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Did International Trade Lower Less-Skilled Wages During the 1980s? Standard Trade Theory and Evidence

John Schmitt
and
Lawrence Mishel

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I. Introduction

Rising wage inequality and a declining standard of living for most U.S. workers have been central economic and, increasingly, political facts of the last two decades. Economists have generally attributed these developments to some combination of changes in technology, labor market institutions, and foreign trade, usually in that order of importance. The broader political debate on inequality-from Congressional and labor opposition to NAFTA to Pat Buchanan's 1996 Republican primary campaign-has fixed much greater responsibility on foreign trade.

Popular concern with trade's effect on living standards is understandable. Inequality has risen, and living standards for the broad middle class have fallen, just as the United States has become more open to foreign trade. Wage inequality (see **Table 1**), measured by the gap in hourly earnings between college and high-school educated workers, increased by about 11 percentage points between 1979 and 1989, reversing a trend toward greater equality over the period 1969-79.' Meanwhile, between 1979 and 1989, imports (see **Table 2)** increased by 2.5 percentage points of GDP (compared to a 1.1 percentage point increase during 1969-79). Imported manufacturing goods, particularly from low-wage, less-developed countries accounted for most of the increase in imports.[2]

Economists' reactions to these basic facts have varied greatly. Some, like Wood (1994, 1995) and Learner (1993, 1994, 1995), view trade as the preeminent determinant of income distribution. Others, such as Bhagwati (1991) and Lawrence and Slaughter (1993) see no role for trade in explaining the recent rise in wage inequality. Most economists, however, have found a moderate role for trade (see, for example, Borjas, Freeman, and Katz 1992, 1996;

Sachs and Shatz 1994, 1995; and Krugman 1995a).

Within the economics profession, a separate debate has also emerged over how best to measure the impact of trade. Oversimplifying somewhat, labor economists have favored "factor content" approaches, where imports and exports are viewed as embodying labor supply or demand (see, for example, Murphy and Welch 1991; and Borjas, Freeman, and Katz 1992, 1996).[3] In this view, imports represent increases in labor supply (or reductions in demand for domestic labor) and, therefore, reduce wages and job opportunities for domestic workers. Trade economists, however, have generally appealed to standard trade theory embodied in the Heckscher-Ohlin (HO) framework and argued that the quantities of imports and exports tell us little or nothing about the impact of trade on income distribution (see, for example, Bhagwati 1991; Lawrence and Slaughter 1993; Learner 1993, 1995). They contend that it is, instead, the *prices* of traded goods that matter.[4]

Several studies have attempted to estimate the effects of trade on income distribution using price-based methodologies inspired by the HO framework (see Lawrence and Slaughter 1993; Learner 1993, 1995; Krugman and Lawrence 1994; Sachs and Shatz 1994, 1995; and Krueger 1995). This paper takes a similar approach, but extends the earlier work in several dimensions. First, while prior studies have classified workers as skilled or less-skilled using a nonproduction-production worker distinction (Krueger is an exception), our data allow skill categories based on educational attainment and an alternative, wage-based skill measure. Second, while most of these studies have concentrated on the decade of the 1980s (Sachs and Shatz examine some data for earlier periods; Krueger looks only at the period 1989-94), we are also able to study the 1960s and 1970s, when trade effects are generally presumed to have been smaller.

The paper proceeds as follows. Section two develops the principal results on the role of trade in the domestic income distribution from the HO model and the complementary Stolper-Samuelson theorem. Section three describes the data and then presents our basic empirical results. Section four extends the empirical analysis by attempting to quantify the impact of trade on key measures of wage inequality in the 1980s. Section five summarizes and comments on the principal results.

II. Standard Trade Theory

In the context of the standard Heckscher-Ohlin (HO) general equilibrium trade theory, the Stolper-Samuelson theorem makes several predictions about the effects of international trade on national income distribution and the pattern of national production. In this section, we develop the principal predictions of the HO model relevant to the discussion of income distribution.[5]

In its simplest form, the HO model assumes that two countries produce two goods using two factors, all under perfectly-competitive conditions. For the discussion that follows, it will be most convenient to think of the two factors as skilled (N_s) and less-skilled labor (N_u), both of which are used in the production of both goods. The skilled factor is used intensively in the production of a "skilled good" (S) and the less-skilled factor is used intensively in the production of a "less-skilled good" (U). One of the countries (the United States, say) is assumed to have an abundance of skilled workers ($N_{1s}/N_{1u}>N_{2s}/N_{2u}$, where the numerical subscripts refer to the first country) and the other (the Rest of the World) is assumed to have an abundance of less-skilled workers. In this context, the returns to the two factors (w_s and w_u) depend entirely on the prices of the two goods in world markets (P, and P_u) and the technology used to produce the two goods, which is here assumed to be fixed.

The Stolper-Samuelson theorem spells out the exact nature of the relationship between product prices and factor returns under international trade. The starting point of the Stolper-Samuelson analysis is the following set of zero-profit conditions, which under perfect competition in the goods and factors markets hold for both industries in both countries[6]:

$$w_s N_{ss} + w_u N_{us} = P_s S \qquad \text{(la)}$$
$$w_s N_{su} + w_u N_{uu} = P_u U \qquad \text{(1b)}$$

where N_{ss} refers to skilled workers in the skilled-good industry, N_{su} refers to skilled workers in the less-skilled-good industry, and so on. Dividing both sides of (la) by the total skilled-good output (S) and (lb) by the total less-skilled-good output (U), we can rewrite (1), in matrix form, using fixed-technology coefficients:

$$\begin{bmatrix} A_{ss} & A_{us} \\ A_{su} & A_{uu} \end{bmatrix} \begin{bmatrix} w_s \\ w_u \end{bmatrix} = \begin{bmatrix} P_s \\ P_u \end{bmatrix} \qquad (2)$$

where A,, is the proportion of skilled workers used to produce a unit of the skilled good, A,, is the proportion of skilled workers used to produce a unit of the less-skilled good, and so on. Equation (2) can be solved for $[w_s\ w_u]'$ by inverting the technology matrix:

$$\begin{bmatrix} w_s \\ w_u \end{bmatrix} = \begin{bmatrix} A_{ss} & A_{us} \\ A_{su} & A_{uu} \end{bmatrix}^{-1} \begin{bmatrix} P_s \\ P_u \end{bmatrix} \qquad (3)$$

which clearly indicates that, given technology, the returns to the factors depend solely on the price of the goods.[7]

Figure 1 presents a graphical solution to the system in (3). Wages for the two types of workers are set at the point of intersection of the two isocost lines. At the initial intersection, at point 1, the wages are w_s^1 and w_u^1. The figure illustrates the first key comparative-statics result of the Stolper-Samuelson theorem. *A decline in the price of the less-skilled good will reduce the relative wage of less-skilled workers.* When the price of the less-skilled good falls from P_u^1 to P_u^2, the intersection of the isocost lines moves from point 1 to point 2, where the less-skilled wage is lower (w_u^2) and the skilled wage (w_s^2) is higher. In the empirical analysis that follows, where we will be assuming that the HO model accurately describes the world, we will reinterpret this prediction: holding technology constant, only a fall in the relative price of the less-skilled good can reduce the relative wage of less-skilled workers.

We can continue the comparative-statics exercise and ask what impact a decline in the price of the less-skilled good will have on the use of less-skilled workers in production. **Figure 2** illustrates the second key prediction of the Stolper-Samuelson theorem: *A decline in the price of the less-skilled good will increase the employment share of less-skilled workers in both industries.* Figure 2, which demonstrates the general comparative statics in the skilled industry,* indicates that the industry will minimize costs by choosing to hire skilled and less-skilled workers at the point where the isoquant (Q,) is tangent to the isocost line, which has a slope equal to the negative of the relative wage rate (w_u^1/w_s^1). Initially, then, the industry will choose the input combination (N_s^1,N_u^1) at point 1. As noted above in the discussion of Figure 1, the decline in the price of the less-skilled good will reduce the relative wage for less-skilled workers to (w_u^2/w_s^2). The wage change appears in the figure as a flattening of the isocost line. The new tangency between the industry isoquant and isocost line occurs at point 2, where the employment of less-skilled labor (N_u^2) is higher and the new employment of skilled labor (N_s^2) is lower than before the goods-price change. The decline in the relative wage of less-skilled workers (induced by the fall in the relative price of the less-skilled good) makes less-skilled workers relatively cheaper to use, leading the industry to hire more less-skilled workers. Similar reasoning induces the less-skilled industry also to increase its share of less-skilled workers.

But how can both industries in an economy with fixed, fully-employed resources both increase their share of less-skilled workers? The less-skilled industry responds to the price decline by reducing its output. The decline in total output in the less-skilled industry disproportionately "releases" less-skilled workers, who are then available to increase the share of less-skilled workers in both industries. Meanwhile, the output of the skilled industry expands, absorbing the skilled workers displaced by the move in both industries toward less-skilled workers. This shift in industry output constitutes the third key prediction of the Stolper-Samuelson theorem: *A decline in the price of the less-skilled good will reduce the share of national output produced by the less-skilled-good industry.*

III. Data and Analysis

The decline in the relative wages of less-skilled workers in the 1980s and 1990s is one of the best-documented developments in empirical labor economics. If trade were responsible for the decline in relative (and absolute earnings) of less-skilled workers, then the preceding discussion of the Heckscher-Ohlin framework and the Stolper-Samuelson theorem suggest that we would also expect to find that: (1) the price of less-skilled goods fell relative to that of skilled goods; (2) the share of skilled workers fell across all industries; and (3) the share of total output in skilled-good industries increased relative to less-skilled-good industries. In this section, we examine industry-level data compiled from a variety of sources to determine whether these three predictions hold. As noted earlier, our methodology differs from the conventional approach taken in empirical economics, where investigators typically test whether a theory adequately explains the real world. Here, we assume that the HO framework and the Stolper-Samuelson theorem accurately describe the real world and ask whether the data are consistent with the possibility that trade, as understood in the HO model, affected the distribution of income in the United States during the 1980s. We begin with a description of our data set and then proceed to analyze the evidence on each of the three Stolper-Samuelson predictions in turn.

A. The Data

The industry-level data for 1959, 1969, 1979, and 1989 used here is compiled from two principal sources. The National Bureau of Economic Research's (NBER) Productivity Data Set provides information on the prices and quantities of industry inputs and outputs, as well as information on the share and annual earnings of nonproduction and production workers. The Public Use Microdata Sample (PUMS) of the decennial census supplies the data on the share and hourly earnings of workers by education and fixed-wage-level groups.

The original NBER data covers more than 400 four-digit SIC manufacturing industries on a consistent basis from 1958 to 1992, obtained primarily from the Annual Survey of Manufacturing (ASM). The decennial census organizes workers into fewer industry categories, which change over the four censuses analyzed here. We have aggregated and matched the NBER and Census data into 56 manufacturing industry categories that are consistent over the full period.

Measuring Skill. Our data allow us to define industry skill levels in three ways. The first skill measure is occupation-based. For each industry we calculate the share of nonproduction workers in the total industry labor force. Since workers are either nonproduction ("skilled") or production ("less-skilled") workers, the share of nonproduction workers is a convenient, though problematic measure of industry skill level. The most significant drawback with the nonproduction-production worker distinction is its potentially poor correlation with the true industry skill level. Nonproduction workers, for example, may include cafeteria workers, office cleaners and other workers generally not considered "skilled." Production workers probably also represent a fairly heterogeneous group, both within and between industries. Many production workers (electricians, plumbers, and industrial maintenance, for example) may have specialized skills generally not associated with less-skilled workers in their own industries. The skill levels of production workers also probably vary significantly across industries (steel versus food preparation, for example).

The second skill measure is education-based. For each industry, we determine the share of workers with four years of college education ("skilled") and with less than four years of college ("less-skilled"). The education measure is probably closer to a pure skills measure, though even here, substantial heterogeneity probably exists within the "noncollege" group.

