Changes in the Wage Structure and Earnings Inequality

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1. Introduction

Studies of the wage structure are as old as the economics profession. Adam Smith in chapter 10 of Book I of *The Wealth of Nations* provided a comprehensive and elegant analysis of the determinants of differences in wages among individuals and employments. Smith emphasized that wage differences were determined by competitive factors (compensating differentials for differences in costs of training, probability of success, steadiness of work, and other workplace amenities), differences in individual innate abilities (which he felt were relatively unimportant), and institutional (non-competitive) factors arising from the "laws of Europe" that regulated wages, restricted labor mobility, and facilitated the creation of barriers to entry. Smith noted that shifts in demand across occupations and space could generate transitory wage differentials, but that highly elastic supply responses would tend to equalize the advantages and disadvantages of different employments over the long-run in the absence of regulatory barriers to entry. The tension found in Smith's analysis between the roles of supply and demand factors and those of institutional forces in affecting wages remains through today a key theme of research on the wage structure.

Early quantitative work on the wage structure examined differences and changes in wages by occupation [Douglas (1930), Ober (1948)] and industry [Slichter (1950), Cullen (1956)]. Paul Douglas (1930), a pioneer in empirical studies of the wage structure, studied the evolution of the wages of white collar (managers and clerical workers) and blue collar workers in the United States from 1890 to 1926. Douglas documented a substantial decline in the wage premium to white collar work over this period (concentrated in World War I) and argued that the rapid expansion of access to public secondary education had led the growth in the supply of qualified workers to outstrip the growth in demand. Slichter (1950) emphasized the persistence of inter-industry wage differentials and the importance of "company wage policies" as well as skill differences as explanations for the observed pattern of differentials.

The human capital revolution of the 1960s and 1970s and the increased availability of large micro data sets with information on earnings and individual characteristics shifted the emphasis to differences in wages by education and age (or potential experience). Human capital models of life-cycle earnings arising from educational and on-the-job training investments [Becker (1962, 1993), Ben-Porath (1967), Mincer (1974)] provide a coherent explanation of relatively timeless qualitative features of the wage structure that have been found in almost every country and data set examined [Willis (1986)]: higher earnings for more-educated workers and upward sloping and concave age-earnings profiles. But the quantitative dimensions of the wage structure do differ substantially over time (as well as across countries and even regions). Tinbergen (1974, 1975) speculated that the evolution of technology tends to increase the demand for more-educated labor and characterized the evolution of the wage structure as "race between technological development and access to education."

Research on changes in the wage structure and earnings inequality for the United States and other OECD countries has literally exploded over the past decade. The reasons for this increased research emphasis on understanding wage structure changes are clear. The wage structures of some OECD nations have changed considerably in recent decades and reasonably consistent and comparable large-scale micro data sets have become increasingly available to carefully study these issues. Educational and occupational wage differentials (especially the relative earnings of college graduates) narrowed substantially in almost all advanced nations during the 1970s. But since then divergent patterns in the evolution of the wage structure have developed. Overall wage inequality and educational wage differentials have expanded greatly in the United States and the United

Kingdom since end of the 1970s. A great effort has been mounted to understand these labor market changes, in part, because widening wage structure has meant widening family income and consumption inequality and associated social problems. More modest increases in overall wage inequality and skill differentials in the 1980s and 1990s are apparent in most other OECD countries.

This chapter presents a framework for understanding wage structure changes and uses this framework to assess the determinants of recent changes in the wage structures of OECD nations. The enormous range of the existing literature motivates a sharp focus on U.S. wage structure changes to illustrate the fruitfulness of alternative methodologies.

The overall wage distribution can be decomposed into differences in wages between groups (typically defined by skill or demographic categories) and within group wage dispersion (residual wage inequality). The basic approach utilized in this chapter links relative wage and employment changes among different demographic and skill groups to changes in both the market forces of supply and demand and to labor market institutions (e.g., unions and government mandated minimum wages). Movements in within-group inequality may also reflect market forces changing the returns to (unmeasured) skills or directly result from changes in wage setting institutions that may serve to "standardize" wages within jobs and across firms and/or industries.

This supply-demand-institution (SDI) explanation for wage structure changes has three parts [Freeman and Katz (1994)]. The first is that different demographic and skill groups are assumed to be imperfect substitutes in production. Thus shifts in the supply of and demand for labor skills can alter wage and employment outcomes. Potential important sources of shifts in the relative demand among skill groups include skill-biased technological change, non-neutral changes in other input prices or supplies (e.g., capital-skill complementarity), product market shifts, and the forces of globalization (trade and outsourcing). Sources of relative supply shifts include variation in cohort size, changes in access to education and incentives for educational investments, and immigration.

The second part is that the same underlying demand and supply shocks may have differential effects on relative wages and employment depending on differences in wage-setting and other labor market institutions. The stronger the role of wage-setting institutions and the less responsive the institutions are to changes in market forces, the more the impact is likely to fall on employment rather than on wages. Regulations governing hiring and firing as well as differences in educational and training institutions may also affect how the wage structure responds to market shifts.

Third, institutional changes themselves, such as product market deregulation and changes in the extent of unionization or degree of centralization of collective bargaining, can also alter the wage structure. A key issue in assessing the impact of institutional forces on changes in the wage structure is determining the extent to which the institutional changes are "exogenous" developments (such as changes in the political climate) or largely reflect responses to supply and demand changes.

This tension between the proper interpretation of how institutions affect wage setting has led to the development of two broad empirical approaches. The first attempts to explain actual relative wage and employment changes using a supply-demand framework and (implicitly) attributes anomalies to institutional factors or unmeasured supply and demand shifts [e.g., Autor, Katz, and Krueger (1998), Katz and Murphy (1992), Murphy and Welch (1992)]. The second takes institutional changes as exogenous and first attempts to adjust observed wages for the impact of institutional changes and then analyzes the remaining "adjusted" wage changes using a supply and demand framework [e.g., Bound and Johnson (1992), Dinardo, Fortin, and Lemieux (1996)]. A key outstanding conceptual and practical issue in this second approach is how to model the impact of institutions on employment as well as wages.

The remainder of this chapter is organized as follows. Section 2 documents the changes in the U.S. wage structure over the past three decades and places these changes into longer-term historical perspective. The U.S. wage structure has widened along several dimensions since the late 1970s, including increases in residual wage inequality as well as wage differentials by education and experience, but differences in the time patterns of these changes suggest they partially reflect distinctive phenomena. The U.S. data and burgeoning recent literature on U.S. wage structure changes are used to illustrate the importance of alternative measurement choices for inferences concerning changes in overall wage inequality and different components of the wage structure. The extent to which changes in cross-section wage inequality reflect transitory or permanent components of individual life-cycle earnings variation is also examined. Section 3 briefly summarizes recent changes in the wage distributions of other advanced nations.

Section 4 develops the SDI framework for studying wage structure changes. Section 5 examines supply and demand models of wage structure changes and assesses the importance of different supply and demand factors in recent and longer-term U.S. wage structure. Section 6 examines the role of changes in labor market institutions and the incidence of labor market rents on changes in the U.S. wage structure. The role of changes in the incidence of industry rents, the decline in unionization, and changes in the minimum wage are highlighted.

The relative earnings of more-educated workers have increased substantially in the United States since 1950 despite large increases in the relative supply of the more-educated. Rapid secular growth in the relative demand for more-skilled workers appears to be a key component of any consistent explanation for the long-run evolution of the U.S. wage structure. Part of this relative demand shift is accounted for by observed shifts in industrial structure, most arises from within-sector skill upgrading which may reflect skill-biased technological change. Fluctuations in the educational wage differentials (e.g., the narrowing of the U.S. college wage premium in the 1970s and its substantial widening in the 1980s) are accounted for by fluctuations in the rate of growth of college workers, institutional changes (e.g., the decline of unions in the 1980s), and possibly by some recent acceleration in the pace of demand shifts favoring the more-skilled. Section 7 summarizes the key implications for future research.

2. Changes in the U.S. Wage Structure

We shall use the recent U.S. experience to illustrate alternative approaches to measuring and explaining wage structure changes. A large and growing literature documents and attempts to explain changes in the U.S. wage structure over the past two decades.[1] Many researchers using a variety of data sets — including both household and establishment surveys — have found that wage inequality and skill differentials in earnings increased sharply in the United States from the late 1970s to the mid-1990s. There is substantial agreement among researchers and data sets concerning some of the basic "facts" that need to be explained.

Recent changes in the U.S. wage structure can be summarized as follows:

1. Wage dispersion increased substantially for both men and women from the end of the 1970s to the mid-1990s. The weekly earnings of the 90th percentile worker relative to the 10th

[1]Key studies documenting the recent evolution of the U.S. wage distribution include Bernstein and Mishel (1997), Blackburn, Bound, and Freeman (1990), Bound and Johnson (1992), Buchinsky (1994), Davis and Haltiwanger (1991), Freeman (1997), Hamermesh (1998), Gottschalk (1997), Juhn, Murphy, and Pierce (1993), Karoly (1993), Katz and Murphy (1992), Katz and Revenga (1989), Levy and Murnane (1992), Murphy and Welch (1992, 1997), and Pierce (1997).

percentile worker increased by over 25 percent for both men and women from 1979 to 1995. The available evidence suggests earnings inequality has expanded even more dramatically if one includes the very top end (top 1 percent) of the distribution.[2] This pattern of rising wage inequality was *not* offset by changes in non-wage compensation favoring the low-wage workers.

2. Wage differentials by education, occupation, and age (experience) have increased. The relative earnings of college graduates and those with advanced degrees increased dramatically in the 1980s. But the gender differential declined both overall and for all age and education groups in the 1980s and 1990s.

3. Wage dispersion expanded within demographic and skill groups. The wages of individuals of the same age, education, and sex (and even those working in the same occupation and industry) were much more unequal in the mid-1990s than two decades earlier.

4. Increased cross-section earnings inequality over the past two decades has not been offset by increased year-to-year earnings mobility. Permanent and transitory components of earnings variation have risen by similar amounts [Gottschalk and Moffitt (1994)]. Thus year-to-year earnings instability has also increased.

