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International Trade and American Wages in General Equilibrium, 1967–1995

James Harrigan

5.1 Introduction

Wage inequality in the United States has increased since the late 1970s, a trend that coincides with an increase in imports. General equilibrium trade theory suggests that these trends may be related, and the theory suggests where to look for links. The purpose of this paper is to use general equilibrium theory and econometrics to analyze time-series data on the prices and quantities of labor, output, and imports, with a view to understanding the forces that have led to increased wage inequality. I take it for granted that an increase in wage inequality is a worrying phenomenon, with social and political as well as economic implications, and that an understanding of the causes of increased wage inequality is an important task for applied economics.

Since the Stolper-Samuelson theorem of trade theory suggests that relative wages may be related to international trade and outlines the mechanism through which trade may affect wages, it is not surprising that a number of economists have used the Stolper-Samuelson theorem in their attempts to explain the growth in wage inequality. Matthew Slaughter's contribution to this volume (see chap. 4) is a good survey of this line of research.

One of the virtues of the Stolper-Samuelson theorem is that it is a gen-

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eral equilibrium result and is therefore well suited to analyzing economywide trends in wages that are common across sectors, age groups, and so on. In some ways, however, the Stolper-Samuelson framework is an overly restrictive way of organizing a study of the relationship between trade and wages. In particular, the Stolper-Samuelson theorem is derived from a one-cone model; that is, it applies only when there are no changes in the product mix. By ruling out changes in the product mix, the Stolper-Samuelson framework also rules out any effect of factor-supply changes on factor prices. The Stolper-Samuelson theorem also has the disadvantage that there is no direct link between trade volumes or import prices and factor prices: The chain of causation is from international prices to domestic final-goods prices to factor prices.

In this paper, I use a less restrictive general equilibrium model, in which factor-supply changes may affect factor prices and changes in the product mix are not ruled out. The model also has the feature that import prices have a direct (as well as an indirect) effect on factor prices. Using U.S. data on prices and quantities of factor supplies, final goods, and imports, I estimate general equilibrium factor-price elasticities, which allow a comparison of the relative importance of various causes of wage changes. I find that relative final-goods prices and relative factor-supply changes are both strongly related to wage changes, and that imports have had a negligible direct effect. The results do not rule out an influence of imports on wages through their effect on domestic prices, but an informal analysis of U.S. price changes suggests that they are determined primarily by domestic rather than foreign influences.

5.2 The Model

The standard neoclassical trade model takes factor supplies as given, with prices of final goods determined in international markets. Within a final-goods sector, domestic output and imports are treated as perfect substitutes, so that they have the same price in equilibrium. In such models, the vector of net exports is residual, arising from differences between domestic demand and supply.

The most cursory glance at disaggregated import statistics, however, makes it clear that imports are often intermediate goods, which are combined with domestically produced intermediates and domestic primary-factor services to produce final output. As shown by Rousslang and To (1993), even imported goods such as consumer electronics and autos have a very large share of domestic value added in the form of shipping, distribution, marketing, and service. This suggests modeling the demand for imports as arising from the production sector, so that (for example) an increase in the final demand for consumer goods leads to a demand for imported inputs.

There is a large literature on trade in intermediate goods that traces out the channels through which trade influences domestic prices and quantities, but here I follow Kohli (1991, chaps. 5 and 11) and take a reduced-form approach that is appropriate for the empirical work that follows. This model imposes no restrictions on the numbers of goods or factors, nor is joint production ruled out. I treat domestic output, which may be consumed domestically or exported, as being produced using primary factors and imports. The GNP identity is

$$\pi = \mathbf{p} \cdot \mathbf{y} - \mathbf{p}_M \cdot \mathbf{m} = \mathbf{w} \cdot \mathbf{v}, \tag{1}$$

where $\mathbf{p}$ and $\mathbf{y}$ are the prices and quantities of domestically produced goods, $\mathbf{p}_M$ and $\mathbf{m}$ are the price and quantities of imports, and $\mathbf{w}$ and $\mathbf{v}$ are the prices and quantities of primary factors.[1] The output quantity $\mathbf{p} \cdot \mathbf{y}$ might be called *gross GNP,* that is, GNP before imports have been paid for. Dividing the definition of π through by π gives $1 = s_Y - s_M$, where s_Y and s_M are the shares of final output and imports in GNP, respectively. This makes clear that the share of domestically produced goods in GNP, s_Y, exceeds 1. The share of imports in GNP, s_M, is defined as a positive number, and imports are measured as positive throughout.

Technology is assumed to be constant returns to scale, and all agents act as competitive price takers. For given prices and factor supplies, the competitive equilibrium will maximize the value of GNP, and this maximized value is given by the GNP function,

$$\pi = r(\mathbf{p}, \mathbf{p}_M, \mathbf{v}, t), \tag{2}$$

where t is time.[2] The properties of the maximization problem ensure that this function is convex in $\mathbf{p}$ and concave in $\mathbf{p}_M$ and in $\mathbf{v}$. In addition, equation (2) is homogeneous of degree one in ($\mathbf{p}$, $\mathbf{p}_M$), and homogeneous of degree one in $\mathbf{v}$. As usual with such dual functions, differentiation of the GNP function with respect to $\mathbf{p}$, $\mathbf{p}_M$, and $\mathbf{v}$ gives the final output, gross import, and factor price vectors,

$$\mathbf{y} = r_p(\mathbf{p}, \mathbf{p}_M, \mathbf{v}, t), \tag{3}$$

$$-\mathbf{m} = r_{pM}(\mathbf{p}, \mathbf{p}_M, \mathbf{v}, t), \tag{4}$$

$$\mathbf{w} = r_v(\mathbf{p}, \mathbf{p}_M, \mathbf{v}, t). \tag{5}$$

Equations (3) and (4) are homogeneous of degree zero in ($\mathbf{p}$, $\mathbf{p}_M$), and homogeneous of degree one in $\mathbf{v}$, while equation (5) is homogeneous of degree one in ($\mathbf{p}$, $\mathbf{p}_M$), and homogeneous of degree zero in $\mathbf{v}$. Closing the model requires the specification of the demand for domestically produced

1. Boldface variables are vectors.
2. All variables are implicitly indexed for time.

goods $\mathbf{y}$ and the supply of imports $\mathbf{m}$, but for now I will simply take the prices of final output and imports as given.

This simple theoretical model can be used to specify an empirical model by making a functional form assumption for equation (2). The translog functional form has good approximation properties and has proven useful in many empirical studies, including Kohli (1991) and Harrigan (1997), so I adopt the assumption that $r(\mathbf{p}, \mathbf{p}_M, \mathbf{v}, t)$ can be well approximated by a translog. For notational convenience, define the vector $\mathbf{q} = (\log \mathbf{p}, \log \mathbf{p}_M)$ and redefine $\mathbf{v}$ as the log of factor supplies. Then the translog GNP function is a quadratic in $\mathbf{q}$, $\mathbf{v}$, and t:

$$(6) \quad \log \pi = k + \mathbf{a} \cdot \mathbf{q} + \mathbf{b} \cdot \mathbf{v} + d_1 \cdot t + \frac{1}{2} \cdot \mathbf{q}' A \mathbf{q} + \frac{1}{2} \cdot \mathbf{v}' B \mathbf{v} + \frac{1}{2} \cdot \mathbf{q}' C \mathbf{v} + d_2 \cdot t^2 + t \cdot (\mathbf{d}_1 \cdot \mathbf{q} + \mathbf{d}_2 \cdot \mathbf{v}).$$