The final skill measure, based on the industry's share of workers in fixed-real-wage ranges, departs conceptually from the previous two measures. The fixed-real-wage ranges are set by the 75th percentile of the overall wage distribution in 1979. The assumption is that workers in the 75th percentile and above of the wage distribution are "skilled" and that those below this are "less-skilled."[9] In each year, we calculate the share of workers in each industry that earn more than the real wage for the 75th percentile of the 1979 wage distribution.

Table 3 shows the correlation over time between the three skill measures. Two features of the table are striking. The first is the high and growing correlation between the occupation and education skill measures. The second is the lower, less stable correlation between the occupation and education measures, on the one hand, and the fixed-real-wage measure, on the other.

Measuring Price. We measure industry prices using the domestic producer price index. At face value, we would prefer to use industry import prices (see, for example, Lawrence and Slaughter 1993). Nevertheless, we have not been able to identify reliable import price data for the industries and time periods under study." We, therefore, adopt the approach taken by Sachs and Shatz (1994) and Krueger (1995) and use the producer price index for domestic output. Since the Heckscher-Ohlin model assumes that "the law of one price" holds, the choice of a domestic deflator is not a radical departure from the framework. Furthermore, since we are only interested in price changes over time, the law of one price need not hold, so long as domestic and import price changes move together.

B. Analysis

Prediction 1: Decline in the relative price of less-skilled goods.

If trade contributed to widening wage inequality during the 1980s, then, by the

Stolper-Samuelson theorem, we should observe a relative decline in the price of less-skilled goods over the same period. An empirical test of this Stolper-Samuelson prediction requires the careful definition of several terms. In the preceding section on data, we discussed the three skill definitions that we will use here. A separate set of questions concern the appropriate price measure. In most of the analysis that follows, we will use four different industry-price measures. The first is a straightforward measure of the industry's output price (the producer price index for the industry group). The second is the output price adjusted for changes in total factor productivity in the industry. Sachs and Shatz (1995) have argued that this is a more appropriate price measure. Their position is based on the simple observation that, if a technological innovation in an industry allows that industry to lower its price by 10%, this reduction in price does not affect returns to the factors. To calculate the "effective output price," we add total factor productivity growth to the output price growth over a given period." The third price measure is the "value-added price." Both the output and effective output prices reflect changes in factor prices (for oil, for example) that have no direct effect on the returns to other factors. The value-added prices used here subtract the cost of energy and other materials from output price. In principle, the remaining price changes reflect returns to the remaining factors. The final price measure is the "effective value-added price," which is analogous to the effective-output price, but controls for changes in energy and other material inputs. Conceptually, the effective value-added price is undoubtedly the best measure. Nevertheless, the estimation of both total factor productivity growth and value-added prices are plagued with practical problems. We therefore conduct tests of price changes using all four price measures.

One important price issue remains. The computer industry experienced very steep price declines during the 1980s, relative both to other industries in the 1980s and to the industry's own experience in the 1960s and 1970s. The principal, reason for the sharp price fall was the application in the 1980s of quality adjustments to the measurement of the industry's prices. These adjustments, which reflect legitimate concerns about the inability of standard price indexing techniques to cope with technological innovation in the industry, however, should not be allowed to "overwhelm the message in the rest of the data" (Sachs and Shatz 1994, p. 37). We, therefore, follow the procedure adopted by Sachs and Shatz (1994) and Krueger (1995) and use controls for the computer industry in most of the analysis that follows."

Table 4 summarizes the empirical evidence on the relationship between the decadal change in an industry's price and its skill level at the beginning of decade. The table presents results from ordinary least-squares regressions of the proportional change in the four price measures against the level of the three skill measures for each of the three time periods. **Table 4A** displays the results for the first skill measure, the ratio of nonproduction-to-production workers. Panel (a) examines the experience of the 1980s. In the simplest test, output prices have a small, statistically insignificant positive correlation (0.057; standard error, 0.246) with the nonproduction-to-production skill ratio.[13] After controlling for the computer industry, however, the relationship is positive, large, and statistically significant at the 1% level (0.285; standard error, 0.106).[14] The price effect is about half as large with the effective output price (0.175; standard error, 0.071), but still statistically significant, now at the 5% level. With the value-added price, the price-skill relationship is again large, and statistically significant at the 5% level. Using effective value-added prices cuts the relationship by more than half and leaves it statistically insignificant.

These results, which are positive and generally large and statistically significant, are consistent with trade lowering the relative wages of less-skilled workers during the 1980s. We can use the experience of the 1960s and 1970s, when trade flows-particularly from low-wage developing countries-were much smaller, as a benchmark for judging the significance of these price effects in the 1980s. In the 1970s (see panel (b)), relative price changes associated with skill were small and statistically insignificant. In the 1960s (see panel (c)), relative prices appear to have been entirely unaffected by industry skill mixes; the coefficient estimates on the nonproduction-to-production ratio are generally close to zero and statistically insignificant in all cases. The data for the 1960s and 1970s, then, suggest that the price-skill relationship observed in the 1980s did not hold in earlier periods when trade was less important.

Table 4B presents the results of an identical analysis for the second skill measure, the ratio of college-to-noncollege educated workers in each industry. The pattern for the 1980s (see panel (a)) is broadly similar to the nonproduction-production data. The output and effective-output prices are positively and significantly associated with the college-to-noncollege ratio.[15] Value-added and effective value-added prices are also positively related to the skill ratio, but the relationship is not statistically significant. The data for the 1970s (see panel (b)) show a positive skill-price relationship, but as with the nonproduction-production data for the same period, this relationship is not statistically significant. The college-noncollege data for the 1960s display a pattern that differs substantially from the corresponding nonproduction-production data. Output prices (with and without computer controls) and value-added prices demonstrate a strong, statistically significant *negative* association with the industry college-to-noncollege ratio. The relationship is small, positive, and statistically insignificant, however, with the price measures that take total factor productivity growth into account. On the whole, the college-noncollege evidence is broadly consistent with that of nonproduction-production workers. Relative industry price is positively related to industry skill levels in the 1980s, when trade with developing countries grew fastest. The relationship was insignificant (1970s) or negative (1960s) in earlier periods, when trade with low-wage countries was smaller.

Table 4C examines the relationship between industry price and the third skill measure, based on shares of workers in fixed-real-wage-level groups. These data generally show a small, statistically insignificant connection between the four price measures and skill in all three time periods.

Taken together, the results here suggest a positive relationship between industry price and industry skill level during the 1980s. This is consistent with the findings of Sachs and Shatz (1994) for the 1980s and Krueger (1995) for the period 1989-94. These results, however, differ from those of Lawrence and Slaughter, who find a negative price-skill relationship for the 1980s. Several factors probably account for these differences. First, as Sachs and Shatz (1994) have noted, Lawrence and Slaughter's data do not provide complete manufacturing sector coverage for the full decade of the 1980s. Lawrence and Slaughter have data on only 50 of 130 three-digit manufacturing industries; data for 20 of these 50 begins between 1981 and 1986. Second, Lawrence and Slaughter do not control for the computer industry in their regressions. When Sachs and Shatz use the 30 industries for which Lawrence and Slaughter have complete data for the full period of the 1980s and control for the computer industry, the Lawrence and Slaughter data show a small, positive price-skill relationship in the 1980s.[16]

Prediction 2: Fall in the share of skilled workers.

If trade contributed to widening wage inequality during the 1980s, then, according to the second Stolper-Samuelson prediction and assuming that technology is constant, we should observe a decline in the share of skilled workers employed in all industries. The data in **Table 5,** however, offer no sign of a decline in the share of skilled workers. Among manufacturing industries (see panel (b) of Table 5), for example, the share of nonproduction workers and college-educated-worker hours increased in the 1980s.

At first glance, the data appear to reject the possibility that Stolper-Samuelson effects were responsible for the decline in less-skilled wages during the 1980s. At least four factors, however, caution against such a conclusion. First, the behavior of industry skill shares is very sensitive to endpoints. Second, the Stolper-Samuelson theorem, at least in the simple form that we have presented here, assumes that technology is fixed. Third, assuming, as the HO framework does, that returns to factors are identical across all industries, any analysis of the skill share arguably should not be limited to the manufacturing sector. Finally, the rise during the 1980s in the use of temporary blue-collar workers (who work in production jobs in manufacturing, but who are designated as service sector workers) may significantly bias upwards estimates of the nonproduction worker share in manufacturing by the end of the 1980s. We will deal with each of these concerns in turn.

Sensitivity to End Points. The conclusion that the share of nonproduction workers (the most common measure of the skilled worker share-see, for example, Berman, Bound, and Griliches 1993) increased during the 1980s depends entirely on the choice of endpoints. According to BLS (1996) data for all manufacturing industries, the share of nonproduction workers in 1979 was 28.4%. The nonproduction share grew rapidly to 32.2% by 1982 and then remained virtually constant through the end of the decade, actually falling to 3 1.8% by 1989. (The nonproduction share continued to fall through 1995, when it reached 30.8%.) All of the increase in the nonproduction share, then, occurred in the three years between 1979 and *1982.”* After 1982, the nonproduction share remained flat or fell slightly. This suggests that a one-time shock in the late 1970s and early 1980s produced a discreet jump in the nonproduction share, an increase that reversed slightly over the rest of the decade and even more noticeably in the first five years of the 1990s. At face value, this pattern appears inconsistent with the widespread belief that computers have played an important role in rising demand for skilled workers in the 1980s and 1990s. The personal computer reached the retail market only in 1981 and was not widely diffused until much later. Even Berman, Bound, and Griliches’s (1993) broader computer measure shows only a 1.13 percentage-point increase in the share of computers in total investment between 1977 and 1982 (from 2.79% in 1977 to 3.92% in 1982), followed by a 3.57 percentage-point increase between 1982 and 1987 (to 7.49%).

The flattening out, and subsequent decline after 1982, of the nonproduction share reflects a long-term deceleration. According to the same BLS data., the share of nonproduction workers grew by 6.6 percentage points in 1950-59; 1.7 percentage points in 1960-69; and 0.6

percentage points in 1970-78; 3.8 percentage points in 1979-82; and then fell by 1.4 percentage-points between 1982 and 1995. (See Appendix Figure 1 for a graph of BLS data on the share of nonproduction workers in manufacturing employment for the period 1947-95.)

Trend Growth in Technology. As mentioned earlier, the simple version of the Heckscher-Ohlin model that we use here (and that has been used in similar analyses by Lawrence and Slaughter (1993) and Sachs and Shatz (1994)) does not incorporate an explicit role for technology. As a result, this framework and empirical tests that grow from it, essentially assume that technology does not change over time. As many researchers have noted, however, technological progress has proceeded at a rapid pace for decades. One of the generally accepted implications of technological growth is that it increases demand for skilled workers relative to those with fewer skills." This technologically-driven demand for skilled workers is the conventional explanation for the rise since the 1930s in the share of nonproduction workers (and other "skilled" workers) in total manufacturing employment.[19] Given that technological growth is a long-standing phenomenon and that the time frame of previous research has been fairly long (the decade of the 1980s), any search for Stolper-Samuelson effects on relative labor demand should attempt to control for technological growth.