5. Since these wage structure changes have occurred in a period of rather slow mean real wage growth, the real earnings of less-educated and lower-paid workers (especially young, less-educated) males appear to be lower in the 1990s than those of analogous workers two decades earlier.[3] The employment rates of less skilled workers also appear to have fallen relative to those of more skilled workers [Juhn (1992), Levinson (1998), Murphy and Topel (1997)].

6. Rising earnings inequality has been the dominant contributor to a substantial increase in family income inequality both from greater dispersion in the earnings of household heads and from an increased correlation in the earnings of husbands and wives [e.g., Karoly and Burtless (1995)]. Inequality of consumption expenditures also expanded from the late 1970s

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[2]For example, Hall and Liebman (1998) document that the mean (median) real total compensation of Chief Executive Officers of large, publicly-traded U.S. corporations increased by 270 percent (140 percent) from 1982 to 1994, as compared to an increase in real average total compensation per employee for entire economy of 7 percent over the same period. They also find that the mean salaries of players in Major League Baseball and the National Basketball Association increased by 207 percent and 378 percent respectively from 1982 to 1994.

[3]These conclusions about real wage growth are based on using the chain-weighted personal consumption expenditures (PCE) deflator from the National Income and Product Accounts to deflate nominal earnings measures. Readers should remember that conclusions concerning changes in real earnings are clearly sensitive to potentially large biases official price indices arising from difficulties in measuring quality change and the value of new goods (Boskin et al., 1996; Moulton, 1997). Such biases in price deflators do not affect the estimates of relative wage changes that are the focus of this chapter. Furthermore, most estimates in the literature indicate the real earnings of young, less-educated men declined from 1979 to 1995 even assuming an upward bias in the PCE deflator of 1% a year.

to the early 1990s is also apparent if one examines consumption measures [e.g., Cutler and Katz (1991); U.S. Department of Labor (1995)].

Thus rising U.S. wage inequality in the 1980s and 1990s has been accompanied by large increases in wage differentials by skill group and by much greater residual inequality (within group wage dispersion). The major exception to this pattern of a widening wage structure has been the substantial narrowing of wage differentials between men and women. An important motivation for understanding these wage structure changes is that diverging U.S. labor market outcomes appear to have translated into increased inequality in economic well-being among individuals and households from the 1970s to the mid-1990s.

Much debate exists concerning the causes of recent expansions in U.S. wage inequality and educational wage differentials. Several prominent (and not necessarily exclusive) explanations have been offered. The first attributes wage structure changes to an increased rate of growth of the relative demand for highly educated and "more-skilled" workers driven by skill-biased technological changes, largely associated with the spread of computers and microprocessor-based technologies in the workplace [Autor, Katz, and Krueger (1998), Berman, Bound, and Griliches (1994), Bound and Johnson (1992), Mincer (1991)].[4] The second explanation focuses on the role of rising globalization pressures (particularly increased trade with less-developed countries and greater foreign outsourcing) in reducing manufacturing production employment and thereby shrinking the

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[4]A related hypothesis is motivated by the spectacular increases in earnings at the extreme top end of the distribution, the rise of within-group inequality even within detailed occupations, and by Rosen's (1981) model of the economics of superstars. This approach emphasizes how changes in technology (especially those reducing communications and transportation costs) may allow the relatively highest ability individuals to sell their services to a greatly expanded market and lead to a increased concentration of economic rewards within occupations [Frank and Cook (1995)]. This hypothesis seems potentially quite relevant for performing artists and possibly many professionals, but it has yet to receive much careful empirical scrutiny to determine its broader relevance for understanding wage structure changes.

relative demand for the less educated and leading to the loss of wage premia (rents) paid to blue collar workers in some manufacturing industries [Borjas and Ramey (1995), Feenstra and Hanson (1996), Wood (1994, 1995, 1998)]. The third attributes rising skill differentials in the 1980s and 1990s to a slowdown in the rate of growth of the relative supply of skills because of a decline in the size of the cohorts entering the labor market and an increased rate of unskilled immigration [Borjas, Freeman, and Katz (1997), Katz and Murphy (1992), Murphy and Welch (1992)]. A fourth explanation emphasizes changes in labor market institutions including the decline in unionization, erosion of the real and relative value of the minimum wage, and changes in wage setting norms [DiNardo, Fortin, and Lemieux (1996), Freeman (1996), Lee (1998)].

Before attempting to evaluate these alternative explanations, we need to develop a more detailed understanding of both recent and historical changes in the U.S. wage structure and of how changes in the U.S. compare with those in other advanced countries. We further document the evolution of the U.S. wage structure in this section and briefly summarize changes in other countries in section 3.

Much of our knowledge of changes in the U.S. wage structure comes from individual level earnings data from the Current Population Survey (CPS), the basic monthly household survey that is also the source of official U.S. unemployment and labor force data. Annual earnings data and weeks worked for the previous calendar year is collected in the Annual Demographic Supplement to the March CPS. Public use micro data from the March CPS is available starting with March 1964 and thereby providing earnings distribution information starting in 1963. Analogous data on annual earnings and weeks for the previous calendar year is available from the Public Use Micro Samples (PUMS) of the decennial Census of Population from 1940 to 1990 (covering earnings data for 1939 to 1989). Data on usual weekly earnings for all wage and salary workers and the hourly wage for hourly workers is available in the May CPS from 1973 to 1978 and monthly in the Outgoing Rotation Groups (ORGs) since 1979. A robust finding of rising overall wage inequality and education/skill differentials from 1979 to the mid-1990s is apparent in the March CPS, the 1980 and 1990 Census PUMS samples, the CPS ORG samples, other household surveys, as well as some available establishment surveys.[5] But some of the nuances of the timing and patterns of changes in the wage structure (especially patterns of changes in within-group or residual inequality) are somewhat sensitive to choice of data set and the precise sample and earnings concept used.

This section first summarizes changes in the U.S. wage structure from 1963 to 1995 using data from the March CPSs. The robustness of these findings across data sets and to alternative measurement decisions is then explored. The recent changes are also compared to longer-term historical trends and used to illustrate alternative approaches to decomposing changes in the wage structure (between-group vs. within-group components, permanent vs. transitory components or earnings variation, and changes in "quality" between cohorts vs. changes in skill prices within cohorts).

2.1 Changes in the U.S. Wage Structure, 1963-95, March CPS Data

Changes in the U.S. wage structure over the past several decades are illustrated using data on the weekly earnings of full-time, full-year, wage and salary workers (those working 35 hours or

[5]Analyses of wage inequality trends using these other household surveys — the Survey of Income and Program Participation (SIPP), the National Longitudinal Survey of Youth (NLSY), and the Panel Study of Income Dynamics (PSID) — include Bernstein and Mishel (1997), Buchinsky and Hunt (1996), Gottschalk and Moffitt (1992, 1994, 1998), Haider (1997), and Lerman (1997). Studies using establishment-level data sets include Davis and Haltiwanger (1991), Groshen and Levine (1997), and Pierce (1997).

more per week and working at least 40 weeks in the previous calendar year) from the March CPSs of 1964 to 1996 (covering earnings from 1963 to 1995).[6] The core sample is further restricted to adults prior to retirement age (those aged 19 to 65 at the survey date), without allocated earnings, who earned at least $67 per week in 1982 dollars (equal to one-half of the 1982 real minimum wage based on a 40 hour week).[7] Weekly earnings are imputed for those with top-coded earnings by multiplying value of the top code by 1.5. The qualitative aspects of the findings are not very sensitive to these restrictions and imputations with the exception of the treatment of outliers with extremely low weekly earnings. When workers with extremely low reported weekly earnings are kept in the sample, we find a pronounced (and implausibly large) reduction in most measures of inequality (especially for women) in the 1960s.[8] The findings reported in this section are quite similar to those of other analyses of the March CPS data including Gottschalk (1997), Juhn, Murphy and Pierce (1993), Karoly (1993), Katz and Murphy (1992), and Murphy and Welch (1992, 1997).

Figure 1 (following the approach of Juhn, Murphy, and Pierce (1993)) plots the change in log real wages by percentile for both men and women from 1963 to 1995. The figure displays a

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[6]Information on weeks worked and usual weekly hours in the previous calendar year is available in the March CPS starting in 1976 (providing data for 1975); the earlier March CPSs only provided bracketed weeks worked information and hours worked last week. A full-time/part-time work indicator for the previous year is consistently available in all years of the March CPS public use samples. Comparisons of features of the distribution of annual or weekly earnings for full-time, full-year workers can be made rather consistently since 1963, but analyses of hourly wages or of broader sets of workers are much more consistent with a focus on data since 1975. The Census PUMSs prior to 1980 have similar limitations and do not contain a measure of usual weeks worked in the previous year. Alternative approaches to imputing hours worked in the previous calendar year in the early March CPS and Census PUMS samples are discussed in Autor, Katz, and Krueger (1998), Juhn, Murphy, and Pierce (1993), Katz and Murphy (1992), and Murphy and Welch (1992). The basic broad patterns of changes in hourly wage distributions for full-time workers or all workers using these imputation techniques prior to 1975 are similar to those of weekly wages of full-time, full-year workers.

[7]Nominal wages are converted into constant dollars using PCE deflator.

[8]Juhn, Murphy and Pierce (1993) reach similar conclusions concerning the sensitivity of conclusions about inequality trends for men to alternative measurement and sample choice decisions using the March CPS data.

substantial widening of both the male and female wage distributions with the wages of workers in the upper end (the 90th percentile) rising by approximately 40 percent (34 log points) relative to those in the lower end (the 10th percentile) for both men and women.[9] There is essentially no real wage gain from 1963 to 1995 for men in the bottom quarter of the distribution. The divergence of earnings is not limited to comparisons of workers at the top and the bottom. The figure indicates an almost linear spreading out of the entire wage distribution for women and for the wage distribution above the 30th percentile for men. Figure 1 also shows that women gained on men throughout the wage distribution with the earnings of the median woman rising 27 percent (23 log points) relative to the median man from 1963 to 1995. Figure 2 illustrates that the overall wage distribution (men and women combined) also spread out substantially over the past few decades, especially in the top half of the distribution.