The matrices A and B are symmetric. Where ι is a conformable vector of ones, homogeneity requires $\mathbf{a} \cdot \iota = 1$, $\mathbf{b} \cdot \iota = 1$, $A\iota = 0$, $B\iota = 0$, $C\iota = 0$, $C'\iota = 0$, $\mathbf{d}_1 \cdot \iota = 0$, and $\mathbf{d}_2 \cdot \iota = 0$. Differentiation of equation (6) with respect to $\mathbf{q}$ and $\mathbf{v}$ gives the output, import, and factor share equations

$$(7) \quad \mathbf{s}_{y,-m} = \mathbf{a} + A\mathbf{q} + C\mathbf{v} + t \cdot \mathbf{d}_1,$$

$$(8) \quad \mathbf{s}_v = \mathbf{b} + C'\mathbf{q} + B\mathbf{v} + t \cdot \mathbf{d}_2,$$

where $\mathbf{s}_{y,-m} = (\mathbf{s}_y' \; -\mathbf{s}_m')'$ is the combined vector of the vector of final output shares of GNP, $\mathbf{s}_y$, and the negative of the vector of (positive) import shares of GNP, $-\mathbf{s}_m$. The term $\mathbf{s}_v$ is the vector of factor shares of GNP. Equation (7) is the share version of equations (3) and (4), while equation (8) corresponds to equation (5). If the actual GNP shares differ from equations (7) and (8) by a stationary stochastic process, then the parameters of the equations can be estimated statistically. Homogeneity implies that the two sets of equations (7) and (8) are each linearly dependent, and the symmetry of A and B combined with the appearance of C in both sets of equations means that there are numerous cross-equation restrictions that make systems estimation efficient. With technological progress that changes the form of equation (2) over time, the time trends in equations (7) and (8) can be interpreted as the reduced-form effect of technological progress on GNP shares.[3] The elasticities of the endogenous variables (factor prices, final output, and imports) with respect to the exogenous variables (factor supplies and prices of final output and imports) are simple functions of the

3. In Harrigan and Balaban (1999), we modeled the effects of technological progress more explicitly and measured Hicks-neutral technological progress using indices of total factor productivity (TFP). The data needed for TFP calculations are not available for the longer sample used in this paper.

parameters of equations (7) and (8) combined with the levels of the various GNP shares.[4] The factor price elasticities, in particular, are of interest, since they give an answer to the question: "What determines wages?"

5.3 Measurement and Estimation

I implement the model given by equations (7) and (8) using annual U.S. data from 1967 to 1995. The length of the sample is determined by data availability; import price data are not available before 1967, and output and labor data for years later than 1995 are not yet available. In this section, I briefly discuss the measurement and aggregation issues involved, and conclude the section with an explanation of the estimation methodology.[5]

The primary data sources are the U.S. National Accounts (USNA; for import, output, and price data), the Bureau of Economic Analysis (BEA; for GNP and capital stock data), and the Current Population Survey (CPS; for labor data). All the data used in this paper are publicly available.

With only 29 time-series observations and a wealth of disaggregated raw data, it is both crucial and problematic to construct aggregates that are appropriate for a study of wage determination. I choose to analyze a model with four primary factors of production (three types of labor, and capital), two final goods (high-skill-intensive and low-skill-intensive), and three types of imports (oil imports and two nonoil import aggregates).

The three labor aggregates that I analyze are (1) high school (HS) dropouts (workers who did not complete high school), (2) HS graduates (workers who completed high school, but who did not complete a 4-year college degree), and (3) college graduates (workers who have completed a 4-year college degree). Data on wages and employment were gathered from the March CPS, 1964–96. The CPS provides, among other variables, information on age, education, industry of employment, and both earned and unearned income. Details of the construction of the wage and weeks worked variables are contained in appendix B. For capital stock I use the real net stock of private nonresidential capital equipment and structures from the BEA.

Data on GNP by two-digit Standard Industrial Classification (SIC) code are available from the BEA. I aggregate economic activity into two sectors based on whether the two-digit industry is more or less intensive in skilled workers than the economy as a whole. This classification was chosen based on two considerations. First, with a short time series it was necessary to have a small number of aggregates. Second, I wanted to group sectors with similar factor shares, since theory informs us that it is the rela-

4. The exact formulas for the elasticities are given in appendix A.

5. Much of the data collection and analysis described in this section was done in collaboration with my co-authors on related projects, Rita Balaban and Susan Miller. I thank both for their permission to use the fruits of their labors in this paper.

Table 5.1 **Composition of Aggregates**

Output	
Nontraded	**Traded**
Unskilled-Labor Intensive	
Public utilities, transportation, construction, communications, wholesale and retail trade	Oil refining, mining, tobacco, leather, primary metals, lumber, textiles and apparel, stone, furniture, fabricated metals, agriculture, paper, food
Skilled-Labor Intensive	
Government enterprises; finance, insurance, and real estate (FIRE); miscellaneous other services (health care, business services, entertainment and recreation, education, legal, lodging)	Transportation equipment, rubber, chemicals, industrial machinery, instruments, electronic equipment, printing and publishing, miscellaneous manufactures

Nonoil Imports
Imports 1
Food and beverages, nonoil industrial supplies, services
Imports 2
Capital goods, consumer goods, autos, other goods

Notes: Disaggregate sectors are classified as unskilled-labor intensive if the share of total (direct and indirect) cost accounted for by less than college educated labor was less than the economywide average in 1977.

tive factor intensity of sectors that influences the Stolper-Samuelson responses of factor prices to goods-price changes. I used CPS data on the educational composition of the labor force by sector and BEA data on sectoral capital stocks to calculate the direct shares of each factor in sectoral value added. These data were combined with the 1977 input-output table to calculate the total (direct plus indirect) factor intensity of each input-output sector, since the total factor intensities are what matter for the Stolper-Samuelson effects. A sector is classified as skilled-labor intensive if the share of cost accounted for by workers with at least some college (13 or more years of education) is greater than the economywide average. The composition of the aggregates is listed in table 5.1. For reference, the components of each aggregate are grouped into traded and nontraded sectors in table 5.1, but this distinction plays no role in the empirical model.

It would be ideal to classify imports in the same way that domestic output is classified, by skill intensity. Unfortunately, this is not possible. I construct three import aggregates from the more disaggregated USNA data: oil imports; and two nonoil categories, Imports 1 (food and beverages, nonoil industrial supplies, and services) and Imports 2 (capital goods, con-

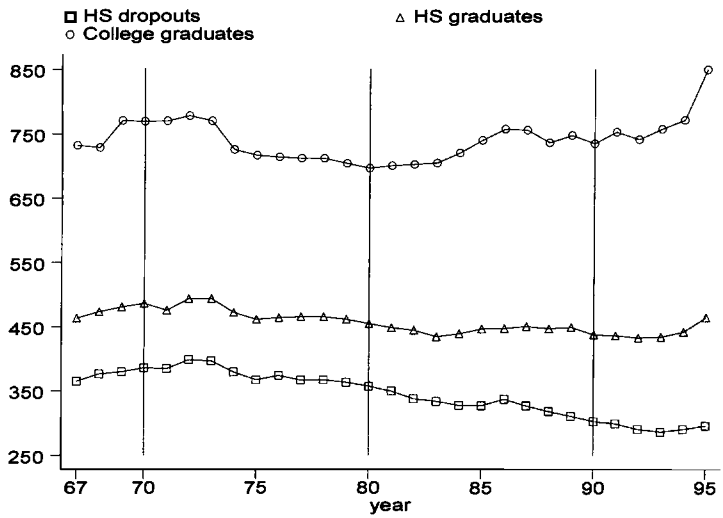

Fig. 5.1 Average real weekly wages by educational attainment, 1967–95, 1992 dollars

sumer goods, autos, and other goods).[6] These aggregates were constructed statistically, by aggregating sectors with highly correlated price and quantity changes.

