Working Paper No. 331

Skills, Computerization, and Earnings in the Postwar U.S. Economy

by
Edward N. Wolff

May 2001

The U.S. economy has undergone major structural changes over the postwar period. First, employment has shifted from goods-producing industries to services. Second, since the 1970s at least, there has occurred a rapid increase in the introduction of new information-based technologies. Third, this has been accompanied by substantial adjustments in operations and organizational re-structuring of firms. Fourth, concomitant with these changes has occurred increasing competition from imports and greater orientation toward exports.

In this paper, I consider how these sources of structural change have affected wage movements in the American economy. In addition, I confront a seeming paradox -- namely, that while skill levels and educational attainment of the labor force continued to rise after 1973, real wages have fallen. The trend is slightly different when we consider both wages and salaries and the fringe benefits provided by employers, which have increased slightly since 1973. However, even in this case, employee compensation exhibits a substantially smaller rise than the increase in skills and schooling levels after the early 1970s.

The paper begins with a summary of some of the recent literature on wage trends in the U.S. economy. The second part presents statistics on trends in the real wage and employee compensation. Alternative wage series are used, including average hourly earnings of nonsupervisory employees and the Employment Cost Index. Trends in earnings will be compared with those of skills, schooling, and productivity.

The third part of the paper examines wage trends at the industry level. It will be clear that wages have changed more in some industries than in others -- particularly, as between goods and service industries. Changes in overall wage levels result from both changes in wages at the industry level and shifts in employment across industries. Section 3 will present a decomposition of overall wage changes into these two components.

Regression analysis is employed in Section 4 to relate the change in wages to changes in average skill levels and human capital such as educational attainment and mean years of experience and to various measures of technological activity, including total factor productivity growth, changes in computer intensity, and research and development intensity. Other factors considered are international trade, the shift of employment to services, and changes in the minimum wage and union density. The regressions are performed at both the aggregate and the industry level.

REVIEW OF PREVIOUS LITERATURE

In contrast to the literature on rising earnings inequality, there has been relatively little work done to explain the growth of average wages in the United States, particularly its slowdown after 1973. Levy and Murnane (1996a) point to skills as an important determinant of changes in earnings. They reported as one of their major findings that employers are now screening employees more on actual skills possessed rather than simply years of schooling or college degree. Using two large sets of panel data, the first of high school graduates in 1972 and the second of high school graduates in 1980, they examined whether the relation between math and reading scores on standardized tests and the earnings of the high school graduates six years after graduating. They found that the correlation between earnings and test scores was higher for the later panel than the earlier one and that high math test scores were, in particular, more highly correlated with wages for the later graduates. They identified several "basic skills" that were now more highly valued by employers: (i) the ability to read and perform mathematics at a ninth-grade level; (ii) effective oral and writing communications skills; (iii) ability to work effectively with workers from different social, racial, and ethnic backgrounds; and (iv) computer skills. The policy message emanating from this work is that the content of education -- that is, what the student actually learns -- not years of schooling, is crucial to success in the labor market.

Some have maintained that technology is the main culprit. Johnson and Stafford (1993) argued that the erosion of large returns from American technological leadership has been the principal factor in explaining the stagnation of American wages since 1973. Acs and Danziger (1993), using CPS data over the period 1979 to 1989, reported that average earnings had declined among male workers. They attributed the decline mainly to increases in the returns to education and experience, which they interpreted as deriving mainly from technological change. They did not find any significant effect from shifts in industrial employment patterns on the basis of 13 broad industry grouping.

Another view is that the expansion of international trade after 1973 was a principal factor in explaining wage stagnation. The prevailing argument derives from the Heckscher-Ohlin model of international trade. As Leamer (1992) argued, increased capital formation among American trading partners abroad has led toward factor price equalization -- in particular, wage equalization across countries. Wage convergence can come about either through a rise in wages among America's trading partners or through a decline in U.S. wages. It is likely that the latter trend has dominated over the last three decades. Wood (1994) makes a similar argument.

Lawrence and Slaughter (1993) concluded that international trade played almost no role in explaining the slow growth of worker compensation since the 1970s, especially in relation to labor productivity growth. Instead, using aggregate time-series data for the U.S. business sector, they found that the stagnation of real wages in the U.S. (and its convergence with that of trading partners) was due mainly to slow productivity growth in the nontraded goods sectors of the American economy between 1979 and 1991. Indeed, worker compensation deflated by production prices (instead of the CPI) grew just as rapidly as worker productivity over this period.

Others looked to institutional factors, such as unionization and the minimum wage. Freeman (1993) argued that the decline of unions in the American economy and/or the decline in the real value of the minimum wage since the late 1960s removed the "safety net" supporting the wage level of unskilled workers, thereby allowing it to fall. Ferguson (1996), using three-digit industry level data on unionization and aggregate time series data on wages over the period 1978-1986, estimated that 18 percent of the increase in the gap between real wage growth and aggregate labor productivity growth could be ascribed to the decline in unionization and perhaps another 25 percent to the declining ability of unions to raise wages.

Gordon (1996) argued that the change in these two factors was part of a broader range of institutional changes in the 1980s in which American corporate mangers exerted increasing pressure on workers, partly in reaction to rising international competition. Gordon further documented the declining real wage of American workers and argued that the growing power of management and the concomitant decline in worker power were largely responsible for this trend. Reich (1998) took issue with Gordon and reported that most of the increase in managerial labor occurred in the early part of the postwar period, when labor power was increasing.

Industry Level Wages

A couple of recent studies have looked at the relation between industry technological change and industry wages. Using CPS data for 1979 and 1989 segmented into 39 industries, Allen (1996) found that returns to schooling are higher in industries that are intensive in R&D and high-tech capital and that wage differentials between industries are positively related to R&D intensity, intensity of usage of high-tech capital, capital vintage, the growth in total factor productivity, and the growth of the capital-labor ratio. However, Bartel and Sicherman (1997), matching industry level measures of technological activity to the National Longitudinal Survey of Youth over the 1979-1993 period and controlling for individual fixed effects, found no evidence that the industry wage premium was correlated with the industry rate of technology change.

Several have looked at the effects of trade on industry level wages. Freeman and Katz (1991) found from regressing industry level wages on industry imports and exports that the former had a depressing effect on wages while the latter had a positive effect. Davis (1992), using industry level wage data from nine advanced countries and four middle-income countries, found that the growth of the import share induced a large and statistically significant convergence toward the average structure of relative industry wages, while the growth in export share caused a smaller but statistically significant divergence. Gaston and Treffler (1994), using 1984 CPS data with worker characteristics matched with trade data, reported that exports had a positive wage effect and imports a smaller negative wage effect, even after controlling for worker characteristics.

Levy and Murnane (1992) concluded in their survey of sources of earnings inequality that firm- and plant-specific effects are important sources of earnings differences among workers. Davis and Haltiwanger (1991), using data on U.S. manufacturing plants from 1963 to 1986, provided some evidence of this, particularly that one half of the total wage variation among manufacturing workers was accounted for by differences in average wages among plants. Moreover, these plant specific effects on wages were associated with such factors as plant size and age, industry, and capital intensity. Groshen (1991) provided similar evidence -- namely, that occupation and establishment along explained over 90 percent of the variation of wages among blue-collar workers.

Dunne and Schmitz (1992), also using manufacturing plant data, estimated that workers at establishments classified as the most technology intensive earned 16 percent more than those at the least technology intensive plants. Dunne, Foster, Haltiwanger, and Troske (2000), using more recent establishment data, concluded that a substantial portion of the rising dispersion in wages is due to increases in wage differentials between establishments. The latter, in turn, are attributable to plant-level productivity differences and are correlated with both computer intensity and overall capital intensity.

Other factors considered in the literature include profitability. Blanchflower, Oswald, and Sanfey (1996), using panel data for the manufacturing sector derived from the CPS over the period 1964 to 1985 and controlling for workers' characteristics, unionization, and industry fixed effects, concluded that a rise in an industry's profitability leads after a lag to increased average wages within the industry. They estimated that rent-sharing alone may account for as much as one quarter of earnings inequality among full-time workers.

OVERALL EARNINGS TRENDS

Figure 1 and Table 1 document trends in both overall average wages and salaries and overall average employee compensation, defined as wages and salaries plus the fringe benefits provided by employers, over the period from 1947 to 1997. I have used as wide an assortment of measures of labor compensation as possible from available data sources. Fortunately, the results are surprisingly consistent among these alternative series. These include the Bureau of Labor Statistics series on hourly wages and salaries of production and non-supervisory workers in the total private sector and the Employment Cost Index (ECI) for all workers in private industry; National Income and Product Account (NIPA) data on employee compensation for all workers, including those employed in the government; and Current Population Survey data on median and mean earnings for year-round, full-time workers. In the case of the NIPA data, I also include a portion of proprietors' income in my measure of total labor earnings and divide this total by the sum of employed and self-employed workers. The reason for including only a portion of proprietors' income is that part of the income of self-employed workers is a return on the capital invested in unincorporated businesses. The results show that the resulting time-series is quite insensitive to the fraction used in the calculation.

The data show a very rapid growth in wages and salaries over the period 1947-1973, where it peaks in almost every series, followed by a moderate decline between 1973 and 1997. For the period before 1973, annual growth rates for wages and salaries are in the range of 1.8 to 2.7 percent. For the period 1973-1997, four of the seven series show a decline in real earnings, ranging from -0.1 to -0.8 percent per year, while the other three show either no change or a very modest increase (at most, 0.3 percent per year). All the wage series except one show some pick up in wage growth (or, at least, a smaller decline) in the period after 1989, compared to the 1973-89 period.

The results are somewhat different for total employee compensation, the sum of wages and salaries and fringe benefits. As with real wages and salaries, all series show robust growth in the period before 1973, ranging from 2.6 to 2.7 percent per year. For the 1973-1997 period, the data show a slight increase, of about 0.1 to 0.2 percent per year. Here, too, the growth in compensation seems to accelerate somewhat after 1989. A comparison of lines 3 and 12 indicates the reason for the difference in time trends between wages and salaries on the one hand and total employee compensation on the other hand. While the former have remained relatively flat after 1973, employee benefits have risen very rapidly, at 1.2 percent per year.

Wages and Skills on the Aggregate Level

One of the most perplexing issues of recent years is that despite the continued growth in educational attainment and even workplace skills, real earnings have stagnated since the early 1970s. Figure 2 shows time trends for selected measures of schooling, skills, and employee compensation, covering the period 1947 to 1997. Median years of schooling among all people 25 years old and over grew from 9.0 years in 1947 to 13.1 in 1997. Most of the gain occurred before 1973. Between 1947 and 1973, median education increased by 3.3 years and from 1973 to 1997 by another 1.0 years.

Trends are even more dramatic for the percentage of adults who completed high school and college (results not shown). The former grew from 33 percent of all adults in 1947 to 82 percent in 1997. Progress in high school completion rates was just as strong before and after 1973 -- from 33 percent in 1947 to 60 percent in 1973 and from 60 percent in 1973 to 82 percent in 1997. The percent of college graduates in the adult population soared from 5.4 percent in 1947 to 24.1 percent in 1997. In this dimension, progress was actually greater after 1973 than before. Between 1947 and 1973, the percentage of adults who had graduated college rose by 7.2 percentage points, while between 1973 and 1997, it grew by 11.5 percentage points.

My skill measures are derived from the fourth (1977) edition of the Dictionary of Occupational Titles (DOT) for my skill measures. For some 12,000 job titles, it provides a variety of alternative measures of job-skill requirements based upon data collected between 1966 and 1974. This probably provides the best source of detailed measures of skill requirements covering the period 1950 to 1990. Three measures of workplace skills are developed from this source for each of 267 occupations, as follows (see Wolff, 1996, for more details):

1. Substantive Complexity (SC) is a composite measure of skills derived from a factor analytic test of DOT variables. It was found to be correlated with General Educational Development, Specific Vocational Preparation (training time requirements), Data (synthesizing, coordinating, analyzing), and three worker aptitudes - Intelligence (general learning and reasoning ability), Verbal and Numerical.

