CLAUDIA GOLDIN
Harvard University

LAWRENCE F. KATZ
Harvard University

Long-Run Changes in the Wage Structure: Narrowing, Widening, Polarizing

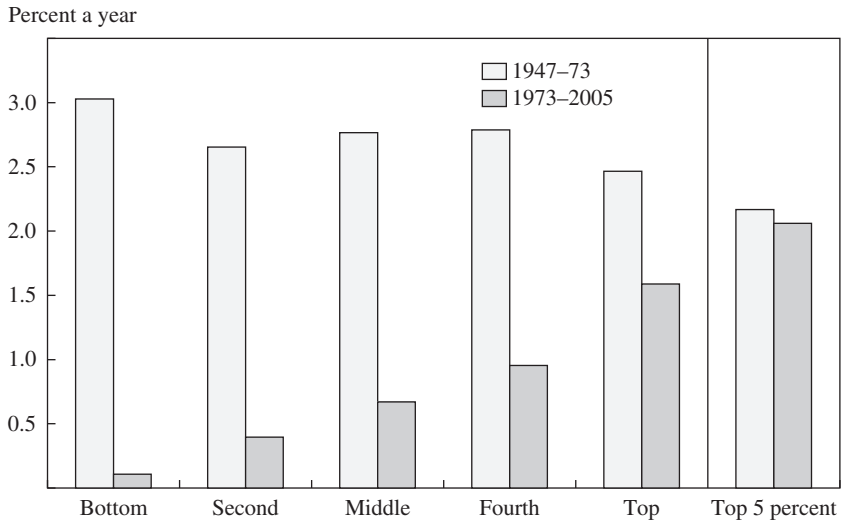
FROM THE CLOSE OF WORLD WAR II TO 1970—the year the *Brookings Papers on Economic Activity* commenced publication—America enjoyed widespread prosperity. Not only did the national economy grow rapidly, driven by robust productivity growth, but all parts of the income distribution expanded at fairly similar rates. America was "growing together." But in the mid-1970s economic growth slowed. By the early 1980s the wage structure had begun a period of widening that has lasted until the present day. Even though productivity growth surged again starting in the mid-1990s, the benefits of economic growth have been concentrated at the top end of the distribution.[1] America has been "growing apart."

These "growing together" and "growing apart" patterns are evident in figure 1, which compares real income growth across the family income distribution for the postwar period before 1973 with that after 1973. Before 1973, real income growth was a bit faster near the bottom of the distribution and somewhat slower near the top, making the changes modestly equalizing. In sharp contrast, from 1973 to 2005 family incomes virtually stagnated for the lowest quintile but grew more than three times as rapidly for the top 5 percent as for the middle quintile.

We are grateful to David Autor for discussions and collaboration over the years on understanding wage structure changes, and for his generous help with the Current Population Survey data. We also thank the Brookings Panel participants for helpful comments.

1. See Dew-Becker and Gordon (2005) on the changing distribution of the benefits of U.S. productivity growth.

Figure 1. Growth in Real Mean Family Income by Income Quintile, 1947–73 and 1973–2005[a]



Source: U.S. Census Bureau, Historical Income Tables, tables F2, F3, and F7.
a. Money incomes before tax and after transfers are converted to constant dollars using the consumer price index research series (CPI-U-RS).

Since most Americans make their living from work, it should not come as a surprise that changes in the labor market and the distribution of wages have been the driving force behind the rising disparity in the economic fortunes of American families.[2] In this paper we document the nature of rising U.S. wage inequality since 1980 and place the recent changes within a century-long historical perspective to understand the sources of change.

The widening of the wage structure that began in the early 1980s differed markedly from the wage structure changes of the early to mid-twentieth century. The wage structure narrowed substantially during the first half of the twentieth century and was relatively stable during the 1950s and 1960s.

The spreading out of the wage structure since 1980 occurred in two stages. From 1980 to around 1987, wage inequality increased in a rapid and monotonic fashion: wages at the top grew most rapidly, those in the

2. Burtless (1999) assesses the contribution of changes in the inequality of labor market earnings to rising family income inequality.

middle less rapidly, and those at the bottom the least of all. Since the late 1980s, wages at the upper end of the distribution have continued to grow rapidly relative to the middle, but the lower end has not lost out relative to the middle. These recent wage structure changes have been associated with a polarization of the labor market, with employment shifting into high- and low-wage jobs at the expense of middle-wage positions.[3]

Why has the wage structure widened so much since 1980? A popular explanation attributes the primary role to an increase in the rate of growth in relative demand for more-skilled workers, due to skill-biased technological change and a reorganization of work driven by the spread of computer-based technologies.[4] Globalization pressures, eroding labor market institutions, and changes in the social norms that constrain pay disparities have also been offered as explanations, and each appears to have played some role.[5] Our focus is on reassessing the skill-biased technological change hypothesis in a long-run historical context.

Skill-biased technological change is not a new phenomenon. Rather, it has driven rapid secular growth in the relative demand for more-educated workers for at least a century. During most of the twentieth century, the narrowing of the wage structure came about largely because the supply of skills grew faster than did the demand for skills. Growth in the relative demand for skills was produced largely by skill-biased technological change. Growth in the supply of skills was due primarily to the rising educational attainment of successive cohorts. That, in turn, was fueled by increased access to public high schools and later to colleges and universities. The upshot of these changes was that the wage structure and educational wage differentials narrowed from 1915 to 1980, especially from 1915 to 1950.

We will show that the majority of the increase in wage inequality since 1980 can be accounted for by rising differences in wages for workers with different educational attainments. Nevertheless, relative demand shifts

3. The polarization terminology is borrowed from Goos and Manning (2007), who document similar recent changes in the employment patterns for Britain, and has been used for the United States by Autor, Katz, and Kearney (2006).

4. See Autor, Katz, and Kearney (forthcoming) and Card and DiNardo (2002) for contrasting evaluations of the role of technological change in U.S. wage structure changes.

5. See Borjas, Freeman, and Katz (1997) on the impacts of trade and immigration, and DiNardo, Fortin, and Lemieux (1996) and Levy and Temin (2007) on institutions and social norms. Katz and Autor (1999) provide an overview of alternative approaches to modeling and measuring wage structure changes.

favoring more-educated workers have *not* been particularly rapid since 1980. Instead growth in the supply of skills slowed considerably after 1980, and the wage structure, in consequence, widened. The deceleration in the relative supply of skills of the working population came about largely from a slowdown in the growth in the educational attainment of U.S. natives for cohorts born since 1950. In contrast, the increase in unskilled immigration accounts for only a small part of the post-1980 slowdown in skill supply growth.

Although the overall rate of relative demand growth for more-skilled workers does not appear to have accelerated since 1980, computerization and foreign offshoring have changed the nature of skill demand shifts. For most of the past century, skill-biased technological change increased the relative demand for skill in a rather *monotonic* manner across the wage distribution. But computerization, a newer form of skill-biased technological change, has increased the relative demand for skill in a *nonmonotonic* manner. Computers strongly complement the nonroutine or abstract tasks of high-wage jobs and, at the other extreme, have little impact on the nonroutine manual tasks of many low-wage service jobs. But computers directly substitute for the skills used to perform the routine tasks characteristic of many traditional middle-wage jobs. This U-shaped pattern of demand shifts appears to have been reinforced by offshoring. The consequence of these changes is a polarization of labor demand that has led to rapidly growing inequality in the top half of distribution with little or no change in inequality in the bottom half.

Trends in the Wage Structure

Two large and representative household datasets have been widely used to document changes in the U.S. wage structure over recent decades.[6] Microdata from the March Current Population Survey (CPS) provide reasonably comparable information for the past four decades on annual earnings, weeks worked, and full- and part-time work status. We use the March files from 1964 to 2006 (covering earnings years 1963 to 2005) to examine

6. See Autor, Katz, and Kearney (forthcoming), Katz and Autor (1999), Lemieux (2006b, 2007), and Mishel, Bernstein, and Allegretto (2007) for comprehensive descriptions of recent U.S. wage structure changes.

trends in the weekly earnings of full-time, full-year workers (FTFY; those working thirty-five or more hours per week for forty or more weeks in the year). We complement the March CPS FTFY series with point-in-time data on the hourly wages of all wage and salary workers, using May CPS samples for 1973–78 and CPS Merged Outgoing Rotation Group (CPS MORG) samples for 1979–2006.[7]

Individual-level data from the federal population censuses on labor market earnings for the previous calendar year, weeks and hours worked, and educational attainment allow us to track the wage structure since 1939.[8] Since no national sample covers all parts of the wage structure before 1939, we have pieced together data from various sources to track wage structure changes from 1890 to 1940. These sources include individual-level data on earnings and educational attainment from the 1915 Iowa state census, wage distributions for manufacturing industries for 1890 to the 1940s, and occupational wage series.[9]

An Overview of Recent Changes

Inequality in hourly, weekly, and annual wages has increased substantially since 1980 for men, for women, and for both combined. The weekly earnings of the 90th-percentile relative to the 10th-percentile FTFY worker increased by 40 log points (49 percent) for men and for women separately from 1980 to 2005 in the March CPS. Expanded wage differentials by education, occupation, and age (or experience), combined with rising within-group (residual) wage dispersion, have all contributed to the rise in wage inequality. The increase in the relative earnings of college graduates and those with advanced degrees has been particularly large. The weekly earnings of FTFY workers with exactly a bachelor's degree increased by 22 log points from 1980 to 2005, while those of FTFY workers with education beyond a bachelor's degree increased by 34 log points, relative to workers with

7. Our wage tabulations from the March CPS and CPS MORG files cover wage and salary workers aged sixteen to sixty-four years and follow the data processing steps documented in the data appendix to Autor, Katz, and Kearney (forthcoming).