In the derivation of equations (3)–(5) I took prices as fixed, which is not an appropriate statistical assumption. Consistent estimation of the translog equation system given by equations (7) and (8) requires valid instruments for the prices, which are correlated with prices, but not with contemporaneous output and import quantities or factor prices. Good instruments are those that are correlated with international supply and domestic demand conditions, and, fortunately, there is no shortage of plausible instruments in this context. To represent international supply, I use the lagged real GNP and lagged real exchange rate for three major trading partners of the United States: Canada, Japan, and Germany. Domestic demand conditions are represented by lagged values of the factor supplies and the lagged ratio of government purchases to potential GNP. Finally, I include an oil-shock dummy equal to 1 in 1974 and 1980, the years when exogenous spikes in world oil prices showed up in the U.S. import price of oil.

Figures 5.1 and 5.2 show wages and employment over the sample pe-

6. The binding data constraint for analyzing imports is a consistent price series, and the only broad-based and long-term price series are those reported in the USNA. The USNA classification system is based on end use rather than production, and it is not possible to construct a useful concordance from the import data to the SIC-based data that was used to construct the output aggregates.

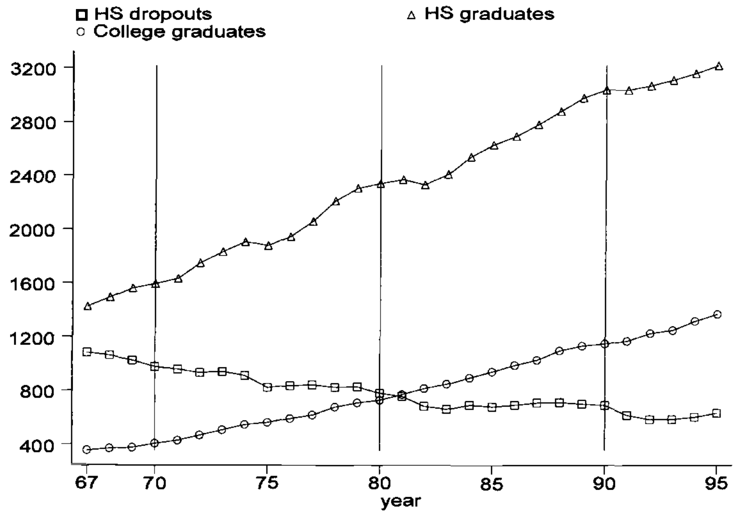

Fig. 5.2 Annual weeks worked by educational attainment, 1967–95, millions

riod. As is well known, real wages have stagnated since 1973, recovering for all three educational classes only in the past few years. At the same time, the labor force has become steadily more educated, with the number of HS dropouts decreasing, and the number of college graduates increasing steadily.

Figure 5.3 shows the wage of college graduates compared to HS graduates, which fell through most of the 1970s and has risen steadily since. Figure 5.4 shows the price of goods relatively intensive in highly skilled workers, or high-skill-intensive goods, compared to the price of goods relatively intensive in less-educated workers, or low-skill-intensive goods. In a pattern suggestive of a Stolper-Samuelson-like effect of relative prices on relative wages, this relative price is highly correlated ($\rho = 0.81$) with the relative wage plotted in figure 5.3.

The behavior of relative prices has been a key point of contention among economists who have looked for Stolper-Samuelson effects (see Slaughter, chap. 4 in this volume, for a discussion), so it is worth scrutinizing the sources of the dramatic changes in relative prices seen in figure 5.4. As noted in table 5.1, oil refining is included in the low-skill sector, which naturally leads to the suspicion that the swings in relative price of skilled and unskilled goods is driven by the well-known fluctuations in the price of oil. In fact, this is not the case: The correlation between the relative prices including and excluding oil is 0.97.

Table 5.2 analyzes the behavior of the price aggregates in greater detail. In looking at rows under the "Nontraded, skilled-labor intensive" heading, it becomes clear that changes in the price of skilled services largely

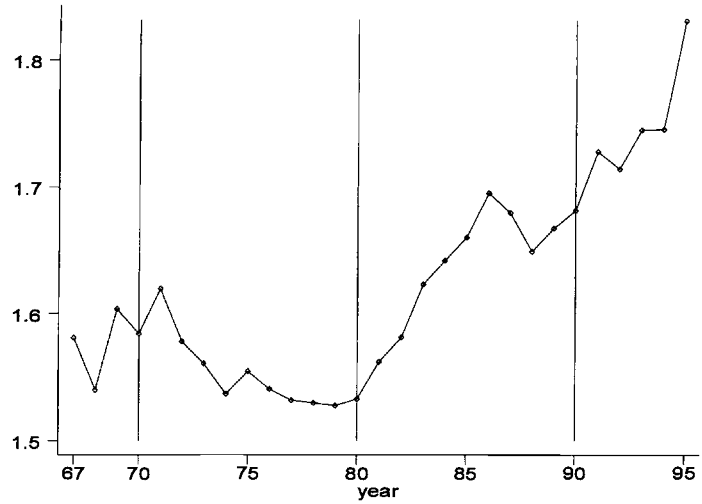

Fig. 5.3 College graduate/high school graduate relative average weekly wage, 1967–95

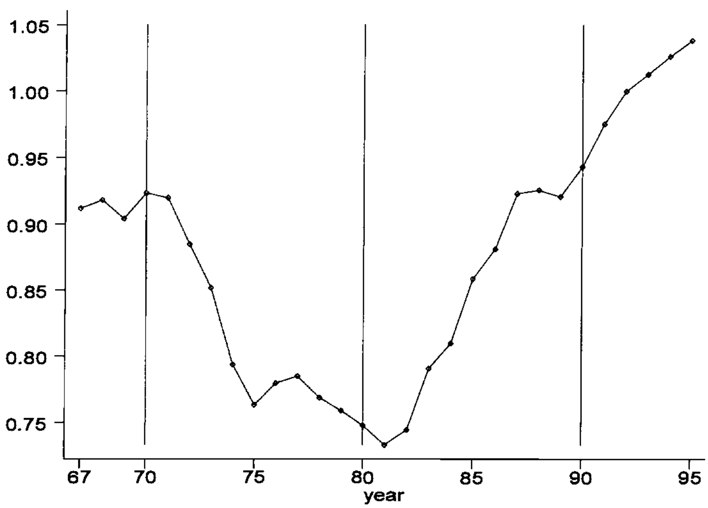

Fig. 5.4 Relative price of high-skill-intensive to low-skill-intensive goods, 1967–95, 1992 = 1

account for the price swings between 1970 and 1990 seen in figure 5.4. The two large sectors FIRE (finance, insurance, and real estate) and other services (a grab-bag sector that includes health care, business services, entertainment, education, and law) had price declines of around 15 percent during the 1970s and price increases on the order of 40 percent during

