labor, i.e. changed the parameters in the production function, such as AX_j (see Acemoglu 2001). Although the process by which this may have occurred is not modelled explicitly, the effect of trade on AX_j is captured through the calibration procedure.

[10] Haskel and Slaughter (2000) find that in the 1980s, level cuts in tariffs and transport costs were concentrated in unskilled intensive sectors. The authors estimate that the price changes induced by tariff and transport costs mandated a rise in the skill premium that was "mostly statistically insignificant."

using an initial tariff rate of 20 percent (in an effort to capture the effect of NTBs). Still, reducing this higher tariff produced a small effect on relative wages.

In general, changes in labor supplies had large effects on relative wages and the wage changes were in the expected direction (Table 3), which is consistent with the findings of Harrigan (1998). For example, the increase in the supply of unskilled labor between 1982 and 1996, all else constant, lowered the unskilled wage by about 12 percent. While Harrigan's model is quite general and does not base itself on any one type of trade model (e.g. Heckshser-Ohlin, Ricardo-Viner etc.), the model adopted in this paper could be interpreted as one theoretical structure that is consistent with his findings. The model was also used to estimate the effect on wages of changes in the stocks of skilled and unskilled labor in the United States between 1982 and 1996 as a result of legal immigration. While the model was not specifically designed to address this question, the broad conclusion that emerges is that between 1982 and 1996, legal immigration reduced both the unskilled and skilled wage by small amounts, with the decline in the unskilled wage exceeding the decline in the skilled wage.[11] Thus, legal immigration did contribute to the increase in the wage gap over the period between 1982 and 1996, and this contribution was greater than that played by changes in trade-related variables—a finding in line with that of Borjas, et al. (1996).

Overall, changes in total factor productivity (TFP) alone reduced wage inequality (Table 4). This occurs because TFP (as measured by changes in AX_j) grew faster in the traded sectors, which are more intensive in unskilled labor, compared to the more skilled intensive nontraded sector. Growth in TFP in the nontraded sector was actually negative by the method of calibration used here. It turns out that this result is not inconsistent with the work of Jorgenson and Stiroh (2000), who find that TFP growth in the nontraded sector between 1959 and 1996 was small or even negative.

The largest impact on relative wages arose from skill-biased technical change, which differed across sectors (changes in α_j in the labor aggregation function), as shown in Table 5. Overall, factor-biased technical change resulted in a 74 percent increase in the skilled wage premium between 1982 and 1996. This more than offset the substantial decline in relative wages that resulted from the increase in factor supplies alone or the decline in relative wages stemming from TFP growth. This result is consistent with Leamer's (1996) observation that the key factor explaining changes in relative wages is the change in skill biases across sectors, not skill bias itself. That is, lower values for α_j effectively increased the demand for skilled labor. Over the period 1982 to 1996, there was a large increase in the supply of skilled labor relative to unskilled labor, yet the skilled wage rose relative to the unskilled wage. This came about through an increase in the demand for skilled labor—a decline in α_j across sectors by

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[11] Between 1982 and 1996, estimates from the model indicate that legal immigration reduced the unskilled wage by a cumulative amount of 5½ percent (0.34 percent per year) and reduced the skilled wage by nearly 4 percent (0.28 percent per year).

Table 4. Effects of Changes in Productivity on Wages Between 1982–96

	Percent Change in (W_S/W_U)	Percent Change in Skilled Wage	Percent Change in Unskilled Wage	Percent Change in Price of Non-Traded Goods	Percent Change in Output of Non-Traded Goods
Effects of all Changes in Productivity					
σ_j = 1.25	-3.5	34.8	39.6	41.6	-16.7
σ_j = 0.75	-5.4	33.6	41.2	42.8	-16.9
Exports skill intensive	2.0	42.4	39.6	43.4	-16.1
Changes in Total Factor Productivity					
σ_j = 1.25	-3.7	33.4	38.6	39.4	-16.3
σ_j = 0.75	-6.1	31.4	39.9	39.3	-16.2
Exports skill intensive	1.9	42.4	39.7	42.9	-16.8
Export Sector					
σ_j = 1.25	-1.2	21.9	23.4	16.6	-2.4
σ_j = 0.75	-2.0	21.3	23.7	16.6	-2.3
Exports skill intensive	6.0	31.5	24.1	19.8	-2.7
Import Sector					
σ_j = 1.25	-1.6	18.6	20.5	16.6	-1.2
σ_j = 0.75	-2.6	17.8	21.0	16.6	-1.2
Exports skill intensive	-4.4	16.2	22.0	16.7	-1.3
Nontraded Sector					
σ_j = 1.25	-1.0	-5.4	-4.5	5.1	-13.0
σ_j = 0.75	-1.6	-5.8	-4.2	5.1	-13.0
Exports skill intensive	0.4	-4.6	-5.0	5.2	-13.2
Changes in Aggregate Labor Productivity					
σ_j =1.25	0.2	1.2	1.0	1.5	-0.7
σ_j =0.75	0.5	1.9	1.4	2.2	-1.0
Exports skill intensive	0.0	0.0	0.0	0.3	0.7