8. Social Security Administration individual-level longitudinal annual earnings data starting in 1937 have recently become available, but these data do not include information on educational attainment or on weeks and hours worked. Kopczuk, Saez, and Song (2007) use these data to examine inequality and mobility from 1937 to 2004.

9. See Goldin and Katz (forthcoming) for details on these datasets and on the wage structure from 1890 to 1940.

exactly a high school diploma. An offsetting factor has been a substantial narrowing of the wage differential between the sexes since 1980. But the 90-10 log weekly wage gap for the entire FTFY workforce (males and females combined) nevertheless increased by 26 log points, from 1.33 in 1980 to 1.59 in 2005.

Rising wage inequality since 1980 was *not* significantly offset—indeed, for some measures actually appears to have been reinforced—by changes in nonwage benefits and workplace amenities.[10] Although transitory earnings variation increased in the 1980s, the bulk of the rise of cross-sectional wage inequality was driven by relatively permanent components of earnings variation, including rising returns to education.[11] Earnings inequality expanded even more when one moves beyond standard household datasets to data on tax returns, which provide better information on the top 1 percent of the annual earnings distribution.[12] But large changes in the wage distribution for the bottom 99 percent remain.

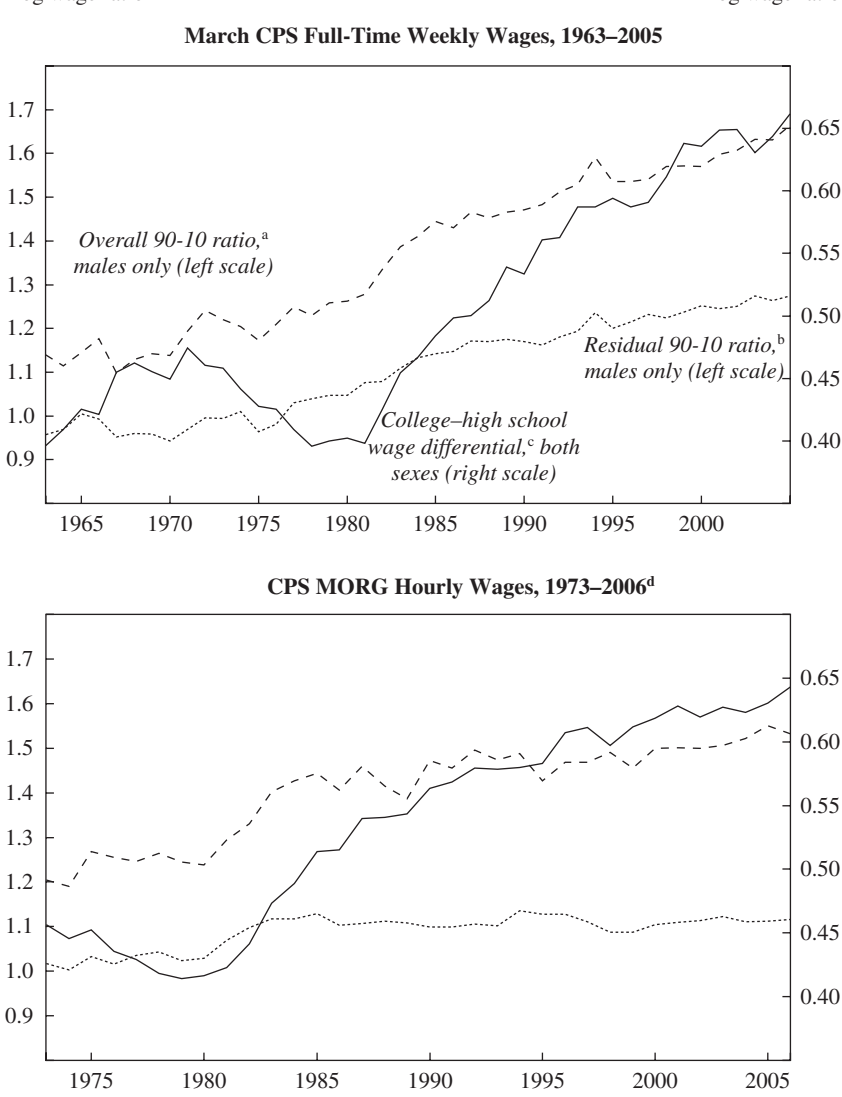
Figure 2 illustrates the timing and the key components of the recent rise in wage inequality. Three aspects of wage inequality are displayed for the March FTFY weekly sample covering 1963–2005 (top panel) and for the CPS MORG hourly wage sample covering 1973–2006 (bottom panel): the 90-10 overall log wage differential (for males), the 90-10 residual log wage differential (for males), and the college–high school log wage differential (for males and females combined). These three measures of inequality rose rapidly and in tandem during the 1980s and then grew more slowly (or flattened) in the 1990s and 2000s. But the college wage premium increased substantially in the 1960s while residual inequality remained quiescent, and the premium declined in the 1970s while residual inequality

10. Pierce (2001, table IV), using the comprehensive microdata on components of employee compensation collected to construct the employment cost index (ECI), finds that the 90-10 log hourly total compensation differential increased by 0.202 from 1982 to 1996, while the 90-10 log hourly wage differential increased by a modestly smaller 0.181 over the same period. Hamermesh (1999) finds that increases in the inequality of working conditions in the 1980s and early 1990s served to exacerbate increases in wage inequality.

11. See, for example, Kopczuk, Saez, and Song (2007). Transitory earnings variation refers to short-run (for example, year-to-year) volatility in earnings, and permanent earnings variation refers to variation across individuals in long-run (for example, decadal) average earnings.

12. See Piketty and Saez (2003, 2007), who document that the share of wage income accruing to the top 1 percent of tax units increased from 6.43 percent in 1980 to 11.62 percent in 2005.

Figure 2. Selected Measures of Weekly and Hourly Wage Inequality



Source: Autor, Katz, and Kearney (forthcoming, figure 2), with updates by the authors to 2006.

a. Difference between log wages at the 90th and those at the 10th percentile.

b. Difference between log wages at the 90th and those at the 10th percentile unexplained by age and education. These are residuals from regressions (estimated separately each year) of log wages on a full set of age and schooling dummy variables and interactions of the schooling dummies with a quartic in age.

c. Fixed-weighted average of the log wage differential between those with at least a bachelor's degree (sixteen or more years of schooling) and those with exactly a high school degree (twelve years of schooling), estimated separately each year by sex for four different experience groups.

d. May CPS samples for 1973–78 and CPS Merged Outgoing Rotation Group (MORG) samples for 1979–2006.

either increased (March CPS) or was flat (CPS MORG). Thus the rise in wage inequality has not been a unitary phenomenon.

All three measures of hourly wage inequality from the CPS MORG display large increases in the first part of the 1980s, but in contrast to the March CPS FTFY series, residual inequality stopped growing after the mid-1980s for hourly wages in the CPS MORG. The greater increase in wage inequality since the mid-1980s for full-time weekly wages in the March CPS than for hourly wages in the CPS MORG partly reflects an increasingly positive covariance of weekly hours and hourly wages even among full-time workers, and likely reflects the growing importance of performance pay (such as annual bonuses), which is presumed to be better reported in the March CPS earnings measure.[13]

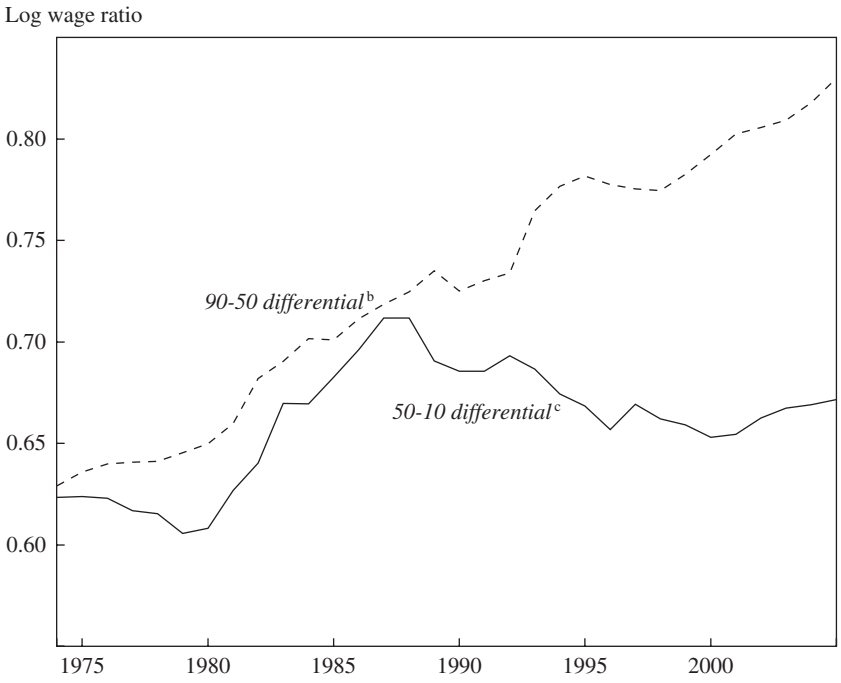
Divergence in Inequality Trends between the Top Half and the Bottom Half

Underlying the pattern just described—rapid growth of overall wage inequality in the 1980s followed by deceleration in the 1990s—is a divergence in inequality trends between the top and the bottom half of the wage distribution. The divergence is shown in figure 3, which contrasts trends in the 90-50 and 50-10 log hourly wage differentials for all workers over the past three decades. Substantial increases in wage inequality occurred in both the upper half (90-50) and the lower half (50-10) of the distribution from 1979 to 1987, expanding the 90-10 log wage differential by 18 log points. But the trends in upper-half and lower-half wage inequality diverged after 1987, with the former continuing to rise steadily and the latter ceasing to rise (and actually contracting by 4 log points from 1987 to 2005).[14] The divergence of upper-half and lower-half inequality since the mid-1980s is also apparent for more-comprehensive measures of compen-

13. Lemieux, MacLeod, and Parent (2007) document the rising incidence of performance pay and its role in rising wage inequality in the upper 20 percent of the wage distribution. The extent to which the growth in performance pay represents an institutional change that increases pay dispersion for a given distribution of worker productivities, as opposed to a mechanism by which employers accommodate a growing dispersion of worker productivities (such as from skill-biased technological change), is difficult to disentangle and remains a key topic for future research.