Figures 3, 4, and **5** graph the distribution of changes between 1979 and 1989 in the skilled worker share in each industry for each of the three skill measures. Since our data do not allow us to examine year-by-year trends in the college and real-wage-level group shares, we focus on the change in skilled-worker shares over the full period, mindful, however, that at least for the nonproduction worker measure, most of the increase in the skilled-worker share is concentrated entirely in the 1979-82 period. Each figure contains a line through the distribution at zero. Industries to the left experienced a decline in the skilled-worker share during the 1980s; industries to the right saw an increase in the skilled-worker share. The first feature to notice about these figures is that all three, especially the figure corresponding to the fixed-real-wage skill measure, include a portion of industries that experienced a decline in their share of skilled workers. The average change in skilled-worker share for all skill measures is positive, but this disguises declines in a portion of industries. Nine of 58 industries, employing 11.4% of all manufacturing workers, experienced declines in their share of nonproduction workers. Six industries, employing 6.0% of all workers, experienced a decline in their shares of college workers. Twenty-nine industries, employing 49.2% of all workers, experienced declines in their share of the highest fixed-real-wage workers. While aggregate numbers for the manufacturing sector suggest that the skilled-worker share increased, some industries (many, in the case of the fixed-real-wage skill measure) did experience declines in skill shares, even over the full 1979-89 period.

The three figures also contain another line to the right of the zero line. This second line marks the employment- (or hours-) weighted-average change in the skilled-worker category in the previous two decades, which we view as a crude proxy for underlying trend growth in technology across all industries. The share of industries that had skilled-worker-share growth below this crude trend is substantial: for nonproduction workers, 17 industries with 24.0% of manufacturing employment; for college worker hours, 36 industries with 56.2% of employment; and, for the highest fixed-real-wage worker hours, 56 of 58 industries with 97.2% of total manufacturing employment. A comparison of growth in the share of skilled workers in the 1980s with the trend from the 1960s and 1970s reveals that growth in the skilled-worker share decelerated in the 1980s for industries employing between one-fourth and nearly all of manufacturing workers, depending on the skill measure.

A slight refinement on the preceding technology-trend control allows each industry to have its own trend. When we compare growth in the skilled share in the 1980s with the average of skilled-share growth in the previous two decades, industry-by-industry, we find that skill growth in the 1980s was slower than trend in: 19 industries representing 21.9% of employment, by the nonproduction measure; 34 industries representing 47.5% of employment, by the college measure; and 50 industries representing 80.5% of employment, by the fixed-real-wage measure.

Even these crude controls for trend-technology growth in manufacturing indicate that a substantial portion of industries with a substantial share of total manufacturing employment did experience declines between 1979 and 1989 in their employment share of skilled workers relative to historical trends. We speculate that Stolper-Samuelson effects could be, in part, responsible for the marked deceleration in the long-term shift toward the greater use of skilled workers in manufacturing.

Nonmanufacturing Sector. The data analyzed so far are also deceptive because they consider only the experience of the manufacturing sector. The rise in the skilled wage should induce *all* industries to employ fewer skilled workers, including those industries in the (unmodelled) nontraded sector. The data in panel (a) of Table 5 show that the share of nonproduction workers in the whole economy increased in the 1980s at a much slower rate (0.007) than in manufacturing (0.042). Moreover, the rate of growth of nonproduction workers in the whole economy in the 1980s was below the rate for the 1960s (0.012) and 1970s (0.011). The growth in the share of college-educated workers in the whole economy (0.043) was slightly higher than in manufacturing (0.042) but below the rate for the whole economy in the 1970s (0.051).

Undercounting Production Workers. A final limitation of the nonproduction worker share measure is the high probability that production workers are increasingly undercounted in the manufacturing sector after the early 1980s. In a study of the use of temporary workers, Segal and Sullivan (1995) find a large increase between 1983 and 1993 in the use of temporary blue-collar workers. These blue-collar workers performed production-worker tasks, but were excluded from the counts of production workers in manufacturing because they were categorized as being employed in the temporary-help industry, SIC 736. While Segal and Sullivan's numbers do not allow for a direct estimate of the likely bias over the period 1979-89, they do suggest that the bias could be sizeable. Segal and Sullivan report that total manufacturing employment in 1983, as conventionally defined, stood at 18,436,000. Blue-collar temporary workers accounted for an additional 56,000 manufacturing workers (0.3% of conventionally-measured manufacturing employment), raising the total employment to 18,491,000. By 1993, the number of conventionally-counted manufacturing workers had fallen to 18,005,000, while the number of temporary blue-collar manufacturing workers had grown to 443,000 (2.5% of conventionally-measured manufacturing employment). **Table 6** demonstrates the magnitude of the impact that such underreporting of production worker employment could have on estimates of the nonproduction employment share. Following Segal and Sullivan, we add the temporary blue-collar workers to total manufacturing employment to produce a revised estimate of total manufacturing employment in 1983 and 1993. We also add these blue-collar workers to the share of production workers and recalculate the share of production and nonproduction workers in total manufacturing employment. Panel © indicates that between 1983 and 1993, the share of nonproduction workers, measured using the conventional approach, fell by 0.6 percentage points. Panel (d) demonstrates that the fall in the nonproduction share would have been twice as large (1.2 percentage points) if the temporary blue-collar workers were included in the manufacturing employment figures."

The Stolper-Samuelson theorem suggests that if trade were responsible for depressing less-skilled wages in the 1980s, then we should expect to see a decline in the skilled-worker employment share in all industries. The rise in the average skilled-worker share in manufacturing industries between 1979 and 1989 has been interpreted as strong evidence that Stolper-Samuelson effects could not have played a role in widening wage inequality. The analysis here, however, suggests that all of the increase in the skilled-worker share as measured by the share of nonproduction workers in manufacturing employment occurred between 1979 and 1982. After 1982, the nonproduction share fell slightly during the rest of the decade and substantially by 1995. Moreover, focusing on the average share of skilled workers in manufacturing: (1) obscures the experience of the many industries that have seen declines in skilled-worker shares even over the 1979-89 period; (2) fails to address the underlying trend in technological growth during the last four decades; (3) may undercount production workers at the end of the 1980s because of the rise in the use of temporary manufacturing workers; and (4) ignores the experience of the nontraded sector, where skillsupgrading generally decelerated over the full 1979-89 period. When these factors are taken into account, the case for Stolper-Samuelson effects appears alive and well. After 1982, we see clear evidence of a decline in the employment share of skilled workers, providing strong support for Stolper-Samuelson effects and casting serious doubt on the skills-biased technological change view.“’

Prediction 3: Increase in the output share of skilled industries.

The final Stolper-Samuelson prediction suggests that if trade lowered less-skilled wages in the 1980s, then we should see a rise in the share of total output (or employment) in skilled industries. **Table 7** presents the results of a straightforward test of this prediction. The table shows the results from OLS regressions of real output growth on the industry skill share. A positive coefficient suggests that output growth over the time periods is higher in industries with higher initial skills levels. Panel (a) reports results including the computer industry. The data for nonproduction and college workers show a similar pattern. In the 1980s, output growth is strongly related to initial skill level and the relationship is statistically well-defined. The output growth-skill relationship is also positive and statistically significant in the 1970s, but about 30-60% lower than in the 1980s. The relationship is smaller still in the 1960s and no longer statistically significant at the 5% level. Using the real-fixed-wage skill measure, output growth does not appear to be related to skill level in the 1980s. The skill-output growth relationship, however, is strong and positive in the 1970s and an even stronger in the 1960s (though in the earliest period the relationship is only statistically significant at the 10% level).

The data excluding computers (see panel (b)) tells a slightly different story. For the nonproduction skill measure, the magnitude of the skill coefficients are small and don't differ much across the three decades. The skill-output growth relationship is only statistically significant at the 10% level in the 1980s and is not at all significant in the earlier periods. The college data show a strong, positive, statistically significant (at the 1% level) link in the 1980s, but one that is economically smaller than in the 1960s (where the relationship is only significant at the 10% level) and 1970s (1% level). Once again, the fixed-real-wage measure shows no economically meaningful or statistically significant connection to output growth in the 1980s, but the link is large, positive, and significant in the 1960s and 1970s.

What do these results tell us about the third Stolper-Samuelson prediction? Three of the six tests of the output-skill relationship in the 1980s are positive, economically meaningful, and statistically significant at the 1% level. A fourth test is positive, smaller, and significant only at the 10% level. The final two tests for the 1980s show no strong economic or statistical relationship between output growth and skill level. On balance, the data, especially those referring to the traditional occupation and education-based skill measures appear, to be consistent with the third Stolper-Samuelson prediction. One notable difference between this third set of results and the earlier two is that the economic relationship between output growth and skill is much stronger in the 1960s and 1970s relative to the 1980s than was the case when the price-skill relationship or skill-upgrading trends were compared across decades. Since 'trade effects were probably much smaller in the 1960s and 1970s than later, this last finding suggests, not surprisingly, that factors other than those modeled in the simple HO framework probably play an important role in shaping the relationship between skill level and output growth.**

IV. Implications for Relative Wages

The evidence in the preceding section suggests that during the 1980s: (1) the relative price of less-skilled goods fell; (2) the growth in the skilled worker share of employment in the whole economy decelerated over the period 1979-89 and the skilled worker share actually declined in manufacturing after 1982; and **(3)** the share of skilled goods in total output increased. These developments are consistent with the view that a rise in international trade played a role in growing wage inequality during the 1980s. In this section, we carry the analysis a step further and attempt to quantify the impact of trade on wage differentials between nonproduction and production workers and between college- and noncollege-educated workers.[23]

As discussed earlier, in the HO framework with fixed technology, changes in returns to factors are determined entirely by changes in relative goods prices. Thus, our attempts to quantify the wage effects of trade involve first translating the relative goods-price changes documented in the previous section into implied wage changes and then comparing these estimates with the actual changes in relative wages during the 1980s. We begin by rearranging equation (3), which describes the relationship between wage levels and goods prices under the Stolper-Samuelson theorem:

$$(w_s - w_u) = \gamma(p_s - p_u) \qquad (4)$$

where $\gamma = 1/(A_{ss} - A_{su})$ and the switch to lowercase letters indicates that the variables refer to proportional changes over time. Since the denominator in y is the share of skilled workers in the skilled-intensive industry minus the share of skilled workers in the less-skilled intensive industry, the denominator must be positive, but less than one. This implies that y is greater than one, a result known as the “factor price magnification effect"—changes in relative goods prices have a magnified effect on factor returns.

Equation (4) suggests that, armed with relative goods-price changes (from the analysis surrounding Stolper-Samuelson prediction 1) and information on skill shares (used in the analysis of all three Stolper-Samuelson predictions), we could quickly calculate implied changes in relative wages. In fact, empirical estimates are much harder to produce because the simple HO model here does not correspond exactly to the data we analyze. The model in (4) has just two goods (one skilled and one less-skilled) and two factors (one skilled and one less-skilled), while our data refer to two factors and 57 goods[24] of varying skill intensities. The two-good, two-factor model establishes a unique mapping between the goods prices and factor returns. With 57 goods and only two factors, however, there is no longer a unique mapping between goods prices and factor returns. We therefore must develop a procedure to “weight” goods-price changes and apportion them to the two factors. Two approaches exist in the literature. Krueger (1995) uses a regression-based methodology; Lawrence and Slaughter (1993) employ a simpler, skill-weighted industry-pricing approach. In the remainder of this section, we use these methods to produce estimates of trade’s contribution to wage inequality during the 1980s.

Krueger’s (1995) approach is rooted in a generalized form of the zero-profit condition summarized in equation (1). In his formulation:

$$p_i = \alpha_{si}w_{si} + \alpha_{li}w_{li} + \alpha_{ki}r + \alpha_{mi}z_i \qquad (5)$$

where, for each industry I, p_i is the output price; w_{si} is the wage for skilled-labor; w_{li} is the wage for less-skilled labor; r is the rental rate of capital (assumed constant across all industries); z_i is the price of material inputs; and the lowercase roman letters indicate that the variable is in proportional change terms. The a coefficients are the share of each corresponding factor in the total output of industry I. Krueger then estimates (5) in the following form:

$$p_i = b_S\alpha_s + b_L\alpha_{li} + d_k(\alpha_{ki}r) + d_m(\alpha_{mi}z_i) + \varepsilon_i \qquad (6)$$

where **b** and **d** are coefficients to be estimated and ε_i is a disturbance term that incorporates sampling error, other noise, and, in some specifications, the effects of total factor productivity growth on output prices. The expected value of b_S in (6) is the expected value of the proportional change in the wage for skilled labor. Similarly, the expected value of b_L is the expected value of the proportional change in the wage for less-skilled labor. As Krueger notes, this specification is convenient because $E(b_S) - E(b_L)$ should equal the observed difference in average wage growth between skilled and unskilled workers, solving the problem of allocating industry-price changes to the two factors. The Stolper-Samuelson theorem suggests that if trade depressed the relative wages of less-skilled workers during the 1980s, then $E(b_S)$ should be greater than $E(b_L)$.