Source: Author's calculations.

Table 5. Effects of Factor-Based Technical Change on Wages Between 1982 and 1996

	Percent Change in (W_S/W_U)	Percent Change in Skilled Wage	Percent Change in Unskilled Wage	Percent Change in Price of Non-Traded Goods	Percent Change in Output of Non-Traded Goods
Effects of Changes in Factor Bias					
σ_j = 1.25	74.0	29.3	-25.7	-3.2	0.0
σ_j = 0.75	138.8	47.4	-38.3	-3.4	-1.4
Exports skill intensive	69.6	23.7	-27.0	-4.3	0.6
Greater Bias Toward Capital					
σ_j = 1.25	2.3	-1.9	-4.1	-2.9	2.6
σ_j = 0.75	3.8	-1.0	-4.6	-2.9	2.6
Exports skill intensive	-1.7	-7.6	-6.0	-4.4	3.7
Export Sector					
σ_j = 1.25	0.5	-2.8	-3.3	-1.3	0.9
σ_j = 0.75	0.9	-2.6	-3.4	-1.3	0.8
Exports skill intensive	-2.8	-8.1	-5.5	-2.6	1.9
Import Sector					
σ_j = 1.25	1.1	-2.5	-3.6	-0.8	1.1
σ_j = 0.75	1.9	-2.1	-3.9	-0.8	1.1
Exports skill intensive	1.4	-2.4	-3.7	-0.8	1.1
Nontraded Sector					
σ_j = 1.25	0.6	3.4	2.8	-0.8	0.5
σ_j = 0.75	1.0	3.7	2.7	-0.8	0.5
Exports skill intensive	-0.3	3.0	3.2	-0.8	0.6
Great Bias Toward Skilled Labor					
σ_j = 1.25	70.6	32.1	-22.6	-0.6	-2.4
σ_j = 0.75	131.0	49.8	-35.2	-0.9	-3.7
Exports skill intensive	69.0	31.8	-22.0	-0.3	-2.9
Export Sector					
σ_j = 1.25	13.3	6.8	-5.7	-0.6	-0.2
σ_j = 0.75	21.8	10.8	-9.1	-1.0	-0.3
Exports skill intensive	3.2	2.0	-1.1	0.2	0.1
Import Sector					
σ_j = 1.25	7.5	4.1	-3.1	-0.5	-0.3
σ_j = 0.75	11.9	6.4	-4.9	-0.7	-0.4
Exports skill intensive	7.6	3.9	-3.4	-0.8	0.0
Nontraded Sector					
σ_j = 1.25	41.7	22.6	-13.5	1.5	-1.5
σ_j = 0.75	69.7	34.5	-20.7	2.2	-2.3
Exports skill intensive	53.4	26.6	-17.5	0.7	-2.5

Source: Author's calculations.

Table 6. Technology-Related Parameters Used in the Model

	Exportables	Importables	Nontraded
Total Factor Productivity (AX_j)			
1982	1.96	1.93	2.00
1996	3.14	3.28	1.76
Percent change	60.2	69.9	-12.0
Productivity Parameter in Labor Aggregation Function ($A0_j$)			
1982	1.88	1.82	1.99
1996	2.00	1.98	1.96
Percent change	6.4	8.8	-1.5
Bias of Labor in Production Function (δ_j)			
1982	0.63	0.42	0.46
1996	0.58	0.32	0.49
Percent change	-7.9	-23.8	6.5
Bias of unskilled labor in labor aggregation function (α_j)			
1982	0.65	0.69	0.53
1996	0.48	0.57	0.41
Percent change	-26.2	-17.4	-22.6

Source: Author's calculations.

proportionately different amounts. The magnitudes of the changes in α_j, as well as the other technology parameters, are given in Table 6.