14. Autor, Katz, and Kearney (forthcoming) document similar patterns of divergence of upper- and lower-half wage inequality trends after 1987 for men and women separately and for both hourly and weekly earnings.

Figure 3. Top-Half and Bottom-Half Hourly Wage Inequality, Both Sexes, 1974–2005[a]



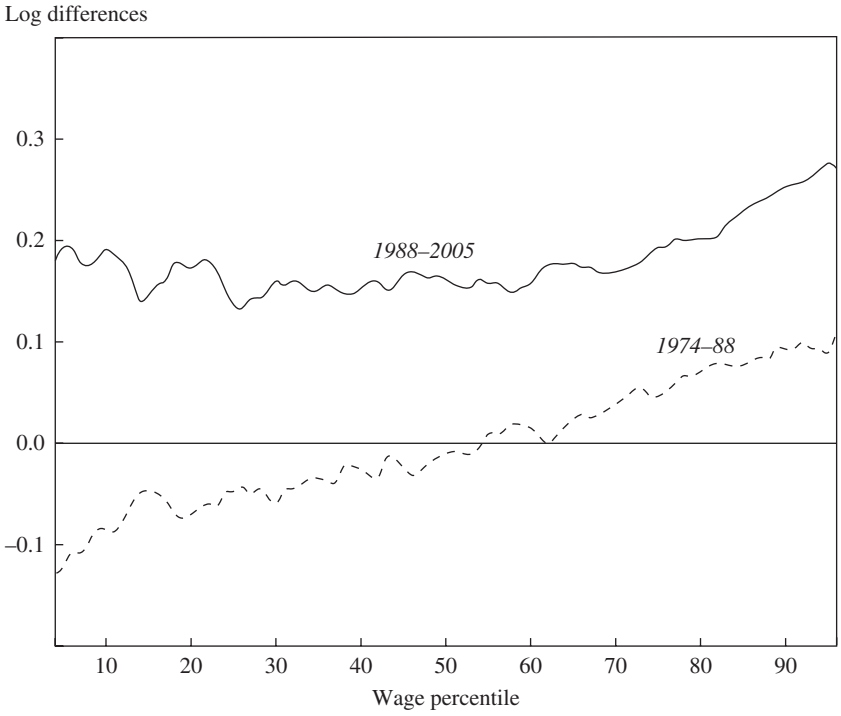
Source: Authors' calculations using 1973–78 May CPS data and 1979–2006 CPS Merged Outgoing Rotation Groups data.
a. Data are three-year centered moving averages.
b. Difference between log wages at the 90th percentile and those at the median.
c. Difference between log wages at the median and those at the 10th percentile.

sation that include the value of employee benefits, and does not simply reflect the disproportionate recent increases in the burden of (and wage offsets from) rising health insurance benefit costs for middle-wage workers.[15]

To show more precisely where in the wage distribution the divergence of upper- and lower-half wage inequality occurred, figure 4 plots cumulative log hourly real wage growth by wage percentile (from the 4th to the 96th percentile) for 1974–88 and for 1988–2005. An almost linear spread-

15. Pierce (2001, 2007), using the microdata from the ECI, finds that the 90-50 log hourly total compensation differential *increased* by 0.108 from 1984 to 1996 and by 0.033 from 1994 to 2005. In contrast, the 50-10 log hourly total compensation differential *decreased* by 0.040 from 1984 to 1996 and by 0.022 from 1994 to 2005.

Figure 4. Changes in Real Hourly Wages by Percentile of the Wage Distribution, Both Sexes, 1974–88 and 1988–2005[a]



Source: Authors' calculations using CPS May survey data for 1973–75 and CPS MORG data for 1987–89 and 2004–06.
a. Wage rates are calculated for 1974, 1988, and 2005 as three-year centered moving averages.

ing out of the wage distribution is apparent from 1974 to 1988, driven by changes in the first half of the 1980s. In contrast, wage growth has polarized since 1988. The 1988–2005 line shows modestly faster wage growth near the bottom than in the middle of the distribution and a continued spreading out of the wage distribution in the top quintile.

Contribution of Increased Returns to Education

Expanded wage differentials between more and less educated workers have been a key component of the rise in wage dispersion since 1980. How much of the overall rise in wage inequality is due to increased returns to schooling? We provide an intuitive answer to the question as follows. We

first use our 1980 and 2005 CPS MORG samples to estimate a modified Mincerian human capital earnings regression of log hourly wages on the following variables: a linear spline in years of schooling, with breakpoints after twelve and sixteen years; a quartic in experience; dummy variables for race, region, and sex; and interactions of sex and the experience quartic. The linear spline in education allows the returns to education to differ for K–12, college, and postcollege (graduate and professional) schooling. We then adjust individual wages in the 1980 sample by imposing the 2005 returns to schooling, and we compare the distributions of actual and adjusted wages in 1980 to determine what wage inequality would have been in 1980 had returns to education been at 2005 levels.[16] Wages in 2005 are analogously adjusted by imposing the 1980 education returns. We then use the average of the results of these two simulations.

Our estimates of the earnings regressions for 1980 and 2005 imply that the returns to schooling both increased and "convexified." Returns to a year of K–12 schooling rose by 0.9 log point, from 0.063 to 0.072, between 1980 and 2005, but returns to a year of college rose by 5.3 log points, from 0.076 to 0.129, and returns to a year of postcollege schooling rose by 6.9 log points, from 0.073 to 0.142. The growing convexification of returns to education has played a key role in the divergence of upper- and lower-half inequality since the late 1980s.

Our simulations show that the increase in returns to schooling (which comes almost entirely from the rise in returns to postsecondary schooling) served to increase the variance of log hourly wages by 0.053 from 1980 to 2005. Thus, increased returns to schooling account for 65 percent of the actual overall variance increase of 0.081 (from 0.248 in 1980 to 0.329 in 2005) for men and women combined. Increased returns to schooling can also account for an increase in the 90-10 log hourly wage differential of 0.133, or about 55 percent of the overall increase of 0.241. In separate analyses by sex, we find that rising returns to schooling explain 62 percent of the growth in hourly wage variance for men and 37 percent for women. Our results reinforce the findings of Thomas Lemieux and his collaborators

16. We adjust 1980 wages for each individual to incorporate 2005 returns to education as follows: we calculate, for each of three educational categories (K–12, college, and postcollege), the product of the individual's years of schooling in that category and the difference in estimated returns to a year of schooling in that category between 2005 and 1980; we then add the sum of these three results to each individual's 1980 wage.

that rising returns to education represent the largest component of recent increases in U.S. male wage inequality.[17]

Long-Run Changes

How does the recent expansion of wage inequality and of educational wage differentials fit into the longer-term changes observed in the U.S. wage structure? We use the Integrated Public Use Micro-samples from the 1940–70 decennial censuses (Census IPUMS) to extend our March CPS series on overall male FTFY weekly wage inequality (from the top panel of figure 2) back to 1939. The resulting series for the male 90-10 log weekly wage differential for 1939–2005 is shown in figure 5.

The growth in wage inequality since the late 1970s was preceded by a substantial narrowing of the wage structure during the "Great Compression" of the 1940s, when the male 90-10 log weekly wage gap decreased by 35 log points, and then by a period of little change in wage inequality during the 1950s and 1960s.[18] Also plotted in figure 5 is a continuous series for 1937–2004 on annual earnings inequality (the Gini coefficient) for male commerce and industry workers, constructed by Wojciech Kopczuk, Emmanuel Saez, and Jae Song from Social Security Administration earnings history data.[19] The time-series pattern is similar to the Census/CPS weekly wage inequality series and reveals that the great narrowing of wages in the 1940s continued until 1953, although it was sharpest during World War II. Both series indicate that the surge in wage inequality during the 1980s undid the changes of the Great Compression and that male earnings inequality is higher today than at any previous time at least back to the 1930s.