2. Interactive Skills (IS) can be measured, at least roughly, by the DOT "People" variable, which, on a scale of 0-8, identifies whether the job requires mentoring (0), negotiating (1), instructing (2), supervising (3), diverting (4), persuading (5), speaking-signaling (6), serving (7) or taking instructions (8). For comparability with the other measures, this variable is rescaled so that its value ranges from 0 to 10 and reversed so that mentoring is now scored 10 and taking instructions is scored 0.

3. Motor Skills (MS) is another DOT factor-based variable. Also scaled from 0 to 10, this measure reflects occupational scores on motor coordination, manual dexterity and "things" - job requirements that range from setting up machines and precision working to feeding machines and handling materials.

Average industry skill scores are computed as a weighted average of the skill scores of each occupation, with the occupational employment mix of the industry as weights. Computations are performed for 1950, 1960, 1970, 1980, and 1990 on the basis of consistent occupation by industry employment matrices for each of these years constructed from decennial Census data. There are 267 occupations and 64 industries.

4. Composite Skills. I also introduce a measure of composite skill, CS, which is based on a regression of hourly wages in 1970 on SC, MS, and IS scores across the 267 occupations (see the next section). The resulting formula is:

$$CS = 0.454\ SC + 0.093\ MS + 0.028\ IS$$

A fifth measure derived from Census data is also used:

5. Mean Years of Schooling. These are derived directly from decennial Census of Population data for years 1950, 1960, 1970, 1980, and 1990.

According to the indices used, there is no evidence of a slowdown in the growth of Substantive Complexity or Interactive Skills after 1973. The former index increased by 0.41 points between 1947 and 1973 and by 0.43 from 1973 to 1997, and the latter index by 0.09 and 0.11, respectively. On the other hand, the Motor Skills index rose by 0.03 in the earlier period and fell by 0.23 in the later one. The Composite Score index gained 0.20 from 1947 to 1973 and 0.19 from 1973 to 1997.

It is at once apparent from Figure 2 that average earnings tracked both schooling and skills very closely from 1947 to 1973 but after 1973 the time paths deviated from each other. Correlation coefficients shown in Table 2 confirm these observations. Over the 1947-1973 period, BLS mean hourly earnings are almost perfectly correlated with trends in both Substantive Complexity (SC) and the Composite Skill Index (CS); median years of schooling, the percent of high school graduates, and the percent of college graduates among persons age 25 and over; and the mean years of schooling of the labor force. However, over the 1973-1996 period, the reverse is true: mean wages are almost directly inversely correlated with both skill levels and educational levels, with correlation coefficients ranging from -0.84 to -0.94.

Like BLS hourly earnings, NIPA mean wages and salaries and NIPA mean employee compensation are also almost perfectly correlated with skill levels and schooling levels over the period form 1947 to 1973. Over the 1973-1997 period, NIPA mean earnings have virtually zero correlation with both skill and schooling levels. Results for the post-1973 period are better for NIPA mean employee compensation. In this case, the correlation coefficients are positive, ranging from 0.57 to 0.61, though still smaller than the correlation coefficients for the pre-1973 period. In sum, for all three earnings measures, a significant break is evident in the association of wages to both skills and schooling in the early 1970s.

A few words should be said about another apparent anomaly, which is that the historical connection between labor productivity growth and real wage growth also appears to have broken down after 1973. In the case of an economy characterized by an aggregate Cobb-Douglas production function, wages and labor productivity should be perfectly correlated. In this case,

$$y = n^{a}k^{(1-a)}$$

where y is total output, n is total employment, k is the total capital stock, and α is the wage share. Labor productivity is given by:

$$y/n = (k / n)^{(1-a)}.$$

The real wage w is given by:

$$w = \partial y/\partial n = \alpha n^{(a-1)}\ k^{(1-a)}$$

$$w = \alpha(k/n)^{(1-a)}$$

$$(1)\quad w = \alpha(y/n)$$

Moreover, it directly follows by taking the time derivative of equation (1) that the growth in wages (w^*) should be equal to that of labor productivity ($y^* - n^*$):

$$(2)\quad w^* = y^*-n^*$$

From 1947 (if not earlier) to 1973, real wages grew almost in tandem with the overall labor productivity growth. As shown in Table 2, the correlation coefficients between the two measures of labor productivity and the three indices of real wages range from 0.99 to 1.00 for this period.

Labor productivity growth plummeted after 1973. Between 1947 and 1973, it averaged 2.0 or 2.4 percent per year, depending on the measure, while from 1973 to 1997 it averaged about 0.8 percent per year (see Panel C of Table 1). The period from 1973 to 1979, in particular, witnessed the slowest growth in labor productivity during the postwar, 0.5 percent per year, and the growth in real wages actually turned negative during this period by all measures. Since 1979, the U.S. economy experienced a modest reversal in labor productivity growth, which averaged 0.9 percent per year by both measures from 1979 to 1997, while real wage growth ranged from -0.2 to 0.6 percent per year, depending on the index. Consequently, for the 1973-1997 period, the correlation coefficients between labor productivity and real earnings are substantially lower than in the early postwar period -- (highly) negative in the case of hourly earnings, slightly positive in the case of NIPA mean wages and salaries, and a value of 0.76 in the case of average employee compensation. In section 4 below, we will return to the issue of how well wages have tracked labor productivity movements.

Wages, Skills, and Educational Attainment on the Occupational Level

The evidence thus far suggest a growing bifurcation between wages and skills at least since the early 1970s. This leads to the intriguing issue of whether the returns to skill (and education) have declined over this period as well.

I first consider the relation between wages and skills on the occupational level. The results for the different components of workplace skill are shown in Table 3. For 1970, Substantive Complexity (SC) is the most important factor in determining relative wages, both in terms of coefficient value and significance level (at the one percent level), followed by Motor Skills (MS), significant at the 5 percent level, and Interactive Skills (IS), which is not significant.

There are some notable changes over time. The return to cognitive skills, both in terms of its coefficient value and its significance level rose markedly between 1950 and 1970, fell off sharply in 1980, and then recovered somewhat in 1990, though its coefficient value for 1990 was still below the corresponding value for 1970. The returns to Motor Skills also show a sharp increase between 1950 and 1960, with the coefficient value more than doubling and its significance level rising from 10 percent to 1 percent. After 1960, the returns to Motor Skills decreased, with the coefficient declining by about a third by 1990 and its significance level falling again to the 10 percent level. In contrast, the returns to Interactive Skills have gradually risen over time. In 1950, its coefficient was actually negative, though not significant. Its coefficient reached 0.085 and was significant at the five percent level by 1980 and rose to 0.15 and the one percent significance level by 1990. Indeed, in 1990, Interactive Skills were second in importance to cognitive skills as a determinant of occupational wages.

Table 4 shows estimates of the return to educational attainment on the basis of data from the same set of occupations. Two regression forms are employed. The first ("Regression Form 1") uses the standard human capital earnings equation, with the logarithm of wages as the dependent variable and mean years of schooling, mean age, and the square of mean age as independent variables (see, for example, Mincer, 1974). The schooling and the age variables are all significant, generally at the one percent level, and with the predicted signs. The return to schooling (the coefficient on mean schooling) rose sharply between 1950 and 1990, from 8.5 percent to 14.2 percent. The increase was continuous over the five years, except for a slight dip in 1980. The goodness of fit (as measured by the adjusted R^2 statistic) almost doubled between 1950 and 1990 and the rise was again continuous over time except for a slight decline in 1980.

The second regression form substitutes the percentage of workers at various levels of educational attainment for mean years of schooling in each occupation. This substitution improves the goodness of fit in all years except 1960 (where there is no change in the adjusted R^2 statistic). Here, again, it is clear that the returns to schooling rose almost monotonically over time, from 1950 to 1990, particularly for college graduates and for those with more than four years of college.[1]

The two tables show a rather different pattern in the returns to workplace skill in comparison to educational attainment. In particular, the evidence suggests, rather surprisingly, that the return to cognitive abilities, after rising steeply between 1950 and 1970, has since fallen off rather substantially. In contrast, the returns to schooling, particularly at the college and advanced levels, climbed almost continuously between 1950 to 1990. This is consistent with the general evidence that the returns to a college degree relative to a high school diploma increased over the last three decades (see, for example, Katz and Murphy, 1992). Moreover, while the explanatory power of the human capital earnings regressions increased almost monotonically over time, from 1950 to 1990, the goodness of fit of the skills regression peaked in 1970. I shall return to this issue in the conclusion of this chapter.

Another interesting result is that while the returns to cognitive skills fell after 1970, the returns to Motor Skills have also declined, in this case since 1960. In contrast, Interactive Skills have been growing in importance since 1950 and by 1990 had overtaken Motor Skills in explaining occupational earnings. These results suggest that the workplace is rewarding people skills more over time and cognitive skills less, at least since 1970. This finding appears to conflict with the findings of Levy and Murnane (1996b) that cognitive abilities have become more important in the workplace over time.

INDUSTRY EFFECTS AND OVERALL WAGE GROWTH

Changes in average earnings are due to both changes in wages on the industry level and shifts of employment between low-wage and high-wage industries. In this section, I examine whether the stagnation of real wages that has occurred over the last two and a half decades is primarily attributable to across-the-board wage declines on the industry level or to the shift of workers from high-wage industries (such as durables manufacturing) to low-wage ones (such as retailing).

Table 5 shows average earnings by major sector in 1970 relative to the overall mean. By all three measures, agriculture had by far the lowest earnings (about half of the overall level), followed by retail trade (about three fourths of the overall level), and other services (about 80 percent of the overall figure). The best paying sector by all three measures is utilities (30 to 43 percent above average), followed by mining, construction, durable manufacturing, transportation, and communications (the rank order of the five sectors varies a bit depending on the measure). Goods producing industries pay about 10 percent above average, while services pay about 7 or 8 percent below average.

The spread is even more extreme on the basis of data for individual industries. The ratio of average employee compensation to the overall average in 1970 ranged from lows of 0.25 in private households, 0.44 on farms, 0.62 in hotels, 0.66 in personal services, and 0.68 in retail trade to highs of 1.57 in transportation equipment (including automobiles), 1.63 among security and commodity brokers, 1.67 in air transportation, and 1.81 in petroleum and coal products.

Table 5 also shows the percentage increase of average earnings by major sector over the 1950-97 period. Here, also, there is considerable variation. For employee compensation, the range is from a paltry 19 percent in retail trade to 162 percent in communications. Goods industries overall have seen faster growth in earnings than services between 1950 and 1997 (about a 10 percentage point difference).[2]

Changes in the overall earnings level are a result of both changes in the wage levels of individual industries and employment shifts among industries. The former is usually interpreted to reflect changes in technology within the industry, as well as other industry specific factors such as the presence of unions and exposure to import competition. The latter depends mainly on changes in demand patterns among consumers.

The formal decomposition is as follows. Let
P = (row) vector showing the distribution of employment among industries.

E = (column) vector showing average earnings by industry.
e = PE = overall average earnings of employees.

Since our data are for discrete time periods, then

$$(3)\ \Delta e = P\Delta E + (\Delta P)E$$

where $\Delta E = E^2 - E^1$, $\Delta P = P^2 - P^1$, and superscripts refer to time period. The results are based on average period weights, which provides an exact decomposition. The first term on the right-hand side of equation (1) measures the effect of changes in the wage levels within industry, while the second term measures the effect of shifts in industry employment.

Table 6 shows the results of this decomposition. For both the 1950s and the 1960s, over 90 percent of the change in average earnings was due to changes in mean earnings within industry according to all three earnings measures. The employment shift effect, on the other hand, was minimal.