B. Assessing the Importance of Nontraded Goods

In order to ascertain the role that nontraded goods play in affecting wages, the effects of changes in trade and technology-related variables on income distribution were compared using the base model and a version of the model where the nontraded sector could not adjust. The results from these experiments are presented in Tables 7 through 10.

Table 7 presents the effects of changes in the trade-related variables for both model structures. Coincidentally, changes in the trade-related variables had approximately the same effect on wages under both model structures, but for completely different reasons. For example, an increase in the trade deficit due, for example, to unanticipated government borrowing from abroad, would have no effect on factor prices if the nontraded sector cannot adjust. On the other hand, when the nontraded goods market is allowed to adjust, the price of nontraded goods rises by about 2¼ percent, due to the increased demand for these goods, and this engenders factor price changes, with the ratio of skilled to unskilled wages rising by about 0.5 percentage points when σ_j equals 0.75 and 0.3 percentage points when σ_j equals 1.25.

In the case of a reduction in the import tariff, adjustment in the nontraded goods market can affect the sign of the change in relative wages. A tariff cut reduces the unskilled wage as expected, since importables are intensive in unskilled labor. When the nontraded sector is permitted to adjust, the tariff cut reduces both the price and output of the nontraded good, which releases inputs—namely skilled labor—to the expanding exportable sector.[12] This contraction in the output of the nontraded good, together with the decline in output of the importable good, reduces the demand for skilled labor and the skilled wage falls by more than the unskilled wage. When the nontraded sector cannot adjust, the opposite occurs: the unskilled wage falls by more than the skilled wage, since output of importables—the most unskilled-intensive sector—falls and the reduction in demand for skilled labor is not as great, since there is no decline in the output of the nontraded good. This result serves to emphasize that developments in the nontraded sector, not just in the traded sectors, can have important implications for factor prices.

Tables 8 and 9 present the results from a 1 percent increase in factor supplies and productivity respectively and show some additional examples where adjustment in the nontraded sector can reverse the sign of wage changes, compared to the case where the nontraded sector cannot adjust. For example, Table 8 compares the effects of a 1 percent increase in factor supplies, both individually and taken together. When all factor supplies are increased simultaneously, both wage rates rise, but the skilled wage rises by slightly more. This result comes partly through an income effect: the rise in all factor supplies increases aggregate income, which pushes up the price of nontraded goods, since it is a normal good. When the nontraded sector cannot adjust, there is no increase in the price of the nontraded good through

[12] This result follows along the lines discussed in Dornbusch (1974).

Table 7. Effects of Changes in Trade-Related Variables on Wages Under Different Model Structures
(percentage change)

	Base Model		No Adjustment in Market for Nontraded Goods 1/	
	$\sigma_j = 0.75$	$\sigma_j = 1.25$	$\sigma_j = 0.75$	$\sigma_j = 1.25$
Effects of all trade-related variables				
(W_S/W_U)	0.3	0.2	0.2	0.1
Skilled wage	2.1	2.1	1.4	1.3
Uskilled wage	1.8	1.9	1.1	1.1
Price of nontraded goods	2.4	2.4	0.0	0.0
Output of nontraded goods	0.2	0.2	0.0	0.0
Increase in the trade deficit				
(W_S/W_U)	0.5	0.3	0.0	0.0
Skilled wage	1.8	1.7	0.0	0.0
Unskilled wage	1.3	1.4	0.0	0.0
Price of nontraded goods	2.3	2.3	0.0	0.0
Output of nontraded goods	0.4	0.4	0.0	0.0
Reduction in the import tariff				
(W_S/W_U)	-0.1	0.0	0.1	0.0
Skilled wage	-0.6	-0.6	-0.3	-0.3
Unskilled wage	-0.5	-0.5	-0.3	-0.3
Price of nontraded goods	-0.7	-0.7	0.0	0.0
Output of nontraded goods	-0.1	-0.1	0.0	0.0
Improvement in the terms of trade				
(W_S/W_U)	-0.1	-0.1	0.2	0.1
Skilled wage	0.9	1.0	1.6	1.6
Unskilled wage	1.0	1.0	1.5	1.5
Price of nontraded goods	0.7	0.7	0.0	0.0
Output of nontraded goods	-0.1	-0.1	0.0	0.0

Source: Author's calculations.