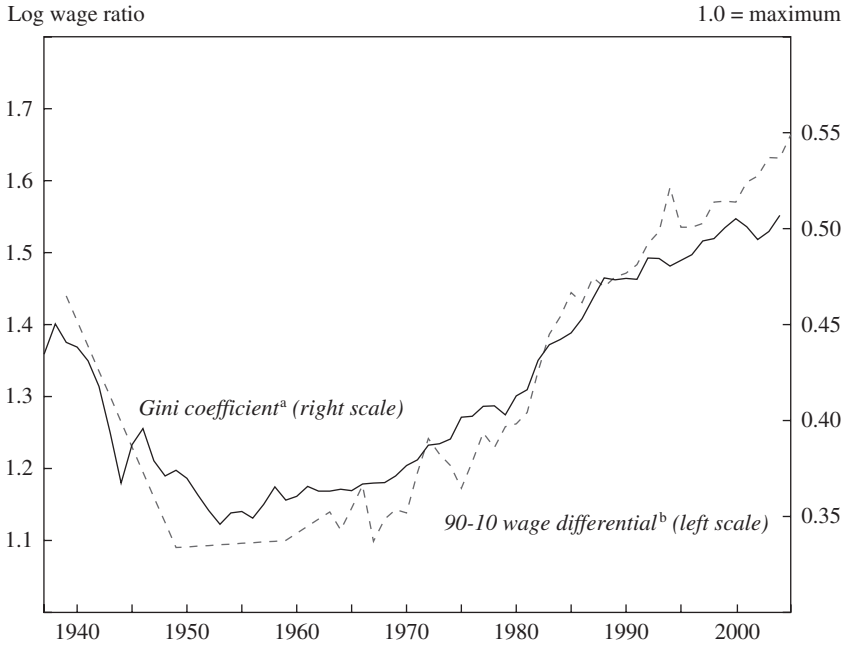
We use the Census IPUMS data to examine educational wage differentials back to 1940, and we link the results to data we obtained from the 1915 Iowa state census to create a consistent measure of returns to education back to that year. Figure 6 plots the college and high school graduate wage pre-

17. Lemieux (2006a), using a formal variance decomposition, finds that higher returns to postsecondary education explain 55 percent of the rise in male log hourly wage variance from 1973–75 to 2003–05. Firpo, Fortin, and Lemieux (2007), using a nonparametric decomposition, find that rising returns to education can explain 0.067 (or 54 percent) of a 0.125 rise in the male 90-50 log hourly wage gap and over 100 percent of increased wage variance from 1988 to 2005.

18. See Goldin and Margo (1992) on the period they describe as the "Great Compression."

19. Kopczuk, Saez, and Song (2007).

Figure 5. Selected Measures of Male Wage Inequality, 1937–2005



Sources: U.S. Census Bureau Integrated Public Use Micro-sample (IPUMS) data for 1940–70 (covering earnings years 1939–69) and March CPS samples for 1964–2006 (earnings years 1963–2005); Kopczuk, Saez, and Song (2007; data available at www.columbia.edu/~wk2110/uncovering).

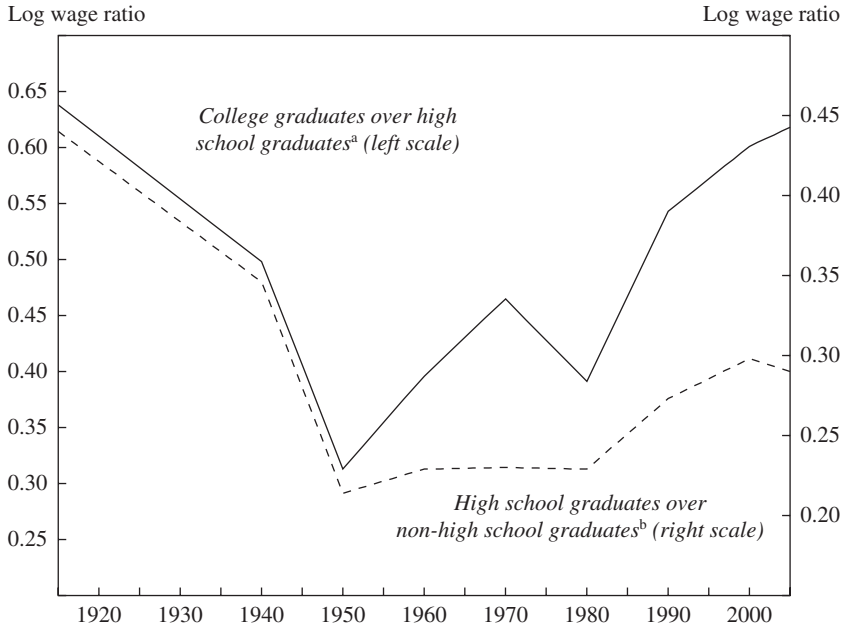
a. For annual earnings of male commerce and industry workers for 1937–2004, from Social Security Administration earnings history data constructed and documented by Kopczuk, Saez, and Song (2007).

b. Difference between log wages at the 90th and those at the 10th percentile for male full-time, full-year wage and salary workers from the Census IPUMS data, which cover males eighteen to sixty-four years old, and the March CPS data, which cover males sixteen to sixty-four years old. Points for 1963–2005 are plotted directly from the March CPS data, and points from 1939–59 are scaled so that the 1959–69 change in the differential equals the actual 1959–69 change for the Census IPUMS.

miums from 1915 to 2005. These premiums were exceptionally high in 1915, when white-collar workers (even ordinary clerks) were considered by many to be a "noncompeting" group. A high school education was, at the time, the ticket to most white-collar and top blue-collar jobs, and high school graduates were a more elite class than college graduates are today.[20]

20. See Goldin and Katz (2000, forthcoming) on returns to education, occupational wage differentials, and "noncompeting" groups in the early twentieth century. Goldin and Katz (forthcoming, table 1.2) find that 14.6 percent of the Iowa workforce had at least a high school diploma in 1915 and that fewer than 12 percent of the U.S. workforce had a high school diploma in that year, whereas 30 percent had a college degree in 2005.

Figure 6. Wage Premiums Earned by High School and College Graduates, 1915–2005



Source: Goldin and Katz (forthcoming, chapter 8, figure 1, and appendix table A8.1).

a. Weighted average of an estimate of the college (exactly sixteen years of completed schooling, or a bachelor's degree) and the postcollege (seventeen or more years of schooling, or a postbaccalaureate degree) log wage premium relative to high school graduates (those with exactly twelve years of completed schooling, or a high school diploma). The weights are the employment shares of college and postcollege workers in 1980. Estimates for 1940–80 are from Census data; estimates for 1915–40 are extended back from the Census data using data from Iowa; estimates for 1990, 2000, and 2005 extend Census data by adding, respectively, the changes in the log college–high school wage ratios from 1980–90 (from the CPS), 1990–2000 (from Census data), and 2000–05 (from the CPS).

b. Difference in log wages between high school graduates as defined above and those who did not continue schooling beyond eighth grade. Data for 1940–80 are from Census estimates; data for 1915–39 are constructed as above; estimates for 1990 and 2005 extend the 1940–80 Census data using the CPS MORG; the 2000 estimate extends the 1940–80 Census data using the February 1990 CPS and the 2000 CPS MORG.

Educational wage differentials narrowed substantially from 1915 to 1940 and again in the 1940s. The college wage premium today has come full circle to its level in 1915, but the high school wage premium is lower today than in the early twentieth century.

Although we lack nationally representative samples to measure the full wage structure before the end of the 1930s, we have uncovered a wide range of data on different parts of the wage structure from 1890 to 1940. All of our sources indicate a substantial narrowing of the wage structure from 1910 to 1940, especially during the World War I years. Declines in

overall earnings dispersion among manual workers in manufacturing, occupational wage differentials between skilled and less skilled manual workers, and white-collar to blue-collar wage differentials reinforce the findings in figure 6 of shrinking educational wage differentials from 1915 to 1940.[21] We conclude that wage inequality and wage differentials by occupation and education shrank substantially during the first half of the twentieth century.

Over the long run the U.S. wage structure has followed a progression from narrowing to widening to polarizing. A substantial narrowing occurred from 1910 to 1950, and relative stability characterized the 1950s and 1960s. A sharp monotonic widening ensued in the 1980s, and the wage structure has polarized since the late 1980s. Even though educational wage differentials and overall wage inequality do not always move closely together in the short run (they did not during parts of the 1970s), changes in returns to education played a major role in declining wage inequality in the first half of the twentieth century and in rising wage inequality over the last three decades. In fact, our estimates imply that the majority of the increase in wage inequality since 1980 can be accounted for by increased returns to education (dominated by large increases in returns to college and postcollege schooling). Thus an understanding of the driving forces behind long-run changes in educational wage differentials is essential to understanding recent changes in the wage structure.

The Race between the Supply of and the Demand for Skills, 1915–2005

We model changes in educational wage differentials using the conceptual framework of a race between the supply of skills (driven by changes in the educational attainment of the workforce) and the demand for skills (driven by skill-biased technological change).[22] We apply this approach to understanding the trends we have observed in the college wage premium from 1915 to 2005.

21. See Goldin and Katz (forthcoming, chapter 2).

22. The notion that long-run changes in the wage structure are the outcome of a race between education and technology is further developed in Goldin and Katz (2007 and forthcoming) and dates back to Tinbergen (1974) and Freeman (1975). We follow the specific analytical framework and empirical methods developed by Katz and Murphy (1992).