This is not to say that employment was not shifting among industries during these years. Three major changes occurred. First, employment shifted out of low wage agriculture (a 1.4 percentage point decline in farm employment in the 1950s and a 1.6 percentage point decline in the 1960s). Second, there was an offsetting decline in employment share in high-paying manufacturing (a 2.35 percentage point drop for the entire sector in both the 1950s and the 1960s). Third, there were substantial gains of employment in the government sector, particularly state and local government, which paid close to average wages (a 2.8 percentage point increase in the 1950s for the entire government sector and a 1.9 percentage point increase in the 1960s). However, the employment shifts were, on net, offsetting (actually slightly positive with regard to the change in average earnings).

The period after 1970 saw four major changes. First, wage gains on the industry level fell off sharply after 1970 compared to the two preceding decades (indeed, in the case of average wages and salaries, the change was negative in the 1970s). Second, by 1970 employment in agriculture had fallen to 2.0 percent of total employment, so that further declines in the agricultural share had a minimal effect on average earnings. Third, the decline in the share of total employment in high wage manufacturing continued unabated after 1970--indeed, accelerated (the share dropped by 3.6 percentage points in the 1970s, 4.5 points in the 1980s, and 1.4 points in the 1990-97 period). Fourth, government employment as a proportion of total employment actually peaked in 1970 and fell off thereafter.

As a result, the employment released from manufacturing was absorbed primarily in relatively low paying service industries, and the employment shift effect turned negative in the 1970s, 1980s, and 1990s. This coupled with the smallest growth of earnings on the industry level of any the five decades (negative in the case of mean wages and salaries) led to the lowest annual increase of earnings during the 1970s of the five decades.

During the 1980s, earnings on the industry level grew considerably faster than in the 1970s, while the employment shift effect became even more negative. However, on net, average earnings increased faster during this decade than in the 1970s. During the period from 1990 to 1997, earnings growth on the industry level again slowed, while the employment shift remained negative, so that overall earnings growth again diminished.

Over the whole 1950-97 period, the predominant effect on overall earnings growth came from the growth of earnings on the industry level. This was due to the very large increases of industry earnings during the 1950s and 1960s. On net, the industry shift effect was negative but relatively small -- resulting in an 8 percent decline in average wages and salaries, a 9 percent decline in average employee compensation, and only a 3 percent decline in average employee compensation plus half of proprietors' income. These results accord with those of Bound and Johnson (1992) and Katz and Murphy (1992), who also found that the change of earnings on the industry level was the main determinant of overall earnings growth over similar periods. However, for the period 1970-1997, because there were no further gains in average wages from the release of labor from agriculture, employment shifts offset increases in industry earnings by between 27 and 47 percent, depending on the measure used.

DETERMINANTS OF WAGE CHANGES

I next investigate the factors that affect wage growth on both the aggregate and the industry level. I first consider the relation between changes of wages and the change in both average skill levels and human capital. Other factors include (1) technological change such as productivity growth and computerization, (2) international trade, (3) structural dimensions such as the split of employment between goods and service industries, (4) and institutional characteristics such as union density.

How does technological change affect wages? The role of the characteristic stages of the innovation process is somewhat complicated. Economic historians emphasize that, typically, when new technology or products reach the market they are relatively difficult to use, unreliable and in need of frequent attention, and limited in their range of application. Introduction is followed by a relatively long period of improvement that increases reliability, expands uses and makes them user friendly. This is the period in which standard measures of technical change (such as total factor productivity or TFP) show steady growth. Clear examples range from Watt's improved steam engine to the electronic computer.

The introduction of new technology thus appears to have two phases. In the first, the development and implementation of new inventions calls forth the need for highly skilled and educated workers and therefore higher paid employees. As a result, the initial period should be characterized by rising wages. The second stage, user friendliness, appears to reverse the process, making it easier for the unskilled to work with the new items. The simplification of technology and its routinization reduces the need for highly skilled and educated workers and makes its use by unskilled and low paid workers easier, increasing their demand. This phase should therefore see a reduction in average wages.[3]

If we accept this argument, then R&D activity, which is an indicator of the development of new technology, should be positively correlated with the growth in earnings. In this regard, the evidence is mixed. Industry R&D expenditures as a share of GDP rose between the 1950s and the 1960s, fell off in the 1970s, increased once again in the 1980s, and then stabilized in the 1990s (see Figure 3.) As a result, it is positively correlated with wage changes over time. However, scientists and engineers engaged in R&D per employee rose almost continuously between the late 1950s and the 1990s, and this variable is negatively correlated with earnings changes.

With regard to investment, the prevailing view is the capital-skills complementarity hypothesis. The argument is that greater investment may lead to a greater demand for skilled and therefore high paid labor since new capital normally embodies the latest and, presumably, more complex technology, which requires greater skills to put into operation (see, for example, Griliches, 1969). Measures of investment are used to allow for the possibility that new technology may normally be embodied in new capital, particularly new equipment and machinery. The growth in the ratio of capital stock to employment may also reflect the rate at which new vintages of capital are introduced into the industry.

A few words should be said about computerization investment. Computers are like a two-edge sword. Their introduction can radically alter the workplace, requiring high-skilled computer experts and technicians and engineers to implement the new technology and therefore be positively associated with earnings. However, once in place, computers tend to simplify tasks and thus increase the demand for low-skilled and lower paid workers.

Here, again, the results are mixed. Total equipment investment as a share of GDP trended gradually upward over time, from the late 1940s to the 1990s (see Figure 4), and this variable is slightly negatively correlated with earnings changes. In contrast, net stocks of office, computing, and accounting machinery (OCA) per worker, after rising slowly from the late 1940s to the late 1970s, accelerated in the ensuing 25 years (see Figure 4.) As a result, this variable is highly negatively correlated with earnings growth.

International competitiveness, as measured by the ratio of exports to GDP and the ratio of imports to GDP, may also affect earnings growth. There are two possibilities. One is that industries competing in international product markets or directly against imports might be forced to upgrade skills faster than domestic industries in order to remain competitive (the "high road" hypothesis). A second possibility is that such industries might be forced to compete on the basis of cost and thus have an incentive to replace high paid workers with low paid ones and downgrade skill levels (the "low road" hypothesis). As shown in Figure 5, both export and import intensity, after rising very slowly from 1947 to 1973, more than doubled between 1973 and 1997, at the same time that earnings stagnated. As a result, the two series have a strong negative correlation.

Structural and organizational dimensions of production may also affect wage growth. Unionization may be associated with earnings growth since unionized trades, firms and industries typically pay more than non-unionized ones. The unionization rate, after peaking in 1953, has fallen steadily over time (see Figure 5), and has a strong positive correlation with wage gains. The minimum wage should have a positive effect on earnings growth, since it raises wages at the bottom and may, through an "accordion effect" increase wages through the bottom of the occupational ladder. As shown in Figure 5, the minimum wage in constant dollars reached its peak value in 1968 and generally fell over time until the early 1990s before rising slightly again. As as a result, the minimum wage valued in constant dollars has small negative correlation with earnings growth.

Another factor that may affect average earnings is the shift of employment to services, since services generally pay less than goods producers. This process has been going on almost steadily over time since the 1940s. As a result, this variable has a relatively strong negative correlation with the growth in earnings.

Aggregate Time-Series Regression Analysis

I next turn to regression analysis, which is conducted in two ways. The first uses annual time series data for wage changes and the other variables of interest. The second employs pooled cross-section time-series data, covering 44 industries (see Appendix Table 1) and four time ten-year periods. The dependent variables in both sets of regressions are annual changes in earnings.

Some preliminary words should be said about interpreting the regression results. As shown in the previous section, part of the growth in earnings is due to earnings changes at the industry level and the remaining part to intersectoral shifts in employment. Some factors like import competition exercise their influence by causing some industries to grow and others to shrink. Its effect will therefore be seen in the aggregate time-series data regressions but not in the industry-level analysis. The effects of other factors such as labor productivity growth will be seen only on the aggregate level since labor market forces (barring impediments to labor mobility) will lead toward wage equality across sectors.[4] Still other variables, like the unionization rate, will affect earnings behavior directly on the industry level. This variable may not be significant in the aggregate time-series regression. The interpretation of the regression results will thus depend on the findings at the two levels of analysis.

Results from time-series regressions covering the period 1948-1997 are shown in Table 7 for four wage measures.[5] I have selected the regression form with the highest adjusted R^2-statistic (or, correspondingly, the lowest standard error of the regression).[6]

Among the technology variables, labor productivity growth has the strongest effect on earnings growth. The coefficient is positive and significant at the one percent level in every case. The coefficient values are not significantly different from the share of the earnings (for the particular measure) in GDP but are significantly different than unity. This latter result is inconsistent with an aggregate Cobb-Douglas production function, since, from Equation 2, earnings should grow at the same rate as labor productivity.[7] On the other hand, neither R&D intensity nor the number of scientists and engineers as a fraction of employment is statistically significant.

Among the investment variables, the most statistically significant is investment in equipment as a share of GDP. Its coefficient is positive and significant at either the five or one percent level in every case. The other important investment variable is the growth in office, computing, and accounting machinery (OCA) per employee. The coefficient of this variable is uniformly negative, and is significant for three of the four earnings measures.[8]

The coefficients of both export and import are statistically significant and have a strong negative effect on earnings growth. The best fit comes from the sum of total imports and exports as a proportion of GDP, whose coefficient is uniformly negative and significant at the one percent level.

The minimum wage in constant (1992) dollars has the predicted positive bearing on changes in earnings but is significant (at the five percent level) in only two of the four cases. Somewhat surprisingly, its effect is stronger on total worker compensation than on wages and salaries. However, neither the unionization rate nor its annual change over time, is statistically significant. The change in the share of service employment in total employment has a coefficient that is generally negative but it is not significant in any of the regression forms.

The human capital and skill variables are next introduced into the regressions. Following the standard human capital model (see Mincer, 1974), we have that:

$$\ln(W_i) = b_0 + b_1 S_i + b_2 A_i - b_3 A_i^2 + u_i,$$

where W_i is wages (or earnings) of worker i, S_i is the level of educational attainment of worker i, A is his or her age, and u_i is a stochastic error term. It then directly follows that the growth in mean earnings is positively related to the change in mean schooling and mean age and negatively related to the change in the square of mean age. It should also follow that the growth in mean earnings should be directly related to the change in worker skills.

However, none of the education or experience variables (including the annual change in median schooling, mean schooling, the fraction of the population with a high school degree, the fraction with a college degree, and mean years of experience) is statistically significant. Moreover, none of the skill variables (including the annual change in Substantive Complexity SC, Interactive Skills IS, Motor Skills MS, and Composite Skills CS) is significant. Indeed, the coefficients of both SC and average schooling are generally negative (see the last two columns of Table 7). Moreover, even when the labor productivity growth, equipment investment, and OCA investment variables are omitted from the regression equation, the skill and human capital variables remain insignificant (results not shown).

Because of the sharp break in all the wage series that occurs after 1973, I have also replicated the regressions for the period 1973-1997 only. These results, shown in Table 8, are remarkably similar to those presented in Table 7 based on the whole 1948-97 period, particularly for the three NIPA earnings measures. The most interesting changes occur for the BLS mean hourly earnings measure. The coefficient of the growth in OCA per employee remains significant (at the five percent level) and has a negative sign. The coefficient of the minimum wage in constant dollars is also now significant (also at the five percent level) and has the predicted positive sign. In addition, the change in the unionization rate now shows up as a significant variable (at the five percent level), with the expected positive sign.

One implication of these two sets of regressions is that the factors that account for wage changes over the "peculiar" 1973-1997 period are by and large very much the same as those which explain wage changes over the whole postwar period. Another way to test this is to include a dummy variable for the 1973-1996 period in the time-series regressions covering the whole 1948-1996 period. When this is done, the coefficient on the dummy variable is found to be negative in every case but not significant (results not shown).