The four panels of Figure 3 decompose changes in wage inequality (and real earnings) from 1963 to 1995 for men and women into 4 sub-periods (1963-71, 1971-79, 1979-87, and 1987-95) that roughly correspond to the 1960s, 1970s, 1980s, and 1990s. There are some striking differences across the sub-periods. There is little overall change in wage inequality and rapid real wage growth for both men and women in the 1960s. Real wage growth slows down in the 1970s and some widening begins in the bottom half of the distribution for males. There is essentially no change in the gender gap from 1963 to 1979. The rise in wage inequality for both men and women over the entire 1963 to 1995 period is dominated by the rapid spreading out of the male and female wage distributions from 1979 to 1987. This pattern of rising inequality continues in a more modest from for 1987 to 1995. Similarly the gender gap narrows in the 1980s and 1990s.

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[9] The convention used in this chapter is to refer to log changes multiplied by 100 as changes in log points.

Figure 4 gives a sense of the full time series of changes in inequality for men and women by plotting the 90-10 log wage differential by sex annually from 1963 to 1995. Table 1 summarizes alternative measures of wage inequality for all, men, and women for selected years from 1963 to 1995. The Gini coefficient, standard deviation of log wages, and 90-10 log wage differential show somewhat similar patterns of increases in inequality for all, men, and women. The standard deviation of log wages is a useful summary measure of wage dispersion if wages are approximately log normal, but is much more sensitive to extreme outliers at the top and the bottom than are the reported quantile measures of wage dispersion. The Gini coefficient is quite sensitive to shifts in earnings in the middle of the distribution. Rising wage inequality has occurred in both the top and bottom halves of the wage distributions.

The changes in overall earnings inequality summarized in Figures 1 to 4 and Table 1 reflect changes in wage differentials between demographic/skill groups and changes in inequality within groups. Table 2 summarizes the between-group changes by presenting log real wage changes from 1963 to 1995 for various groups defined by education, potential experience (age), and sex.[10] Mean (predicted) log real weekly earnings were computed in each year for 64 detailed sex-education-experience groups and mean wages for broader groups in each year are weighted averages of the relevant sub-group means using a fixed set weights (the 1980 share of total hours worked from the

[10]Important changes in wage differentials by race, ethnicity, and immigrant status have also occurred over the past several decades. In particular, the black/white wage differential narrowed substantially from the mid-1960s to the mid-1970s , but shows little change over the past two decades and some erosion of progress for young workers [e.g., Heckman and Donohue (1991)]. These dimensions of wage structure changes are beyond the scope of this chapter. See the chapter by Altonji and Blank (1998) on racial wage differentials and the chapter by Borjas (1998) on relative wage movements by immigration status.

198O Census PUMS sample) to adjust for compositional changes within these broader groups.[11] The first row of Table 2 indicates that (composition-adjusted) real wages grew by 7 percent (or 6.6 log points) over the entire period, but this growth reflects rapid growth in the 1960s and modest declines since the early 1970s. This measure of real wage growth differs from standard measures in being a geometric (rather than arithmetic) mean and by reflecting wages for a fixed demographic distribution. Hence it does not reflect changes in the level of wages arising from shifts in the education, gender, or experience composition of the work force.

The next two rows of Table 2 indicate that the (fixed-weight) mean log wage of women increased by 15 log points relative to men from 1963 to 1995 with the improvement almost entirely concentrated in the 1980s and 1990s.[12] In fact, the earnings of women increased relative to those of men in almost all education-experience categories from 1979 to 1995. Panel A of Figure 5

[11]The 64 sex-education-experience groups are based on a breakdown of the data into 2 sexes, 8 education categories (0-8, 9, 10, 11, 12, 13-15, 16-17, and 18+ years), and 4 potential experience categories (1-10, 11-20, 21-30, and 31+ years). Changes in the coding of education in the CPS starting in 1992 make it difficult to be fully consistent over time in defining education groups. We follow the approach suggested by Jaeger (1997a) in forming "consistent" education categories before and after the data changes. To make sure changes from 1987 to 1995 are not driven by changes in the education codes, the wage change for each group from 1990 to 1991 is calculated for full-time workers using the CPS Outgoing Rotation Groups which use the old education codes for each of these years and the 1987 to 1995 March CPS change is adjusted for the difference between the CPS ORG and March CPS change from 1990 to 1991. Log weekly wages of full-time, full-year workers are regressed each year separately by sex on the dummy variables for the 8 consistent education categories, a quartic in experience, 3 region dummies, black and other race dummies, and interactions of the experience quartic with 3 broad education categories (high school graduate, some college, and college plus). The (composition-adjusted) mean log wage for each of the 64 groups in a given year is the predicted log wage from these regressions evaluated for whites, living in the mean region based on the 1980 Census distribution of employment, at the relevant experience level (5, 15, 25 or 35 years depending on the experience group). Potential experience in the earnings year (previous calendar year) is measured as survey data age minus years of schooling minus 7.

[12]Real wage growth from 1963 to 1995 for both men and women is much more rapid when one uses the simple (unweighted) average weekly wage of full-time, full-year workers, rather than the fixed-weighted averages presented in Table 2. We find the unweighted average of log weekly wages increased by 0.36 for women and 0.16 for men from 1963 to 1995. Educational upgrading (rather than changes in the age distribution of workers) largely accounts for the faster growth in simple average wages than in fixed-weighted averages holding the education-experience composition of the workforce constant. Murphy and Welch (1992) report similar results for different measures of real wage growth for males from 1963 to 1989.

illustrates the similar time pattern of changes in the female/male log wage differential for high school graduates (those with 12 years of schooling) and college graduates (those with 16 or more years of schooling).

The next six rows of Table 2 show the evolution of real wages by education group. The real wage changes are, for the most part, increasing by education group over the full period reflecting a rise in education-based wage differentials (particularly a sharp increase in the relative earnings of those with at least a college degree). The changes in educational wage differentials differ substantially across sub-periods. College graduates (particularly those with 18 or more years of schooling) gained substantially in the 1960s, but the college wage premium narrowed (especially for younger workers in the 1970s). Educational wage differentials increased sharply from 1979 to 1987 with the college plus/high school was differential rising by 12 log points. The relative earnings of college graduates continued rising into the 1990s, but those with some college have done particularly poorly in the 1990s. The much studied time pattern of the overall college/high school wage differential and the college/high school wage differential for young workers (those with 5 years of schooling) are shown in panel B of Figure 5. Occupational wage differentials (e.g., the earnings of professional and managerial workers relative to production workers) also narrowed in the 1970s and then exploded in the 1980s [Blackburn, Bloom, and Freeman (1990), Murphy and Welch (1993a)].

The bottom rows of Table 2 summarize changes in real wages for older versus younger males both overall and for high school and college graduates separately. Over the entire sample period, the wage gap between older and younger males expanded with the earnings of peak earners, those with 25 to 35 years of experience, rising by 12 log points relative to younger workers with 5 years of experience. The differences in time pattern of changes in experience differentials for high school and college graduates are shown in panel C of Figure 5. Experience differentials rose more sharply for college graduates in the 1960s and 1970s, then increased rapidly in the early 1980s for high school graduates and narrowed in the 1980s for college graduates. The overall change for both high school and college graduates had involved substantial increases in the relative earnings of peak earners to young workers. Wage differences by age (potential experience) also expanded for women in the 1980s [Gottschalk (1997), Katz, Loveman, and Blanchflower (1995)].

We have so far considered wage differentials for groups distinguished by sex, education, and age/experience. But these factors account for only about one third of overall wage variation so that changes in wage dispersion within these groups are likely to be an important part of changes in the overall wage inequality. Residual (or within-group) inequality is examined here by looking at changes in the distribution of log wage residuals from separate regressions by sex each year of log weekly wages on a full set of 8 education dummies, a quartic in experience, interactions of the experience quartic with 3 broad education categories, 3 region dummies, and 2 race dummies. Panel D of Figure 5 and Table 3 summarize the time pattern of changes in the log wage differential between the 90th and 10th percentiles of the residual wage distribution. Residual log weekly wage inequality for full-time, full-year workers increased substantially by 27 log points for men and 25 log points for women from 1963 to 1995. Residual wage inequality started increasing in the 1970s and continued rising rapidly in the 1980s and at a somewhat slower pace in the 1990s. The rise in wage inequality within groups suggests that the "least-skilled" or least-lucky" workers within each category as well as less-educated and less-experienced workers have seen their relative earnings decline substantially over the past two decades. But the time patterns of changes in within group inequality, educational wage differentials, and experience differentials are distinctive.

In summary, we conclude from the March CPS data on the weekly wages of full-time, full-year (FTFY) workers that overall U.S. wage inequality for both men and women expanded from the early 1960s to the mid-1990s, with changes in the 1980s accounting for much of the increase. Between- and within-group inequality increases both contributed to rising wage dispersion. More specifically, the college wage premium rose from 1963 to 1971, declined substantially in the 1970s, increased sharply in the 1980s, and continued to rise at a more modest pace in the first half of the 1990s. Experience differentials also expanded from 1963 to 1995. Relative earnings declines for young workers are largest in the 1970s for college workers and in the 1980s for the less educated. Residual wage inequality is rather stable in the 1960s, starts to increase for men in the 1970s, and increases dramatically for men and women from 1980 to 1995. After remaining fairly stable in the 1960s and 1970s, male/female wage differentials narrowed substantially in the 1980s and 1990s. The narrowing of the gender gap in earnings means that overall wage inequality for men and women combined increased by much less than wage inequality for either men or women analyzed separately. The 90-10 log weekly wage differential for all FTFY workers increased by 19 log points from 1979 to 1995 as compared to increasing by 27 log points for men and 31 log points for women over the same period.

Changes in the U.S. wage structure over the past several decades seem, at least superficially, consistent with a general rise in the labor market returns to "skill." The returns to observed skill proxies (education, occupation, and experience) have increased, and some interpret the rise in within group inequality as reflecting a rise in the returns to unobserved skills [Juhn, Murphy, and Pierce (1993)]. An increase in the gap between the rate of growth of the relative demand for more-skilled workers and the relative supply of such workers represents a potential market-driven explanation for rising skill returns. The substantial decline in the gender gap since 1979 might reflect increased relative skills (e.g., actual experience and training) within education-age groups or shifts in labor demand favoring more female-intensive labor market segments (industries, occupations, particular skills). An alternative interpretation for the widening between and within group inequality is a weakening of labor market institutions and norms that compressed wages both across and within skill groups.