1/ Results are presented for exogenous changes that occur in the exportable and importable sectors only.

the income effect, and hence, no increase in the skilled wage relative to the unskilled wage through this channel.

An interesting result shown in Table 8 is that an increase in the supply of one type of labor alone lowers the return to that factor, but raises the return to the other type of labor. This occurs because increases in the endowment of one labor type raise the marginal productivity of the other labor type. In Harrigan's model (1998), however, increases in the supply of one type of labor lower the return to all types of labor. Also, it is important to note, as shown in Table 8, that increases in the stock of capital used in each sector, all else constant, raise both wage rates, and the skilled wage rises by proportionately more than the unskilled wage. Harrigan (1998) finds a similar result, namely, that the effect of capital accumulation is to increase the wage premium of college graduates relative to high-school graduates. He concludes that his result is consistent with the view that "technical progress is both skill-biased and embodied in new capital goods."

C. Wages "but for" Trade

While it is useful to have a sense of how changes in trade and technology-related variables affect wages (Subsections A and B above), to determine how trade affects wages one should really compare factor prices when the economy is open to trade with what factor prices would be when the economy has no opportunity to trade (autarky), a point emphasized by both Krugman (2000) and Deardorff and Hakura (1994). Indeed, it is possible to use the model developed here to calculate how factor prices would change if the economy were closed to trade. This experiment is conducted with and without adjustment in the nontraded goods market. An advantage of using an applied general equilibrium model is its capability of addressing questions such as these, which are not easily handled using other modeling approaches.

Table 11 presents the effects on wages, prices, output, and welfare from shutting off trade. In order to move to autarky, output of the exportable good must contract, while output of the importable sector must expand, so the relative price of exportables falls. As the exportable sector contracts, it releases relatively more skilled labor than unskilled labor. When the nontraded sector can adjust, it absorbs some of the skilled labor released by the exportable sector, so output of the nontraded good rises, as the nontraded good is the most skill intensive sector. In this case, the expansion in output of the nontraded good mitigates some of the decline in the skilled wage, but the unskilled wage falls by more, leading to a rise in the skilled wage, relative to the unskilled wage. So, shutting off trade worsens wage inequality, or alternatively, expanding trade lessens wage inequality. This result obtains due to the adjustments that take place in the nontraded goods market.

Table 8. Elasticities of Wages with Respect to Changes in Factor Supplies Under Different Model Structures

(percentage change)

	Base Model		No Adjustment in Market for Nontraded Goods 1/	
Effects of a 1 percent increase in the following:	$\sigma_j = 0.75$	$\sigma_j = 1.25$	$\sigma_j = 0.75$	$\sigma_j = 1.25$
Effects of changes in all factor supplies				
(W_S/W_U)	0.0	0.0	-2.1	-1.3
Skilled wage	0.1	0.1	-3.3	-2.7
Unskilled wage	0.1	0.1	-1.3	-1.5
Price of nontraded goods	0.1	0.1	0.0	0.0
Output of nontraded goods	1.0	1.0	0.0	0.0
Unskilled labor				
(W_S/W_U)	1.3	0.8	3.4	2.0
Skilled wage	0.2	-0.1	0.7	-0.3
Unskilled wage	-1.1	-0.9	-2.7	-2.3
Price of nontraded goods	0.1	0.1	0.0	0.0
Output of nontraded goods	0.3	0.3	0.0	0.0
Skilled Labor				
(W_S/W_U)	-1.3	-0.8	-5.3	-3.2
Skilled wage	-1.2	-0.9	-4.9	-3.4
Unskilled wage	0.1	-0.1	0.5	-0.2
Price of nontraded goods	0.0	0.0	0.0	0.0
Output of nontraded goods	0.2	0.2	0.0	0.0
Capital 2/				
(W_S/W_U)	0.0	0.0	0.0	0.0
Skilled wage	1.0	1.0	0.9	0.9
Unskilled wage	1.0	1.0	1.0	1.0
Price of nontraded goods	0.0	0.0	0.0	0.0
Output of nontraded goods	0.6	0.6	0.0	0.0

Source: Author's calculations.