Table 5.2 **Relative Price Changes 1970–90**

	Price Change 1970–80			Price Change 1980–90		
	Share 1970	Value Added	Gross Output	Share 1980	Value Added	Gross Output
Nontraded, unskilled-labor intensive						
Wholesale and retail trade	0.173	−0.076	−0.065	0.156	−0.138	−0.058
Construction	0.076	0.099	0.063	0.067	0.063	0.007
Transportation	0.044	−0.172	−0.066	0.042	0.000	−0.029
Communications	0.028	−0.401	−0.329	0.032	0.150	0.148
Utilities	0.028	0.270	0.597	0.030	0.443	0.012
Traded, unskilled-labor intensive						
Agriculture	0.034	−0.094	−0.012	0.025	−0.339	−0.223
Food	0.023	−0.204	−0.040	0.021	−0.028	−0.109
Mining	0.047	2.680	1.211	0.021	−0.452	−0.288
Fabricated metals	0.015	−0.014	0.031	0.012	−0.023	−0.047
Paper	0.010	−0.020	0.025	0.011	0.094	0.022
Primary metals	0.014	0.031	0.099	0.010	−0.094	−0.096
Apparel	0.008	−0.433	−0.272	0.006	−0.118	−0.075
Lumber	0.007	0.056	0.058	0.006	−0.105	−0.093
Stone	0.008	0.021	0.049	0.006	−0.176	−0.089
Oil refining	0.009	7.411	1.836	0.005	−0.932	−0.417
Furniture	0.004	−0.312	−0.145	0.004	0.076	0.017
Textiles	0.005	−0.530	−0.236	0.004	−0.221	−0.107
Tobacco	0.002	0.099	0.053	0.003	3.134	1.063
Leather	0.002	0.059	0.011	0.001	0.041	0.004
Nontraded, skilled-labor intensive						
Other services	0.178	−0.140	−0.114	0.244	0.472	0.334
Finance, insurance, real estate	0.119	−0.172	−0.147	0.141	0.377	0.311
Government enterprises	0.016	−0.028	0.012	0.017	0.028	0.022
Traded, skilled-labor intensive						
Transport equipment	0.035	0.151	0.027	0.026	−0.152	−0.067
Industrial machinery	0.030	−0.162	−0.086	0.024	−0.491	−0.291
Chemicals	0.021	0.187	0.143	0.021	−0.080	−0.049
Electronics	0.021	−0.387	−0.219	0.019	−0.255	−0.139
Printing and publishing	0.015	−0.124	−0.081	0.016	0.259	0.150
Instruments	0.014	−0.373	−0.246	0.014	−0.031	−0.023
Rubber	0.012	−0.088	0.004	0.011	−0.165	−0.093
Miscellaneous manufactures	0.004	−0.046	0.025	0.004	−0.193	−0.123

Notes: This table reports sectoral proportional relative price changes, grouped by the aggregates defined in table 5.1. For each decade, the first column lists the sector's share of GDP at the start of the decade, and the next two columns give the change in the value added and gross output prices relative to overall GDP.

the 1980s. Unfortunately, the data do not permit greater disaggregation of the service sectors. Excessive aggregation combined with the well-known problems of measuring real output in services suggest that these numbers should be interpreted with caution.

Turning to the data for "Traded, unskilled-labor intensive" sectors, the

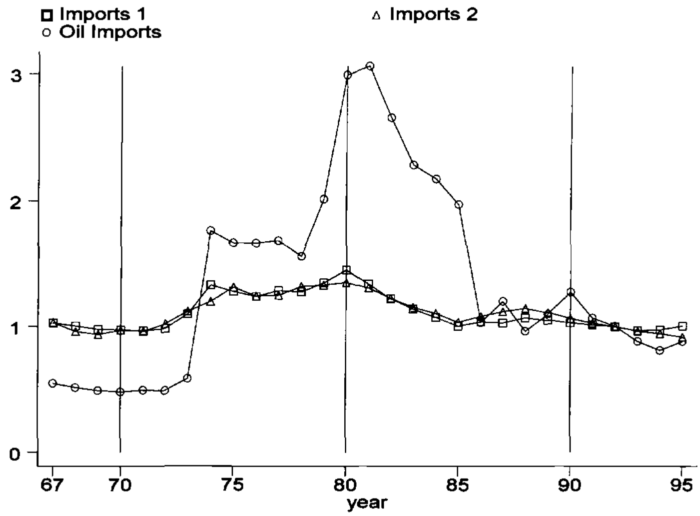

Fig. 5.5 Prices of imports relative to GDP, 1967–95, 1992 = 1

Note: Imports 1 comprises food and beverages, nonoil industrial supplies, and services; Imports 2 comprises capital goods, consumer goods, and autos.

collapse in the price of textiles and apparel during the 1970s stands out. This is the relative price that Leamer (1996) focuses on as an explanation for the rise in the skill premium during the 1980s. While small sectors may be influential, it is worth noting that even in 1970 these two sectors accounted for only 1.5 percent of GDP, a share that fell to 1 percent by 1980. Finally, note the large drops in the prices of the skilled-labor-intensive high-tech tradables, electronics and instruments, from 1970 to 1990.

Figure 5.5 plots the price of the three types of imports relative to the overall GDP deflator, with 1992 = 1. The price of imported oil has had far and away the biggest swings, while the price of nonoil imports rose slightly during the 1970s and has fallen fairly steadily since. The relative price of the two types of nonoil imports has not fluctuated much, although Imports 1 (food and beverages, nonoil industrial supplies, and services) has been flat as a share of GNP, while Imports 2 (capital goods, consumer goods, and autos) has risen steadily, as seen in figure 5.6.

5.4 Results

This section reports the results of estimating the system of equations given by (7) and (8). With two output categories and three types of imports, equation (7) amounts to five GNP-share equations, only four of which are linearly independent. The four primary factors lead to four factor-share GNP equations, three of which are linearly independent. The result is a system of seven linear equations, where each GNP share is a

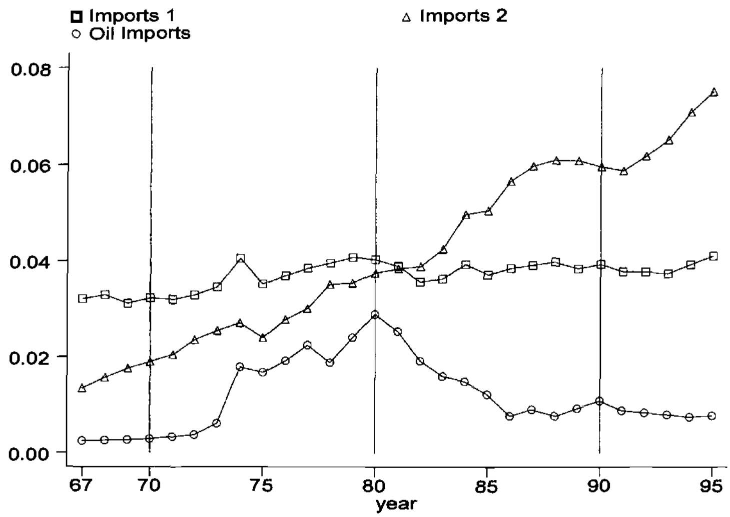

Fig. 5.6 Imports as a share of GDP, 1967–95

function of the log of two output and three import prices as well as three labor supply and one capital stock variables, a constant, and time. Theory provides homogeneity and symmetry conditions, which are implemented as within-equation and cross-equation restrictions on the system of equations. Concavity in prices and convexity in factor supplies together supply nine inequality restrictions, one for each equation, which may or may not be binding. Details on the exact form of the equations and constraints are given in appendix A.

The seven linearly independent equations are estimated jointly by generalized method of moments (GMM). Maximization of the objective function subject to the inequality constraints is a quadratic programming problem, with the constraints imposed where binding (at the optimum, six constraints bind; see appendix A for details). Misspecification tests for first-order autocorrelation fail to reject the null of no autocorrelation, and sample autocorrelation coefficients are small; details are in appendix A.