2.2 Robustness of Wage Structure Trends Across Data Sources

The basic pattern of wage structure changes from the early 1960s to the mid-1990s documented in this section for the weekly wages of FTFY workers appear rather robust and is consistent with other studies using data on weekly and hourly wages for a wide variety of samples from the March CPSs, Census PUMS, and the CPS May samples and ORGs [e.g, Gottschalk (1997), Juhn, Murphy and Pierce (1993), and Katz and Murphy (1992) with the March CPSs; Bernard and Jenson (1998) with the Census PUMS; Bound and Johnson (1992), DiNardo, Fortin and Lemieux with (1996), and Bernstein and Mishel (1997) with the CPS May and ORG samples]. While we focus on the March CPS in this chapter because it provides the longest consistent U.S. earnings series collected at high frequency, we briefly compare trends in inequality measures in the March CPS with other U.S. data sources below.

A. Educational differentials

Table 3 provides comparisons of annualized log changes in the college-plus/high school, some college/high school and high school/ninth-grade wage differentials for weekly and hourly earnings for the years 1959 – 1996 using (as available) data from the March CPS, May CPS, CPS Outgoing Rotation Groups, and Census PUMS.[13] All samples exclude allocated observations, the lowest one-percent of earners, and those whose hourly wage exceeds the top-coded value for full-time earners.[14] Hourly samples include both full- and part-time workers while weekly earnings samples are limited to full-time workers and, in the March CPS and Census PUMS, those working 40-plus weeks. Sample weights are used throughout and are multiplied by weekly hours in hourly wage samples to weight equally all hours of labor input (e.g., DiNardo, Fortin, and Lemieux, 1996; Lerman, 1997).[15] Earnings are imputed for top-coded observations by multiplying the value of the top code by 1.5.

For the 1960 – 1996 period, trends in educational differentials are highly comparable across data sources and weekly and hourly samples and are consistent with widely documented findings. Earnings differentials expand modestly in the 1960s, contract substantially in the 1970s, expand even more dramatically during the 1980s, and continue to grow at a slower rate in the 1990s.[16] Two sources of uncertainty are worth noting. First, in the 1960s, the March CPS data indicate substantially more growth in the college-plus/high school differential than the Census PUMS, a pattern driven by very large estimated wage differentials in the March 1963 CPS.[17] Second, due to

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[13] The March CPS sample covers 1963-95, the May CPS sample covers 1973-79, the ORG sample covers 1979-96, and the Census PUMS covers 1959-89. All estimates of changes in wage differentials are calculated as 10 times annualized log changes to facilitate comparisons among data sources that may only be available for part of a decade (e.g., the March sample for 1963-69). Wage differentials are estimated from separate cross-sectional log earnings regressions in each year by gender and with genders combined. See the table note for further details.

[14] As noted, March samples exclude those earning less than ½ the 1982 minimum wage in real dollars. Allocation flags are not available for May CPS samples and hence allocated observations are retained.

[15] Census samples are weighted by weeks worked in the previous year rather than hours in the previous week.

[16] Implausibly large growth in the high-school/9th grade differential during the 1990s is most likely due to changes to the education question after 1992.

[17] As noted previously, the March data for the 1960s are quite sensitive to the treatment of extremely low hourly earnings.

incompatibilities introduced in the CPS education measure in 1992 and the subsequent redesign of the CPS survey in 1994, estimated trends in inequality metrics are less reliable in the 1990s than in other periods.[18]

To explore the robustness of these relationships, we have employed a variety of earnings cutoffs (½ the minimum wage, 1/3rd the minimum wage, 2% dropped, \$0.50 - \$250 real hourly earnings) and sub-samples (white, non-agricultural, white and non-agricultural). The time pattern of results in Table 3 is relatively insensitive to these manipulations.

B. Overall and residual earnings inequality

In contrast to our findings on educational ratios, however, trends in overall and residual inequality as measured by wage quantiles, the Gini coefficient, and the variance of log earnings are less consistent across data sources and are more sensitive the choice of lower cut-off (i.e., handling of outliers), top-coding, and choice of sample (full-time, all), earnings concept (weekly, hourly) and weights (bodies, weeks, labor hours supplied).

Table 4 presents measures of annualized decadal changes in overall and residual inequality for the 1959-96 period using the CPS and Census samples as above. The Census PUMS indicates modest expansion in overall weekly earnings inequality in the 1960s for men and women separately and combined, the bulk of which is accounted for by growth in the 90-50 log earnings ratio. Hourly earnings inequality for women, however, shows no overall increase during this period and the female hourly 50-10 ratio contracts slightly. The March CPS data for the 1960s shows slight overall contraction in inequality for both weekly and hourly samples, a pattern that is again likely to be driven by very low earnings values in the 1963 data.

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[18] See Jaeger (1997a, 1997b), Polivka (1996), Mishel and Bernstein (1997), and Lerman (1997) for discussion.

The 1970s data present a largely consistent picture of stable between group inequality and growing residual inequality. Both March CPS and Census PUMS indicate moderate growth in overall male earnings inequality for both weekly and hourly earnings concentrated in the lower half of the distribution and almost entirely accounted for by the growth in the residual. Trends in male earnings inequality in the May CPS are comparable, with the exception that the May data show no growth in overall male weekly earnings inequality as measured by the 90-10 ratio. All data sources indicate either no growth or modest contraction of female earnings inequality (overall and residual) during the 1970s, with a more pronounced contraction visible in hourly samples.

Overall inequality expands dramatically across all data sources and sub-samples in the 1980s, with the expansion roughly evenly split between the upper and lower halves of the distribution for male and pooled-gender samples, and concentrated in the lower half for female samples. Trends in residual inequality are less consistent across data sources, however. While residual inequality growth accounts for approximately 2/3rds of overall inequality growth in weekly and hourly samples in March and ORG CPS data during the 1980s, this is not true for the Census PUMS where the variance of log wage residuals is essentially static between 1979 and 1989 (the 90-10 residual earnings ratio in the Census indicates modest growth during this period, however).

An important pattern not visible from Table 4 is that the expansion of earnings inequality during the 1980s is not smooth but rather is concentrated in the 1979-85 period, particularly for pooled-gender and male samples. In the ORG and March data, approximately 80 percent of the growth of overall male inequality, and 90 percent of the growth of pooled-gender inequality, occurs between 1979-85. Residual inequality grows somewhat more smoothly during the entire decade, however, and in particular shows little deceleration for women after 1985, especially in the March data.

Due to the redesign of the CPS, trends in wage inequality during the 1990s are less certain and a subject of current debate (e.g., Bernstein and Mishel, 1997, Lerman, 1997). Our reading of the data is that overall and residual inequality in the upper half of the distribution have continued to expand modestly during 1989-96 for both pooled-gender and by-gender samples, although the trend is likely overstated by the survey redesign.[19]

Based on these comparisons of data and methods, we offer the following conclusions. First, estimates of educational differentials are quite consistent across data sources, sub-samples, and earnings concepts. Second, for most inequality outcomes, trends in full-time weekly earnings and overall hourly earnings are largely comparable within any given data source and are not particularly sensitive to the weighting scheme employed (bodies, weeks, or hours). Third, inferences regarding the residual distribution of earnings are far less consistent in sign, magnitude, and timing among data sources and are sensitive to the handling of outliers and selection of sub-samples. Although all data sources point to a growth of residual inequality starting in the 1970s, the relative magnitude, precise timing, and sample-specificity of this trend are elusive. These vagaries are unfortunate because shifts in the residual earnings distribution are less well understood than 'between group' inequality and, moreover, account, for the preponderance of recent inequality growth by most estimates. To make further progress in understanding these trends, researchers should carefully explore the robustness of their conclusions to choice of data source, sub-sample, and methodology.

2.3 Total Compensation Inequality vs. Wage Inequality

[19] Inequality measures make discreet upward jumps in 1994 in the ORG and 1993 in the March CPS, coincident with the redesign of the survey.

A sharp increase in U.S. wage inequality from the late 1970s to the mid-1990s is a well-documented and robust finding across a wide variety of data sets and studies. But wages do not represent the full economic returns to work. Non-wage employee benefits (fringe benefits), such as employer pension contributions and employer-provided health insurance, represent a significant share of total (pecuniary) compensation in the United States. Aggregate data from the National Income and Product Accounts indicates that supplements to wages and salaries as a percentage of total compensation increased rapidly from 7.5 percent in 1959 to 16.5 percent in 1979 to 18.9 percent in 1994, before declining slightly to 17.9 percent in 1996 [*Economic Report of the President* (1998, Table B28, p. 312). Pierce (1997), using a somewhat broader measure of employee benefits, estimates that non-wage compensation represented 27.3 percent of total employer compensation costs in 1994. The nonpecuniary returns to work (working conditions) also vary substantially among jobs and individuals.

The interpretation and welfare consequences of rising wage inequality clearly depends on whether it represents increased inequality in the overall economic returns to work as opposed to a change in the distribution of the composition of total compensation between wage and non-wage components. Thus a crucial research question is the extent to which changes in wage inequality are a good proxy for changes in the dispersion of the total economic returns to work. Research on changes in the distribution of the overall economic returns to work has been hampered by a lack of individual-level data sets with information on the incidence and value of non-wage benefits and by the difficulties involved in measuring and valuing nonpecuniary working conditions.