INDUSTRY LEVEL REGRESSIONS

I next turn to multivariate regressions on the industry level. I use 44 industries in the regression analysis.[9] The period of analysis is 1950-1990.[10] The sample consists of pooled cross-section time-series data, with observations on each of the 44 industries in 1950-60, 1960-70, 1970-80 and 1980-90, for a total of 176 observations. The error terms are assumed to be independently distributed but may not be identically distributed and I use the White procedure for a heteroschedasticity-consistent covariance matrix in the estimation (see White, 1980).

The dependent variable in the regressions is the average annual change in earnings over the ten-year period. Generally, I use the same set of independent variables for the industry level regressions as for the aggregate ones. Results are shown in Table 9 for three earnings measures.[11] I have again selected the regression forms with the highest adjusted R^2-statistic (or, correspondingly, the lowest standard error of the regression). Dummy variables distinguishing the 1960-70, 1970-80, and 1980-90 periods from the 1950-60 period are also introduced but are not significant (results not shown).

As in the aggregate regressions, investment in both equipment and OCA remain very significant variables. The coefficients of these two variables are significant at the one percent level in all cases. The coefficient of the growth of total equipment per employee is again positive, while the coefficient of the growth in OCA per employee is again negative. In contrast to the aggregate time-series regressions, industry labor productivity growth (as well as TFP growth) is not found to be a significant determinant of wage changes on the industry level.

The change in exports as a share of total sales is also found to have a negative effect on wage changes in all cases. Its coefficient is significant at the one percent level in regressions without human capital variables and is significant at only the 10 percent level in regressions that include such variables. However, none of the other trade variables, including (the level of) either exports or imports as a percent of total sales, and the change in the share of imports in gross output, is significant.

A dummy variable discriminating between service and goods industries is also introduced and found to be significant in a few cases. The coefficient is negative, indicating that once controlling for other factors, earnings compensation growth tends to be lower in services than among goods producers. Human capital variables are also introduced. In only one of the three cases does the change in mean education within an industry have a positive effect on industry earnings, and even here its coefficient is significant at only the 10 percent level. The change in mean age is a more powerful variable, significant at the one percent level in two of the three cases and at the ten percent level in the other. However, it is unclear whether the higher wages associated with an older work force reflect the productivity enhancing effects of work experience or the higher wages paid on the basis of seniority. The fact that the age squared variable is generally insignificant suggests the latter interpretation.

As in the aggregate regressions, none of the R&D variables or the number of scientists and engineers engaged in R&D per employee, is found to be statistically significant. Nor are any of the skill change variables significant, including Substantive Complexity, Interactive Skills, Motor Skills, and Composite Skills. Somewhat surprisingly, the unionization rate, as well as the change in the rate of unionization over the period, also turn out to be insignificant. Regressions run over different sub-periods do not materially differ from those reported in Table 9 for the whole 1950-90 period.

In sum, when we consider both the aggregate time-series and the pooled cross-section industry results, we find that average earnings has a strong correlation with labor productivity on the aggregate level but not on the industry level. A similar result was reported by Leslie (1985) on the basis of regression analysis on twenty two-digit manufacturing industries over the period 1948-1976. This makes sense since labor market forces will tend to equalize wages across industries unless there are barriers, such as imposed by unions, to cross-industry labor mobility.[12] Other technological factors such as R&D investment do not affect wages directly but may affect them indirectly by stimulating productivity growth.

Both investment in equipment as a share of GDP and the growth in the stock of equipment per worker exert strong positive effects on wage growth. This force operates on both the aggregate and industry level. These results are consistent with the capital-skills complementarity argument -- namely, that the adoption of new capital equipment calls forth the need for high skilled (and thus high paid) workers.

In contrast, investment in OCA and information technology equipment in general, as well as the rate of growth of both OCA and IT equipment per worker, have a strong negative bearing on earnings growth. This effect too operates on both the aggregate and industry level. This result is consistent with the argument that IT investment eliminates average paying jobs and replaces them with low paid positions.

International trade has a decidedly negative impact on average earnings, on the aggregate level. This is true for both imports and exports. It is also found that on the industry level the change in export intensity has a negative effect on wage changes, though no significant effect is found for import intensity. These results support the argument that import competition has eliminated many high paying manufacturing jobs and caused employment in these industries to decline. Moreover, the results on the industry level with regard to export intensity lend credence to the low road hypothesis about export competition. In particular, industries that remain competitive in terms of exports accomplish this by eliminating high skill jobs and thus inhibiting wage growth.

On the aggregate level, the growth in education, experience, or worker skills is not found to have any significant effect on the growth in wages. One possibility is that increases in human capital or skill levels affect wages indirectly by promoting productivity growth. However, the skill and human capital variables remain insignificant even when the labor productivity growth variable is eliminated from the aggregate regression equation. On the industry level, skill growth remains uncorrelated with earnings growth but there is some weak evidence that increases in worker schooling levels may be positively associated with wage gains and some stronger evidence that worker age is positively related to wage increases.

The aggregate time-series results support the view that the falling minimum wage in the U.S. has induced employers to hire relatively greater numbers of low-paid workers. These results also provide some weak evidence that the decline in unionization, at least after 1973, has led to a reduction of earnings for non-supervisory workers. However, on the industry level there is no statistical evidence that the level or change in unionization within industry has affected average wages within that industry.

Earnings Growth by Educational Level

On the basis of CPS data, the only educational groups that have seen growth in earnings since 1975 are college graduates without advanced schooling (a 10 percent gain in earnings between 1975 and 1997) and college graduates with advanced degrees (a 27 percent gain). High school graduates have generally held steady in terms of earnings, while those with less than a high school degree have seen their real compensation decline (by 13 percent). This divergence in earnings explains the rising returns to education over the last two decades.

Table 10 presents time-series regressions of the growth of earnings by educational level on the same set of factors as in Section A above to shed light on some of the reasons for this divergence. Due to data limitations, the regressions are performed only for the period from 1976 to 1997, so that they have to be interpreted with some caution. However, notwithstanding, four results are particularly striking.

First, OCA investment has a depressing effect on earnings for all educational groups but its effect is statistically significant only for schooling groups with less than a B.A. degree. Second, international trade has a similar negative impact on earnings among all educational classes and its coefficient is significant for all schooling levels except for those with 5 or more years of university education. Third, R&D intensity reduces earnings at all levels of educational attainment except among those with more than four years of college but its coefficient is significant only for those groups with less than a college degree. Fourth, somewhat surprisingly, the minimum wage, the change in the minimum wage, the unionization rate, and the change in the unionization rate are not significant in any of the regressions, though the shorter time period used here is the likely explanation.

CONCLUSION

One of the basic tenets of human capital theory is that rising schooling will cause, or at least be associated with rising wages. However, the paper began by raising the seeming paradox that while earnings and education did grow hand in hand from the end of World War II to the early 1970s, this relation appeared to end after this point. After 1973, in fact, while earnings stagnated (or declined, in the case of BLS average hourly and weekly earnings) educational attainment continued to grow.

Annual time-series regressions of earnings growth on the change in educational attainment fail to produce a significant (or even a positive) coefficient on the change in average schooling levels. Cross-industry regressions do establish a small but positive effect of changes in average educational attainment among workers within the industry on the change in average industry earnings but the coefficient is significant in only one case and even then just marginally significant (at the ten percent level).

Evidence establishing a positive and significant relation between earnings growth and changes in worker skill levels is even bleaker. As with educational attainment, cognitive and people skills continued to growth after 1973 at about the same pace as before 1973, while earnings either flattened or declined. As a result, both annual time-series regressions and cross-industry regressions fail to establish any significant relation between gains in earnings and changes in skill levels.

The strongest positive evidence is provided in the cross-occupation regressions of occupational earnings on average educational attainment within occupation, which show not only positive and significant coefficients on schooling level but rates of return rising over the 1950-1990 period. Moreover, regressions of occupational earnings on occupational skill do show positive and significant coefficients on cognitive skills, motor skills, and, in later years, people skills. However, while the coefficient and significance level of these coefficients peak in 1970 for cognitive and motor skills, they increase over time for people skills through 1990.

It was also argued that in an economy characterized by an aggregate Cobb-Douglas production function, earnings should rise at exactly the same rate as overall labor productivity. This was generally the case in the period from 1947 to 1973, with correlations between earnings growth and labor productivity growth close to unity, but for the period after 1973 correlations between the two are much lower (and, in some cases, negative). In annual time-series regressions over the full 1947 to 1997 period, labor productivity growth is found to be a positive and highly significant (at the one percent level) determinant of earnings growth. However, its coefficient is (significantly) less than unity. Moreover, in cross-industry regressions, industry labor productivity growth fails to appear as a significant factor in explaining industry earnings growth, a result that implies that earnings in an industry are influenced by economy-wide productivity growth, not that of the particular industry.

Another factor that might affect wage growth is interindustry employment shifts. Over the entire postwar period, employment has generally shifted out of high-paying goods producing industries into low-paying services. During the 1950s and 1960s, this negative effect of employment shifts on average earnings was offset by the reduction of jobs in low-paying agriculture, so that the net effect was minimal. However, in the 1970-97 period, further reduction of employment in agriculture was limited, so that the net effect of employment shifts was substantially negative, offsetting increases in industry

A third factor is investment activity. The prevailing view is the capital-skills complementarity hypothesis. This states that investment will lead to greater demand for skilled labor since new capital embodies the latest technology, which requires greater skills to put into operation. Results from both the annual time-series and the cross-industry regressions indicate that investment in equipment exerts strong positive effects on wage growth.

A fourth is computerization, which, I argued, may have two contradictory effects. The first is that the introduction of computers can radically alter the workplace, requiring high-skilled computer experts and engineers to implement the new technology. The second is that once in place, computers tend to simplify tasks and thus increase the demand for low-skilled and lower paid workers. The regression results on both the annual time-series data and the cross-industry data provide strong support for the second hypothesis, that computerization depresses average wages. This retardant effect on wages is particularly strong for less educated workers (those with less than four years of college).

A fifth is international trade, which also may have two opposing effects. One is the high road hypothesis that industries competing in international product markets or directly against imports might be forced to upgrade skills in order to remain competitive. The other is the low road hypothesis that such industries might be forced to compete on the basis of cost and thus have an incentive to replace high paid workers with low paid ones. The time-series regression results indicate that both exports and imports have a decidedly negative impact on average earnings, while results of the cross-industry regressions find a negative relation between export growth and earnings growth. These findings are consistent with those of Leamer (1992) and Wood (1994) but not with those of Lawrence and Slaughter (1993). International trade also appears to reduce wages for all educational groups except those with more than four years of college.

The last possibility relates to organizational and structural dimensions. The aggregate time-series results provide some, though relatively weak, evidence to support the view that the falling minimum wage in the U.S. has been a contributor to stagnant wages. There is also some evidence, though even weaker, that the decline in unionization, at least after 1973, has led to a reduction of earnings for non-supervisory workers. These results are not as strong as those reported by Freeman (1993), Ferguson (1996), or Gordon (1996).

What then is responsible for the stagnation of labor earnings after 1973? The major contributing factors appear to be rising international trade, which doubled as a share of GDP over the period from 1973 to 1997; the slowdown in labor productivity growth, which fell by about two thirds between the 1947-73 and the 1973-97 periods; and the acceleration in the growth of OCA per employee, which almost doubled between the two periods. These negative effects were partially offset by the growth in equipment investment, which increased by more than 50 percent as a share of GDP between the two periods.

A final word should be added on the skill-biased technical change hypothesis that has been advanced to explain the rising returns to education observed over the last two and a half decades (see, for example, Bound and Johnson, 1992; and Katz and Murphy, 1992). The results reported here indicate that rising returns, particularly to a college degree, is not a simple skill-bias demand story. Indeed, while real earnings of college graduates haven risen moderately since the early 1970s, those of high school graduates have remained flat, and those of other educational groups have declined. This divergence in earnings accounts for the rising returns to education over the last two decades.