Our illustrative framework starts with a constant-elasticity-of-substitution production function for aggregate output Q with two factors, skilled workers (S) and unskilled workers (U):

$$(1) \qquad Q_t = \left[\alpha_t \left(a_t L_{S_t}\right)^{\rho} + \left(1 - \alpha_t\right)\left(b_t L_{U_t}\right)^{\rho}\right]^{\frac{1}{\rho}},$$

where L_{S_t} and L_{U_t} are the quantities of skilled labor and unskilled labor, respectively, employed in period t; a_t and b_t represent skilled and unskilled labor-augmenting technological change, respectively; and α_t is a time-varying technology parameter that can be interpreted as indexing the share of work activities allocated to skilled labor. The parameter ρ is related to σ_{SU}, the aggregate elasticity of substitution between skilled and unskilled labor, such that $\sigma_{SU} = 1/(1 - \rho)$. Skill-neutral technological improvements raise a_t and b_t by the same proportion. Increases in (a_t/b_t) or in α_t both represent skill-biased technological change. We focus on the college–high school divide so that skilled workers (S) are defined as "college equivalents" (college graduates plus half of those with some college), and unskilled workers (U) are "high school equivalents" (those with twelve or fewer years of schooling plus half of those with some college).

Under the assumption that college and high school equivalents are paid their marginal products, we can use equation 1 to solve for the ratio of the marginal products of the two skill groups, yielding a relationship between relative wages and relative skill supplies in t given by

$$(2) \qquad \ln\left(\frac{w_{S_t}}{w_{U_t}}\right) = \frac{1}{\sigma_{SU}}\left[D_t - \ln\left(\frac{L_{S_t}}{L_{U_t}}\right)\right],$$

where D_t, measured in log quantity units, depends on the skill-biased technological change parameters and indexes relative demand shifts favoring college equivalents.[23] The terms in brackets in equation 2 show how changes in the college wage premium over time depend on a race between the relative demand for and the relative supply of skills. The aggregate elasticity of substitution between college and high school equivalents (σ_{SU}) is the key parameter determining how much a change in skill supply affects the college wage premium. The greater is σ_{SU}, the smaller is the impact of a shift

23. $D_t = \sigma_{SU} \ln[\alpha_t/(1 - \alpha_t)] + (\sigma_{SU} - 1) \ln(a_t/b_t)$.

in relative supply on wages, and the greater must be fluctuations in demand shifts (D_t) for any given time series of relative wages to be consistent with a given time series of relative quantities.

How important have shifts in skill supply and skill demand been in determining the college wage premium series from 1915 to 2005 as shown in figure 6? We directly measure the college wage premium and the relative supply of college equivalents. Assuming a plausible value for σ_{SU}, we then use equation 2 to generate an implied time series of relative demand shifts (D_t). Our preferred model estimated on national data for 1914 to 2005, with demand shifts given by smooth time trends and an allowance for institutional wage setting in the 1940s, indicates that a 10 percent increase in relative skill supply reduces the college wage premium by 6.1 percent, implying that $\sigma_{SU} = 1.64$.[24] We also find little evidence that σ_{SU}, measured in this manner, has changed much over the last century. A value for σ_{SU} of 1.64 is consistent with a large empirical literature that typically finds σ_{SU} to be in the range of 1 to 2.5, from the estimation of extended versions of equation 2 on both national time-series and regional panel data.[25]

The large increase in the log college wage premium, from 0.313 in 1950 to 0.618 in 2005 (see figure 6), took place while the relative supply of college workers was sharply increasing. The college graduate share of full-time equivalent employment increased from 7.8 percent in 1950 to 31.8 percent in 2005, and the college equivalent share increased from 12.4 percent to 46.2 percent.[26] Rapid secular growth in the relative demand for college workers is needed to reconcile a rising college wage premium with these large increases in their relative supply. Long-run shifts in the industrial and occupational mix of employment toward more education-intensive sectors and jobs have played an important role in rapid secular growth in the relative demand for skills.[27]

Furthermore, substantial evidence suggests that skill-biased technological change has been the primary contributor to rising relative demand for skills.

24. See table 8.2 of Goldin and Katz (forthcoming). Autor, Katz, and Kearney (forthcoming) obtain almost identical estimates of σ_{SU} for a variety of specifications of time trends estimated on data for 1963–2005.

25. Katz and Autor (1999) review much of this literature.

26. These tabulations use the 1950 Census IPUMS and the 2005 CPS MORG for the workforce aged eighteen to sixty-five years.

27. See, for example, Autor, Katz, and Krueger (1998), Goldin and Katz (1998), and Juhn and Murphy (1995).

In recent decades the relative employment of more-skilled workers has increased rapidly within detailed industries and individual establishments, despite sharp increases in their relative wages.[28] The adoption of new technologies (and associated organizational changes), more R&D, and greater capital intensity of production have been strongly associated with higher utilization of more-skilled workers in firms and industries. Evidence of technology-skill complementarity has been associated with the electrification of the factory in the early twentieth century and the introduction of computer-based technologies more recently.[29]

Changes in the college wage premium and in the relative supply and demand for skilled (college equivalent) workers are reported in table 1 for selected periods from 1915 to 2005.[30] The college wage premium, in the first column of the table, was about the same in 2005 as in 1915. Thus supply and demand forces kept pace over the long run, each growing at about 2.9 percent a year on average. On the other hand, from 1915 to 1980 supply growth substantially outstripped demand growth. The pattern was reversed after 1980. Although our estimates imply faster growth in the relative demand for college workers since 1950 than in the first half of the twentieth century, they do not imply particularly rapid demand growth from 1980 to 2005 and, in fact, suggest a slowdown since 1990.

A key message from table 1 is that a sharp slowdown in skill supply growth rather than a persistent acceleration in demand growth has been the driving force behind the large rise in the college wage premium from 1980 to 2005. Consider that the college wage premium did not rise from 1960 to 1980 but increased by 0.90 percent a year from 1980 to 2005, whereas relative demand growth was slightly slower from 1980 to 2005 (3.76 percent a year) than it had been from 1960 to 1980 (3.85 percent a year). In contrast,

28. See Dunne, Haltiwanger, and Troske (1997) and Autor, Katz, and Krueger (1998). Foreign outsourcing of less-skilled jobs is another possible explanation for this pattern, but large within-industry shifts toward more-skilled workers have been pervasive even in sectors with little or no observed international trade or outsourcing activity.

29. See Goldin and Katz (1998, forthcoming) on skill-biased technological change in the early twentieth century, Griliches (1969) on capital-skill complementarity in the mid-twentieth century, and Doms, Dunne, and Troske (1997) and Bartel, Ichniowski, and Shaw (2007) for more recent evidence on technology adoption and skill utilization.

30. The figures in the table assume $\sigma_{SU} = 1.64$. We measure skill supplies in efficiency units, taking into account systematic differences in productivity (wages) by age, sex, and education within each skill aggregate and adjusting for changes in the age-sex-education group composition of hours worked within each skill aggregate.

Table 1. Changes in the College Wage Premium and in the Supply and Demand for College-Educated Workers: 1915–2005
Annual log change × 100

Period	Change in the relative wage[a]	Change in relative supply[b]			Change in relative demand[c] ($\sigma_{SU} = 1.64$)
		Overall	Native-born component	Immigrant component	
1915–40	–0.56	2.82	2.57	0.25	1.90
1940–50	–1.86	2.69	2.48	0.21	–0.36
1950–60	0.83	3.23	3.02	0.21	4.60
1960–70	0.69	2.86	2.72	0.14	4.00
1970–80	–0.74	4.91	4.94	–0.02	3.69
1980–90	1.51	2.69	2.85	–0.16	5.18
1990–2000	0.58	2.26	2.35	–0.09	3.21
1990–2005	0.50	1.99	2.15	–0.16	2.81
1940–60	–0.51	2.96	2.75	0.21	2.12
1960–80	–0.02	3.89	3.83	0.06	3.85
1980–2005	0.90	2.27	2.43	–0.16	3.76
1915–80	–0.38	3.19	3.01	0.18	2.57
1915–2005	–0.02	2.94	2.85	0.08	2.90

Source: Authors' calculations using data from tables 8.1 and 8.6 of Goldin and Katz (forthcoming), which are derived from data in the 1915 Iowa State Census, the 1940–2000 Census IPUMS, and the 1980–2005 CPS MORG.

a. The relative wage is defined as the log college–high school wage differential (the college wage premium). The underlying college wage premium series is plotted in figure 6.

b. For college equivalents (college graduates plus half of those with some college) relative to high school equivalents (those with twelve or fewer years of schooling plus half of those with some college). Relative skill supply is measured in efficiency units. The native-born and immigrant relative supply columns decompose overall relative skill supply growth into the respective contributions, using equation 3 in the text.

c. For college equivalents relative to high school equivalents. The log relative demand measure (D_t) is based on equation 2 in the text and is given by $D_t = \ln(L_{S_t}/L_{U_t}) + \sigma_{SU} \ln(w_{S_t}/w_{U_t})$ under the assumption that $\sigma_{SU} = 1.64$.

the growth in relative supply of college workers decreased from 3.89 percent a year from 1960 to 1980 to 2.27 percent a year from 1980 to 2005. Thus the deceleration in relative supply growth more than fully explains the post-1980 rise in the college wage premium.

Our supply-and-demand framework is a useful tool for most of the 1915–2005 period, but certain anomalies call out for a more nuanced explanation. For example, the implied negative relative demand growth in the 1940s is probably picking up strong institutional interventions in wage setting during World War II and a surge in unionization. Similarly, some of the rapid implied demand growth in the 1950s may reflect a partial unraveling of these institutional forces. The rapid implied skill demand growth in the 1980s may also reflect a weakening of wage-setting institutions that had supported the earnings of non-college-educated workers, such

as the steady erosion of the real value of the federal minimum wage from 1981 to 1990 and the steep decline in unionization.