Pierce (1997) represents the most comprehensive study of the inequality of total hourly compensation (wage plus non-wage benefits) for the United States. Pierce examines reasonably representative national samples of jobs for 1986 and 1994 using the establishment survey micro data collected to produce the Employment Cost Index (a quarterly index of total employer compensation costs). This data provides information on hourly wages and on the incidence and value (employer cost) of a wide range of both legally required and voluntary benefits. Pierce finds that cross-sectional compensation inequality is greater than wage inequality. High wage jobs are more likely to have specific benefits (especially employer-provided health insurance, pensions, and paid leave) and a greater value of benefits. The differences in the incidence of voluntary benefits is especially large in the bottom-half of the wage (or total compensation) distribution. Pierce estimates a 90-10 log hourly compensation differential of 1.75 in 1994 as compared to a 90-10 log hourly wage differential of 1.568. Thus the cross-section data is suggestive of strong income effects in the demand for benefits with the benefit share increasing in total compensation. Furthermore Pierce's examination of data from 1986 to 1994 indicates a somewhat larger rise in compensation inequality than in wage inequality, especially in the bottom half of the compensation distribution.

Information on the incidence (but not on the valuation) of employer-provided health insurance and pension coverage is periodically available for nationally representative samples of employees from the Current Population Survey. These data indicate that changes in the incidence of employer-provided health insurance and pension coverage have exacerbated relative wage changes with a substantial decline in the relative likelihood of coverage for less-educated and low-wage workers from 1979 to the mid-1990s [e.g., Bloom and Freeman (1992), Even and McPherson (1994), and Mishel, Bernstein, and Schmitt (1997a)]. For example, Farber and Levy (1998) document that the fraction of workers with health insurance from their own employer declined from 0.67 in 1979 to 0.50 in 1997 for high school dropouts as compared to a decline from 0.81 to 0.76

over the same period for college graduates.

Hamermesh (1998) provides a fascinating initial attempt to examine changes in the inequality of (non-pecuniary) workplace amenities. Hamermesh examines patterns of changes in inter-industry differentials in both wages and the total burden of occupational injuries from 1979 to 1995. He finds a widening of cross-industry inequality in the total burden of injuries with a relative drop in injuries in industries with rising relative earnings. Hamermesh similarly finds in analysis of the timing of work from 1973 to 1991 that the incidence of work at unattractive hours (evenings and nights) has increased relatively for low-wage workers. Changes in the distribution of these workplace amenities also move in the direction of greater inequality in the total economic returns to work in the United States over the last two decades.

In summary, the limited available evidence strongly indicates that changes in the distribution of non-wage benefits and nonpecuniary workplace amenities tend to reinforce rather than offset observed increases in U.S. wage inequality and wage differentials by education. This is an important area for future research, but a tentative conclusion is that recent changes in the wage distribution provide a reasonable proxy for changes in the distribution overall distribution of economic returns to work.

2.4 Observable and Unobservable Components of Changes in Wage Inequality

Models of wage structure changes emphasizing shifts in the supply and demand for different labor inputs are likely to be easier to implement and interpret when applied to changes in relative wages among workers classified by observable skill categories. It is more difficult to separate out the contribution of changes in skill prices and quantities to changes in residual wage inequality.

This raises the question of the extent to which changes in wage inequality reflect changes in the relative price and quantities of observed worker attributes as opposed to changes in residual inequality.

A common approach to assessing the quantitative contributions of observable and unobservable components of wage dispersion to changes in overall wage inequality is a standard variance decomposition. We start with a simple wage equation of the form

$$(1) \qquad Y_{it} = X_{it}B_t + u_{it}$$

where Y_{it} is the log wage of individual i in year t, X_{it} is a vector of observed individual characteristics (e.g., experience and education), B_t is the vector of estimated (OLS) returns to observable characteristics in t, and u_{it} is the log wage residual (which depends on the prices and quantities of unobserved skills, measurement error, and estimation error). The orthogonality of the predicted values ($X_{it}B_t$) and the residuals (u_{it}) in an OLS regression implies the variance of Y_{it} can be written as

$$(2) \qquad Var(Y_{it}) = Var(X_{it}B_{it}) + Var(u_{it}).$$

Thus the variance of log wages can be decomposed into two components: a component measuring the contribution of observable prices and quantities and the residual variance (a component measuring the effect of unobservables). These two components are typically referred to as between-group and within-group inequality. The change in variance of log wages between two periods can similarly be decomposed (by differencing equation (2)) into the change in the variance in the predicted values (change in between-group inequality) and the change in the residual variance (change in within-group inequality). This approach provides a clean and clear decomposition of wage inequality into observables and unobservables. The shortcoming of a reliance only on this approach is that the variance may not be the only inequality metric of interest especially given the sensitivity of the variance to changes in the tails of the distribution.

Table 5 presents such a between- and within-group decomposition of the growth of the variance of log weekly wages from 1963 to 1995 for our basic March CPS samples of full-time, full-year workers. Changes in the between-group variance component for men and for women reflect changes in relative returns to and the distribution of quantities of workers by education, experience, race, and region. The growth of residual inequality accounts for about a 60 percent of the increase in the variance of log weekly wages for both men and women over the full 1963-1995 period. This pattern reflects a somewhat more rapid proportional growth in between-group than residual inequality. In fact, for males the share of overall variance explained by the observables rises from the 32 percent in 1963 to 36 percent in 1995. The narrowing of the gender wage differential since 1979 reduces the between-group variance and implies a quite large contribution (75 percent) of residual inequality to the growth in overall wage inequality for men and women combined. The between group component plays a much larger role in the period of rising educational differentials and accounts for 47 percent of the growth in male wage inequality from 1979 to 1995.[20]

[20]The estimates of Juhn, Murphy, and Pierce (1993) similarly imply that an increase in residual wage inequality accounted for approximately 61 percent of the rise in the variance of log weekly wage for full-time, adult, white males in the March CPSs from 1964 to 1988. They also find a much larger contribution of the between-group component in the 1980s. DiNardo, Fortin, and Lemieux (1996) find using data on hourly wages of all employees aged 16 to 65 from the CPS ORG samples that the majority (57 percent) of the increase in wage inequality from 1979 to 1988 is accounted for by rising between-group variance.

Increases in between-group and within-group inequality are both important contributors to rising U.S. wage inequality over the last several decades. A full explanation for changes in wage inequality needs to account not only for changes in returns to observed skill measure, but also for large changes in within-group inequality.

A further issue concerning the decomposition of changes in wage inequality into observable and unobservable components is the extent to which changes in between-group wage inequality reflects changes in the returns to observed skills as opposed to changes in the distribution of worker characteristics. The full-sample distribution accounting scheme developed by Juhn, Murphy, and Pierce (1993) is a useful approach that allows one to make such assessments for any measure of inequality (not just the variance). This approach begins with a simple wage equation such as (1) and conceptualizes the wage equation residual u_{it} as having two components: an individual's percentile in the wage distribution θ_{it} and the distribution function of the residuals $F_t(\ )$. By the definition of the cumulative distribution function, we can write the residual as

(3) $$u_{it} = F_t^{-1}(\theta_{it}|X_{it}),$$

where $F_t^{-1}(\bullet|X_{it})$ is the inverse cumulative residual distribution for workers with characteristics X_{it} in year t.

The framework given by equations (1) and (3) decomposes changes in inequality into three sources: (1) changes in the distribution of individual characteristics (changes in the distribution of the X's); (2) changes in the prices on observable skills (changes in the B's); and (3) changes in the distribution of residuals. By defining β as the average returns to observables over the whole period under study and $G(\bullet|X_{it})$ to be the average cumulative distribution, we can decompose the level of inequality into corresponding components using

(4) $$Y_{it} = X_{it}\beta + X_{it}(B_t - \beta) + G^{-1}(\theta_{it}|X_{it}) + [F_t^{-1}(\theta_{it}|X_{it}) - G^{-1}(\theta_{it}|X_{it})].$$

The first term captures the effect of changing distribution of worker characteristics; the second measures the effects of changing skill returns; and the third term accounts for changes in the distribution of the residuals. This framework allows one to reconstruct the (hypothetical) wage distribution that would attain with any subset of the components held fixed. One does not need to hold any of the components fixed at the average level for the entire sample, one could simulate hypothetical wage distributions using any base period and replace β and $G(\bullet|X_{it})$ with the values for a reference period of interest.

If observable prices and the residual distribution are held fixed so that only observable quantities are allowed to vary, then wages would be determined by

(5) $$Y^1_{it} = X_{it}\beta + G^{-1}(\theta_{it}|X_{it}).$$

If observable skill returns and quantities are allowed to vary over time with only the residual distribution held fix, then wages are generated by

(6) $$Y^2_{it} = X_{it}B_t + G^{-1}(\theta_{it}|X_{it}).$$

The recommended approach of Juhn, Murphy, and Pierce (1993) is to calculate the distributions of Y^1_{it}, Y^2_{it}, and Y_{it} for each year studied and to attribute the change through time in the Y^1_{it} distribution to changes in observable quantities. Any additional change in inequality in Y^2_{it} beyond inequality changes in Y^1_{it} is attributed to observable skill returns. Further change in actual overall inequality of Y_{it} beyond those found in Y^2_{it} is attributed to residual inequality (changes in the distribution of residuals). The advantage of this approach over a standard variance decomposition is it allows one to look at how changes in each component affected the entire wage distribution and not just the variance. A disadvantage of moving away from the variance and examining other measures of inequality, such as quantile measures like the 90-10 log wage differential, is that these alternative measures typically do not uniquely decompose into between and within components. The actual allocations of changes in inequality to different components using the full sample accounting scheme are sensitive to the order in which one does the decomposition. The order chosen implicitly implies an assignment of interaction terms among the different components. Further ambiguities can arise since the specific results also depend on the base period chosen to hold components of the wage distribution fixed.[21]

Juhn, Murphy and Pierce (1993) have implemented this approach for several quantile measures of wage dispersion using March CPS data on adult white males for 1964 to 1988. Table 6 summarizes their findings for the 90-10 log weekly wage differential. Increases in residual inequality account for 56 percent of the rise (.208 of an increase of .373) of the 90-10 log weekly wage differential from 1964 to 1988. The contribution of residual inequality to the rise in the 90-10 differential is quite similar to findings from a standard variance decomposition. Table 6 also

[21]For example, Goldin and Margo (1992) find substantial sensitivity of results to the choice of a base period in using this approach to decompose changes in U.S. wage inequality from 1940 to 1950.

indicates that almost 80 percent of the contribution of observables to rising inequality for the whole 1964-1988 period from increases in returns to observable skills (experience and education). In fact, increase in returns to observed skills (mainly rising educational wage differentials) accounts for the majority (55 percent) of the increase male wage inequality in the 1980s. Juhn, Murphy and Pierce (1993) also report that increased returns to observed skills are more important for the increases in wage inequality in the upper half of the wage distribution than in the bottom half of the wage distribution as might be expected from the large increase in returns to college and advanced degrees in the 1980s.