Table 5.3 reports the parameter estimates. Each column represents one of the nine equations, and the rows are the explanatory variables, all in logs except for time. Because of homogeneity, one of the first five columns is equal to the sum of the other four, and one of the last four columns is equal to the sum of the other three; the same applies to the first five and second four rows. The symmetry of cross-effects is also evident in the table—the cross-price effects on the output-import shares, the cross-quantity effects on the factor shares, and the equality of the factor quantity/output-import share and price/factor-share effects. (Standard errors are in parentheses below each slope coefficient.) Because the slopes are derivatives of shares

Table 5.3 **Regression Results**

	GDP Shares								
	Final Output		Imports			Primary Factors			
	High Skilled	Low Skilled	Imports 1	Imports 2	Oil Imports	HS Dropout	HS Graduates	College Graduates	Capital
Prices									
High skilled, final output	2.337	−2.582	−0.184	0.054	0.376	0.549	−1.114	0.282	0.282
	(0.51)	(0.69)	(0.13)	(0.17)	(0.08)	(0.14)	(0.37)	(0.20)	(0.45)
Low skilled, final output	−2.582	2.436	0.569	−0.092	−0.331	−0.761	0.926	−0.153	−0.012
	(0.69)	(1.01)	(0.20)	(0.25)	(0.11)	(0.20)	(0.53)	(0.28)	(0.65)
Imports 1	−0.184	0.569	−0.287	−0.100	0.002	0.328	−0.290	0.049	−0.087
	(0.13)	(0.20)	(0.08)	(0.08)	(0.02)	(0.06)	(0.14)	(0.10)	(0.18)
Imports 2	0.054	−0.092	−0.100	0.110	0.029	−0.100	0.471	−0.184	−0.187
	(0.17)	(0.25)	(0.08)	(0.13)	(0.03)	(0.07)	(0.19)	(0.13)	(0.24)
Oil imports	0.376	−0.331	0.002	0.029	−0.076	−0.017	0.007	0.006	0.004
	(0.08)	(0.11)	(0.02)	(0.03)	(0.02)	(0.02)	(0.06)	(0.03)	(0.08)
Factor supplies									
HS dropouts	0.549	−0.761	0.328	−0.100	−0.017	0.454	−0.667	−0.483	0.696
	(0.14)	(0.20)	(0.06)	(0.07)	(0.02)	(0.09)	(0.16)	(0.11)	(0.19)
HS graduates, some college	−1.114	0.926	−0.290	0.471	0.007	−0.667	2.276	−1.653	0.044
	(0.37)	(0.53)	(0.14)	(0.19)	(0.06)	(0.16)	(0.58)	(0.24)	(0.66)
College graduates	0.282	−0.153	0.049	−0.184	0.006	−0.483	−1.653	1.003	1.133
	(0.20)	(0.28)	(0.10)	(0.13)	(0.03)	(0.11)	(0.24)	(0.25)	(0.35)
Capital	0.282	−0.012	−0.087	−0.187	0.004	0.696	0.044	1.133	−1.874
	(0.45)	(0.65)	(0.18)	(0.24)	(0.08)	(0.19)	(0.66)	(0.35)	(0.89)
Other									
Constant	4.702	6.654	−1.665	0.211	−9.902	7.403	0.508	8.063	−15.973
	(2.28)	(3.32)	(0.87)	(1.18)	(0.40)	(0.99)	(3.23)	(1.53)	(4.25)
Time	0.063	−0.052	−0.015	0.024	−0.020	−0.030	0.012	0.011	0.007
	(0.01)	(0.02)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Notes: Dependent variables are GDP shares, listed as columns. Explanatory variables are in logs (except for time), listed as rows. Standard errors are in parentheses below the slopes, and parameters are multiplied by 10 for readability. All nine equations are estimated jointly by constrained GMM; see also appendix A for details on the instruments, cross-equation restrictions, and inequality constraints.

Table 5.4 General Equilibrium Factor Price Elasticities

	HS Dropouts	HS Graduates, Some College	College Graduates	Capital
Factor supplies				
HS dropouts	−0.425	−0.064	−0.112	0.373
	(0.10)	(0.04)	(0.05)	(0.08)
HS graduates, some college	−0.284	−0.039	−0.286	0.440
	(0.17)	(0.14)	(0.10)	(0.27)
College graduates	−0.278	−0.158	−0.337	0.687
	(0.11)	(0.06)	(0.11)	(0.14)
Capital	0.986	0.260	0.735	−1.501
	(0.20)	(0.16)	(0.15)	(0.35)
Final output prices				
High-skill-intensive goods	1.279	0.433	0.818	0.810
	(0.15)	(0.09)	(0.08)	(0.18)
Low-skill-intensive goods	−0.408	0.616	0.330	0.391
	(0.21)	(0.12)	(0.12)	(0.26)
Import prices				
Imports 1	0.312	−0.104	−0.015	−0.071
	(0.07)	(0.03)	(0.04)	(0.07)
Imports 2	−0.145	0.073	−0.117	−0.114
	(0.08)	(0.04)	(0.06)	(0.09)
Oil imports	−0.057	−0.037	−0.036	−0.037
	(0.02)	(0.02)	(0.01)	(0.03)

Notes: Each column represents a set of elasticities of a factor price with respect to exogenous changes in one of the four factor supplies and the five prices. Standard errors are in parentheses below each elasticity. These elasticities are derived from the estimated parameters reported in table 5.3, combined with GDP shares for 1982. By construction, for each factor price the factor supply elasticities sum to 0, and the price elasticities sum to 1.

with respect to log levels, the results of table 5.3 are somewhat hard to interpret, and I will focus my discussion on the elasticities reported in table 5.4.

Table 5.4 shows factor-price elasticities for 1982 that are derived from table 5.3 and the GNP shares for 1982 (1982 was chosen as a representative year in the middle of the sample). Each column is a set of elasticities of one of the four factor prices with respect to each of four factor quantities and five prices (with standard errors in parentheses below each elasticity). The factor-supply effects clearly show that the factor prices respond to factor-supply changes; except for HS graduates, the own-effects are negative and statistically significant, and there are substantial cross-effects as well. The fairly large own-elasticity for HS dropouts of −0.425 implies that the declining numbers of HS dropouts served to prop up their wages substantially. The different types of labor appear to be competitors in general equilibrium; a 10 percent increase in the supply of one type of worker reduces the wage of the other types by 1 to 3 percent.

Of particular interest is that the effect of capital accumulation is to increase the college graduate–HS graduate premium: Subtracting the capital elasticity of HS graduate wages from the capital elasticity of college graduate wages gives an elasticity of the college graduate–HS graduate premium of $0.735 - 0.260 = 0.475$, so that a 10 percent increase in the capital stock raises the college graduate–HS graduate premium by almost 5 percent. The return on capital is increased by increases in all types of labor, and the point estimate of the effect is increasing in the level of education. These results together are consistent with the view that technological progress is both skill-biased and embodied in new capital goods.

The large factor-supply effects on factor prices found here are inconsistent with the one-cone models used by most of the researchers surveyed by Slaughter (chap. 4 in this volume). Since these elasticities are calculated holding prices constant, they are not picking up the indirect effect (through induced price changes) of factor-supply changes emphasised by, for example, Krugman (1995). In short, wages appear to respond directly to factor-supply changes, and factor-price insensitivity, to use Leamer's (1995) useful phrase, does not hold empirically. There are a number of theoretical reasons for the empirical failure of factor-price insensitivity, including more factors than goods or joint production. The most economically intuitive explanation is that the factor-supply changes that have taken place have been large enough to lead to changes in the product mix. In particular, as capital and skilled labor have become more abundant, the economy may have stopped producing some low-skill-intensive goods and shifted toward a more skill- and capital-intensive product mix, in the process reducing the economywide demand for less-educated workers. This interpretation makes no reference to the skill bias of technological progress and is consistent with the pattern of elasticities seen in table 5.3.