Technology, we conclude from table 1, has been racing ahead of education in the recent period because growth in educational attainment has been sluggish, *not* because the rate of skill-biased technological change has accelerated. What drove rapid relative skill supply growth for most of the twentieth century, and what accounts for the post-1980 slowdown in skill supply growth?

National skill supplies can change because of shifts in the educational distribution of the native-born workforce and because of immigration. Immigration was a major source of U.S. labor force growth in the early twentieth century, became much less important with the imposition of immigration restrictions in the 1920s, and has surged in recent decades after the immigration laws were reformed in 1965. The foreign-born share of the workforce declined from around 21 percent in 1915 to 5.4 percent in 1970 before rebounding to 15.1 percent in 2005.[31] Immigrants in the early twentieth century had considerably less schooling on average than native-born workers. Recent waves of immigrants have a bimodal educational distribution relative to the native-born: immigrants are disproportionately found among those with no high school education and, at the same time, among those who have more education than a college degree.[32]

The relative supply of skilled (college equivalent) to unskilled (high school equivalent) workers can be decomposed into native-born and immigrant components as follows:

$$(3) \qquad \log\left(\frac{L_{S_t}}{L_{U_t}}\right) = \log\left(\frac{N_{S_t}}{N_{U_t}}\right) + \left[\log\left(1 + \frac{M_{S_t}}{N_{S_t}}\right) - \log\left(1 + \frac{M_{U_t}}{N_{U_t}}\right)\right],$$

where N_{j_t} is the supply of native-born and M_{j_t} that of immigrant workers in skill group j in year t, and $L_{j_t} = N_{j_t} + M_{j_t}$.[33] The first term on the right-hand side of equation 3 is the native-born contribution to the log skill supply ratio. The second term, in brackets, is the immigrant contribution.

We use equation 3 to assess the contributions of native-born and immigrant workers to changes in skill supply in the third and fourth columns of

31. These estimates are from tabulations using the 1910, 1920, and 1970 Census IPUMS and the 2005 CPS MORG.

32. See Goldin and Katz (forthcoming, table 8.5).

33. This decomposition approach follows Borjas, Freeman, and Katz (1997).

table 1. The decline in the immigrant share of the workforce contributed modestly to relative skill supply growth from 1915 to 1970, and the recent surge in unskilled immigration has played a small role in the slowdown of that growth.

But long-run skill supply growth has been dominated by growing educational attainment of the native-born. The post-1980 slowdown in skill supply growth is mainly due to slower growth in the educational attainment of this group. The annual rate of growth in the relative supply of college equivalents declined by 1.62 percentage points, from 3.89 percent a year for 1960–80 to 2.27 percent a year for 1980–2005. Of that decrease, 1.40 percentage points (86 percent of the total) was due to the slowdown in the relative supply of the college educated among the native-born. Only 0.22 percentage point (14 percent) was due to immigration.

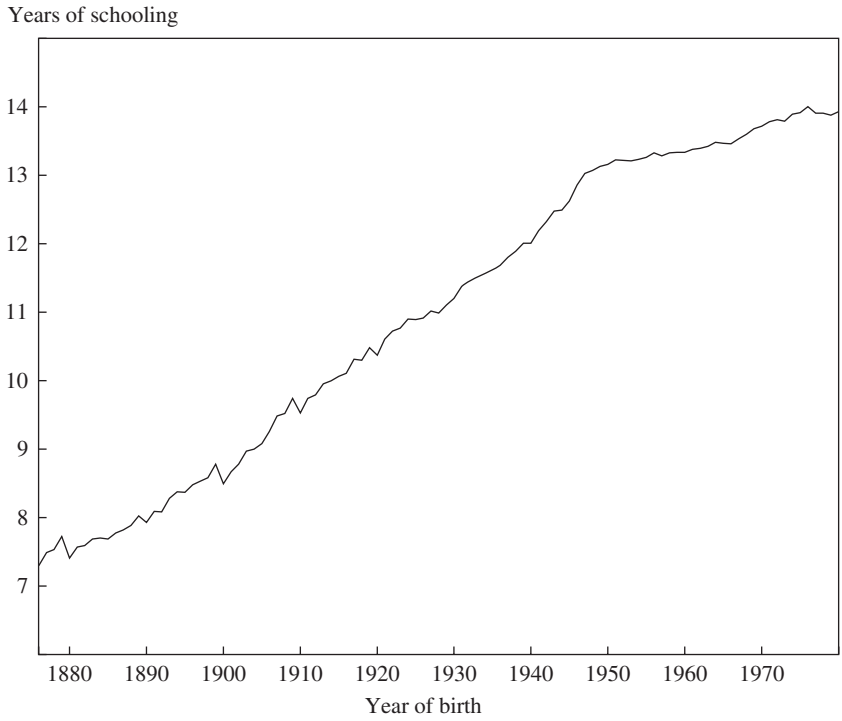
Changes in the growth of the relative skill supply of the native-born can arise either from changes in the growth of educational attainment of successive birth cohorts or from changes in the size of entering cohorts due to baby booms and baby busts. The main source of rising national skill supply from 1915 to 1980 was the rapidly increasing educational attainment of successive cohorts of the native-born. Similarly, the main factor in the slowing of skill supply growth since 1980 has been slower growth in the educational attainment of post-1950 cohorts of the native born. These trends are shown in figure 7, which plots mean years of schooling (measured at age thirty) for birth cohorts of native-born Americans from 1876 to 1980.

Educational attainment increased rapidly for the 1876–1950 birth cohorts. This growth accelerated with the high school movement in the 1910s, that is, for those born starting around 1900. Each generation of Americans born in the first half of the twentieth century had about two more years of schooling on average than their parents. Average educational attainment increased by 4.67 years (or 0.93 year per decade), from 8.49 years for those born in 1900 to 13.16 years for those born in 1950. In contrast, those born in 1975 have only 0.74 year of schooling more (0.30 year per decade) than their parents' generation born in 1950.

We decompose the growth of relative skill supply of the native-born into educational attainment growth across cohorts and changes in cohort size.[34]

34. The methodology is analogous to that based on equation 3 for decomposing overall relative skill supply growth into immigrant and native-born components, and uses data on skill supply by single-year-of-age birth cohorts.

Figure 7. Mean Years of Schooling by Annual Birth Cohort, Native-Born Workers, 1876–1980[a]



Source: U.S. Census Bureau Integrated Public Use Micro-samples (IPUMS) data from 1940–2000 and 2005 CPS MORG data.

a. Results are adjusted to thirty years of age using results of a regression of the log of mean years of schooling by birth cohort–year cell on a full set of birth cohort dummies and a quartic in age, using IPUMS data for 1940–2000. The samples include all native-born residents aged twenty-five to sixty-four. For further details on the method and data processing, see Goldin and Katz (forthcoming, figure 1.4).

Of the total decline in the annual growth rate of domestic supply of college-educated workers of 1.4 percentage points (3.83 percent − 2.43 percent) from 1960–80 to 1980–2005 (third column of table 1), almost 70 percent (0.97 percentage point) was due to the slowdown in the growth of educational attainment across successive birth cohorts. The deceleration in the educational attainment of the native-born explains a 0.59 percent a year rise in the college wage premium (for $\sigma_{SU} = 1.64$), compared with an actual increase of 0.90 percent a year, from 1980 to 2005.

The slower growth of educational attainment for the native-born after 1950 is the largest source of the post-1980 increase in the college wage

premium. Accelerated growth of educational attainment due to increased access to public high schools starting around 1910 was the major factor in the narrowing of the high school wage premium from 1915 to 1940.[35] In both periods the growth in skill supply through changes in educational attainment was paramount.

These differences in skill supply growth between the early twentieth and early twenty-first centuries raise the question of whether the United States has reached an upper bound for educational attainment. We do not think so. Other industrial nations have achieved far higher secondary school graduation rates than the United States, and some have passed the United States in four-year college completion rates.[36] More convincing is the fact that the returns to further educational investments, from marginal expansions in financial aid and in access to college as well as from recent increases in state compulsory schooling requirements, continue to be substantial.[37]

The Polarization of the Labor Market

The U.S. wage distribution spread out monotonically and rapidly from 1979 to 1987, but then polarized. Ever since around 1987, the paths of upper-half and lower-half wage inequality have diverged, with a continuing persistent rise in upper-half wage inequality and a slight reversal of inequality growth in the lower half of the distribution (see figures 3 and 4). This polarization can also be observed in educational wage differentials. The wage gap between postcollege-educated and college-educated workers has continued to expand rapidly since the late 1980s, even as the growth in the wage gap between high school graduates and dropouts has abated.[38]

35. See Goldin and Katz (2007, forthcoming) for a supply-demand analysis of the high school graduate wage premium.

36. The Organization for Economic Cooperation and Development (OECD, 2006) reports the U.S. high school graduation rate in 2004 at 75 percent, compared with 83 percent among EU nations. The U.S. high school graduation rate was in the bottom third of twenty-six OECD nations in 2004. The United States ranked only seventh out of the twenty richest OECD nations in secondary school completion among 25- to 34-year-olds in 2004, even when General Educational Development (GED) diploma recipients are included as secondary school completers. The OECD data also indicate that the United States is at about the OECD average for four-year college completion rates among young cohorts, trailing twelve other nations.