2.5 Permanent and Transitory Components of Earnings Inequality

An increase in cross-sectional earnings inequality could reflect a rise in the permanent and/or the transitory component of earnings inequality. An explanation for the observed rise in cross-sectional inequality in the United States over the past several decades based on greater returns to skills (such as schooling and other persistent abilities) implies increased inequality in long-run (permanent) earnings. The substantial contribution of expanding educational wage differentials to growing earnings inequality is consistent with such a scenario. But the large increase in residual wage inequality could reflect increased returns to persistent (unobserved) worker attributes or a rise in transitory earnings variability. A sharp increase in the returns to (unobserved) skills is likely to have a much larger impact on long-run earnings inequality than an increase in transitory earnings instability. Explanations for increased wage inequality emphasizing the weakening of labor market institutions (e.g., unions, government wage regulation, internal labor markets) that increase the exposure of wages to market shocks may be consistent with increased year-to-year earnings turbulence. Understanding the contributions of changes in permanent and transitory components of earnings variation to increased cross-sectional earnings inequality is helpful for evaluating alternative hypotheses for wage structure changes and for determining the likely welfare consequences of rising inequality.

Following Baker and Solon (1998) and Moffitt and Gottschalk (1995), a rudimentary model of earnings dynamics allowing for time-varying earnings inequality is given by

(7) $y_{it} = p_t\alpha_i + \lambda_t v_{it}$

where y_{it} is the log earnings of individual i in year t, α_i is individual I's permanent earnings component (assumed to be time-invariant in this simple framework) with variance σ^2_α, v_{it} is the transitory earnings component with variance σ^2_v, α_i and v_{it} are orthogonal to each other, and p_t and λ_t are time-varying factor loadings on the permanent and transitory components of earnings. One interpretation of this framework is that α_i reflects persistent worker skills and p_t reflects the time-varying skill price (returns to skill). This model implies the variance of y_{it} can be written as

(8) $\text{Var}(y_{it}) = p^2_t\,\sigma^2_\alpha + \lambda^2_t\,\sigma^2_v$.

Equation (8) shows that an increase in either factor-loading generates an increased cross-sectional earnings dispersion. The nature of the change in inequality depends on which factor loading changes. A persistent rise in p_t increases long-run earnings inequality (earnings dispersion across individuals measured over a long horizon such as a decade or lifetime) as the relative labor market advantage of high skill workers is enhanced. An increase in λ_t without an increase in p_t increases cross-section earnings inequality by rising year-to-year earnings volatility, but there is no increase in the dispersion of long-run earnings. An increase in p_t essentially maintains the rank order of individuals in the wage distribution, but spreads them out further in a persistent manner. An increase in λ_t leads to more changes in individuals' order in the earnings distribution, but the changes are quickly undone.

Measures of earnings mobility, the rate at which individuals shift positions in the earnings distribution (i.e., transition across quantiles of the earnings distribution), are closely related to the importance of permanent and transitory components in earnings variation. A large contribution of the permanent component implies that individuals' earnings are highly correlated over time (those with low relative earnings in one year are likely to have low relative earnings in other years) and thereby implies low rates of earnings mobility. Thus the extent to which changes in cross-sectional earnings inequality are driven by the permanent or transitory component has implications for changes in mobility rates. A rise in inequality caused solely by an increase in the permanent component will be associated with a decline in mobility rates. A rise in transitory component alone will increase mobility rates. Equal proportional increases in the permanent and transitory components will leave mobility rates unchanged even though earnings instability (the variation in year-to-year changes in log earnings for a typical individual) will be increased.

Since increases in the factor loading for either the permanent or the transitory component in equation (7) raises the cross-sectional variance of y_{it}, information on the time pattern of the variance of y_{it} from repeated cross-sections is not sufficient to identify whether p_t or λ_t has changed. Information on individual-level autocovariances of earnings is necessary to sort out changes in the permanent and transitory components of variance [Baker and Solon (1998)]. Thus longitudinal data on individual earnings histories are required to assess the contributions of permanent and transitory components of earnings variation to levels and changes in earnings inequality.

A burgeoning literature has attempted to examine the contribution of permanent and transitory components of earnings variation to recent changes in U.S. earnings inequality using data from several longitudinal data sets (the PSID, NLSY, and March-March matched files from the CPS).[22] A consistent finding across studies and data sets is that large increases in both the permanent and transitory components of earnings variation have contributed to the rise in cross-section earnings inequality in the United States from the late 1970s to the early 1990s. The increase in the overall permanent component consists of both the sharp rise in returns to education and a large increase in the apparent returns to other persistent (unmeasured) worker attributes. The rise in cross-sectional residual inequality for males (controlling for experience and education) in the 1980s seems to consist of approximately equal increases in the permanent and transitory factors [Moffitt and Gottschalk (1995)].

Gottschalk and Moffitt's (1994) simple decomposition of the change in the variance of log earnings from the 1970s to the 1980s for male household heads in the PSID provides an illustrative set of results. Gottschalk and Moffitt sub-divide their data into two nine-year periods, 1970-78 and 1979-87. After adjusting earnings for life-cycle earnings growth (controlling for an experience

[22]Gottschalk and Moffitt (1994), Haider (1997), and Moffitt and Gottschalk (1997) examine adult males using the PSID. Buchinsky and Hunt (1996) examine young workers using the NSLY. Gittleman and Joyce (1995, 1996) examine adult males and females using March-March matched files from the Annual Demographic Files of the CPS. Baker and Solon (1998) provide a sophisticated study of male earnings dynamics and changes in earnings inequality using a rich longitudinal data set of income tax records for Canada. See OECD (1997) for a summary of evidence on recent a changes in earnings mobility among other advanced nations. Studies of earnings mobility tend to focus on measures of annual earnings.

profile), they calculate for each individual the mean of his log earnings over the nine-year period (permanent earnings) and the deviation of his log earnings from the mean in each year (transitory earnings). The variance of permanent log earnings in each nine-year period is the variance of these nine-year means across individuals. They calculate the variance of transitory log earnings by computing the variance of the nine transitory components separately for each individual and then averaging them across individuals.[23]

Table 7 summarizes some of the key findings of Gottschalk and Moffitt (1994). The permanent and transitory variances both increased by about 40 percent from the 1970s to the 1980s. The similar proportional increases in transitory and permanent variances imply little change in earnings mobility. Roughly two-thirds of the increase in earnings variance (for both annual and weekly earnings) from the 1970s to the 1980s is accounted for by the permanent component, but the rise in earnings instability is still quantitatively significant. The changes in permanent and transitory variance are of similar magnitude when one looks within education groups (controls for much of the increase in returns to education). The increase in earnings instability appears largest for less educated workers.

The implicit model of earnings dynamics used by Gottschalk and Moffitt (1994) is quite restrictive. For example, recent research on earnings dynamics provides evidence of (1) persistent heterogeneity across individual not only in their level of earnings but also in their life-cycle growth rates; (2) the possibility of an important random-walk component to earnings; and (3) serial correlation in transitory shocks to earnings [e.g., Baker (1997); Abate and Card (1989)]. But more sophisticated empirical analyses that use more realistic (and complicated) models of earnings

[23]This approach could be justified by an earnings dynamics model such as equation (1) if p_t and λ_t are fixed within each nine-year period but allowed to differ across the two nine-year periods.

dynamics reach similar conclusions of substantial contributions of both permanent and transitory variances to the rise in cross-sectional earnings variance and little change in earnings mobility rates [e.g., Haider (1997); Moffitt and Gottschalk (1995)].

A complete explanation for the recent rise in U.S. wage inequality needs to account for both a growth in transitory earnings volatility and a large increase in the permanent variance component that appears associated with higher returns to education and other persistent worker attributes. The rise of earnings instability appears to be a bit of a puzzle for hypotheses only emphasizing rising skill prices associated with increased growth in the demand for skills relative to the supply of skills. A period of rapid skill-biased technological change associated with the spread of computer-based technologies and new organizational practices could both increase the relative demand for skill and (at least in a transition period) generate greater earnings instability since firms are likely to have much initial uncertainty concerning the abilities of individual workers' to perform new tasks and adapt to a new organizational environment. Rodrik (1997) has argued that increased globalization and international capital mobility can also increase earnings instability by making labor demand curves more elastic so that shocks to product market prices have a larger impact on wages. An important agenda for future work is to attempt to examine the extent to which patterns of changes in transitory earnings variability are related to changes in technology, organizational and personnel practices, exposure to international competition, changes in domestic product market competition, and changes in unionization and other labor market institutions.

2.6 Cohort vs. Time Effects in Inequality and the Returns to Education

The interpretation of recent increases in educational wage differentials and of within-group inequality (at least the persistent component of residual inequality) as largely reflecting increases in the returns to skills is facilitated by the (implicit) assumption that the distribution of unobserved ability is relatively similar across successive labor market cohorts.[24] An alternative possibility is that increased wage inequality may arise from increased dispersion of unobserved labor quality within recent entry cohorts, possibly from increasingly unequal school quality and diverging social conditions across neighborhoods. A decline in the unobserved ability of those with less education relative to those with more education in younger cohorts could potentially imply a rise in education returns reflecting an increase in ability bias.[25] In other words, changes in the wage structure could reflect changes in the average quality of different groups of workers rather than changes in the average wage for groups of workers of fixed quality.