However, there is no evidence that high tech investment, such as computers, has caused the earnings of college graduates to rise. Rather, the econometric evidence suggests that computerization has had a negative effect on the earnings of all educational groups, though the depressive impact has been greater for those with less schooling than more. Thus, IT and other high tech investment have helped raise the returns to a college degree by **lowering** the earnings of high school graduates rather than by raising the earnings of college graduates.

These results are not inconsistent with those of Krueger, (1993) and Autor, Katz, and Krueger (1998), who found an earnings premium of 15 percent or more to users of computers relative to workers who do not use computers. However, the apparent mechanism is not that computer usage leads to growth of real earnings grow but rather that non-users have seen their real earnings drop.

DATA APPENDIX

1. **Employee Compensation and Employment Data**

   a. BLS mean hourly and weekly earnings.
   Figures are from the Bureau of Labor Statistics and refer to the wages and salaries of production and non-supervisory workers in the total private sector.
   Source: Council of Economic Advisers, *Economic Report of the President, 1999* and *Economic Report of the President, 1981.*
   b. BLS Employment Cost Index (ECI).
   Figures are from the Bureau of Labor Statistics' Employment Cost Index for private industry, including both wages and salaries and the employer costs to employee benefits, as of December of that year. The index controls for the influence of employment shifts among occupations and industries.
   Sources: Department of Labor, *Report on the American Workforce, 1995* and Council of Economic Advisers, *Economic Report of the President, 1999.*
   c. NIPA employee compensation.
   Figures are from the National Income and Product Accounts (NIPA), available on the Internet. No adjustment is made for hours worked. Employee compensation includes wages and salaries and employee benefits. Proprietors' income is net income to self-employed persons, including partners in businesses and owners of unincorporated businesses.
   d. NIPA employment data.
   Figures are from the National Income and Product Accounts, available on the Internet. Full-time equivalent employees (FTEE) equals the number of employees on full-time schedules plus the number of employees on part-time schedules converted to a full-time basis. The number of full-time equivalent employees in each industry is the product of the total number of employees and the ratio of average weekly hours per employee for all employees to average weekly hours per employee on full-time schedules. Persons engaged in production (PEP) equals the number of full-time and part-time employees plus the number of self-employed persons. Unpaid family workers are not included.
   e. CPS earnings data.
   Figures are from the Current Population Survey, available on the Internet. The overall median is computed as a weighted average of male and female median earnings, with employment shares as weights. The data refer to persons 15 years old and over with earnings beginning in March 1980, and persons 14 years old and over as of March of the following year for previous years. Prior to 1989 earnings are for civilian workers only.

2. **Educational Attainment and Age**

   a. Median years of schooling, adult population;
   b. percent of adults with 4 years of HS or more; and
   c. percent of adults with 4 years of college or more.
   Adults refer to persons 25 of age and over in the noninstitutional population (excluding members of the Armed Forces living in Barracks).
   Source: U.S. Bureau of the Census, *Current Population Reports* , available on the Internet.
   d. Mean years of schooling of employed workers.
   Figures are for the private business sector. Mean schooling is calculated by weighting educational attainment of workers by hours of work. The figures are updated to 1997 on the basis worksheet data graciously provided by Larry Rosenblum of the Bureau of Labor Statistics.
   Source: U.S. Bureau of Labor Statistics (1993), *Labor Composition and U.S. Productivity Growth, 1948-90* , Bulletin 2426, December, Washington, D.C.: U.S. Government Printing Office.
   e. Mean (or median) schooling and mean age of workers by industry for 1950, 1960, 1970, 1980, and 1990 are derived from the decennial U.S. Census of Population Public Use Samples for the corresponding years.

3. **Output, Investment and Capital Stock Data**

   a. Investment data refer to non-residential fixed investment in constant (1992) dollars and GDP to GDP in constant (1992) dollars.
   Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts, Internet.
   b. For technical details, see Katz and Herman (1997). Capital stock figures are based on chain-type quantity indexes for net stock of fixed capital in $1992, year-end estimates. Equipment and structures, including information technology equipment, are for the private (non-government) sector only. Information processing and related equipment includes: (a) computers and peripheral equipment; (b) other office and accounting machinery; (c) communication equipment; (d) instruments; and (e) photocopy and related equipment.
   Source: U.S. Bureau of Economic Analysis, CD-ROM NCN-0229, "Fixed Reproducible Tangible Wealth of the United States, 1925-97."
   c. Investment flows by industry and by type of equipment or structures are for the private (non-government) sector only.
   Source: U.S. Bureau of Economic Analysis, CD-ROM NCN-0229, "Fixed Reproducible Tangible Wealth of the United States, 1925-97."

4. Research and development expenditures performed by industry include company, federal, and other sources of funds.
Company-financed R&D performed outside the company is excluded. Industry series on R&D and full-time equivalent scientists and engineers engaged in R&D per full-time equivalent employee run from 1957 to 1997.

Source: National Science Foundation, Internet. For technical details, see National Science Foundation, *Research and Development in Industry*, (Arlington, Va.: National Science Foundation), NSF96-304, 1996.

5. Imports and exports.
The data are interpolated for years 1950, 1960, 1970, 1980, and 1990.
Source (aggregate data): U.S. Bureau of Economic Analysis, National Income and Product Accounts, Internet. Sources (industry-level data): U.S. input-output data for years 1947, 1958, 1963, 1967, 1972, 1977, 1982, 1987, 1992, and 1996 provided on computer tape or diskette by the Bureau of Economic analysis.

6. Unionization
Percent of labor force covered by unions. Estimates for 1950-1983 are the annual average number of dues paying members reported by labor unions. Estimates for 1983-1997 are annual averages from the Current Population Survey. Data exclude numbers of professional and public employee associations.
Sources: (a) U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics 1978*, Bulletin 2, (Washington, D.C.: U.S. Government Printing Office), 1979; (c) U.S. Department of Labor, B.ureau of Labor Statistics, *Handbook of Labor Statistics 1989,* Bulletin 23, (Washington, D.C.: U.S. Government Printing Office), 1990; and (d) Eva E. Jacobs, Editor, *Handbook of U.S. Labor Statistics,* Second Edition, (Lanham, MD: Bernan Press), 1998.
Other sources for the industry level data include in addition to the above: Kokkelenberg and Sockell (1985); Hirsch and Macpherson (1993), accompanying data files; and Bureau of Labor Statistics, Office of Employment Projections, Output and Employment data base..

7. Service sector employment.
Sectors include wholesale and retail trade; finance, insurance, real estate; personal and business services; and government. The employment concept is Persons Engaged in Production (PEP).
Source: U.S. Bureau of Economic Analysis, National Income and Product Accounts, Internet.

8. Minimum wage.
Source: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1998,* 118th edition, (Washington, D.C.: U.S. Government Printing Office), 1998.

REFERENCES

Acs, Gregory, and Sheldon Danziger. 1993. "Educational Attainment, Industrial Structure, and Male Earnings Through the 1980s." *Journal of Human Resources* 28, 3 (Summer): 618-648.

Allen, Steven G. 1996. "Technology and the Wage Structure." *NBER Working Paper No*. 5534, April.

Autor, David, Lawrence F. Katz, and Alan B. Krueger. 1998. "Computing Inequality: How Computers Changed the Labor Market?" *Quarterly Journal of Economics* 113, 4 (November): 1169-1214.

Bartel, Ann P., and Nachum Sicherman. 1997. "Technological Change and Wages: An Inter-Industry Analysis." Columbia University, mimeo.

Baumol, William J., Sue Anne Batey Blackman, and Edward N. Wolff .1989. *Productivity and American Leadership: The Long View.* Cambridge, Mass.: MIT Press.

Becker, Gary S. 1975. *Human Capital: A Theoretical and Empirical Analysis.* 2nd edition. New York: Columbia University Press and National Bureau of Economic Research.

Blanchflower, David G., Andrew J. Oswald, and Peter Sanfey. 1996. "Wages, Profits, and Rent-Sharing," *Quarterly Journal of Economics* 111, 1 (February): 227-251.

Bound, John, and George E. Johnson. 1992. "Changes in the Structure of Wages in the 1980s: An Evaluation of Alternative Explanations." *American Economic Review* 82: 371-392.

Davis, Steven J. 1992. "Cross-Country Patterns of Change in Relative Wages." *NBER Macroeconomics Annual.* Cambridge, Mass.: MIT Press.

Davis, Steven J., and John Haltiwanger. 1991. "Wage Dispersion Between and Within U.S. Manufacturing Plants, 1963-86." *Brookings Papers on Economic Activity: Microeconomics:* 115-180.

Dunne, Timothy, Lucia Foster, John Haltiwanger, and Kenneth Troske. 2000. "Wage and Productivity Dispersion in U.S. Manufacturing: The Role of Computer Investment." NBER Working Paper No. 7465.

Dunne, Timothy, and John A. Schmitz, Jr. 1992. "Wages, Employer Size-Wage Premia and Employment Structure: Their Relationship to Advanced-Technology Usage at U.S. Manufacturing Establishments." U.S. Department of Commerce, Center for Economic Studies Discussion Paper CES 92-16, December.

Ferguson, William D. 1996. "Explaining the Rising Wage-productivity Gap of the 1980s: Effects of Declining Employment and Unionization." *Review of Radical Political Economics* 28, 2: 77-115.

Freeman, Richard B. 1993. "How Much Has De-Unionization Contributed to the Rise in Male Earnings Inequality." In Danziger, Sheldon, and Peter Gottschalk, eds. *Uneven Tides: Rising Inequality in America.* New York: Russell Sage Press.

Freeman, Richard B., and Lawrence F. Katz. 1991. "Industrial Wage and Employment Determination in an Open Economy." In Abowd, John W., and Richard B. Freeman eds., *Immigration, Trade, and Labor Markets.* Chicago: NBER.

Gaston, Noel, and Daniel Treffler. 1994. "Protection, Trade, and Wages: Evidence from U.S. Manufacturing." *Industrial and Labor Relations Review* 47, 4 (July): 574-593.

Gordon, David M. 1996. *Fat and Mean: The Corporate Squeeze of Working Americans and the Myth of Managerial "Downsizing."* New York: Free Press.

Griliches, Zvi .1969. "Capital-Skill Complementarity." *Review of Economics and Statistics* 51 (November): 465-468.

Groshen, Erica. 1991. "Source of Intra-Industry Wage Dispersion: How Much Do Employers Matter?" *Quarterly Journal of Economics* 106, 3 (February): 869-884.

Hirsch, Barry T., and David A. Macpherson. 1993. "Union Membership and Coverage Files from the Current Population Surveys: Note." *Industrial and Labor Relations Review* 46, 3 (April): 574-78.

Johnson, George E., and Frank P. Stafford. 1993. "International Competition and Real Wages." *American Economic Review Papers and Proceedings* 83, 2 (May): 127-130.

Katz, Arnold J., and Shelby W. Herman. 1997. "Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-95." *Survey of Current Business* (May): 69-92.

Katz, Lawrence F., and Kevin M. Murphy. 1992. "Changes in Relative Wages, 1963-1987: Supply and Demand Factors." *Quarterly Journal of Economics* 107, 1: 35-78.

Kokkelenberg, Edward C., and Donna R. Sockell. 1985. "Union Membership in the United States, 1973-81." *Industrial and Labor Relations Review* 38, 4 (July): 497-543.

Krueger, Alan B. 1993. "How Computers Have Changed the Wage Structure: Evidence from Microdata." *Quarterly Journal of Economics* 108 (February): 33-60.

Lawrence, Robert Z., and Matthew J., Slaughter. 1993. "Trade and US Wages: Great Sucking Sound or Hiccup." *Brookings Papers on Economic Activity: Microeconomics* 2: 161-210.

Leamer, Edward E. 1992. "Wage Effects of a U.S.-Mexican Free Trade Agreement." NBER Working Paper No. 3991.

Levy, Frank, and Richard Murnane. 1992. "U.S. Earnings Levels and Earnings Inequality: A Review of Recent Trends and Proposed Explanations." *Journal of Economic Literature* 30, 3 (September): 1333-1381.