Table 8 presents results from various estimates of (6) for the 1980s using our data set. Taken together, the regressions perform poorly and shed little light on the contribution of Stolper-Samuelson effects to wage inequality. Table 8A refers to the nonproduction-production worker skill measure. Panel (a) contains estimates where the industry output price or the effective industry output price were regressed against the shares of nonproduction workers, production workers, capital, and materials in the total value of industry output. All regressions also include a dummy variable for the office machinery industry to control for computer-quality price adjustments. The first regression in panel (a) is unweighted. It suggests that the nonproduction-worker wage should have grown by 4.9% over the 1980s, while the production-worker wage should have risen by 8.7% over the same period. Neither estimate, however, is statistically significant. The F-test reported in the last row of the column also indicates that the difference between the two coefficient estimates is not statistically significant. The statistically significant, negative coefficient on the capital costs variable, a result repeated in every regression using this approach, is a separate cause for concern.[25] The employment-weighted regressions in the next column produce very different results. The results imply an increase in nonproduction wages of 125.2% and a decline in production wages of 3.5%. Again, neither of the two estimates, nor the difference between them are statistically significant. The next two columns of the same panel display results for versions of (6) using effective output prices, that is, prices that take changes in total factor productivity into account. As in the output price regressions, these wage estimates are erratic and statistically insignificant.

The regressions reported in panel (b) adapt equation (6) for use with value-added prices. In practice, this means dropping the capital and material costs variables that effectively seek to convert the output prices in panel (a) into value-added concepts. The first regression, of value-added prices against the nonproduction and production share in value-added, indicates that price changes should have induced a 132.2% increase in nonproduction wages in the 1980s and a 77.2% decline in production wages over the same period. Neither estimate is statistically significant, but the difference between the two (209.4%) is almost significant at the 10% level. The second regression is identical, except that it is weighted by industry employment. The coefficient estimates are similar to those in the unweighted regression. Once again, neither is statistically different from zero, but now the difference between the two (185.9) is almost significant at the 5% level. The final two columns contain the results for regressions using effective value-added prices. Both suggest declines in the nominal wages for the two skill groups. None of the wage estimates is statistically different from zero.

Table 8B contains the corresponding results for college and noncollege workers. Qualitatively, the college-noncollege results differ little from those for nonproduction-production data. The wage estimates vary widely across specifications and none of the wage-growth estimates are statistically significant at conventional levels. As with the nonproduction-production data, the statistically most meaningful regressions appear to be those using value-added prices in the first two columns of panel (b). The first (unweighted) of these specifications predicts a difference in nominal wage growth of 236.1% between college- and noncollege-educated workers. The two estimates that produce this figure are not statistically different from zero, but their difference is significant at the 10% level. The employment-weighted version of this regression implies a 216.7% difference in relative wages over the 1980s. In this case, the probability-value of the difference is 0.12 1.

The underlying data indicate that between 1979 and 1989 nominal wages increased by about 73% for nonproduction workers; 66% for production workers.; 72% for college-educated workers; and 52% for noncollege-educated workers. The difference in nominal-wage growth between skilled and less-skilled workers, then, was about seven percentage points for nonproduction-production workers and 20 percentage points for college-noncollege workers. Separately, we calculated the college-noncollege wage differential using the Outgoing

Rotation Croup of the Current Population Survey for the years 1979 and 1989. After controlling for experience (and its square) and region of residence, in our sample of 18 to 64 year old, full-time and part-time employees, the college premium rose 13.9 percentage points between 1979 and 1989. The best estimates from Table 8 suggest differences of 185-210% for nonproduction-production workers and 215-240% for college-noncollege workers using the raw decennial census data from our principal data set. This implies that, during the 1980s, Stolper-Samuelson effects accounted for about 2,800% of the growth in the nonproduction-production differential; about 1,100% of the growth in the raw college-noncollege differential; and about 1,600% of the regression-controlled differential. If Stolper-Samuelson effects were this large, a very powerful force (or forces) must have been working to counteract the implied Stolper-Samuelson effect. We find it more plausible to conclude that this particular estimation technique, while theoretically compelling, does not provide an accurate measure of Stolper-Samuelson effects using our data for the 1980s.

Krueger's (1995) results for 150 manufacturing industries between 1989 and 1994 are better-behaved, but they also suggest a very large potential role for Stolper-Samuelson effects. His main regression (see his Table 6) suggests that Stolper-Samuelson effects could have produced a 52.4 percentage-point increase in the relative skilled wage in 1989-94. Since the actual rise over the period in the relative wage was about 19 percentage points (see his page 17), this suggests that Stolper-Samuelson effects accounted for about 275% of the growth in skilled wage relative to less-skilled wages. Even his smallest estimates predict that Stolper-Samuelson effects should have raised relative nominal wages by about 20 percentage points, which still imply that Stolper-Samuelson effects could have been responsible for more than

100% of the observed change in relative wages.

Lawrence and Slaughter (1993) employ a different method for estimating the effect of relative prices changes on relative wages. They allocate the price changes across a large number of industries of varying skill-intensities to changes in the relative wages of the two labor inputs by calculating skilled-employment-weighted industry price changes. Their procedure is simple. First, they calculate the average price change across all industries by weighting individual industry price changes over time using the total number of skilled workers in each industry. Next, they calculate the same average price change using the industries' total number of less-skilled workers. The difference in the two average price changes, Lawrence and Slaughter argue, reflects the impact of relative price changes on relative wages for the two groups of workers. The preceding discussion of the factor price magnification effect, however, makes clear that the size of the relative-price changes represents a lower bound for the estimate of the effect of the goods-price changes on relative wages. The most accurate translation of goods-price changes into relative wage changes should scale up the goods-price change to reflect the factor price magnification effect.

Table 9 shows the change in skill-weighted industry output and value-added prices (with and without adjusting for total factor productivity growth) for the occupation and education skill measure for the 1960s, 1970s, and 1980s, excluding the computer industry. **Table 9A** displays the results for nonproduction versus production workers. In the 1980s (see panel (a)), all four prices grew more rapidly in nonproduction-worker-intensive industries than in production-worker-intensive industries. The smallest price difference (for effective value-added prices) was 1.8%; the largest (for value-added prices) was 5.4%. Skilled-weighted output prices grew 4.5% faster than less-skilled weighted output prices; 2.7% faster after adjusting for differential total-factor-productivity growth. Panels (b) and (c), which report that skill-weighted price changes were much smaller in the 1960s and 1970s, make clear that faster price growth in the skilled-intensive industries was a phenomenon of the 1980s. Table 9B presents results for college versus noncollege workers. The data for the 1980s in panel (a) generally show smaller skilled-worker-weighted price increases than with the nonproduction-production worker data. Output prices grew 1.5% more rapidly in college-intensive industries and 0.8% faster after controlling for growth in total factor productivity. Using value-added prices, the college-weighted increases were 2.9% and 2.3% (total-factor-productivity adjusted) faster. The data for the 1970s in panel (b) contrast sharply with the nonproduction-production worker results in Table 9A. The education data indicate strong growth in college-weighted prices in the 1970s, with college-weighted output prices increasing by about 7% and college-weighted value-added prices growing by about 16% compared to corresponding noncollege-weighted price changes. The college-noncollege-weighted data for the 1960s (see panel (c)), show no significant change in relative prices over the period.

The data in Table 9, then, allow us to place a lower bound on the impact of Stolper-Sarnuelson effects on relative wage declines for less-skilled workers during the 1980s. The 1.8-5.4 percentage-point range for price effects on the nonproduction-production differential represent 26-77% of the seven percentage-point rise in the nominal nonproduction-production differential during the 1980s. The 0.8-2.9 percentage point range for college versus noncollege workers accounts for 4-15% of the 20 percentage-point increase in the raw college-noncollege differential or 6-21% of the estimated 13.9 percentage-point rise in the regression-controlled differential over the same period.

These estimates, however, ignore the factor-price-magnification effect. Since less-skilled workers represent only a portion of each industry's total costs, the zero-profit condition requires that changes in factor costs be larger than the corresponding changes in output prices. The multiplicative effect is equal to one over the share of the relevant factors in total output (or total value-added, as appropriate). Data for the 1979-89 period from the Bureau of Labor Statistics indicate that labor costs as a portion of value-added in manufacturing were, on average, about 0.70, suggesting a factor-price-magnification effect for value-added prices of about 1.4. Applying this factor to the value-added estimates in Table 9 suggests that, Stolper-Samuelson effects in the 1980s accounted for 36-108% of the rise in the nonproduction-production differential; 6-20% of the increase in raw college-noncollege differential; and 8-28% of the rise in the regression-controlled college-noncollege differential.

V. Some Conclusions

Standard trade theory embodied in the HO model and the complementary Stolper-Samuelson theorem make clear predictions about how trade will affect the domestic income distribution. With technology fixed, factor returns are determined solely by the international prices of goods. When the relative price of a good falls, the returns to factors that are used relatively intensively in the production of that good also fall. Industries respond to the decline in the factor's cost by using more of the newly cheaper factor. Industries that produce the goods whose prices have fallen respond by reducing output; resources freed by this reduction in output are diverted to other industries where the relative price of output is now higher. The evidence presented here for the 1980s is broadly consistent with this description of how trade affects the income distribution. The relative prices for less-skilled goods declined between 1979 and 1989, while the relative wages of less-skilled workers fell. After a large, discrete increase between 1979 and 1982 in the share of skilled workers in manufacturing, the skilled-worker share fell slightly through the end of the decade and then more rapidly in the first half of the 1990s. Even over the 1979-89 period, in many manufacturing industries, and in the majority of industries in the economy as a whole, the long-term trend toward the greater use of skilled workers decelerated. Meanwhile, the output of skilled-intensive goods grew more rapidly than for less-skilled-intensive goods.

A central issue in the debate over wage inequality concerns differentiating between the effects of trade and technology. The most important obstacle to separating these two effects is the complete flexibility of the technology thesis. It is possible to tell a skill-biased-technological-growth story to fit every conceivable change in the wage distribution.[26] Even skill-neutral technological change could have contributed to widening wage inequality in the 1980s if it were concentrated in skill-intensive industries. Mishel and Bernstein (1996) have emphasized that any explanation of rising wage inequality in the 1980s must point to factors that, over that period, differed from earlier periods. The trade thesis passes this first test, since trade in manufactures, particularly with low-wage countries, expanded more rapidly in the 1980s than in the 1970s or 1960s. Meanwhile, Mishel and Bernstein argue that, during the 1980s, neither the degree of technological advancement nor the impact of those advances on labor demand exceeded their historical trend, making technology a poor suspect for the upheaval in the U.S. wage distribution since the late 1970s.

Much of the specific evidence here argues against aspects of popular versions of the technological-change explanation. First, the decline in price of less-skilled-intensive goods relative to skilled-intensive goods (excluding computers) is inconsistent with skill-neutral technological growth in "high tech" sectors, which we would generally expect to result in declining relative prices for these goods (as occurred in computers, but apparently not elsewhere). Second, the deceleration between 1979 and 1989 in the shift to skilled workers for both manufacturing and the economy as a whole, and the fall after 1982 in the share of nonproduction workers in manufacturing, argues strongly against skill-biased technological explanations.