1/ Results are presented for exogenous changes that occur in the exportable and importable sectors only.

2/ 1 percent increase in the stock of capital in each sector.

Table 9. Effects of Changes in Productivity on Wages Under Different Model Structures

(percentage change)

	Base Model		No Adjustment in Market for Nontraded Goods 1/	
Effects of a 1 percent increase in the following:	$\sigma_j = 0.75$	$\sigma_j = 1.25$	$\sigma_j = 0.75$	$\sigma_j = 1.25$
Effects of all changes in Productivity				
(W_S/W_U)	0.0	0.0	0.0	0.0
Skilled wage	1.1	1.1	1.1	1.1
Unskilled wage	1.1	1.1	1.0	1.0
Price of nontraded goods	0.2	0.2	0.0	0.0
Output of nontraded goods	1.5	1.5	0.0	0.0
Change in total factor productivity				
(W_S/W_U)	0.0	0.0	0.0	0.0
Skilled wage	1.1	1.1	1.0	1.0
Unskilled wage	1.1	1.1	1.0	1.0
Price of nontraded goods	0.1	0.1	0.0	0.0
Output of nontraded goods	1.0	1.0	0.0	0.0
Exportables				
(W_S/W_U)	-0.1	0.0	0.1	0.0
Skilled wage	0.4	0.4	0.7	0.6
Unskilled wage	0.4	0.4	0.6	0.6
Price of nontraded goods	0.3	0.3	0.0	0.0
Output of nontraded goods	-0.1	-0.1	0.0	0.0
Importables				
(W_S/W_U)	-0.1	0.0	-0.1	0.0
Skilled wage	0.3	0.3	0.4	0.4
Unskilled wage	0.3	0.3	0.4	0.4
Price of nontraded goods	0.2	0.2	0.0	0.0
Output of nontraded goods	0.0	0.0	0.0	0.0
Nontraded				
(W_S/W_U)	0.1	0.1	na	na
Skilled wage	0.5	0.4	na	na
Unskilled wage	0.3	0.4	na	na
Price of nontraded goods	-0.4	-0.4	na	na
Output of nontraded goods	1.1	1.1	na	na
Change in aggregate labor productivity				
(W_S/W_U)	0.0	0.0	0.0	0.0
Skilled wage	0.0	0.0	0.1	0.1
Unskilled wage	0.0	0.0	0.0	0.0
Price of nontraded goods	0.1	0.1	0.0	0.0
Output of nontraded goods	0.5	0.5	0.0	0.0

Source: Author's calculations.

1/ Results are presented for exogenous changes that occur in the exportable and importable sectors only.

Table 10. Effects of Factor-Biased Technical Change on Wages Under Different Model Structures
(percentage change)