Under the assumption that quality is relatively fixed within cohorts after school completion and labor market entry, these considerations have motivated investigations of the extent to which changes in inequality and educational differentials reflect changes within as opposed to between cohorts. Juhn, Murphy and Pierce (1993) examine within-cohort changes in overall wage inequality (the 90-10 log weekly wage differential) for six-year experience cohorts of white men. They find little within-cohort change in inequality in the 1960s, modest increases in the early 1970s, and large

[24]Card and Lemieux (1996) provide an interesting formal assessment of the extent to which an increase in the returns to a single index of skill can account for the observed pattern of changes in wage differentials by education and age and in residual wage dispersion for the United States during the 1980s. They find that such a "single-index" model of skills provides a fairly accurate, but overly simplified, description of wage structure changes for white men and white women from 1979 to 1989.

[25]A distinctive but related alternative hypothesis is that estimated changes in educational wage differentials reflect changes in the returns to unobserved ability rather than changes in "true" returns to education [e.g., Cawley, Heckman, and Vytlacil (1998)]. Changes in the returns to unobserved ability could lead to changes in ability bias even with unchanging distributions of unobserved ability within and between cohorts and education groups. This is a difficult issue requiring strong and controversial identification assumptions, but our reading is that the limited available evidence suggests substantial increases in the U.S. college wage premium in the 1980s even after attempting to account for a rise in returns to unobserved ability [e.g., Chay and Lee (1996)].

increases in the 1980s. The time pattern of average within-cohort inequality changes closely track average within-experience group changes. And Murphy and Welch (1993b) show that average within-cohort changes in the college wage premium similarly closely follow average within-experience group changes with a modest increase in the late 1960s, a decline in the 1970s, and substantial increases in the 1980s. Within-cohort changes (time differences) in inequality (or educational wage differentials) eliminate fixed cohort effects but could represent age or time effects or both. Although one can't separately identify the levels of cohort, age, and time effects without very strong assumptions, a differences-in-differences approach of comparing within-cohort changes for different cohorts going through the same age ranges in different time periods can eliminate age and cohort effects and leave only changes in the time effect (the change in inequality growth over time). For example, a comparison of the change in inequality in the 1980s for the cohort aged 25-29 in 1980 to the change in inequality in the 1970s for the cohort aged 25-29 in 1970 provides an estimate of the difference in the time effect for the 1980s to the time effect for the 1970s.

Thus the findings of Juhn, Murphy and Pierce (1993) shows an accelerating increase in inequality with time from the 1960s to the 1980s that cannot be explained by any combination of age and cohort effects. The sharp swings in within-cohort changes in educational wage differentials across decades (and even shorter periods in which changes in labor force composition are quite small) also strongly suggest that fluctuations through time in the college wage premium largely reflect changes in the relative price of educated labor and are not artifacts of changes in the composition of the college and high school populations.

A key role for changes in skill prices in movements in U.S. educational wage differentials does not imply the absence of cohort or "vintage" effects in the returns to education. An exploratory analysis by Card and Lemieux (1998) reject the hypothesis that the return to education is the same for different cohorts in the U.S. labor market. Their findings are suggestive of changing cohort effects in the college wage premium especially among recent U.S. entry cohorts. The much larger rise (within-experience group) rise in the college wage premium for younger than older workers in the 1980s could be attributed to either such changing cohort effects or from the larger impact of labor market shocks on younger than on older workers. Freeman's (1975) "active labor market" hypothesis postulates that changes in labor market conditions (changes in the supply and demand for skills) show up most sharply for new entrants because more senior incumbent workers are partially insulated from shocks by internal labor markets.

2.7 Longer-Term Historical Changes in the U.S. Wage Structure

Many explanations for recent wage structure changes emphasize factors, such as skill-biased new technologies and reduced barriers to international economic transactions, that are sometimes characterized as sharp breaks from the past. But rapid technological progress and reductions in communications and transportation costs have characterized advanced market economies for a long historical period stretching back at least to the industrial revolution. This raises the issue of how wage structure changes over the past several decades fit into longer-term historical patterns. Individual-level data on earnings and worker characteristics from the decennial Census of Population allow one to make reasonably consistent comparisons of wage structure changes (particularly for full-time, full-year workers) over the 1940 to 1990 period.[26] Nevertheless the 1940 Census PUMS is the first nationally-representative sample with information on both earnings or

[26]Recent studies using the Census data to examine wage structure changes over the full 1940 to 1990 period include Autor, Katz, and Krueger (1998), Juhn (1994), Juhn, Kim and Vella (1996), and Murphy and Welch (1993a).

educational attainment. Thus the analysis of wage structure changes prior to 1940 is greatly constrained by data limitations and requires a focus on changes in wage differentials by occupation and/or industry [e.g., Chiswick (1979), Cullen (1956), Douglas (1930), Goldin and Katz (1995, 1998), and Williamson and Lindert (1980)] .

Table 8 uses data on log weekly wages of full-time, full-year, non-agricultural workers from the Census PUMSs to summarize the evolution of overall wage inequality (as measured by the 90-10 log wage differential) and the college wage premium (as measured by the regression-adjusted wage differential between those with exactly 16 years of schooling and those with exactly 12 years of schooling) from 1940 to 1990.[27] The existence of a large number of outlier observations with extremely low weekly earnings (especially for women in 1940) motivates our presentation of overall inequality measures based on two different approaches to trimming this bottom tail. The first approach deletes the lowest 1 percent (and leads to findings that are quite similar to no deletions), and the second approach (following Juhn (1994)) deletes all individuals who earned less than half the contemporaneous Federal minimum wage. This second approach could potentially be misleading given substantial changes in the coverage and relative generosity of the Federal minimum wage over the period of study (especially from 1940 to 1950).

The most striking feature of the data presented in Table 8 is the tremendous narrowing of wage inequality for both men and women in the 1940s.[28] Wage inequality for men then rises in each subsequent decade with an acceleration of the pace of widening inequality in the 1980s.[29] The entire

[27]The Census collects information on annual earnings in the previous calendar year. Thus the data in Table 8 actually cover the 1939 to 1989 period. We focus on non-agricultural workers given the difficulties in measuring agricultural earnings especially in the early Census samples.

[28]Goldin and Margo (1992) refer to the 1940s as the period of the "Great Compression."

[29]Juhn (1994) reaches similar conclusions in an analysis of weekly earnings of full-time, white males from 1940 to 1990.

compression of the wage structure in the 1940s is undone by 1990. The pattern for women is roughly similar. The U.S. wage structure in the 1990s appears to be more unequal than at any point of time at least since 1940. The college wage premium also declines substantially in the 1940s, rises modestly in the 1950s and 1960s, narrows in the 1970s, and then sharply expands in the 1980s. Juhn (1994) shows that a wide variety of measures of educational and occupational wage differentials evolve similarly to the college wage premium from 1940 to 1990.

Overall wage inequality and educational wage differentials have expanded greatly since 1950 despite rapid educational advance and a large increase in the relative supply of more-educated workers. Thus strong secular increases in the relative demand for skills is likely to be an important component of any explanation for U.S. wage structure changes. The sharp contrast between the pattern of wage compression in the 1940s (a period of rapid expansion of unions, extremely tight labor markets for less-skilled workers associated with World War II, and government intervention in the economy) and of widening inequality in the 1980s (a period of eroding unions and sharp declines in blue collar employment in manufacturing) is suggestive of the possible importance of both institutional factors and changes in the relative demands for and supplies of different skill groups.

The available evidence on occupational wage differentials indicates a substantial decline in the earnings of white collar workers to blue collar workers from 1890 to 1939 [Goldin and Katz (1995)]. This decline in the white collar wage premium occurs almost entirely in the decade surrounding World War I (especially from 1914 to 1919). The widening of occupational wage differentials from 1950 to 1990 has been large enough to offset the Great Compression of the 1940s, but it has not undone the compression that occurred around World War I . Thus the occupational wage structure has probably narrowed over the past century. The decades surrounding the two World Wars account for almost all the egalitarian movements in the wage structure in the twentieth century. The sources of these seemingly persistent effects of changes occurring during the period of the World Wars is an important question for an understanding of the long-run evolution of the U.S. wage structure. One possibility is that wars enable the erosion of customary wage differentials [Phelps Brown (1977)]. The precise timing of the large declines in occupational/educational wage premiums in the 1910s and 1940s may reflect special factors related to the wars, but their persistence may reflect the role of market forces related to rapid expansions of the relative supply of more-educated workers associated with the high school movement after World War I and the growth of higher education after World War II.

3. Changes in Other Advanced OECD Countries

Have wage differentials by skill and overall wage inequality increased in other advanced countries since the late 1970s to the same extent they have in the United States? A number of recent studies have attempted to assemble as comparable as possible data across advanced nations to answer this question.[30] Thus, in this section, we provide only a brief summary of the basic patterns of wage structure changes among advanced OECD nations over recent decades.

Table 9 classifies twelve countries by the way their educational and/or occupational wage differentials changed in the 1970s and the 1980s. During the 1970s, all the countries shared a common pattern of narrowing wage differentials by skill. Overall wage dispersion for males also

[30]See, for example, Berman, Bound, and Machin (1998), Davis (1992), Freeman and Katz (1994, 1995), Gottschalk and Smeeding (1997), Haskell and Slaughter (1998), and OECD (1993, 1996, 1997). The chapter by Layard and Nickell (1998) examines cross-country differences in labor market institutions and labor market performance.

narrowed in all of these countries with the exception of the United States. The trend toward reduced educational wage differentials and stopped or strongly reversed itself by the mid-1980s in all of these countries (except South Korea).

Furthermore patterns of changes in educational wage differentials and overall wage inequality are much more divergent in the 1980s and 1990s than in the 1970s. Table 10 measures changes in overall wage inequality for men from 1979 (or the earliest year available) to 1994 (or the latest year available) in terms of the 90-10 log wage differential. The United States and the United Kingdom experienced sharp increases in overall wage inequality, residual wage inequality, and, educational and occupational wage differentials of similar magnitude [Katz, Loveman, and Blanchflower (1995)]. The pattern of declining wage inequality apparent throughout the OECD (except the United States) in the 1970s ceased in the 1980s and 1990s in almost all nations (with Germany and Norway as possible exceptions). Canada, Australia, Japan, and Sweden had modest increases in wage inequality and educational/occupational differentials starting in the early 1980s.