37. See Card (2001) and Oreopoulos (2007).

38. See Autor, Katz, and Kearney (forthcoming) and Lemieux (2007).

A more nuanced view of skill-biased technological change directly examines how rapid price declines in computer technology affect the demand for workers to perform specific job tasks and serves to explain many details of the recent wage polarization. David Autor, Frank Levy, and Richard Murnane have amassed evidence consistent with a task demand framework in which computerization has nonmonotonic impacts on the demand for skill.[39] Changes in the organization of work associated with computerization raise the demand for the cognitive and interpersonal skills (called "abstract tasks") used by educated professionals and managers and reduce the demand for the clerical and routine analytical and mechanical skills (called "routine tasks") that characterize many middle-educated white-collar positions and manufacturing production jobs. Computerization has probably had little direct impact on the demand for the nonroutine manual skills (called "manual tasks") used in many low-skilled service jobs (such as health aides, security guards, and cleaners) and in many jobs in the building trades.[40]

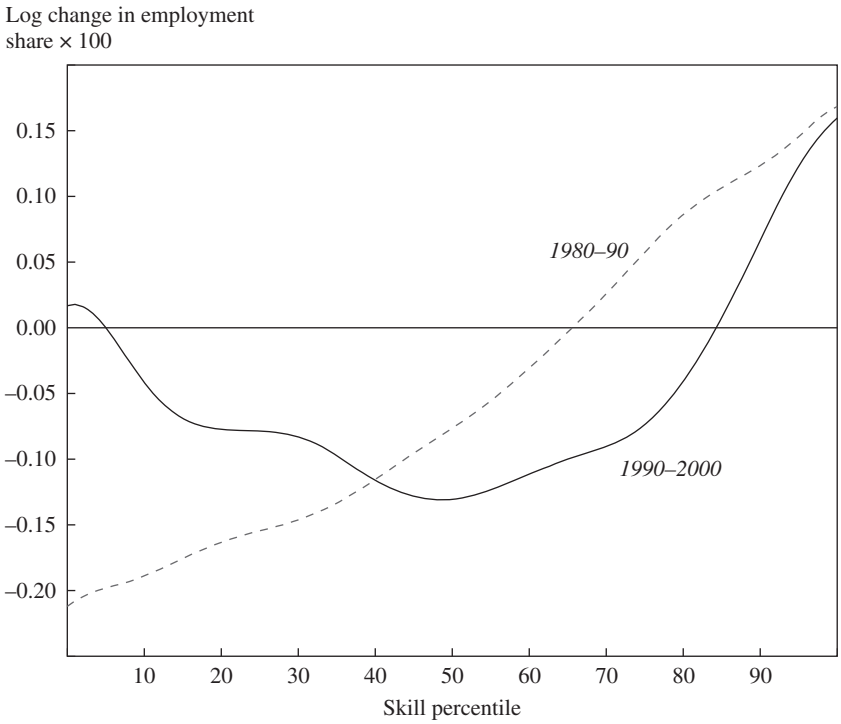
The Autor-Levy-Murnane framework suggests that computerization has led to changes in the organization of work that have raised the demand for more-educated workers, depressed the demand for middle-educated workers, and left the lower echelons of the wage distribution, in the in-person service sector, comparatively unscathed. The indirect effects of computerization in reducing the communication and coordination costs that facilitate international outsourcing are likely to have reinforced this pattern.

The computer task demand hypothesis suggests that wage polarization is substantially a demand-side phenomenon induced by rising relative demands for high- and low-skill tasks. An implication is that employment demand growth (and employment growth) should have been monotonically rising in the skill distribution in the 1980s and should have been nonmonotonic (lowest in the middle) since the late 1980s.

39. See Autor, Levy, and Murnane (2003). Autor, Katz, and Kearney (2006) extend the Autor-Levy-Murnane framework and show that declining computer prices may initially lead to monotonically increasing shifts in skill demand (if, at first, routine tasks in low-wage jobs are easier to computerize than routine tasks in higher-wage jobs), followed by nonmonotonic shifts favoring the top and the bottom at the expense of the middle of the wage distribution.

40. The interpersonal and environmental adaptability demanded by these manual tasks, particularly for many in-person services, have so far proved difficult to computerize. The in-person nature of many service jobs also serves to insulate them from offshoring.

Figure 8. Changes in Share of Employment by Percentile of the Occupational Skill Distribution, 1980–90 and 1990–2000[a]



Source: Autor, Katz, and Kearney (forthcoming, figure 11A), based on Census IPUMS 5 percent samples for 1980, 1990, and 2000 for those currently employed in the civilian labor force and aged eighteen to sixty-four.

a. Occupational skill percentiles are those for 1980 derived from mean years of schooling in each occupation in that year. Results are smoothed using a locally weighted regression with a bandwidth of 0.8 and 100 observations.

To investigate this implication, figure 8 plots changes in the share of total hours worked by occupational skill (education) percentile for 1980–90 and 1990–2000. During the 1980s employment shares declined substantially at the bottom of the skill distribution, and employment growth increased continuously as one moves up the distribution. In contrast, employment growth polarized in the 1990s: the most rapid employment growth was in the highest-skilled jobs, declines in employment shares occurred for middle-skilled jobs, and employment shares in the lowest-skilled occupations were flat or even rising. The polarization of employment growth since 1990

represents a sharp break in a long line of successive technological advances that have generated monotonically rising demand by skill level since at least 1940.[41] Furthermore, figure 8 shows that the mean gap in employment share growth rates between "college jobs" (those in the top half of the skill distribution) and "noncollege jobs" (the rest) shrank from the 1980s to the 1990s in a manner consistent with the slowdown in relative demand growth for college equivalents from the 1980s to the 1990s reported in table 1.

The computer task demand hypothesis has implications concerning within-group shifts in skill demand and wage inequality by education group. Computers are strong complements to the skills of college graduates in performing abstract tasks in top-end professional and management positions, whereas they substitute for the skills of lower-end college graduates in performing tasks in middle management and certain professional positions. Computers eliminate many of the manufacturing production and administrative jobs often found in the upper half of the noncollege wage distribution, but they have little direct impact on the lower-end service jobs mostly held by noncollege workers in the lower half. The implication is that within-group wage inequality should have been sharply rising for college graduates and possibly even declining for high school workers since the late 1980s. And that is, in fact, exactly what the CPS wage data show.[42]

Conclusions

The U.S. wage structure has followed a distinct pattern across the last century, narrowing from 1910 to 1950, then achieving relative stability in the 1950s and 1960s, then rapidly widening in a monotonic fashion during the 1980s, and finally polarizing since the late 1980s. The majority of the large increase in wage inequality since 1980 is accounted for by expanded educational wage differentials dominated by sharply increased returns to postsecondary schooling. Of course, wage inequality has also increased sub-

41. For example, Juhn and Murphy (1995) examine the relative demand for occupation-industry cells (ranked by skill in terms of average wage percentiles) and find labor demand growth monotonically rising in skill for 1940–80.

42. Autor, Katz, and Kearney (2005) and Lemieux (2006b) document rising within-group wage inequality for both male and female college graduates from 1988 to the early 2000s, and little change or declining within-group wage inequality for high school workers over the same period.

stantially *within* education groups since 1980, particularly for the college educated.

Skill-biased technological change has generated rapid secular growth in the relative demand for more-educated workers for at least the past century. But rapid increases in the supply of skills, stemming from rising educational attainment of the workforce, more than kept pace with this growing demand for most of the twentieth century and served to reduce educational wage differentials and narrow the wage structure. A sharp decline in relative skill supply growth, driven by a slowdown in growth in educational attainment of successive cohorts of the native-born, has been the largest contributor to the surge in the college wage premium since 1980.

The economic returns to completing high school today appear substantial, and the economic benefits of college and postcollege schooling are at historically high levels. But the educational attainment of American youth is not rising as rapidly as it did over much of the twentieth century. Although college enrollment rates among new high school graduates have been rising since the early 1980s in response to high returns to a college education, the high school graduation rate as traditionally measured (that is, not including GEDs) has been stagnant for three decades, and the share of young adults completing four-year college degrees has risen only modestly for post-1950 birth cohorts (especially for males).[43] After leading the world in education for most of the twentieth century, U.S. young adults are now in the middle of the pack among OECD countries in terms of educational attainment.[44] Expanding the educational attainment of U.S youth requires increasing the college readiness of children from poor and disadvantaged backgrounds and ensuring that the college-ready have access to financial support for their higher education.[45]

The polarization of the wage structure since the late 1980s has been accompanied by a polarization of employment growth: employment has bifurcated into high-wage and low-wage jobs at the expense of traditional middle-class jobs. Changes in task demand resulting from the adoption of

43. See Goldin and Katz (forthcoming) for a detailed documentation and analysis of trends in U.S. high school graduation rates and in college enrollment and graduation rates, as well as of policies to increase educational attainment.

44. OECD (2006) reports that the United States ranked eleventh for males and tenth for females out of thirty countries in its summary measure of educational attainment (mean years of schooling) for 25- to 34-year-olds in 2004.

45. See Heckman and Krueger (2003) for different perspectives on the problems with the U.S. education and training system and on the effectiveness of alternative human capital policies.

computer-based technologies have been a major source of this shift in the pattern of skill demands, and the growth of offshoring is likely to have reinforced these changes. A key uncertainty with respect to future wage structure developments concerns the longer-run impacts on skill demands and worker bargaining power from increased international economic integration and greater offshoring opportunities. Top-end knowledge jobs are likely to benefit from growing international markets, and offshoring is unlikely to be able to substitute for in-person services and for construction jobs.[46] The returns to abstract skills from college and postcollege training are likely to remain high, and demand is likely to grow for the interpersonal (soft) skills needed for in-person services.