	Base Model		No Adjustment in Market for Nontraded Goods 1/	
Effects of a 1 percent increase in the following:	$\sigma_j = 0.75$	$\sigma_j = 1.25$	$\sigma_j = 0.75$	$\sigma_j = 1.25$
Effects of all changes in factor bias				
(W_S/W_U)	2.8	2.4	4.3	3.0
Skilled wage	0.6	0.3	1.8	0.9
Unskilled wage	-2.2	-2.0	-2.4	-2.0
Price of nontraded goods	-0.1	-0.1	0.0	0.0
Output of nontraded goods	-0.1	0.0	0.0	0.0
Greater bias toward capital				
(W_S/W_U)	0.0	0.0	0.0	0.0
Skilled wage	-1.0	-1.0	-1.2	-1.2
Unskilled wage	-1.1	-1.1	-1.1	-1.2
Price of nontraded goods	-0.1	-0.1	0.0	0.0
Output of nontraded goods	0.1	0.1	0.0	0.0
Exportables				
(W_S/W_U)	0.1	0.1	-0.1	-0.1
Skilled wage	-0.3	-0.4	-0.9	-0.9
Unskilled wage	-0.4	-0.4	-0.8	-0.8
Price of nontraded goods	-0.2	-0.2	0.0	0.0
Output of nontraded goods	0.1	0.1	0.0	0.0
Importables				
(W_S/W_U)	0.1	0.1	0.1	0.0
Skilled wage	-0.1	-0.1	-0.3	-0.3
Unskilled wage	-0.2	-0.2	-0.4	-0.4
Price of nontraded goods	0.0	0.0	0.0	0.0
Output of nontraded goods	0.1	0.1	0.0	0.0
Nontraded				
(W_S/W_U)	-0.2	-0.1	na	na
Skilled wage	-0.6	-0.6	na	na
Unskilled wage	-0.5	-0.5	na	na
Price of nontraded goods	0.1	0.1	na	na
Output of nontraded goods	-0.1	-0.1	na	na
Greater bias toward skilled labor				
(W_S/W_U)	2.8	2.4	4.3	3.1
Skilled wage	1.6	1.4	3.0	2.1
Unskilled wage	-1.1	-1.0	-1.3	-0.9
Price of nontraded goods	-0.1	0.0	0.0	0.0
Output of nontraded goods	-0.1	-0.1	0.0	0.0
Exportables				
(W_S/W_U)	0.6	0.5	2.2	1.7
Skilled wage	0.3	0.2	1.5	1.1
Unskilled wage	-0.3	-0.2	-0.7	-0.5
Price of nontraded goods	-0.1	0.0	0.0	0.0
Output of nontraded goods	0.0	0.0	0.0	0.0
Importables				
(W_S/W_U)	0.6	0.4	2.1	1.4
Sklled wage	0.3	0.2	1.5	1.0
Unskilled wage	-0.3	-0.2	-0.6	-0.4
Price of nontraded goods	-0.1	0.0	0.0	0.0
Output of nontraded goods	0.0	0.0	0.0	0.0
Nontraded				
(W_S/W_U)	1.6	1.5	na	na
Skilled wage	1.0	0.9	na	na
Unskilled wage	-0.6	-0.6	na	na
Price of nontraded goods	0.1	0.1	na	na
Output of nontraded goods	-0.1	-0.1	na	na

Source: Author's Calculations.

1/ Results are presented for exogenous changes that occur in the exportable and importable sectors only.

When no adjustment in the nontraded sector is permitted, the skilled and unskilled labor released by the exportable sector must be absorbed by the importable sector; they cannot be absorbed by the nontraded sector. Consequently, the decline in both wage rates is larger in this case, compared to the case where the nontraded sector can adjust. The skilled wage falls by relatively more than the unskilled wage, since the exportable sector is more skilled-labor intensive than the importable sector and because the nontraded sector cannot absorb any labor. In this case, shutting off trade lessens wage inequality; or, expanding trade worsens wage inequality. As this experiment shows, including a nontraded sector can lead to results that differ sharply from models that omit this sector.

D. Sensitivity of Results and Qualifications

The approach used in this paper requires specifying particular functional forms and using values for unknown parameters. To partly address this concern, the experiments conducted are reported for different values for the elasticity of substitution between skilled and unskilled labor, as well as different assumptions regarding the factor intensity of production. Tables 3 through 10 report the results for two different values of σ_j. Although the magnitude of the wage changes vary, the general conclusion that relative wage changes were driven primarily by differential rates of skill-biased technological change across sectors remains unchanged. Altering the factor intensity of production, i.e. making exports the most skill intensive sector, alters the magnitude of the changes in both the skilled and unskilled wage, and thus, the sign of the change in relative wages, but leaves the basic conclusions unaffected.

Still, the analysis presented in this paper is subject to a number of shortcomings both with respect to the modeling framework and the data. The model used in this paper is an "equilibrium" model, so phenomena such as unemployment are ruled out. Also, the applied general equilibrium model presented here is highly aggregated and does not allow trade in intermediate goods, which have grown rapidly in the last two decades. Although it is not possible to avoid choosing functional forms in applied work, the functional forms chosen here (constant elasticity of substitution functions) allow a fair degree of flexibility. Nevertheless, it is possible to choose other functional forms, such as the translog, which allow complementatity between factors in production. In future work, it might be an interesting exercise to explore the role of complementarity among factors in assessing wage changes. Finally the results are dependent on the elasticity values chosen, but as the sensitivity analysis shows, the basic conclusions are not overturned for alternative values of a key parameter—the elasticity of substitution between skilled and unskilled labor.