Wood (1994) has emphasized the difficulties inherent in disentangling trade and technology effects. Price pressures resulting from trade expansion may have driven the technological innovations in the traded sector during the 1980s.

Our most plausible estimates of the contribution of trade to wage inequality indicate that trade accounted for 6-20% of the 20 percentage-point increase during the 1980s in the raw college-noncollege differential in manufacturing and 35-100% of the seven percentage-point increase over the same period in the nonproduction-production worker differential. The same estimates suggest that trade could have been responsible for 8-28% of the regression-controlled rise in the college-noncollege differential. The nonproduction-production worker differential is higher than most recent estimates of trade effects. The college-noncollege estimate falls somewhere in the middle of the range of recent estimates of trade effects (see, for example, Borjas, Freeman, and Katz 1992, 1996; Sachs and Shatz 1994, 1995; Krugman 1995a).

Endnotes

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1. The change between 1979 and 1989 in the college-to-high-school hourly wage differential is calculated here, from Table 2, as: ($15.86/$9.68)-($15.59/$10.22). The change in the nonproduction-production workers wage gap, using annual earnings, rose by 6.5 percentage points over the same period: ($34,825/$22,226) - ($33,736/$22,466).

2. Sachs and Shatz (1994) provide data that suggest that the share of manufactured imports from less-developed countries (LDCs) accounted for just under half of the total increase in imports between 1979 and 1989. Their data appear in rows 5 and 6 of Table 1 (2.7-1.6)/(9.9-7.4).

3. Adrian Wood (1994, 1995) also takes this line.

4. Krugman (1995b) critiques the "only prices matter" view and defends factor-content-based assessments of the impact of trade.

5. Stolper and Samuelson (1941) is the classic reference. For textbook treatments of the Stolper-Samuelson theorem, see Krugman and Obstfeld (1991), Salvatore (1995), or Chacholiades (1978).

6. For simplicity's sake, we concentrate on the comparative statics in the skilled-labor-abundant economy.

7. For the moment, the use of fixed-coefficients technology simplifies exposition. All of the key results hold for more flexible technology.

8. Here we temporarily abandon the fixed-coefficients technology used to motivate the first Stolper-Samuelson prediction. Relaxing the assumption has no effect on the predicted relationship between goods and factor prices above. Assumptions about the elasticity of substitution between factors will become important in the interpretation of some of the empirical results presented in the next section. We will raise and address these issues at that point.

9. We do not feel comfortable calling the vast majority of U.S. workers in 1979 "less-skilled," but these proportions correspond roughly to the share of noncollege or production workers in the total economy, two groups referred to frequently as "less-skilled" or even "unskilled" in many analyses.

10. In an earlier version of this paper, we also examined two other price measures, import and export price indices produced by INFORUM, a private data source, and available for 25 industry categories covering the entire manufacturing sector. The INFORUM data were constructed using comparisons with domestic deflators; changes in industry-specific, trade-weighted foreign exchange rates; import and export price data from the Bureau of Labor Statistics available for some industries in some years during the 1980s; and, unit-value indices. Uncertainty about the quality of the data for our purposes here have led us to drop the discussion of those data and to adopt the more conventional approach used by Sachs and Shatz (1994) and Krueger (1995) of examining only the more reliable domestic data. For the record, the import data, controlling for the computer industry, show a statistically insignificant, negative relationship in the 1980s between import price and nonproduction-production and college-noncollege skill level. The price-skill relationship is mixed and not significant in earlier periods. The export price data demonstrate a positive, statistically insignificant association with skill in the 1980s and mixed, statistically insignificant relationship in the 1960s and 1970s.

11. The industry total factor productivity figures are taken directly from the NBER productivity data set, as calculated by Wayne Gray.

12. While Sachs and Shatz's (1994) results depend on using dummy variables to control for computer-related industries during the 1980s, Krueger's (1995) results for the 1989-94 period do not. Note that the use of a dummy variable to control for the computer industry affects only the output price of the industry. The dummy variable specification allows computer inputs to continue to reduce costs in other industries that purchase computers.

13. A one-point difference in the ratio of nonproduction-to-production workers (about a 4 standard deviation difference) would be associated with a 5.7 percentage point faster rate of growth in the output price over 11 years. A one point difference in the nonproduction-to-production ratio corresponds to a situation where the less-skilled-intensive industry has, for example, an 0.250 share of nonproduction workers and the skilled-intensive industry has an 0.429 share of nonproduction workers.

14. Here, a two standard deviation difference in the nonproduction-to-production ratio translates to a 15.8 percentage point difference in the output price over 11 years.

15. Economically, the effects here are very similar to the nonproduction-production analysis. A 2 standard deviation difference in the industry college-to-noncollege ratio is associated with a 15.7 percentage point difference in the relative output price and a 9.4 percentage point difference in the relative effective output price over 11 years.

16. Our own data demonstrate a much flatter price-skill relationship before the computer industry control is implemented.

17. Howell (1994) and Feenstra and Hanson (1996) have also noted that the sharp jump in nonproduction worker shares during the 1980s is entirely concentrated in the 1979-82 period.

18. Mishel and Bernstein (1996) demonstrate a long-term, complementary relationship between workers' skills and capital, but also find that technological innovations in some time periods have had a positive impact on industry demand for less-skilled workers.

19. Given that it is conventionally assumed that the pace of technological progress accelerated in the 1980s and 1990s, it is difficult to explain why the nonproduction employment share in manufacturing was flat between 1982 and 1991 and actually decelerated between 1991 and 1995.

20. Segal and Sullivan (1995) do not report figures on the use of temporary nonproduction workers in the manufacturing sector. If we assume that the manufacturing sector uses non-blue-collar temporary workers in the same proportion as the rest of the economy, and that all such workers are nonproduction workers, and add these workers to the total nonproduction employment figures for 1983 and 1993, then the nonproduction share still declines by 0.8 percentage points-about one-third faster than when we ignore the role of temporary workers. As Segal and Sullivan note, the exclusion of what represents 2.5% of the labor force in manufacturing has significant implications for the calculation of manufacturing productivity over the period.

21. Lawrence and Slaughter (1993) perform a test of this second Stolper-Samuelson prediction by graphing the percent change in the ratio of nonproduction-to-production wages against the percent change in nonproduction-to-production worker ratio for a number of manufacturing industries over the 1980s. They maintain that if Stolper-Samuelson effects were at work, most industries would find that the relative wage of less-skilled workers fell while their relative employment rose. Since only a small share of the industries that they study exhibit this behavior, Lawrence and Slaughter conclude that Stolper-Samuelson effects were not important during the 1980s or that they were outweighed by other probably technological factors, pushing the skill mix in the opposite direction. Their approach, however, suffers from several of the problems discussed above: sensitivity to beginning and endpoints; failure to control for trend growth in technology; and the undercounting of production workers at the end of the 1980s. Neither Sachs and Shatz (1994) nor Krueger (1995) test this Stolper-Samuelson proposition with their data.

22. Lawrence and Slaughter (1993), Sachs and Shatz (1994), and Krueger (1995) do not test this third prediction. Krugman and Lawrence (1994) attempt to test this proposition by graphing the *change* during the 1980s *in the skill ratio in* each industry against the skill level at the beginning of the decade. The test seems well designed to determine whether skilled industries increased their skill intensity faster (or slower) than less-skilled industries, but that is not the issue under discussion. Our regression analysis seems a much more direct test.

23. We do not conduct an analysis of skill differentials for the fixed-real-wage groups since, by construction, the differentials are fixed over time.

24. In the analysis-that follows, we effectively exclude the office machinery category, which includes computers, either by dropping it from the samples analyzed or by assigning it its own dummy variable in the regression analyses.

25. Krueger's (1995) regressions suffer from the same problem.

26. Krugman (1995b) argues that it is possible to put some empirically testable limits on the skills-biased technological change thesis, but his test appears to have little power.

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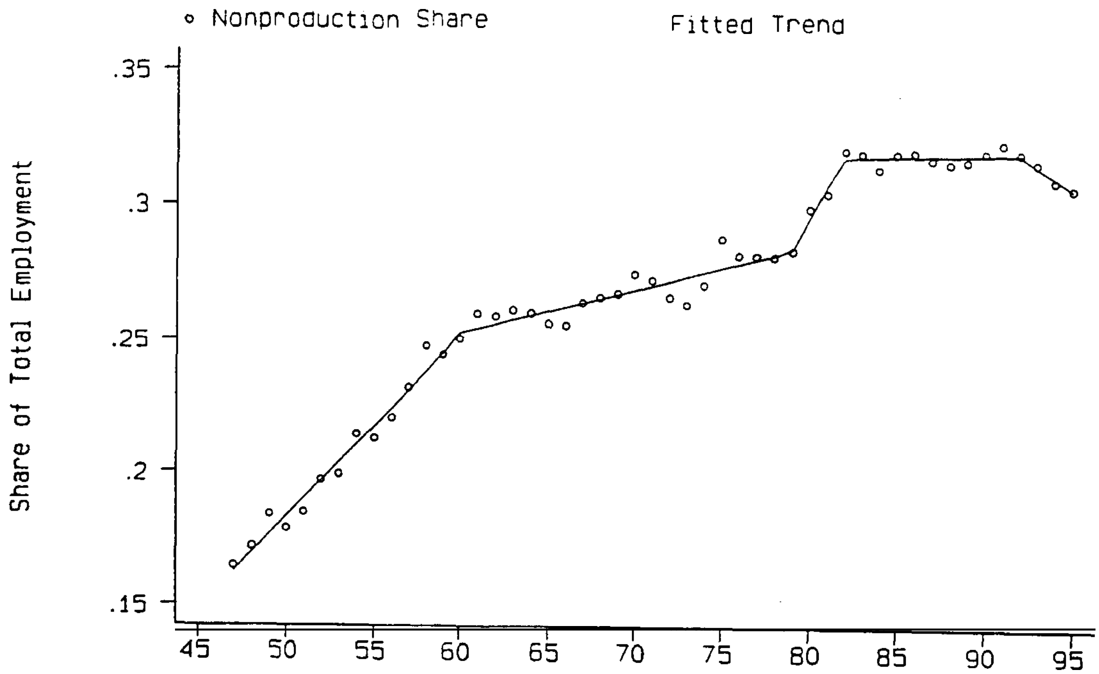


App. Fig.1: Nonproduction Employment Share, 1947-95

TABLE 1
Average Real Wages, 1959-89
(1989 Dollars)*

	1959	1969	1979	1989	Percentage change 1959-69	1969-79	1979-89
(a) *Whole Economy*							
Average (hourly)	$8.83	$11.25	$11.34	$11.47	27.5%	0.8%	1.1%
Nonproduction (hourly)							
Production (hourly)	7.93	9.57	10.32	9.66	20.7	7.9	-6.4
College (hourly)	13.53	17.72	15.59	15.86	31.0	-12.0	1.7
Some College (hourly)	10.08	12.06	11.35	10.98	19.7	-5.9	-3.3
High School (hourly)	8.50	10.39	10.22	9.68	222	-1.6	-5.4
Less than HS (hourly)	7.85	9.54	9.43	8.50	21.5	-1.1	-9.9
(b) *Manufacturing*							
Average (hourly)	$9.80	$11.94	S12.28	$12.32	21.8%	2.9%	0.3%
Nonproduction (Per year)	27,437	32,010	33,736	34,825	16.7	5.4	32
Production (Per year)	17,486	20,737	22,466	22326	18.6	8.3	-1.1
College (hourly)	15.96	20.44	18.17	1827	28.1	-11.1	0.6
Some College (hourly)	1159	13.70	13.03	12.67	182	-4.9	-2.8
High School (hourly)	9.54	11.29	1150	10.84	18.4	1.8	-5.7
Less than HS (hourly)	8.96	10.47	10.55	9.52	16.8	0.8	-9.8

*All wages deflated by the CPI-U-Xl .