Levy, Frank, and Richard Murnane. 1996a. *Teaching the New Basic Skills.* New York: Free Press.

------ . 1996b. "With What Skills are Computers a Complement?" *American Economic Review Papers and Proceedings* 86, 2 (May): 258-262.

Mincer, Jacob. 1974. *Schooling, Experience, and Earnings.* New York: National Bureau of Economic Research.

Reich, Michael. 1998. "Are U.S. Corporations Top-heavy? Managerial Ratios in Advanced Capitalist Countries." *Review of Radical Political Economics* 30 (September): 33-45.

Vernon, R. 1966. "International Investment and International Trade in the Product Cycle." *Quarterly Journal of Economics* 80.

------- .1979. "The Product-Cycle Hypothesis in a New International Environment." *Oxford Bulletin of Economics and Statistics* 41.

Wolff, Edward N. 1996. "Technology and the Demand for Skills." *OECD Science, Technology and Industry Review* 18: 96-123.

Wood, Adrian. 1994. *North-South Trade, Employment, and Inequality: Change Fortunes in a Skill-Driven World.* New York: Oxford University Press.

Appendix Table 1
45-Sector Industry Classification

Industry Number	1987 SIC Codes
1. Agriculture, forestry, and fishing	01-09
2. Metal mining	10
3. Coal mining	11,12
4. Oil and gas extraction	13
5. Mining of nonmetallic minerals, except fuels	14
6. Construction	15-17
7. Food and kindred products	20
8. Tobacco products	21
9. Textile mill products	22
10. Apparel and other textile products	23
11. Lumber and wood products	24
12. Furniture and fixtures	25
13. Paper and allied products	26
14. Printing and publishing	27

15. Chemicals and allied products	28
16. Petroleum and coal products	29
17. Rubber and miscellaneous plastic products	30
18. Leather and leather products	31
19. Stone, clay, and glass products	32
20. Primary metal products	33
21. Fabricated metal products, including ordnance	34
22. Industrial machinery and equipment, exc. electrical	35
23. Electric and electronic equipment	36
24. Motor vehicles and equipment	371
25. Other transportation equipment	37 [exc. 371]
26. Instruments and related products	38
27. Miscellaneous manufactures	39
28. Transportation	40-42,44-47
29. Telephone and telegraph	481,482,484,489
30. Radio and TV broadcasting	483
31. Electric, gas, and sanitary services	49
32. Wholesale trade	50-51
33. Retail trade	52-59
34. Banking; credit and investment companies	60-62,67
35. Insurance	63-64
36. Real estate	65-66
37. Hotels, motels, and lodging places	70
38. Personal services	72
39. Business and repair services except auto	73,76
40. Auto services and repair	75
41. Amusement and recreation services	78-79
42. Health services, including hospitals	80
43. Educational services	82
44. Legal and other professional services and non-profit organizations	81,83,84,86,87,89
45. Public Administration	--

Table 1. Annual Percentage Growth Rate of Real Labor Earnings per Worker, Selected Measures, 1947-1997				
	1947-1973	**1973-1997**	**1973-1989**	**1989-1997**
A. Wages and Salaries				
1. BLS mean hourly earnings	2.1	-0.5	-0.7	-0.1
2. BLS mean weekly earnings	1.8	-0.8	-1.1	-0.1
3. BLS ECI Wage and Salary Index		0.1[a]	0.1[b]	0.0
4. NIPA wages and salaries per FTEE	2.3	0.0	-0.2	0.4
5. NIPA wages and salaries plus half of proprietors' income per PEP	2.4	-0.1	-0.4	0.5
6. CPS Median earnings for year-round, full-time workers	2.4[c]	-0.4	-0.4	-0.4
7. CPS Mean earnings for year-round, full-time workers	2.7[d]	0.3	0.2	0.4
B. Total Employee Compensation				
8. NIPA employee compensation per FTEE	2.6	0.2	0.1	0.3
9. NIPA employee compensation plus half of proprietors' income per PEP	2.7	0.1	0.0	0.4
10. NIPA employee compensation plus three fourths of proprietors' income per PEP	2.6	0.1	-0.1	0.4
11. BLS Employment Cost Index (ECI)		0.0[e]	-0.1[f]	0.3
12. BLS ECI Fringe Benefit Index		1.2[a]	1.5[b]	0.8
C. Labor Productivity				
13. GDP [1992$] per FTEE	2.0	0.8	0.8	0.9
14. GDP [1992$] per PEP	2.4	0.8	0.8	1.0

Note: All figures are in 1995 dollars, based on the CPI-U-X1 deflator. See the Data Appendix for sources and methods.
Key:
FTEE: Full-time equivalent employees
PEP: Persons engaged in production
a. 1980-1996.
b. 1980-1989.
c. 1960-1973.
d. 1967-1973.
e. 1976-1996.
f. 1976-1989.

Table 2. Correlation Coefficients between Real Labor Earnings per Worker And Skills, Schooling, and Productivity, 1947-1997

	1947-1997	1947-1973	1973-1997
A. BLS mean hourly earnings			
1) Substantive Complexity (SC)	0.69	0.96	-0.93
2) Composite Skill Index (CS)	0.72	0.96	-0.94
3) Median years of schooling (adults over 25)	0.90	0.98	-0.84
4) Percent HS graduates (adults over 25)	0.70	0.99	-0.93
5) Percent college graduates (adults over 25)	0.60	0.98	-0.92
6) Mean years of schooling (employed workers)	0.75	0.98	-0.94
7) GDP [1992$] per FTEE	0.79	0.99	-0.85
8) GDP [1992$] per PEP	0.82	0.99	-0.86
B. NIPA wages and salaries per FTEE			
1) Substantive Complexity (SC)	0.84	0.97	-0.06
2) Composite Skill Index (CS)	0.85	0.97	-0.07
3) Median years of schooling (adults over 25)	0.97	0.98	0.03
4) Percent HS graduates (adults over 25)	0.83	0.99	-0.06
5) Percent college graduates (adults over 25)	0.76	0.98	-0.06
6) Mean years of schooling (employed workers)	0.87	0.99	-0.08
7) GDP [1992$] per FTEE	0.91	0.99	0.18
8) GDP [1992$] per PEP	0.93	0.99	0.17
C. NIPA employee compensation per FTEE			
1) Substantive Complexity (SC)	0.92	0.97	0.58
2) Composite Skill Index (CS)	0.93	0.98	0.57
3) Median years of schooling (adults over 25)	0.98	0.97	0.61
4) Percent HS graduates (adults over 25)	0.92	0.99	0.59
5) Percent college graduates (adults over 25)	0.86	1.00	0.59
6) Mean years of schooling (employed workers)	0.95	1.00	0.57
7) GDP [1992$] per FTEE	0.97	1.00	0.76
8) GDP [1992$] per PEP	0.98	1.00	0.76

Note: Correlation coefficients are computed from annual data. All earnings figures are in 1995 dollars, based on the CPI-U-X1 deflator. See the Data Appendix for sources and methods.
Key:
FTEE: Full-time equivalent employees
PEP: Persons engaged in production

Table 3. Regressions of Hourly Wages in 1970 Dollars (HOURWAGE) on Workplace Skills Across Occupations, 1950-1990					
	Year				
Independent Variables	1950	1960	1970	1980	1990
Constant	0.836 **	0.742 **	1.145 **	1.452 **	1.363 **
	(4.63)	(2.78)	(4.78)	(5.99)	(4.84)
SC	0.292 **	0.414 **	0.454 **	0.315 **	0.37 **
	(10.52)	(10.28)	(12.14)	(8.36)	(8.44)
MS	0.054 #	0.123 **	0.093 *	0.098 *	0.084 #
	(1.87)	(2.86)	(2.37)	(2.49)	(1.84)
IS	-0.017	-0.006	0.028	0.085 *	0.15 **
	(0.60)	(0.13)	(0.70)	(2.14)	(3.21)
R^2	0.503	0.487	0.535	0.418	0.457
Adjusted R^2	0.495	0.480	0.530	0.411	0.451
Std. error	0.652	1.016	1.037	1.039	1.208
Sample Size	196	215	267	262	262

Note: The unit of observation is the occupation. The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. The 1950 hourly wage is estimated as median income by occupation in 1950 divided by average hours worked per year for all workers in 1970 (1,961 hours). The 1960 hourly wage by occupation is estimated as median labor earnings by occupation in 1960 divded by average hours worked per year for all workers in 1970 (1,961 hours). For 1970, 1980, and 1990, hourly wage by occupation is computed mean annual earnings for that occupation divided by average hours worked per year in the occupation.
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Table 4. Regressions of the Logarithm of Hourly Wages in 1970 Dollars (LNWAGE) On Age and Educational Attainment Across Occupations, 1950-1990					
Independent Variables	Year				
	1950	1960	1970	1980	1990
Regression Form 1					
Constant	-2.663 **	-7.336 **	-5.554 **	-3.734 **	-6.022 **
	(3.04)	(7.03)	(6.05)	(3.01)	(4.24)
Mean Years of Schooling	0.085 **	0.109 **	0.12 **	0.115 **	0.142 **
	(7.42)	(9.59)	(14.22)	(13.00)	(14.52)
Mean Age	0.114 *	0.331 **	0.248 **	0.164 *	0.253 **
	(2.56)	(6.39)	(5.57)	(2.58)	(3.52)
Mean Age	-0.124 *	-0.376 **	-0.283 **	-0.187 *	-0.29 **
Squared/100	(2.20)	(5.85)	(5.17)	(2.32)	(3.21)
R^2	0.285	0.426	0.473	0.445	0.546
Adjusted R^2	0.273	0.418	0.467	0.439	0.540
Standard Error	0.387	0.417	0.308	0.262	0.253
Sample Size	196	215	267	262	262
Regression From 2					
Constant	-1.440	-6.358 **	-3.039 **	-3.684 **	-5.654 **
	(1.59)	(5.56)	(2.82)	(2.66)	(3.37)
Percent with HS 1-3	-0.012 *	0.006	-0.007	0.015	0.013
	(2.11)	(0.78)	(1.46)	(1.53)	(1.31)

Percent with HS 4	0.015 **	0.016 **	0.011 **	0.019 **	0.024 **
	(4.91)	(4.82)	(4.48)	(4.64)	(4.76)
Percent with College 1-3	-0.012 *	-0.002	-0.003	0.009 #	0.015 **
	(2.42)	(0.32)	(0.84)	(1.69)	(2.68)
Percent with College 4[a]	0.009 **	0.019 **	0.012 **	0.022 **	0.025 **
	(4.16)	(3.96)	(3.56)	(4.37)	(4.48)
Percent with College 5 or more	0.013 **	0.010 **	0.021 **	0.026 **	
	(3.84)	(4.23)	(4.65)	(3.14)	
Mean Age	0.091 *	0.301 **	0.180 **	0.154 *	0.232 **
	(2.05)	(5.63)	(3.72)	(2.44)	(3.14)
Mean Age	-0.093 #	-0.335 **	-0.204 **	-0.171 *	-0.265 **
Squared/100	(1.68)	(5.63)	(3.47)	(2.14)	(2.87)
R^2	0.337	0.437	0.497	0.482	0.571
Adjusted R^2	0.317	0.417	0.483	0.468	0.559
Standard Error	0.376	0.415	0.303	0.255	0.247
Sample Size	196	201	267	262	260

Note: The unit of observation is the occupation. The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. See the note to Table 3 for details on the construction of the wage variable. Mean years of schooling (and age) are computed for all workers in a given occupation with reported earnings in the preceding year.
a. For 1950, percent of workers with four years of college or more.
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Table 5. Mean Earnings by Major Industry in 1970 and the Percentage Change in Mean Earnings from 1950 to 1997

	Mean Earnings, 1970			Percentage Change, 1950-1997		
	NIPA Wages/ FTEE	NIPA Comp/ FTEE	Comp + PI x 0.5 / PEP	NIPA Wages/ FTEE	NIPA Comp/ FTEE	Comp + PI x 0.5 / PEP
Agriculture, forestry, and fishing	54	52	55	91	118	81
Mining	122	126	132	115	136	152
Construction	127	124	118	45	64	75
Durable manufacturing	115	117	120	74	98	98
Nondurable manufacturing	99	101	103	71	95	96
Transportation	121	122	122	41	63	61
Communications	113	125	129	142	162	174
Electric, gas, and sanitary services	130	135	143	117	145	174
Wholesale trade	119	116	118	60	80	74
Retail trade	76	74	74	8	19	25
Finance, insurance, and real estate	101	102	107	116	139	126
Other services	83	80	82	106	131	125
Government	103	104	107	75	116	116
Goods industries	110	112	110	72	113	105
Service industries	93	92	93	65	105	90
Total	100	100	100	63	85	91

Note: Earnings Levels are normalized so that the overall wage level = 100 in 1970. See the Data Appendix data sources and methods. Key:
Wages: NIPA wages and salaries
Comp: NIPA total employee compensation
PI: Proprietors' income
FTEE: Full-time equivalent employees
PEP: Persons engaged in production
Goods-producing industries include: (1) agriculture; (2) mining; (3) construction; (4) manufacturing; and (5) transportation, communications and public utilities.
Service industries include: (1) wholesale and retail trade; (2) finance, insurance, and real estate; (3) other services; and (4) government services.