Turning to the effect of relative price changes, the elasticities of HS-graduate and college-graduate wages with respect to the price of high-skill-intensive and low-skill-intensive goods is consistent with Stolper-Samuelson-like reasoning: By comparing the size of the elasticities, it can be seen that a 10 percent increase in the relative price of skill-intensive goods raises the college-HS premium by 2.8–3.8 percent. This result offers a partial explanation for the time path of the college premium since 1970; as shown in figure 5.4, the relative price of skill-intensive goods has had a long-term upward trend, but fell during the 1970s. The same can be said for the college-HS premium, as seen in figure 5.3. To the extent that the relative price fall was due to a decline in the relative demand for skill-intensive goods, the elasticities reported in table 5.4 show how relative wages responded. The price effects on the return to capital are similar to effects on the wage of college graduates, with no statistically significant difference in the elasticities.

Only for HS dropouts are there magnification effects, with one wage elasticity greater than 1 and one less than 0. This is surprising in light of the generality of magnification effects that was shown by Jones and Scheinkman (1977), which requires only the lack of joint production. The simplest way to rationalize the scarcity of magnification effects is to note that the empirical aggregates may be obscuring substantial heterogeneity. For example, an increase in the aggregate price index for high-skill-intensive goods might include increases in some component prices and decreases in others; the resulting aggregate effect on a particular wage would then be a weighted average of the individual price effects, and the average effect would tend to be less than 1 and greater than 0. A similar argument applies if the factor-supply aggregates encompass distinct factors whose individual elasticities with respect to a particular price change differ in sign.

The final set of elasticities show the effect of import prices on factor prices, and they are generally small. Oil import price increases have a statistically significant negative effect on all factor prices, with a doubling of the oil price reducing wages and the return to capital by 3.5 or 4 percent. An increase in the price of Imports 1 (food and beverages, industrial supplies, and services) benefits HS dropouts and hurts HS graduates, with the opposite being true for an increase in the price of Imports 2 (capital goods, consumer goods, and autos). There are no measurable nonoil import price effects on the wages of college graduates or the return to capital.

With small elasticities and small changes in relative import prices (see fig. 5.5), I conclude that import competition has had a negligible direct effect on U.S. wages in the past 3 decades. Of course, import-price changes may have contributed to the changes in the relative prices of domestic final output, which (according to table 5.4) have influenced relative wages. For example, the large drop in textile and apparel prices (see table 5.2) is surely in large part due to import competition. However, as noted previously the biggest swings in relative prices documented in table 5.2 seem to have occurred primarily in services and high-tech goods, with technological progress clearly a major force in (at least) the latter category. To my knowledge, there are no scholarly studies of relative price determination in the United States that might shed light on the causes of the changes shown in table 5.2, and until we understand the causes of these price changes we cannot rule out an important role for import competition.

It is important to keep in mind that all the results reported here are conditional on a number of bold assumptions. These assumptions come in two categories: those having to do with measurement and those having to do with theory. Among the important assumptions are that the prices of final goods and imports have been measured accurately, and that price changes do not simply reflect changes in product mix or quality. A related assumption concerns the labor aggregates, where I have not controlled for age or experience, nor have I modeled labor supply. On the theoretical front, the model here is fairly general in that imposes little beyond homogeneity and symmetry. But these assumptions are not meaningfully testable, nor is the assumption that the translog is an acceptable functional form, or that the adjustment of, for example, wages to equilibrium in response to labor-demand shocks generally takes place within 1 year.

The fundamental limitation of this exercise is that the time-series data are short, and I am asking subtle questions. I hope that the data analysis is sufficiently compelling that it will move the reader's posterior some distance from her or his prior, but I make no claim that this paper is definitive.

5.5 Conclusion

This paper has argued that understanding the causes of increased wage inequality requires an empirical general equilibrium approach. I implemented such a model for the United States using data on prices and quantities of labor, capital, final output, and imports.

The results of the model are striking. Changes in factor supplies have large effects on relative factor prices, and the pattern of effects is consistent with skill-biased technological change that is embodied in new capital goods; changes in relative final-goods prices can partially explain the time path of the college graduate–HS graduate wage differential; and nonoil import price changes appear to have had at most small direct effects on relative wages, and big oil price increases hurt all factors roughly equally. In other words, these results support the view that the causes of increased wage inequality are mainly domestic rather than foreign. An important caveat to this view is that foreign prices and quantities may have an important influence on domestic relative prices, which were shown to affect domestic relative wages, but an analysis of this possibility is beyond the scope of this paper.

Appendix A
Functional Form and Estimation

This appendix discusses the details of the functional form and estimation of the model given in section 5.2 of the paper.

Equations (7) and (8) give the shares of output, imports, and factors in national income as functions of output prices, import prices, and factor supplies. As noted in the text, there are four linearly independent output/import-share equations and three linearly independent factor-share equations, and maximum likelihood estimates are invariant to which equation is omitted. Writing these out and incorporating the symmetry of the matrices A and B give the following seven equations to be estimated:

$$\text{(A1)}\quad s_1 = a_1 + a_{11}p_1 + a_{12}p_2 + a_{13}p_{M1} + a_{14}p_{M2} + a_{15}p_{M3} + c_{11}v_1 + c_{12}v_2 + c_{13}v_3 + c_{14}v_4 + d_{11}t,$$

$$\text{(A2)}\quad s_2 = a_2 + a_{12}p_1 + a_{22}p_2 + a_{23}p_{M1} + a_{24}p_{M2} + a_{25}p_{M3} + c_{21}v_1 + c_{22}v_2 + c_{23}v_3 + c_{24}v_4 + d_{21}t,$$

$$\text{(A3)}\quad -s_{M1} = a_3 + a_{13}p_1 + a_{23}p_2 + a_{33}p_{M1} + a_{34}p_{M2} + a_{35}p_{M3} + c_{31}v_1 + c_{32}v_2 + c_{33}v_3 + c_{34}v_4 + d_{31}t,$$

$$\text{(A4)}\quad -s_{M2} = a_4 + a_{14}p_1 + a_{24}p_2 + a_{34}p_{M1} + a_{44}p_{M2} + a_{45}p_{M3} + c_{41}v_1 + c_{42}v_2 + c_{43}v_3 + c_{44}v_4 + d_{41}t,$$

$$\text{(A5)}\quad r_1 = b_1 + c_{11}p_1 + c_{21}p_2 + c_{31}p_{M1} + c_{41}p_{M2} + c_{51}p_{M3} + b_{11}v_1 + b_{12}v_2 + b_{13}v_3 + b_{14}v_4 + d_{12}t,$$

$$\text{(A6)}\quad r_2 = b_2 + c_{12}p_1 + c_{22}p_2 + c_{32}p_{M1} + c_{42}p_{M2} + c_{52}p_{M3} + b_{12}v_1 + b_{22}v_2 + b_{23}v_3 + b_{24}v_4 + d_{22}t,$$

$$\text{(A7)}\quad r_3 = b_3 + c_{13}p_1 + c_{23}p_2 + c_{33}p_{M1} + c_{43}p_{M2} + c_{53}p_{M3} + b_{13}v_1 + b_{23}v_2 + b_{33}v_3 + b_{34}v_4 + d_{32}t,$$

where p_1 and p_2 are output prices, import prices are p_{M1}, p_{M2}, and p_{M3}, and factor supplies are v_1, v_2, v_3, and v_4. National income shares are denoted s_j for output and import quantities ($j = 1, 2, M1, M2, M3$), and r_i for factors ($i = 1, 2, 3, 4$). All variables are implicitly subscripted for time, and all parameters (a, b, c, and d) are fixed, unknown constants to be estimated. Note that in equations (A3) and (A4), s_{M1} and s_{M2} are defined as positive numbers, so that $-s_{M1}$ and $-s_{M2}$ are negative numbers. The following substitutions into equations (A1)–(A7) are implied by homogeneity:

$$a_{15} = -a_{11} - a_{12} - a_{13} - a_{14} \qquad c_{14} = -c_{11} - c_{12} - c_{13}$$

$$a_{25} = -a_{12} - a_{22} - a_{23} - a_{24} \qquad c_{24} = -c_{21} - c_{22} - c_{23}$$

$$a_{35} = -a_{13} - a_{23} - a_{33} - a_{34} \qquad c_{34} = -c_{31} - c_{32} - c_{33}$$

$$a_{45} = -a_{14} - a_{24} - a_{34} - a_{44} \qquad c_{44} = -c_{41} - c_{42} - c_{43}$$

$$b_{14} = -b_{11} - b_{12} - b_{13} \qquad c_{51} = -c_{11} - c_{21} - c_{31} - c_{41}$$

$$b_{24} = -b_{12} - b_{22} - b_{23} \qquad c_{52} = -c_{12} - c_{22} - c_{32} - c_{42}$$

$$b_{34} = -b_{13} - b_{23} - b_{33} \qquad c_{53} = -c_{13} - c_{23} - c_{33} - c_{43}.$$

Elasticities are time-varying functions of the parameters of the translog and the national income shares. Using the notation that $\varepsilon(x,y)$ is the elasticity of x with respect to y, some of the elasticities of the endogenous variables are as follows:

Output quantities

(A8) $$\varepsilon(y_j,p_j) = a_{jj}/s_j + s_j - 1 \geq 0$$

(A9) $$\varepsilon(y_j,p_k) = a_{jk}/s_j + s_k, \quad j \neq k$$

Imports quantities

(A10) $$\varepsilon(m_j,p_{Mj}) = -a_{jj}/s_j - s_j - 1 \leq 0$$

(A11) $$\varepsilon(m_j,p_{Mk}) = -a_{jk}/s_j - s_k, \quad j \neq k$$

Factor prices

(A12) $$\varepsilon(w_i,v_i) = b_{ii}/r_i + r_i - 1 \leq 0$$

(A13) $$\varepsilon(w_i,v_k) = b_{ik}/r_i + r_k, \quad i \neq k$$

(A14) $$\varepsilon(w_i,p_j) = c_{ji}/r_i + s_j, \quad j = 1,2,M1,M2,M3$$

The inequality restrictions on these elasticities come from the requirement that $r(\mathbf{p}, \mathbf{p}_M, \mathbf{y}, t)$ is convex in $\mathbf{p}$ and concave in $\mathbf{p}_M$ and in $\mathbf{v}$. With five prices and four factor supplies, there are a total of nine inequality restrictions. They can be rewritten in terms of the shares in the data as

(A15) $$a_{11} \geq (1 - s_1) \cdot s_1,$$

(A16) $$a_{22} \geq (1 - s_2) \cdot s_2,$$

(A17) $$a_{33} \geq -s_3 \cdot (1 + s_3),$$

(A18) $$a_{44} \geq -s_4 \cdot (1 + s_4),$$

(A19) $$-(a_{11} + a_{22} + a_{33} + a_{44} + 2a_{12} + 2a_{13} + 2a_{14} + 2a_{23} + 2a_{24} + 2a_{34}) \geq s_5 \cdot (1 + s_5),$$

(A20) $$b_{11} \leq (1 - r_1) \cdot r_1,$$

(A21) $$b_{22} \leq (1 - r_2) \cdot r_2,$$

(A22) $$b_{33} \leq (1 - r_3) \cdot r_3,$$

(A23) $$(-b_{11} - b_{22} - b_{33} - 2b_{12} - 2b_{13} - 2b_{23}) \leq (1 - r_4) \cdot r_4.$$

Table 5A.1 Inequality Constraints

Constraint	Lagrange Multiplier
(A15) Convex in skilled output price	50.1
(A15) Convex in unskilled output price	22.3
(A16) Concave in Imports 1 price	0.0
(A17) Concave in Imports 2 price	0.0
(A19) Concave in Imports 3 price	35.2
(A20) Concave in HS dropouts quantity	33.6
(A21) Concave in HS graduates quantity	42.0
(A22) Concave in college graduates quantity	0.0
(A23) Concave in capital stock	53.0

To implement these inequalities, I substitute the maximum sample values of the expressions on the right-hand side for the greater-than inequalities, and I substitute the minimum sample values for the less-than inequalities. This ensures that the inequalities hold for all observations.

Estimation of the system of equations (A1)–(A7) is by inequality-constrained GMM, which in this linear model with Gaussian errors is equivalent to constrained three-stage least squares (3SLS). The estimator minimizes the objective function subject to the nine inequality constraints (A15)–(A23), using a sequential quadratic programming algorithm implemented in the software package Gaussx. When the constraints are binding, the Lagrange multiplier on the constraint is positive, and the value of the Lagrange multipliers are reported in table 5A.1. The size of the Lagrange multipliers is related to how binding the constraints are, but tractable test statistics based on the Lagrange multipliers are not available even asymptotically (see Wolak 1989).

The errors appended to equations (A1)–(A7) are assumed to be serially uncorrelated. This assumption is tested against the alternative of AR1 errors using a Lagrange multiplier test as follows (see, for example, Davidson and MacKinnon 1993, sec. 10.10):

1. Estimate the model and collect the residuals from each estimated equation.
2. For each equation, regress the residuals on their lag as well as all the exogenous and predetermined variables in the model, including instruments.
3. The t-statistic on the lagged residual is a valid test statistic for the null of no-first-order autocorrelation.

When this procedure is carried out for each equation separately, the t-values obtained range 0.046 ($p = 0.96$) to 1.75 ($p = 0.11$). As pointed out by Berndt and Savin (1975), in a singular equation system such as the ones estimated in this paper, the autoregressive parameter must be the same in each equation. This suggests estimating all seven residual regressions together by SURE and imposing the restriction that the autoregressive parameter is the same in each equation. The result of this procedure is a t-statistic of -1.25 ($p = 0.223$) on the lagged residual. To summarize, both the single equation and pooled tests fail to reject the null of no autocorrelation. This is no doubt because the time trends in equations (A1)–(A7) soak up any potential persistence in the errors.

The estimated covariance matrix of the parameters is the usual GMM/3SLS estimate, and the standard errors reported in table 5.3 come from this estimate. With binding inequality constraints, however, the confidence intervals around the estimated parameters are not symmetric, so t-statistics should be interpreted carefully. Since the estimated elasticities in table 5.4 are linear functions of the data and the estimated parameters from table 5.3 (see equations [A8]–[A14]), the standard errors on the elasticities are simply equal to the relevant parameter standard error divided by the relevant factor share. For example, the elasticity of factor price i with respect to goods price j is given by equation (A14), and the standard error on this elasticity is the standard error of c_{ji} divided by r_i.

Appendix B

Construction of Labor Data

Data on wages were gathered from the March Annual Demographic file of the Current Population Survey (CPS), 1964–96. The CPS provides, among other variables, information on labor force participation, age, education, industry of employment, and both total income and income components. The data on income and employment refer to the preceding year; hence the series include the years 1963–95.