Sources:
Whole economy average and education: Census 1960,1970, 1980, 1990.
Whole economy production: Bureau of Labor Statistics Homepage.
Manufacturing average and education: Census 1960,1970, 1980, 1990.
Manufacturing occupation: NBER productivity data set.

TABLE 2

Key Macroeconomic Indicators, 1959-89

	1959	1969	1979	1989	Percent change 1959-69	1969-79	1979-89
(a) GDP (b 19928)	2312	3,388	4,624	6,060	53.1	36.5	31.1
(b) Employment							
Total (m)	64.6	77.9	98.8	117.3	20.5	26.9	18.7
Manufacturing (m)	17.8	19.8	19.3	16.3	11.1	-2.4	-15.4
(c) Productivitiy							
Nonfarm Bus. (19921100)	54.1	71.7	86.4	95.8	32.5	20.5	10.9
Manuf. TF P (1987=100)	88.0	94.7	96.7	100.9	7.7	2.0	4.4
(d) Prices							
GDP Deflator (1992=100)	23.0	29.0	553	89.7	26.1	90.7	62.2
PPI Manuf. (1987=100)	33.4	38.9	79.3	109.1	16.6	103.7	37.5
CPI-U-X1 (19891100)	25.5	31.8	59.7	100.0	24.7	87.8	67.6
					Percentage-point change		
(e) Trade							
Exports/GDP (%)	3.3	4.2	6.5	8.6	1.0	23	2.1
Imports/GDP (%)	4.8	63	7.4	10.0	1.5	1.1	2.5
Manuf. Imports/GDP (%)*	2.1	..	5.4	7.3	..	..	1.9
LDC Manuf. Imp./GDP (%)*	..	..	1.6	2.7	..	..	1.1

● Datareikto 1960, 1970, 1978, and 1990.

sources

GDP: ERP 19%. Table B-2.

Total employment: ERP 19%. Table B-32

Manufacturing employment: NBER productivity data set.

Nonfarm business productivity: ERP 1996, Table B-45.

Total factor productivity in manufacturing: Calculated by Wayne Gray for the NBER productivity data set.

GDP deflator: Chain-type price index from ERP 19%. Table B-3.

Producer price index for manufacturing: NBER productivity data set.

CPI-U-X1: Derived from ERP 1996, Table B-58.

Exports as a percent of GDP: Ratio of real exports to real GDP, derived from ERP 1996, Table B-2.

Imports as a percent of GDP: Ratio of real imports to real GDP, derived from ERP 19%. Table B-2.

Manufactured imports as a percent of GDP: From Sachs and Shatz (1994). Table 1.

Manufactured imports from LDCs as a percent of GDP: From Sachs and Shatz (1994), Table 1.

TABLE 3
Correlation* of Skill Measures Across Industries, 1959-89

	Year	Nonproduction Share Unweighted	Nonproduction Share Weighted**	College Share Unweighted	College Share Weighted**	Top 25% (1979) Share Unweighted	Top 25% (1979) Share Weighted**
Nonproduction Share	1989	1.000	1.000				
	1979	1.000	1.000				
	1969	1.000	1.000				
	1959	1.000	1.000				
College Share	1989	0.858	0.8%	1.000	1.000		
	1979	0.810	0.859	1.000	1.000		
	1969	0.644	0.715	1.000	1.000		
	1959	0.601	0.636	1.000	1.000		
Top 25% (1979) Share	1989	0.586	0.605	0.605	0.742	1.000	1.000
	1979	0.443	0.362	0.362	0.488	1.000	1.000
	1969	0.581	0.585	0.585	0.741	1.000	1.000
	1959	0.420	0.408	0.408	0.709	1.000	1.000

*All coefficients are statistically significant at 0.001 level.
**Weighted coefficients calculated using total industry employment.

TABLE 4A
Proportional Change in Producer Prices and **Skill** Ratio:
Nonpmduction-Production Worker Ratio

	Mean [S.D.]	Output Prices	Output Prices	Effective Output Prices	Value-Added Prices	Effective Value-Added Prices
(a) *1979-89*						
Nonproduction	**0.379**	0.057	**0.285****	**0.175***	**0.334***	0.144
Production	**[0.278]**	(0.246)	(0.106)	(0.07 1)	(0.150)	(0.09 1)
Computer	0.017	**-.-**	**-1.304****	**0.704****	**-2.009****	**1.896****
	[-.-]		(0.083)	(0.057)	(0.116)	(0.070)
R-squared	**-.-**	0.003	0.337	0.346	0296	0.519
Root-USE.	**-.-**	0.278	0.229	0.167	0.385	0.261
D.V.						
Mean	**-.-**	0.478	0.478	0.549	0.575	0.753
[S.D.]	**-.-**	**[0.276]**	**[0.276]**	**[0.203]**	**[0.450]**	**[0.370]**
(b) 1969-79						
Nonproduction	0.348	**-0.223**	-0.130	-0.019	-0.141	0.053
Production	**[0.247]**	**(0.188)**	(0.176)	(0.137)	(0501)	(0.42 1)
Computer	0.017	**-.-**	-0.997	-0.260	**-1.633****	-0.365
	[-.-]		(0.085)	(0.070)	(0.354)	(0313)
R-squared	**-.-**	0.013	0.079	0.008	0.015	0.001
Root-M.S.E.	**-.-**	0.490	0.478	0.397	1.856	1.611
D.V.						
Mean	**-.-**	1.054	1.054	1.097	1.569	1.639
[S.D.]	**-.-**	**[0.489]**	**[0.489]**	**[0.392]**	**[1.837]**	**[1.583]**
(c) *1959-69*						
Nonproduction	0.322	0.015	0.013	0.054	-0.008	-0.078
Production	**[0.219]**	**(0.075)**	(0.075)	(0.070)	(0.118)	(0.133)
Computer	0.017	**-.-**	**0.052****	**0.102****	**0.081****	**0.139****
	[-.-]		(0.016)	(0.015)	(0.026)	(0.03 1)
R-squared	**-.-**	0.001	0.006	0.043	0.004	0.015
Root-M.S.E.	**-.-**	0.100	0.101	(0.089)	0.180	0.200
D.V.						
Mean	**-.-**	0.145	0.145	0.244	0.148	0.364
[S.D.]	**-.-**	**[0.099]**	**[0.099]**	**[0.089]**	**[0.177]**	**[0.198]**

#p<=0.10
*p<=0.05
**p<=0.01

TABLE 4B
Proportional Change in Producer Prices and Skill Ratio:
College-Noncollege Hours Ratio

	Mean [S.D.]	Output Prices	Output Prices	Effective Output Prices	Value-Added Prices	Effective Value-Added Prices
(a) *1979-89*						
College Noncollege	0.125 [0.093]	0.112 (0.743)	0.848** (0.3 10)	0.505# (0.261)	0.862 (0.578)	0.237 (0.418)
Computer	0.017 [-.-]	-.-	-1.316** (0.098)	0.701** (0.082)	-1.986** (0.181)	1.943** (0.130)
R-squared	-.-	0.001	0.334	0.341	0.286	0.512
Root-M.S.E.	-.-	0.278	0.229	0.168	0.387	0.263
D.V.						
Mean	-.-	0.478	0.478	0.549	0.575	0.753
[S.D.]	-.-	[0.276]	[0.276]	[0.203]	[0.450]	[0.370]
(b) X969-79						
College Noncollege	0.087 [0.073]	0.106 (1.599)	0.915 (1.799)	1.101 (1.610)	6.392 (8.438)	5.975 (7.537)
Computer	0.017 [-.-]	-.-	-1.210** (0.406)	-0.494 (0.364)	-3.001 (1.941)	-1.582 (1.735)
R-squared	-.-	0.000	0.091	0.044	0.070	0.066
Root-MSE.	-.-	0.493	0.475	0.390	1.803	1.557
D.V.						
Mean	-.-	1.054	1.054	1.097	1.569	1.639
[S.D.]	-.-	[0.489]	[0.489]	[0.392]	[1.837]	[1.583]
(c) *1959-69*						
College Noncollege	0.069 [0.054]	-0.587** (0.196)	-0.622** (0.190)	0.058 (0.161)	-1.088** (0.324)	0.010 (0.428)
Computer	0.017 [-.-]	-.-	0.093** (0.018)	0.105** (0.015)	0.150** (0.028)	0.129** (0.037)
R-squared	-.-	0.104	0.086	0.027	0.113	0.007
Root-M.S.E.	-.-	0.095	0.095	0.089	0.170	0.201
D.V.						
Mean	-.-	0.145	0.145	0.244	0.148	0.364
[S.D.]	-.-	[0.099]	[0.099]	[0.089]	[0.177]	[0.198]

#p<=0.10
*p<=0.05
**p<=0.0 1

TABLE 4C
Proportional Change in Producer Prices and Skill Ratio:
Wage Quantity Hour Ratio

	Mean [S.D.]	output Prices	output prices	Effective output Prices	Value-Added Prices	Effective Value-Added Prices
(a) *1979-89*						
Top 25%	0.370	-0.063	-0.016	-0.050	-0.135	-0.142
Bottom 75%	[0.321]	(0.094)	(0.099)	(0.080)	(0.224)	(0.149)
Computer	0.017	-.-	-1.076**	0.855**	-1.711**	2.046**
	[-.-]		(0.042)	(0.033)	(0.086)	(0.059)
R-squared	-.-	0.00s	0.265	0.303	0.269	0.524
Root-M.S.E.	-.-	0.277	0.240	0.173	0.392	0.259
D.V.						
Mean	-.-	0.478	0.478	0.549	0.575	0.753
[S.D.]	-.-	[0.276]	[0.276]	[0.203]	[0.450]	[0.370]
(b) 1969-79						
Top 25%	0.259	0.297	0.645	0.710	2.970	2.79s
Bottom 75%	[0.172]	(0.644)	(0.667)	(0.556)	(3.062)	(2.687)
Computer	0.017	-.-	-1.315**	-0.589*	-3.003#	-1.620
	[-.-]		(0.339)	(0.285)	(1.597)	(1.405)
R-squared	-.-	0.011	0.121	0.094	0.083	0.082
Root-M.S.E.	-.-	0.491	0.089	0.380	1.791	1.544
D.V.						
Mean	-.-	1.054	1.054	1.097	1.569	1.639
[S.D.]	-.-	[0.489]	[0.489]	[0.392]	[1.837]	[1.583]
(c) *1959-69*						
Top 25%	0.103	-0.211	-0.224	0.181	-0.630#	0.198
Bottom 75%	[0.062]	(0.201)	(0.202)	(0.199)	(0.333)	(0.424)
Computer	0.017	-.-	0.063 **	0.100**	0.110	0.121
	[-.-]		(0.016)	(0.015)	(0.027)	(0.032)
R-squared	-.-	0.017	0.024	0.041	0.051	0.01 1
Root-MSE.	-.-	0.099	0.100	0.089	0.176	0.201
D.V.						
Mean	-.-	0.145	0.145	0.244	0.148	0.364
[S.D.]	-.-	[0.099]	[0.099]	[0.089]	[0.177]	[0.198]

#p<=0.10
*p<=0.05
**p<=0.01

TABLE 5

Employment Shares by Skill Level, 1959-89

	1959	1969	1979	1989	Point change 1959-69	1969-79	1979-89
(a) Whole *Economy*							
Nonproduction*	0.160	0.172	0.183	0.190	0.012	0.011	0.007
Production*	0.840	0.828	0.817	0.810	-0.012	-0.011	-0.007
College	0.103	0.134	0.186	0.229	0.03 1	0.051	0.043
Some College	0.105	0.132	0.197	0.301	0.026	0.065	0.104
High School	0.305	0.376	0.399	0.314	0.071	0.023	-0.085
Less than HS	0.487	0.358	0.219	0.156	-0.128	-0.139	-0.063
(b) Manufacturing							
Nonproduction	0.237	0.250	0.264	0.307	0.013	0.014	0.042
Production	0.764	0.750	0.736	0.694	-0.013	-0.014	-0.042
College	0.069	0.086	0.119	0.156	0.017	0.033	0.037
Some College	0.087	0.106	0.157	0261	0.019	0.052	0.104
High School	0.295	0.378	0.434	0.377	0.083	0.056	-0.058
Less than HS	0.549	0.431	0.290	0.206	-0.119	-0.141	-0.084

*Data refers to private, nonagricultural payrolls in 1960, 1969, 1979, and 1988.