On the data side, the definition of what constitutes a skilled worker and an unskilled worker involves some degree of judgment. Unfortunately, data are not readily available which resolves this question unambiguously. Also, it is extremely difficult to measure value added and hence total factor productivity growth in service sectors. No data are available on changes in labor productivity that cannot be accounted for by changes in the amounts of skilled and unskilled labor (the parameter $A0_j$ in the labor aggregation function).

Table 11. Effects of Moving to Autarky Under Different Model Structures

(percentage changes)

	Base Model		No Adjustment in Market for Nontraded Goods	
	1982 Base	1996 Base	1982 Base	1996 Base
Wage effects				
Change in relative wages (W_S/W_U)	1.6	2.2	-4.5	-6.0
Change in skilled wage	-19.4	-23.9	-46.2	-60.3
Change in unskilled wage	-20.7	-25.6	-43.6	-57.7
Price effects				
Change in the price of nontraded goods	-15.0	-18.8	0.0	0.0
Change in the price of exportables	-44.3	-60.5	-65.5	-81.8
Change in the price of importables 1/	na	Na	na	na
Effects on sectoral outputs				
Exportables	-25.7	-32.7	-35.2	-43.4
Importables	8.1	7.8	20.8	21.8
Nontraded	2.8	3.4	0.0	0.0
Equivalent variation (Billions of dollars)	-104.6	-469.1	-147.8	-628.3
Percent of GDP	-3.2	-6.0	-4.5	-8.0

Source: Author's calculations.

1/ The world price of importables is the numeraire.

IV. Conclusions

What is the effect of trade on wages? This is a subtle question, as a number of researchers have pointed out. Most of the work to date on this issue has focused on the standard model of international trade which includes only tradeable goods (exports and imports) whose prices are determined on world markets. The role of nontraded goods—a fairly large and important sector in many economies—has not received much attention in the search for explanations of the fairly dramatic widening of the gap between wages of skilled and unskilled wages in the United States, as well as in other countries where this phenomenon has occurred. As Cassing and Cassing (1996) and Robinson and Thierfelder (1994) point out, nontraded goods provide a channel through which exogenous changes could have effects on wages—a channel that is often absent in trade models.

This paper attempted to advance the work on understanding how trade affects wages in three ways. First, the paper provided quantitative estimates of the effects of changes in various exogenous variables on skilled and unskilled wages in the United States over the period between 1982 and 1996. The results indicate that two changes had the largest impact on wages: the large increase in the relative supply of skilled workers and a corresponding increase in demand for skilled workers. In other words, the relative rise in skilled wages in the United States is largely explained by skill-biased technical change which differed across sectors. Changes in trade-related variables (changes in the terms of trade, the balance of trade, and tariff barriers) had a negligible effect on relative wages. Growth in TFP contributed very little to the rising wage gap also. These results are broadly consistent with the findings of a number of econometric studies.

Second, changes in exogenous variables can have effects on wages through their impact on the nontraded goods market—a channel that is often neglected in studies that examine the effect of trade on wages. In some cases, the adjustments to exogenous changes that take place through the nontraded sector can reverse the sign of the wage effect, compared with the case where the nontraded sector cannot adjust or is not even considered.

Finally, this paper provided some estimates of the effects of shutting off trade on wages. Many authors contend that comparing factor prices that would obtain under autarky with the factor prices that occur under trade is the proper way to asses the impact of trade on wages. The results show that the effect on relative wages of moving to autarky depends on interactions between the nontraded sector and the rest of the economy. When the nontraded sector can adjust, a move to autarky worsens wage inequality slightly, since the nontraded sector absorbs some of the skilled labor released by the exportable sector. When the nontraded sector cannot adjust, a move to autarky causes the skilled wage to fall by more, since the nontraded sector cannot absorb any of the skilled labor released by the exportable sector. In this case, autarky implies a narrowing of the wage gap. Overall, using both model structures, the welfare cost to the economy of a move to autarky is substantial. In the end, these exercises demonstrate the importance of including the nontraded sector in any analysis of the impact of trade on wages. In particular, the results demonstrate that expanding trade could, contrary to public belief, actually reduce wage inequality, through interactions between the nontraded sector and the rest of the economy.

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