The sample includes the weekly wage and salary earnings of all non-self-employed workers who were between the ages of 16 and 65 and worked at least 1 hour for pay in the previous year. I omitted self-employed workers because they tend to misrepresent their true income and may also have negative earnings. Wage and salary data were chosen because they contain a good measure of earned income by industry and education. Ideally, an hourly measure would be the best measure of relative labor supply or total effort for each educational group. However, neither hourly wages nor number of hours worked is asked consistently in this data set and an imputed hourly wage would not be reliable.[7]

7. The survey asks how many hours were worked last week, which can be very different from the average number of hours worked per week in the previous year. The latter is more important since we must match it with the previous year's income data.

I use weekly wages as opposed to annual wages because the relative number of total workers by group (picked up by annual numbers) can vary from the relative number of total weeks worked (picked up by weekly numbers). The method used for computing weekly wages is described here.

For 1964–75, actual number of weeks worked is not recorded. However, a categorical variable is provided that indicates whether the earner worked 0, 1–13, 14–26, 27–39, 40–47, 48–49, or 50–52 weeks in the previous year. Actual weeks worked for the years 1976–88,[8] were used to fit values for the missing data by regressing each categorical variable for weeks on 755 cells that controlled for race, sex, education (as defined later), census region, and experience.[9]

Each coefficient from these equations was then regressed on a weighted time trend, where the weight was equal to the number of observations, to see if weeks worked by cell could be predicted based upon a linear trend. For those that were significant at the 10 percent level, a number-of-weeks-worked value was fit. For those that were not significant, a weighted average was used to estimate the number of weeks worked with a given weeks category. Here, each cell mean was weighted by the number of observations for a given cell in year *t* divided by the total number of observations for a given cell over the entire time period 1976–88.[10]

Next, a weekly wage was computed by dividing the annual wage and salary income by the number of weeks worked for each observation. Finally, a mean wage for each educational group (as defined later) was computed as a weighted average of each cell within that educational group. More explicitly, the mean wage[11] of each cell in the HS-dropout group, for example, was weighted by the number of weeks that cell worked in a given year *t* relative to the total number of weeks worked by all HS dropouts in year *t*. It is this weighted mean that is used in the analysis.

Before proceeding, it should be noted that the CPS top codes annual wage and salary incomes above a certain level. Prior to computing the average weekly wage, we corrected for this censoring by adopting the method employed by Katz and Murphy (1992). That is, we multiplied each top-coded value by 1.45.

We divided workers into three educational groups: did not complete high school (0–11 years of education), completed high school and some college (12–15 years of education); and college graduates (16+ years of education).[12] Individuals were assigned to a grade based on their comple-

8. The data from 1964–88 are contained in a uniform data file. The years 1989–92 were not used for this fitting procedure to omit any changes in survey method or data adjustment that might have occurred in these later survey years.

9. The procedure used to compute experience is described in Murphy and Welch (1992).

10. A more detailed description of this imputation process is available from the author.

11. It should be noted that there are many observations within each cell. The mean wage of the cell is weighted by the March supplemental weight.

12. This is the same breakdown used by Baldwin and Cain (1997).

tion of that grade, with one exception. Those individuals who did not complete the 13th grade were grouped with the 13th grade instead of the 12th because, based on Park (1996), it is better to treat these individuals as having some college education rather than associating them with those who only have a high school diploma.

Total wage and salary employment was obtained from the Bureau of Labor Statistics, from which the share of total employment for each skill was computed.

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Comment Jonathan Eaton

Jim Harrigan provides us with a very elegant and general framework with which to address the question at hand: Were changes in U.S. import prices responsible for growing U.S. trade inequality? While the approach is rooted in factor-endowments theory, it casts off many of the special and unrealistic assumptions that bound much previous empirical work. Here, factor endowments can affect factor prices; technologies can shift, quite generally, over time; and no cross-country similarities are invoked.

The framework delivers a set of equations relating sector shares, import shares, and factor shares to domestic goods prices, import prices, factor endowments, and, to capture the effect of technical progress, time. Harrigan estimates this set of equations, imposing the various restrictions implied by theory, on annual U.S. data for 29 years.

Harrigan finds that changes in factor supplies and in domestic prices, but not in import prices, are the culprits behind growing U.S. wage inequality. Because he has taken a more rigorous and general approach than has come before, any subsequent work on U.S. wage inequality is going to have to take Harrigan's findings seriously. But more work must be done before these results displace others at center stage. For one thing, some of the steps used to get to them are on a somewhat precarious footing. For another, the results themselves raise as many questions as they answer.

Where would one like some reassurance about the estimates themselves? Harrigan acknowledges that 29 observations provide a rather meager source of data for identifying the many parameters of the model. Still, anyone looking at figures 5.3 and 5.4 can see the comovement between the returns to skill, on one hand, and the price of skill-intensive goods, on the other. But what about the effect of factor endowments on factor rewards? The three series on factor endowments, depicted in table 5.2, appear to the naked eye pretty much as trend lines with small wobbles around them. Since the econometric specification attributes trends to technical progress, any inference about how factor endowments affect factor rewards must come from the wobbles. Given that one of the two key findings is the inverse relationship between factor endowments and factor rewards, it would be good to know more about what in the data drives the result. Some analysis of subperiods would be useful here.

What about the second key finding on the effect of domestic prices on factor rewards? Harrigan provides striking evidence of comovement between the relative wages of skilled workers and the relative price of skill-intensive goods. But it is not clear what we should make of this comove-

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ment. By entering domestic final-goods prices separately from import prices, he has dispensed with the trade economist's standard small-open-economy excuse for ignoring demand. But instead of modeling demand, Harrigan uses a set of kitchen-sink instruments to deal with the potential for simultaneity bias. We do not see the first-stage regressions, nor do we know what happens without instrumenting. A concern is that, with 29 annual observations, 10 (by my count) instruments are likely to fit the price series so well that instrumenting has little effect. Procedures exist to avoid first-stage overfitting, and this situation seems an appropriate place to use them.

These estimation issues aside, what are we to make of the results themselves? They present us with at least two major puzzles.

First, why did final-goods prices move? Supply-side explanations (such as technological progress) must be ruled out, since production is already modeled. So the answer has to be on the demand side. But how big a shift in demand is needed (1) under plausible assumptions about the elasticity of substitution in demand between high- and low-skill-intensive goods and (2) given the elasticity of transformation in their supply implied by the model? I would expect both elasticities to be fairly high. Yet figure 5.4 indicates swings in relative prices during the period of 25–30 percent, suggesting pretty big demand shifts.

Second, how do the results here jive with what happened to factor use within industries? Central to earlier discussion were findings, by Lawrence and Slaughter (1991) and by Berman, Bound, and Griliches (1994), for example, that the ratio of skilled to unskilled workers had risen during the period of rising wage inequality within industries. This evidence has been widely seen as bad news for trade-based explanations for growing wage inequality. But it is bad news for any demand-based explanation. Whether the demand for low-skilled workers fell because of imports from low-wage countries or because of a shift in tastes toward skill-intensive goods, within industries firms should have responded to the lower wages of unskilled workers by hiring more of them, contrary to what apparently happened. It would be useful, and should be straightforward, to extend Harrigan's framework to incorporate within-industry factor demands to see how the model goes about reconciling their evolution over this period with its explanation of what happened to output, import, and factor shares.

Harrigan suggests that within-industry heterogeneity may explain some of the paradoxes in what he finds, and such heterogeneity might help reconcile Harrigan's findings with evidence on intraindustry factor demands. But one would then like a theoretical framework that introduced intraindustry heterogeneity explicitly.

To summarize, Harrigan has not only made a very nice analytic contribution to the trade-and-wages literature, he has provided intriguing new evidence on the relationship between goods prices and factor rewards. But his explanation for it is at odds with other information we have. The next step is to put all this evidence together to see where we stand.

References

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