Sources:

Whole economy occupations: BLS (1989). Tables 68 and 69.

Whole economy education: Census 1960, 1970, 1980, 1990.

Manufacturing occupations: NBER productivity data set.

Manufacturing education: Census 1960, 1970, 1980, 1990.

TABLE 6

Temporary Blue-Collar Workers and the Production Worker Share in Manufacturing

	1983	1993	Change
(a) Conventional Employment (Thousands)			
Manufacturing *(Conventional)*	18,436	18,005	-431
Nonproduction	5,908	5,664	-244
Production	12,528	12,341	-187
Conventional Employment Share (Percent)			
Nonproduction (Conventional)	32.0%	3 1.5%	-0.6
Production (Conventional)	68.0	68.5	0.6
(b) Adjusted Employment (Thousands)			
Temporary Blue-Collar	56	443	387
Manufacturing	18,491	18,447	-44
Nonproduction	5,908	5,664	-244
Production	12,584	12,784	200
Adjusted Employment Share I (Percent)			
Nonproduction (Adjusted)	32.0%	30.7%	-1.2
Production (Adjusted)	68.0	69.3	1.2

*See text for a discussion of adjustment method used in panel (b).

Sources:

Manufacturing Employment (Conventional): Segal and Sullivan (1995), Table 4.

Temporary Blue-Collar Employment: Segal and Sullivan (1995). Table 4.

Manufacturing Employment (Adjusted): Segal and Sullivan (1995), Table 4.

Nonproduction and Production Shares (Conventional): BLS (19%).

TABLE 7

Growth in Real Output by Skill Level

	1959-69	1969-79	1979-89
(a) Including computers			
Nonproduction	0.105	0.416 *	1.083 **
Production	(0.275)	(0.191)	(0.309)
College	2.131 #	2.571 **	3.670 **
Noncollege	(1.071)	(0.577)	(0.900)
Top 25% (1979)	1.769 #	0.950 • *	0.165
Bottom 75% (1979)	(0.947)	(0.255)	(0.295)
(b) Excluding computers			
Nonproduction	0.088	0.245	0.222 #
Production	(0276)	(0.147)	(0.121)
College	2.015 #	1.526 **	0.972 **
Noncollege	(1.089)	(0.500)	(0355)
Top 25% (1979)	1.693 #	0.515 *	-0.059
Bottom 75% (1979)	(0.955)	(0.216)	(0.101)

Note:

#p<=0. 10; ● p<=O.o5; **p<=0.01

(a) Coefficients from regression of real value of industry shipments against industry skill ratio.

(b) Coefficients fiom regression in (a) with a dummy variable for the computes industry.

TABLE 8A

Relative Price Changes and Implied Relative Wage Changes: Production-Nonproduction Workers, 1979-89

(a) Output Prices

	Mean [S.D]	Output Prices	Output Prices	Effective Output Prices	Effective Output Prices
Nonproduction Share in Output	0.064 [0.036]	0.049 (1.579)	1.252 (0.775)	-0.270 (0.987)	0.406 (0.488)
Production Share in Output	0.127 [0.054]	0.087 (0318)	-0.035 (0.312)	0.101 (0.222)	-0.172 (0.223)
Capital costs	-0.040 [0.013]	-14.751 (4.994)	-10371 (2.424)	-11.457 (3.179)	-8.871 (1.481)
Material costs	0.230 [0.066]	1.048 (0.345)	1.479 (0.279)	1.019 (0.213)	1.189 (0.172)
Computer	0.017	a.885 (0.121)	-0.848 (0.112)	1.071 (0.016)	1.067 (0.061)
R-squared		0.686	0.770	0.741	0.811
Root M.S.E.		0.162	0.110	0.108	0.075
Weight		None	Emp	None	Emp
F-test		0.000	1.870	0.120	0.940
(prob-value)		(0.982)	(0.177)	(0.729)	(0.338)

(b) Value-added Prices

	Mean [S.D]	Value-Added Prices	Value-Added Prices	Effective Value-Added Prices	Effective Value-Added Prices
Nonproduction Share in V.A.	0.133 [0.047]	1322 (1.953)	1.252 (1.018)	0.028 (1.282)	-0.499 (0.748)
Production Share in V.A.	0.275 [0.093]	-0.772 (0.893)	-0.607 (0.489)	-0.570 (0.613)	-0.635 (0.379)
Computer	0.017	-2021 (0.126)	-1950 (0.129)	1928 (0.078)	2008 (0.087)
R-squared		0.301	0.495	0.529	0.695
Root M.S.E.		0.387	0.252	0.261	0.188
Weight		None	Emp	None	Emp
F-stat		2.620	3.550	0.440	0.040
(prob-value)		(0.111)	(0.065)	(0.512)	(0.851)

Notes:

1. Means and standard deviations of the dependent variables as in Table 5A, panel (a).

2 F-statistic for test of equality of coefficients for nonproduction and production share.

3. Means and standard deviations for independent variables are for unweighted regressions. The corresponding unweighted figures are: nonproduction share in output, 0.076[0.039]; production share in output, 0.138[0.043]; nonproduction sham in value-added, 0.147[0.048]; production share ill value-added, 0.283[0.079].

TABLE 8B

Relative Price Changes **and Implied** Relative Wage Changes:

College-Noncollege Workers, 1979-89

(a) *Output Prices*

	Mean [S.D]	output Prices	Output Prices	Effective Output Prices	Effective Output Rices
College Share in Output	0.030 [0.022]	-0.305 (2.403)	1.136 (1.099)	-0.649 (1.492)	0.599 (0.592)
Noncollege Share in Output	0.162 [0.064]	0.134 (0.294)	0336 (0.256)	0.085 (0.207)	-0.018 (0.205)
Capital costs	-0.040 [0.013]	-15.005 (5.042)	-11.159 (2.436)	-11.622 (3312)	-9.050 (1.496)
Material costs	0.230 [0.066]	1.041 (0338)	1.519 (0.293)	1.022 (0.207)	1.276 (0.180)
Computer	0.017	-0.866 (0.128)	-0.797 (0.111)	1.084 (0.079)	1.093 (0.067)
R-squared		0.686	0.789	0.742	0.835
Root M.S.E.		0.162	0.113	0.108	0.077
Weight		None	Hours	None	Hours
F-test (prob)		0.040 (0.851)	0.510 (0.478)	0260 (0.615)	0940 (0.336)

(b) *Value-added Prices*

	Mean [S.D]	Value-Added Prices	Value-Added Prices	Effective Value-Added Prices	Effective Value-Added Prices
College Share in V.A.	0.060 [0.029]	2.858 (2.639)	2.005 (1545)	0.206 (1.652)	-0.085 (1.004)
Noncollege Share in V.A.	0.348 [0.102]	-0.497 (1.009)	-0.162 (0.543)	0.493 (0.690)	-0.465 (0.430)
Computer	0.017	-2.071 (0.143)	-1918 (0.136)	1931 (0.084)	1391 (0.077)
R-squared		0.304	0.534	0.528	0.730
Root M.S.E.		0386	0.265	0261	0.200
Weight		None	Hours	None	Hours
F-test (prob)		3.170 (0.081)	2490 (0.121)	0.390 (0.537)	0.200 (0.658)

Notes:

1. Means and standard deviations of the dependent variables as in Table 5B, panel (a).
2. F-statistic for test of equality of coefficients for nonproduction and production share.
3. Means and standard deviations for independent variables are for unweighted regressions. The corresponding unweighted figures are: college share in output, 0.036[0.023]; noncollege share in output 0.178[0.054]; college share in value-added 0.063[0.031]; noncollege share in value-added. 0.319[0.115].

Table 9A
Weighted Relative Price Changes by Skill Level:
Production-Nonproduction Workers

	output Prices	Effective Output Prices	Value-Added Prices	Effective Value-Added Prices
(a) 1979-89				
Nonproduction	0.518	0.539	0.620	0.687
Production	0.473	0.5 12	0.566	0.669
Difference	0.045	0.027	0.054	0.018
(b) 1969-79				
Nonproduction	1.024	1.063	1.370	1.445
Production	1.016	1.050	1.375	1.445
Difference	0.008	0.013	-0.005	0.000
(c) 1959-69				
Nonproduction	0.156	0.255	0.161	0.347
Production	0.147	0.244	0.162	0.353
Difference	0.009	0.011	-0,001	-0.006