Table 6. Decomposition of the Change in the Overall Wage Level into An Industry Effect and an Employment Shift Effect, 1950-1997 (Earnings are in 1995 dollars)

	Decomposition			Percentage Decomposition		
Period	Actual Change in Average Overall Earnings	1st Effect: Change in Earnings Within Industry	2nd Effect: Shifts in Employment Among Industries	Total Change	1st Effect: Change in Earnings Within Industry	2nd Effect: Shifts in Employment Among Industries
A. Wages and salaries per FTEE						
1950-60	5,597	5,484	113	100	98	2
1960-70	5,625	5,508	117	100	98	2
1970-80	-1,201	-887	-314	100	74	26
1980-90	1,578	2,114	-536	100	134	-34
1990-97	972	1,334	-363	100	137	-37
1950-97	12,570	13,553	-983	100	108	-8
1970-97	1,349	2,561	-1,213	100	190	-90
B. Total employee compensation per FTEE						
1950-60	6,695	6,504	190	100	97	3
1960-70	7,135	6,978	157	100	98	2
1970-80	981	1,353	-372	100	138	-38
1980-90	2,365	3,266	-901	100	138	-38
1990-97	796	1,465	-669	100	184	-84
1950-97	17,971	19,567	-1596	100	109	-9
1970-97	4,142	6,084	-1,942	100	147	-47
C. Total employee compensation plus one half of proprietors' income per PEP						
1950-60	6,622	6,132	490	100	93	7
1960-70	7,485	6,991	494	100	93	7
1970-80	623	706	-83	100	113	-13
1980-90	2,252	3,027	-775	100	134	-34
1990-97	1,045	1,645	-601	100	158	-58
1950-97	18,027	18,502	-475	100	103	-3
1970-97	3,920	5,378	-1,459	100	137	-37

Note: The decomposition is based on 65 industries (see Equation 3). See the Data Appendix for data sources and methods.
Key:
FTEE: Full-time equivalent employees
PEP: Persons engaged in production

Table 7. Regressions of the Annual Growth in Earnings on Labor Productivity Growth and Other Variables Using Time-Series Data for 1948-1997

	Dependent Variable					
Independent Variables	Growth in BLS Mean Hourly Earnings	Growth in NIPA Mean Wages and Salaries	Growth in NIPA Mean Employee Compensation	Growth in Mean Empl. Comp.+1/2 Prop. Inc.	Growth in NIPA Mean Wages Salaries	
					Form 2	Form 3
Constant	0.012	-0.003	-0.020	-0.025 #	-0.01	0.00
	(1.22)	(0.40)	(1.25)	(1.78)	(1.08)	(0.02)
Labor Productivity Growth	0.455**	0.610**	0.624**	0.738**	0.62**	0.56**
	(3.27)	(5.02)	(5.07)	(6.62)	(4.96)	(4.57)
Investment in Equipment/GDP	1.086*	1.291**	1.142*	1.413**	1.49**	1.44**
	(2.41)	(3.18)	(2.57)	(3.51)	(3.27)	(3.04)
Growth in OCA per PEP		-0.052*	-0.073*	-0.091**	-0.060*	-0.05*
		(2.34)	(2.64)	(3.66)	(2.40)	(2.10)
Imports plus Exports/GDP	-0.458**	-0.372**	-0.331**	-0.398**	-0.38**	-0.45**
	(3.80)	(3.58)	(3.04)	(4.03)	(3.40)	(3.90)
Minimum Wage in 1992 Dollars			0.005*	0.006*		
			(2.10)	(2.69)		
Change in Substantive Complexity (SC)					-0.14	
					(0.64)	
Change in Interactive Skills (IS)					1.17	
					(1.24)	
Change in Motor Skills (MS)					0.33	
					(1.16)	
Change in Mean Schooling						-0.02
						(0.75)
Change in Mean Experience						0.13
						(0.58)
Change in Mean Experience Squared/100						0.39
						(0.59)
R^2	0.63	0.68	0.69	0.79	0.70	0.76
Adjusted R^2	0.60	0.65	0.65	0.77	0.64	0.71
Standard Error	0.013	0.011	0.011	0.010	0.010	0.010
Durbin-Watson	1.88	1.74	1.99	1.77	1.84	1.83
Sample Size	50	50	50	50	50	50

Note: The sample is based on time-series data covering the period 1948 to 1997. The estimation technique is Ordinary Least Squares (OLS). The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. See the Data Appendix for sources and methods. Labor productivity is measured by the ratio of GDP in 1992 dollars to Persons Engaged in Production (PEP)
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Table 8. Regressions of the Annual Growth in Earnings on Labor Productivity Growth and Other Variables Using Time-Series Data for 1973-1997

Independent Variables	Dependent Variable: Growth in BLS Mean Hourly Earnings	Growth in NIPA Mean Wages and Salaries	Growth in NIPA Mean Employee Compensation	Growth in Mean Employee Compensation Plus Half Proprietor Income
Constant	-0.221*	-0.144	-0.131	-0.117
	(2.47)	(1.61)	(1.58)	(1.38)
Labor Productivity Growth	0.858**	0.926**	0.957**	1.078**
	(4.66)	(5.03)	(5.61)	(6.21)
Investment in Equipment/GDP	3.279**	2.687**	2.312**	2.411**
	(3.66)	(3.00)	(2.89)	(2.95)
Growth in OCA per PEP	-0.172*	-0.134*	-0.145*	-0.151*
	(2.71)	(2.13)	(2.47)	(2.52)
Total Imports Plus Exports/GDP	-0.469**	-0.419**	-0.395**	-0.452**
	(3.03)	(2.83)	(3.01)	(3.10)
Minimum Wage in 1992 Dollars	0.029*	0.017	0.019#	0.017#
	(2.34)	(1.38)	(1.89)	(1.80)
Change in Unionization Rate	0.009*	0.005	0.005	0.004
	(2.11)	(1.33)	(1.45)	(0.96)
R^2	0.70	0.72	0.75	0.79
Adjusted R^2	0.59	0.63	0.66	0.72
Std. error	0.010	0.010	0.009	0.009
Durbin-Watson	1.87	2.03	2.14	2.30
Sample Size	25	25	25	25

Note: The sample is based on time-series data covering the period 1973 to 1997. The estimation technique is Ordinary Least Squares (OLS). The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. See the Data Appendix for sources and methods. Labor productivity is measured by the ratio of GDP in 1992 dollars to Persons Engaged in Production (PEP)
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Table 9. Regressions of Average Annual Earnings Growth on Technology and Other Variables Using Industry Level Data for 1950-1990

	Dependent Variable					
	Growth in NIPA Mean Wages and Salaries		Growth in NIPA Mean Employee Compensation		Growth in Mean Employee Compensation plus Half Proprietor Income	
Independent Variables	Form 1	Form 2	Form 1	Form 2	Form 1	Form 2
Constant	0.015**	0.013**	0.019**	0.016**	0.019**	0.016**
	(11.21)	(7.35)	(13.24)	(8.06)	(11.87)	(7.46)
Investment in Equipment/GDP	0.132**	0.116**	0.133**	0.116**	0.163**	0.141**
	(5.44)	(4.79)	(5.26)	(4.49)	(5.71)	(4.87)
Growth in OCA per PEP	-0.037**	-0.040**	-0.040**	-0.044**	-0.043**	-0.048**
	(4.55)	(5.05)	(4.78)	(5.27)	(4.53)	(5.02)
Change in Exports/GDP	-0.140**	-0.079*	-0.117**	-0.074#	-0.158**	-0.090#
	(3.63)	(1.96)	(2.90)	(1.73)	(4.53)	(1.87)
Dummy variable for services		-0.003		-0.003#		-0.004*
		(1.63)		(1.70)		(2.06)
Change in Mean Years of Schooling		0.003		0.005#		0.004
		(1.53)		(1.94)		(1.43)
Change in Mean Age		0.002**		0.001#		0.002**
		(3.52)		(1.98)		(2.78)
Change in Age Squared/100		-0.038*		-0.015*		-0.022
		(1.92)		(0.70)		(0.95)
R^2	0.28	0.32	0.26	0.28	0.28	0.30
Adjusted R^2	0.26	0.30	0.24	0.25	0.27	0.28
Standard Error	0.010	0.010	0.011	0.011	0.012	0.012
Sample Size	176	176	176	176	176	176

Note: The sample consists of pooled cross-section time-series data, with observations on each of 44 industries (excluding the government sector) in 1950-60, 1960-70, 1970-70, and 1980-90. The coefficients are estimated using the White procedure for a heteroschedasticity-consistent covariance matrix. The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. See the Data Appendix for sources and methods. Labor productivity is measured by the ratio of GDP in 1992 dollars to Persons Engaged in Production (PEP) Mean schooling and age are computed for the employees in each sector.
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Table 10. Regressions of Annual Earnings Growth by Educational Level onProductivity Growth and Other Variables Using Time-Series Data for 1976-1997

	Educational Group					
	All Workers	High School 3 Or Less	High School Graduate	College 1 -3 (No B.A)	College (B.A.)	College 5 or More
Constant	0.008	0.065	0.070#	0.190#	0.919	-0.096
	(0.30)	(1.36)	(1.84)	(1.89)	(1.19)	(1.14)
Labor Productivity Growth	0.715**	1.105*	1.055*	0.656	0.988#	2.087*
	(3.57)	(2.45)	(2.61)	(1.72)	(1.83)	(2.43)
Investment in Equipment/GDP	1.649**	6.727**	5.468**	6.858**	4.523**	2.123
	(2.97)	(7.62)	(7.53)	(9.96)	(3.03)	(1.35)
Growth in OCA per PEP	-0.062*	-0.138**	-0.158**	-0.116**	-0.123	-0.118
	(2.18)	(3.05)	(4.46)	(3.36)	(1.61)	(1.49)
Imports plus Exports/GDP	-0.577**	-1.728**	-1.438**	-1.935**	-1.597**	-0.330
	(3.17)	(5.93)	(6.19)	(8.54)	(3.27)	(0.63)
R&D expenditures / GDP	0.464	-7.890**	-6.139**	-5.706**	-2.468	2.502
	(0.32)	(3.26)	(3.14)	(3.08)	(0.63)	(0.59)
R^2	0.72	0.79	0.73	0.81	0.58	0.47
Adjusted R^2	0.63	0.69	0.61	0.73	0.41	0.22
Standard Error	0.009	0.018	0.015	0.015	0.023	0.035
Durbin-Watson	1.88	2.36	2.11	2.22	2.21	2.09
Sample Size	22	21	21	21	22	21
Est. Tech.	OLS	AR(1)	AR(1)	AR(1)	OLS	AR(1)

a. The sample is based on time-series data covering the period 1976 to 1997. The dependent variables is the annual rate of change of Current Population Survey (CPS) mean wages and salaries. The absolute value of the t-statistic is shown in parentheses below the coefficient estimate. See the Data Appendix for sources and methods.
Key:
OLS: Ordinary Least Squares.
AR(1): Autoregressive process, First-order: $u_t = \epsilon_t + \rho_1 u_{t-1}$, where u_t is the error term of the original equation and ϵ_t is a stochastic term assumed to be identically and independently distributed.
Significant at the 10% level (two-tailed test)
* Significant at the 5% level (two-tailed test)
** Significant at the 1% level (two-tailed test)