Policy changes may be necessary to shift America from its current path of increasingly "growing apart" back to a trajectory of shared prosperity. As a first step the nation's education and training system needs to be better positioned to rapidly increase the supply of workers with abstract and interpersonal skills. A complementary approach to reducing labor market inequities might involve trying to "professionalize" the growing workforce of in-person service workers and to develop labor market institutions to enhance their bargaining clout.

References

Autor, David H., Lawrence F. Katz, and Melissa S. Kearney. 2005. "Rising Wage Inequality: The Role of Composition and Prices." Working Paper 11628. Cambridge, Mass.: National Bureau of Economic Research (September).

_____. 2006. "The Polarization of the U.S. Labor Market." *American Economic Review* 96 (May): 189–94.

_____. Forthcoming. "Trends in U.S. Wage Inequality: Revising the Revisionists." *Review of Economics and Statistics.*

Autor, David H., Lawrence F. Katz, and Alan B. Krueger. 1998. "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics* 113, no. 4 (November): 1169–1213.

Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Investigation." *Quarterly Journal of Economics* 118, no. 4 (November): 1279–1333.

Bartel, Ann P., Casey Ichniowski, and Kathryn L. Shaw. 2007. "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product

46. See Blinder (2007) and Levy and Murnane (2006) on how offshoring may affect the U.S. labor market.

Innovation, Process Improvement, and Worker Skills." *Quarterly Journal of Economics* 122, no. 4 (November): 1721–58.

Blinder, Alan. 2007. "How Many U.S. Jobs Might Be Offshorable?" CEPS Working Paper 142. Princeton University (March).

Borjas, George J., Richard B. Freeman, and Lawrence F. Katz. 1997. "How Much Do Immigration and Trade Affect Labor Market Outcomes?" *BPEA,* no. 1: 1–90.

Burtless, Gary. 1999. "Effects of Growing Wage Disparities and Changing Family Composition on the U.S. Income Distribution." *European Economic Review* 43, no. 4–6 (April): 853–65.

Card, David. 2001. "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems." *Econometrica* 69, no. 5 (September): 1127–60.

Card, David, and John E. DiNardo. 2002. "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles." *Journal of Labor Economics* 20, no. 4 (October): 733–83.

Dew-Becker, Ian, and Robert J. Gordon. 2005. "Where Did the Productivity Growth Go? Inflation Dynamics and the Distribution of Income." *BPEA,* no. 2: 67–127.

DiNardo, John, Nicole M. Fortin, and Thomas Lemieux. 1996. "Labor Market Institutions, and the Distribution of Wages, 1973–1992: A Semiparametric Approach." *Econometrica* 64, no. 5 (September): 1001–44.

Doms, Mark, Timothy Dunne, and Kenneth R. Troske. 1997. "Workers, Wages, and Technology." *Quarterly Journal of Economics* 112, no. 1 (February): 253–90.

Dunne, Timothy, John Haltiwanger, and Kenneth R. Troske. 1997. "Technology and Jobs: Secular Changes and Cyclical Dynamics." *Carnegie-Rochester Conference Series on Public Policy* 46 (June): 107–78.

Firpo, Sergio, Nicole Fortin, and Thomas Lemieux. 2007. "Decomposing Wage Distributions Using Recentered Influence Function Regressions." University of British Columbia (June).

Freeman, Richard B. 1975. "Overinvestment in College Training?" *Journal of Human Resources* 10, no. 3 (Summer): 287–311.

Goldin, Claudia, and Lawrence F. Katz. 1998. "The Origins of Technology-Skill Complementarity." *Quarterly Journal of Economics* 113, no. 3 (June): 693–732.

_____. 2000. "Education and Income in the Early Twentieth Century: Evidence from the Prairies." *Journal of Economic History* 60, no. 3 (September): 782–818.

_____. 2007. "The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005." Working Paper 12984. Cambridge, Mass.: National Bureau of Economic Research (March).

_____. Forthcoming. *The Race between Education and Technology.* Harvard University Press.

Goldin, Claudia, and Robert A. Margo. 1992. "The Great Compression: The Wage Structure in the United States at Mid-Century." *Quarterly Journal of Economics* 107, no. 1 (February): 1–34.

Goos, Maarten, and Alan Manning. 2007. "Lousy and Lovely Jobs: The Rising Polarization of Work in Britain." *Review of Economics and Statistics* 89, no. 1 (February): 118–33.

Griliches, Zvi. 1969. "Capital-Skill Complementarity." *Review of Economics and Statistics* 51, no. 4 (November): 465–68.

Hamermesh, Daniel S. 1999. "Changing Inequality in Markets for Workplace Amenities." *Quarterly Journal of Economics* 114, no. 4 (November): 1085–1123.

Heckman, James J., and Alan B. Krueger. 2003. *Inequality in America,* 1st ed. MIT Press.

Juhn, Chinhui, and Kevin M. Murphy. 1995. "Inequality in Labor Market Outcomes: Contrasting the 1980s and Earlier Decades." *Economic Policy Review* 1, no. 1 (January): 26–32.

Katz, Lawrence F., and David H. Autor. 1999. "Changes in the Wage Structure and Earnings Inequality." In *Handbook of Labor Economics,* vol. 3A, edited by O. Ashenfelter and D. Card. Amsterdam: Elsevier Science.

Katz, Lawrence F., and Kevin M. Murphy. 1992. "Changes in Relative Wages, 1963–87: Supply and Demand Factors." *Quarterly Journal of Economics* 107, no. 1 (February): 35–78.

Kopczuk, Wojciech, Emmanuel Saez, and Jae Song. 2007. "Uncovering the American Dream: Inequality and Mobility in Social Security Earnings Data since 1937." Working Paper 13345. Cambridge, Mass.: National Bureau of Economic Research (August).

Lemieux, Thomas. 2006a. "Postsecondary Education and Increased Wage Inequality." *American Economic Review* 96, no. 2 (May): 195–99.

_____. 2006b. "Increased Residual Wage Inequality: Composition Effects, Noisy Data, or Rising Demand for Skill?" *American Economic Review* 96, no. 3 (June): 461–98.

_____. 2007. "The Changing Nature of Wage Inequality." Working Paper 13523. Cambridge, Mass.: National Bureau of Economic Research (October).

Lemieux, Thomas, W. Bentley MacLeod, and Daniel Parent. 2007. "Performance Pay and Wage Inequality." Working Paper 13128. Cambridge, Mass.: National Bureau of Economic Research (May).

Levy, Frank, and Richard J. Murnane. 2006. "How Computerized Work and Globalization Shape Human Skill Demands." Massachusetts Institute of Technology (May).

Levy, Frank, and Peter Temin. 2007. "Inequality and Institutions in Twentieth Century America." Working Paper 13106. Cambridge, Mass.: National Bureau of Economic Research (May).

Mishel, Lawrence, Jared Bernstein, and Sylvia Allegretto. 2007. *The State of Working America 2006/2007.* Cornell University Press and Economic Policy Institute.

Oreopoulos, Philip. 2007. "Would More Compulsory Schooling Help Disadvantaged Youth? Evidence from Recent Changes to School-Leaving Laws." University of Toronto (April).

Organization for Economic Cooperation and Development. 2006. *Education at a Glance: OECD Indicators, 2006.* Paris.

Pierce, Brooks. 2001. "Compensation Inequality." *Quarterly Journal of Economics* 116, no. 4 (November): 1493–1525.

_____. 2007. "Recent Trends in Compensation Inequality." Washington: U.S. Bureau of Labor Statistics. www.nber.org/~confer/2007/CRIWs07/pierce.ppt.

Piketty, Thomas, and Emmanuel Saez. 2003. "Income Inequality in the United States, 1913 to 1998." *Quarterly Journal of Economics* 118, no. 1 (February): 1–39.

_____. 2007. "Updated Tables and Figures to Income Inequality in the United States: 1913–2002." University of California, Berkeley (March). elsa.berkeley.edu/~saez/TabFig2005prel.xls.

Tinbergen, Jan. 1974. "Substitution of Graduate by Other Labor." *Kyklos* 27, no. 2: 217–26.

General Discussion

Frank Levy commented on some historical causes of the growth in wage inequality. He noted that the interaction of existing labor market institutions and rapid cost-of-living increases in the 1970s led to a bump in labor's share of income. The deregulation of the late 1970s and early 1980s pushed the labor share in the opposite direction by amplifying the impact of other market and technological changes.

Gary Burtless highlighted the puzzle that male educational attainment has been declining while returns to education have been rising. The amount of schooling accumulated by men between the time they are sixteen and twenty-four years old is about the same today as in 1979. If rising wage inequality is caused in part by rising earnings premiums for college and postcollege degrees, and if the popular media are aware of this point, why do men not read the newspaper and decide to acquire more education in order to raise their lifetime earnings? He noted that this puzzle is not so apparent among women. Robert Hall replied that women may perceive fewer good career opportunities without a college education than do men. Lawrence Katz noted that girls have always done better in school than boys, and that this difference is an increasing problem for men because high-salary jobs for people with little education are vanishing. He wondered whether the lack of educational attainment were due partly to low self-control and whether people might benefit from stricter compulsory schooling rules.

Robert Lawrence was interested in the finding that immigration has not been a very significant factor in the labor market. In particular, the lack of decline in the high school wage premium suggests that immigrants have not pushed down wages substantially for less educated native-born workers. Lawrence also questioned the connection between outsourcing

and technology. There is significant outsourcing of high-technology tasks, particularly to India, including answering phones at the lower end and writing software at the higher end.and