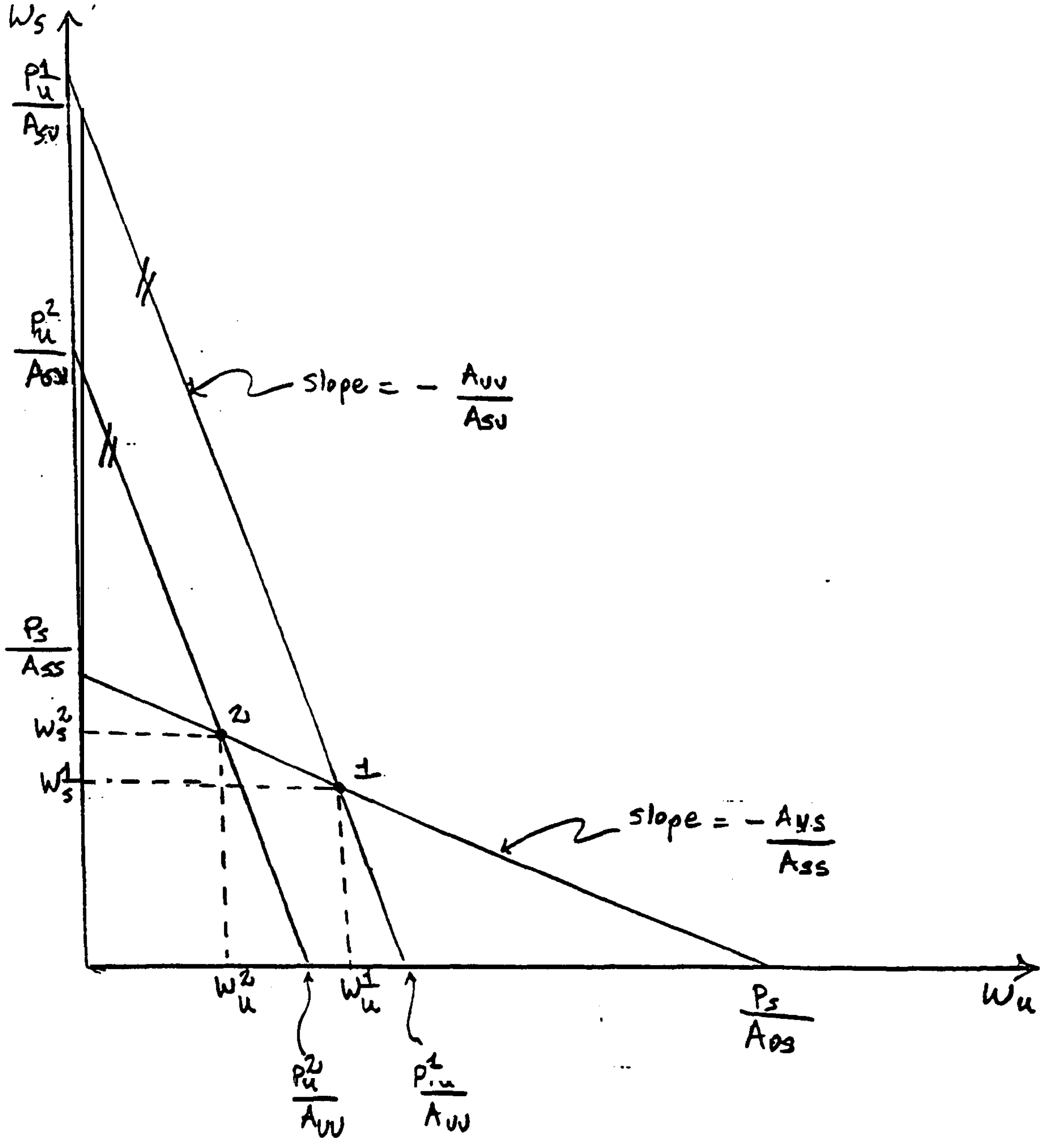
Table **9B**

Weighted Relative Price Changes by **Skill Level:**

College-Noncollege Hours

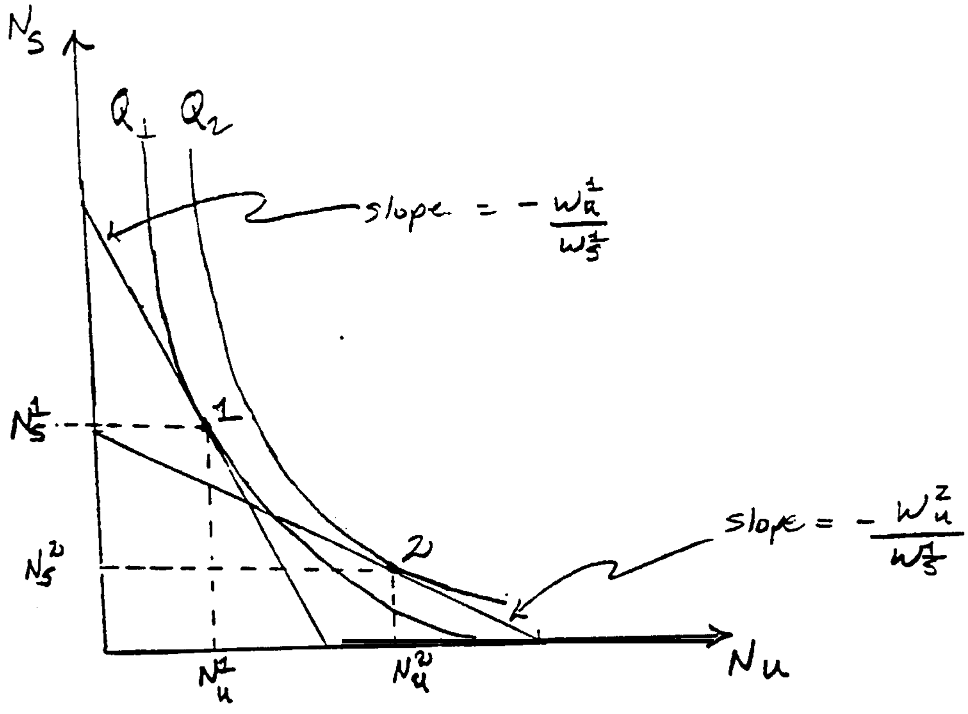
	output Prices	Effective output Prices	Value-Added Prices	Effective Value-Added Prices
(a) 1979-89				
College	0.502	0.530	0.614	0.703
Noncollege	0,487	0.522	0.585	0.680
Difference	0.015	0.008	0.029	0.023
(b) 1969-79				
College	1.102	1.133	1.595	1.649
Noncollege	1.035	1.067	1.428	1.489
Difference	0.067	0.066	0.167	0.160
(c) 1959-69				
College	0.147	0.256	**0.129**	0.368
Noncollege	0.153	0.248	0.151	0.356
Difference	-0.006	0.008	-0.022	0.012

Figure 1



W_s
$\frac{P_u^1}{A_{su}}$
$\frac{P_u^2}{A_{su}}$
$\frac{P_s}{A_{ss}}$
W_s^2
W_s^1
slope = $-\frac{A_{uu}}{A_{su}}$
slope = $-\frac{A_{us}}{A_{ss}}$
2
1
W_u^2
W_u^1
$\frac{P_u^2}{A_{uu}}$
$\frac{P_u^1}{A_{uu}}$
$\frac{P_s}{A_{us}}$
W_u

Figure 2



N_s
Q_1
Q_2
slope = $-\frac{w_u^1}{w_s^1}$
1
N_s^1
N_s^2
2
slope = $-\frac{w_u^2}{w_s^1}$
N_u^1
N_u^2
N_u

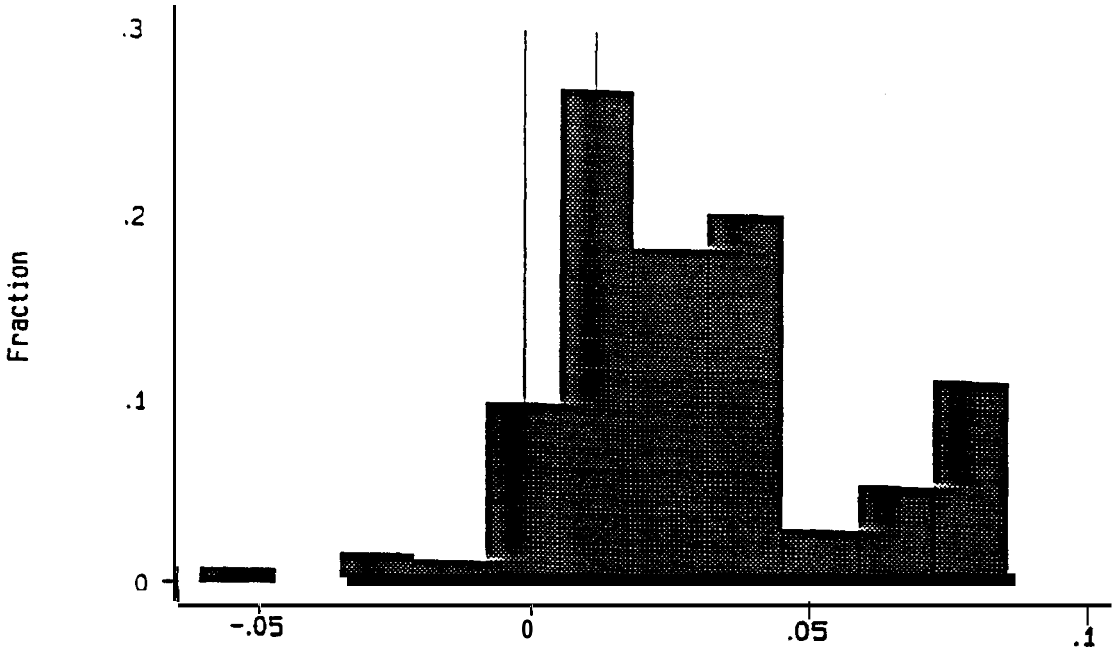


Fig 3: Change in nonprod. share, 1979-89

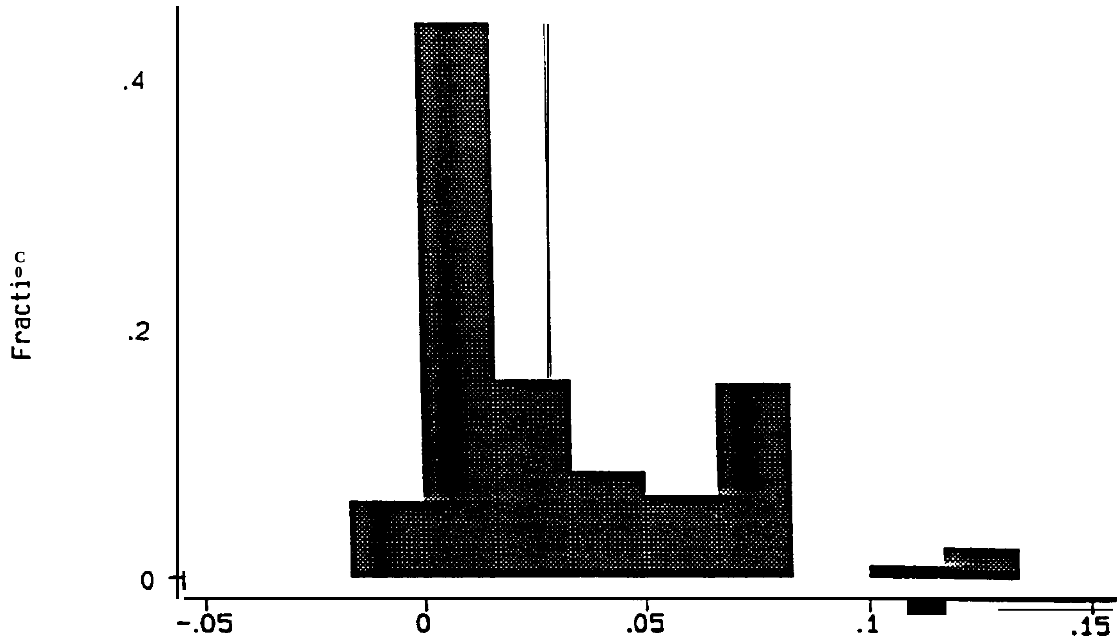


Fig 4: Change in college share, 1979-89

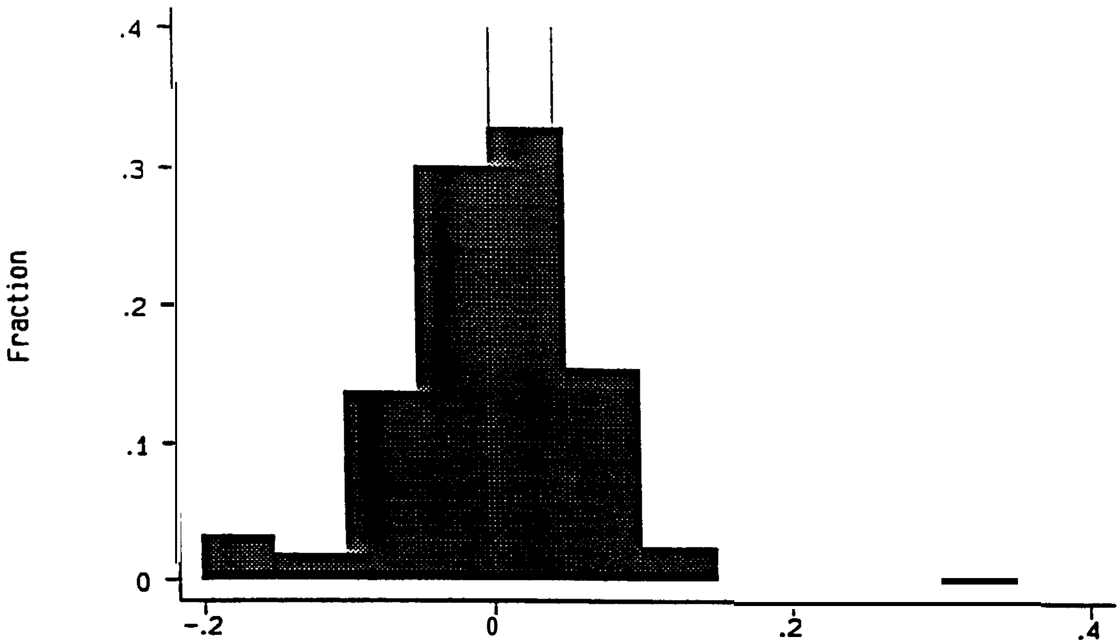


Fig 5: Change in top fixed-wage share, 1979-89