Figure 1. Labor Earnings Indices, 1947-1997
[1973=100]

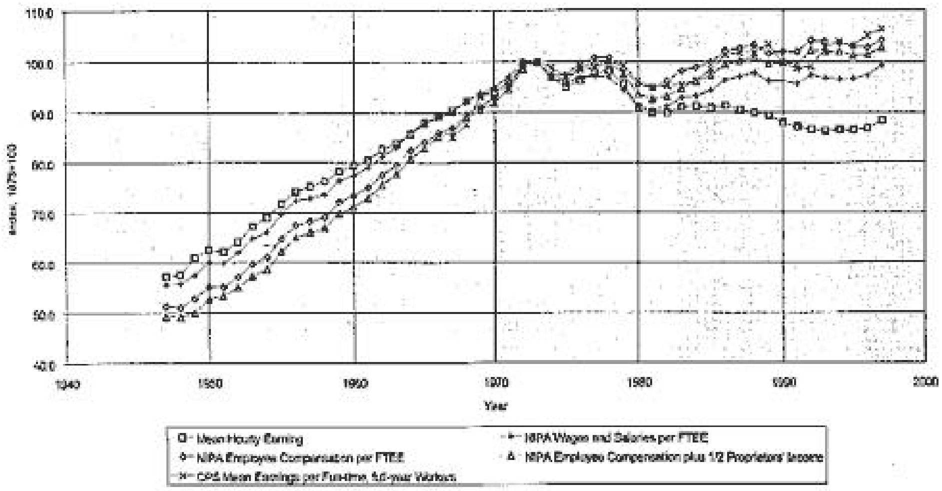


Figure 2. Earnings, Skills, Schooling
And Productivity, 1947-1997

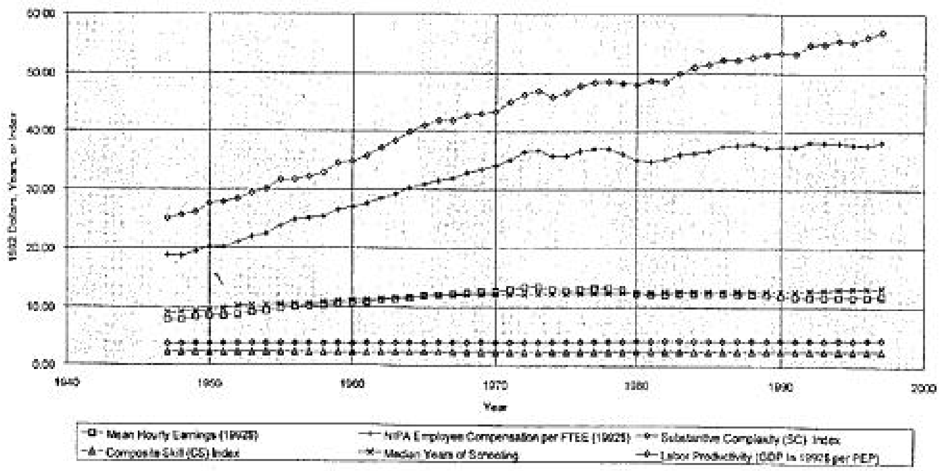


Figure 3. Earnings and R&D Investment, 1947-1997

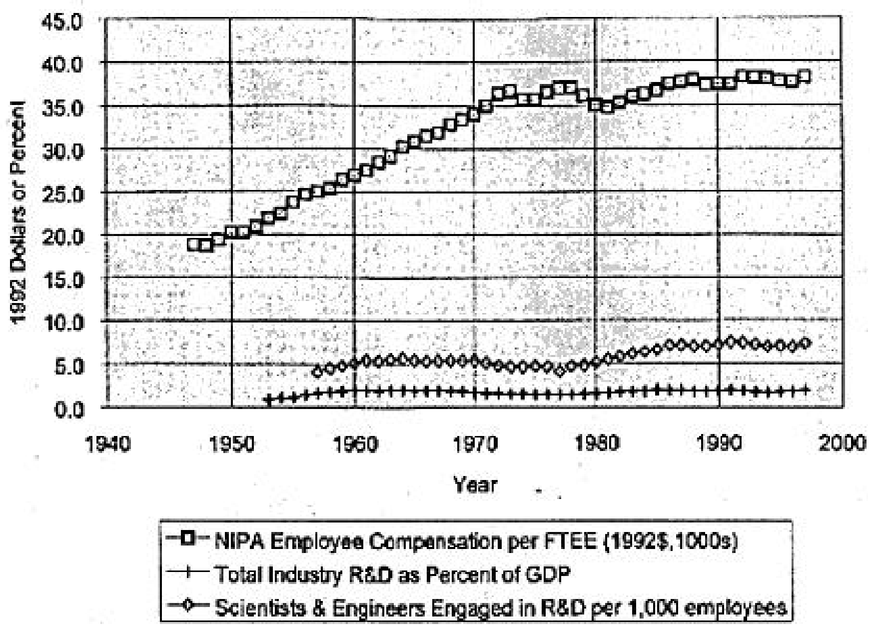


Figure 4. Earnings, Equipment Investment, and OCA Investment, 1947-1997

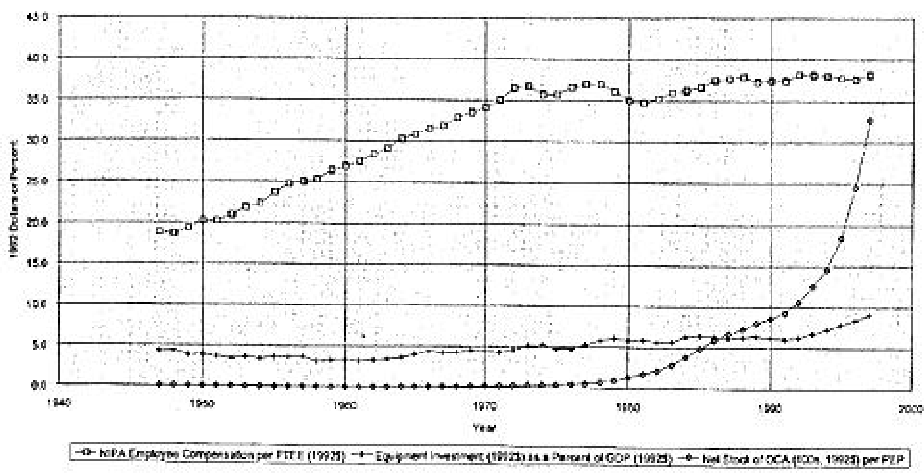
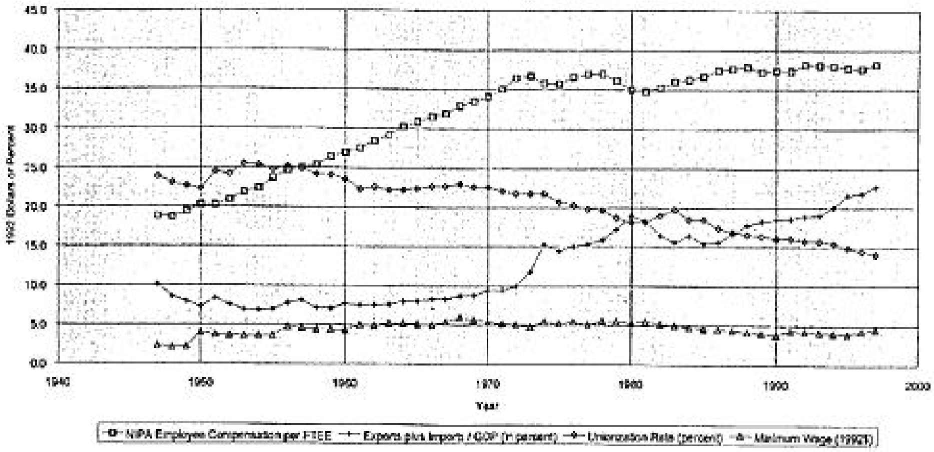


Figure 6. Earnings, International Trade, Unionization, And the Minimum Wage, 1947-1997



NOTES

Several alternative regression forms were also used. First, median years of schooling and median age and age squared were substituted for the mean values of these variables. The resulting coefficients are almost identical to those estimated from the mean values, though the goodness of fit is slightly worse. Second, for 1970, I introduced a variable measuring median years of work experience by occupation in place of median age. Since the correlation of median age with median work experience is 0.94, the coefficient estimate of median work experience is almost identical to that of median age.

It might seem paradoxical that wages increased faster in both the goods producing sector (110 percent) and services (115 percent) than overall (80 percent). The reason is that the change in overall earnings depends on both changes in earnings in each sector and the shift of employment between sectors. In this case, employment shifted out of high wage goods producers to the low wage services, which had a negative effect on the change in the overall wage level. See below for details on the decomposition.

This argument is also consistent with product life cycle models. See Vernon (1966, 1979), for example.

For example, the fact that measured labor productivity growth in the government sector has been close to zero over the postwar period has not prevented government salaries from rising at about the same rate as private sector earnings.

Regressions were also run on two CPS earnings series: median and mean wages and salaries of workers. However, the data are available only for shorter time periods (1961-1997 and 1968-1997, respectively. Still, the results are broadly similar to those reported in Table 7.

Because the dependent variables in these regressions are annual rates of growth, there is unlikely to be a problem with non-stationarity. However, to be sure, I use the Dickey-Fuller Unit Root (DF) test statistic to test for non-stationarity in the four dependent variables. Each of the regressions includes a time trend and the lagged value of the dependent variable. The results are as follows:

Variable	**Z Test Statistic**	**Critical Value (5%)**	**Reject Unit Root?**
Growth in BLS Mean Hourly Earnings	- 33.17	- 20.70	Yes
Growth in NIPA Mean Wages and Salaries	- 35.02	- 20.70	Yes
Growth in NIPA Mean Employee Compensation	- 39.12	- 20.70	Yes
Growth in NIPA Mean Employee Compensation Plus On Half of Proprietors' Income	- 35.77	- 20.70	Yes

Similar results are found using the t-statistic test. In each case, we can reject the hypothesis of a unit root at the five percent level.

A related result is that TFP growth, when labor productivity growth is omitted from the regression equation, also has a coefficient that is positive in every case and significant at the one percent level in three of the four cases and at the five percent level in the other. However, when both labor productivity growth and TFP growth are included in the same equation, labor productivity growth is the dominant effect.

The coefficients of the growth of information processing and related equipment per employee, as well as those of the growth in OCA plus communication equipment per employee, are all negative as well and usually significant though the coefficients of the growth of computers and peripheral equipment per employee are generally not significant. However, the strongest effect comes from the OCA variable.

Capital stock data are generally not available for the government sector and this sector is therefore excluded from the data analysis.

Though data on unionization rates and R&D spending on the industry level are generally not available before 1960, these variables turned out to be insignificant, so that results are reported here for the full time-series.

The BLS hourly earnings data and the CPS earnings data are not available on the industry level.

Industries with low labor productivity growth will adjust to this by raising relative prices. See Baumol, Blackman, and Wolff (1989, Chapter 6) for more discussion of the unbalanced growth effect.