Wage differentials and inequality narrowed through the mid-1980s in Italy and France with some hint of expanding in France in the late 1980s and with a large increase in inequality in Italy in the 1990s following the abolition of an automatic cost-of-living index favoring low-wage workers (the *scala mobile*) and the ending of synchronization of bargaining across industries. New Zealand also shows large increases in inequality in a period following substantial deregulation of product and labor markets (OECD, 1996).

These patterns are suggestive of an important role of differences and changes in labor market institutions and regulations in explaining the cross-country divergence of wage structure changes in the 1980s and 1990s. But differences in supply and demand factors may also play a role (e.g., greater decelerations in the rate of growth of relative skill supply growth in the United States and Great Britain from the 1970s to the 1980s). And the existence of either a decline in the relative wages of the less skilled, a sharp rise in the unemployment of the less skilled, or both in almost all OECD countries over the past two decades despite expanding relative supplies of highly educated workers is strongly suggestive of a common shift in labor demand against the less skilled [Bell and Nickell (1995); Katz (1994); Wood (1994)]. We next develop a framework to assess the roles of market forces and institutional factors in the evolution of national wage structures.

4. Conceptual Framework: Supply, Demand, and Institutions

This section develops a supply-demand-institutions (SDI) framework to assess the role of market forces (supply and demand shifts) and institutional factors in changes in the wage structure. The specific approach taken borrows from the informal conceptual framework of Freeman and Katz (1994) and the more formal model of the determinants of between-group wage differentials of Bound and Johnson (1992).

The basic idea is that the actual wage of an individual can be decomposed into a latent "competitive" wage (or competitive total compensation level) and a deviation from the competitive compensation level for that individual. Actual wages may deviate from the competitive compensation level because of either institutional/non-competitive forces (unions, minimum wages, etc.) affecting wage setting or "measurement" problems arising from differences in non-wage compensation across jobs. The actual wage for individual i (w_i) can be defined as the product of the competitive wage for i (w_{ic}) and a relative rent for i (μ_i): $w_i = w_{ic}\mu_i$. If the non-wage employment attributes of all jobs were identical and there were no institutional or non-competitive factors causing wages to deviate from their competitive norm, then all the μ_i's would be equal to 1. But much evidence suggests that wages for given "quality" workers appear to systematically differ across industries and employers and by union status suggesting that deviations of μ_i from 1 are likely to be quantitatively important.[31] Deviations of wages from "full" competitive compensation whether arising from compensating differentials for non-wage attributes of employment or from non-competitive influences on wages are interpreted here as variation in relative rents.

This approach provides a useful framework for examining both changes in relative (log) wages among labor force groups and changes in residual (within-group) wage inequality. The aggregate work force is composed of K demographic groups (typically defined by age, education, and sex) indexed by k. The log wage for individual i in group k (Y_{ik}) can be expressed as the sum of the log competitive wage for i (Y_{ikc}) and the log relative rent for i (R_{ik}):

$$(9) \qquad Y_{ik} = Y_{ikc} + R_{ik}$$

where $Y_{ik} = \log(w_{ik})$, $Y_{ikc} = \log(w_{ikc})$, and $R_{ik} = \log(\mu_{ik})$. The mean log wage of group k (the geometric mean of the wage rate of group-k workers) Y_k is conveniently equal to the sum of the competitive wage for group k (mean log competitive wage of group-k workers) and the average (log) rents for workers in group k

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[31]Studies documenting and evaluating the evidence on inter-industry wage differentials include Slichter (1950), Krueger and Summers (1988), Katz and Summers (1989), Murphy and Topel (1990), and Gibbons and Katz (1992). Groshen (1991) examines U.S. evidence on inter-employer wage differentials within detailed industries. Lewis (1986) carefully summarizes the U.S. research on union/nonunion wage differentials, and Card (1996) provides a thoughtful empirical analysis of differences in the "treatment" effect of unions on individual wages by skill group.

$$(10) \qquad Y_k = Y_{kc} + R_k.$$

The competitive (log) relative wages (the Y_{kc}'s) are determined by the interaction of relative supplies and relative demands for the groups. To assist in the interpretation of the empirical literature, we concentrate on relative rents arising from three potentially measurable sources: (1) "true" industry wage differentials; (2) union wage effects; and (3) impacts of minimum wages or other forms of direct government intervention in wage setting. This focus leads us to also classify employment into J industries indexed by j.

The actual log wage of individual i of group k working in industry j is given by the sum of the competitive log wage for group k (Y_k); the mean industry wage differential (conditional on union status) for workers of group k employed in industry j (I_{jk}); a union status indicator (U_{ik} = 1 if i is unionized and 0 otherwise) times the associated mean union wage premium (λ_k) for group k; a minimum wage impact status indicator (M_{ik} = 1 if I's wage is affected by the minimum wage and 0 otherwise) and the associated mean minimum wage impact (δ_k) for affected workers in group k; and a (mean zero) individual error term (ϵ_{ijk}) reflecting measurement error and individual-level (within group) variation in ability and rents:

$$(11) \qquad Y_{ijk} = \log(w_{ijk}) = Y_{kc} + I_{jk} + \lambda_k U_{ijk} + \delta_k M_{ik} + \epsilon_{ijk}.$$

The industry wage differentials (I_{jk}'s) potentially reflect differential effects of unions on wage levels by industry and demographic group (differences in union bargaining power by industry, union threat effects, and union spillover effects), other sources of non-competitive wage variation across industries (efficiency wage and other rent sharing considerations), as well as equalizing differences for between-industry variation in working conditions and non-wage compensation. The mean minimum wage impact (δ_k) includes direct effects on for those earning the minimum wage as well as potential positive spillover effects above the minimum wage or possible negative crowding effects on wages in the uncovered sector.

The mean log wage for group-k workers can be written as:

$$(12) \qquad Y_k = Y_{kc} + \Sigma_j I_{jk}\phi_{jk} + \lambda_k U_k + \delta_k M_k$$

where $\phi_{jk} = N_{jk}/N_k$ is the share of workers in group k that work in industry j; U_k is the fraction of group-k workers that are unionized; and M_k is the fraction of group-k workers that are affected by the minimum wage. We assume that log wages in each period are measured as deviations from the overall mean log wage. The change in the relative log wage of each group k is

$$(13) \qquad dY_k = dY_{kc} + \Sigma_j(dI_{jk}\phi_{jk} + I_{jk}d\phi_{jk}) + d\lambda_k U_k + \lambda_k dU_k + d\delta_k M_k + \delta_k dM_k\,.$$

The relative wage of a particular group of workers can change either because market forces lead its mean competitive wage to rise faster or slower than the overall average or because of changes in its relative rents. Equation (13) indicates that changes in average relative rents for a group can arise from changes in the average level or incidence of industry wage premia, changes in the group's unionization rate or union wage premium, and changes in the impact of the minimum wage on that group.

Equations (9) to (12) analogously imply that changes in within group wage dispersion can arise from market forces affecting the distribution of competitive wages within a group (e.g., changes in the returns to unmeasured skills) or from institutional factors altering the within group distribution of rents (e.g., a change in the unionization rate for the group).

The SDI framework can be used to illuminate the strengths and weaknesses of the two primary empirical approaches to analyzing wage structure changes. The first approach assumes that changes in the wage structure largely reflect changes in competitive forces and uses a supply-demand model to explain actual relative wage and employment changes [e.g., Freeman(1975), Katz and Murphy (1992), and Murphy and Welch (1992)]. The basic idea is to see how far one can go with a pure competitive framework. The remaining "anomalies" can then be examined to determine the importance of institutional/non-competitive factors. The inherent difficulties in decomposing changes in within group wage dispersion into changes in prices and quantities means this approach is typically more straightforward to use in assessing the determinants of between group wage changes. The pure supply-and-demand approach can potentially be misleading to the extent exogenous institutional changes have a substantial effect on observed wages, especially if firms operate off their labor demand curves. Furthermore numerous difficult decisions arise concerning the appropriate level of aggregation of skill groups and strong assumptions are often required to separate out relative supply and demand shifts and to decompose measured relative demand shifts into interpretable factors such as the influences of skill-biased technological change, domestic product market demand shifts, and globalization factors (international trade and outsourcing). A more in-depth examination of the issues arising in the implementation of the supply-and-demand methodology and an assessment of the existing empirical literature using this approach is contained in Section 5.

The second approach more closely follows the framework illustrated in equations (9) to (13) and tries to directly estimate the separate contributions of changes in institutional factors and competitive factors to observed changes in group relative wages and/or overall wage dispersion. The implementation of this approach to between-group wage differences typically uses relative wage change decomposition similar to equation (13) and involves three steps: (1) estimate the impact of changes in industry rents, union wage effects, and minimum wage influences on relative wages; (2) adjust actual wage changes for these institutional influences to uncover changes in relative competitive wages (the dY_{kc}'s); and (3) use an appropriate supply-demand model to examine the determinants of these changes in the structure of competitive wages. Bound and Johnson (1992) have developed an elegant framework to implement this methodology to account for between-group wage changes. Dinardo, Fortin, and Lemieux (1996) have extended this approach to examine changes in overall, between-group, and within-group wage dispersion; but their specific implementation limits the influence of supply and demand factors to only affecting between-group wage changes.

Two key issues arise in the implementation of the more direct SDI approach to sorting out institutional and competitive influences on the wage structure. The first is the issue of whether one can reliably estimate the direct influences of institutional/non-competitive factors on the wage structure and how these effects change over time. For example, this approach can generate misleading inferences of changes the influence of changes in industry rents to the extent estimates of industry wage differentials partially capture differences in unmeasured worker quality across industries [Gibbons and Katz (1992); Murphy and Topel (1990)]. And changes in minimum wages (real changes or changes relative to the median of the wage distribution) may not imply changes in the "bite" of the minimum wage if the underlying shadow competitive wages for low-wage workers are simultaneously changing. Furthermore estimates of union/nonunion wage differential do not necessarily capture the full (general equilibrium) impact of unions on the wage structure, they provide estimates of differences in wages for given worker in union and nonunion setting conditional on the current locus of unionization. Thus it is not clear how reliable existing estimates of union wage effects (or union effects on wage dispersion) are for doing counterfactuals of how the wage structure would differ if the locus of unionization were different. The attribution of wage structure movements to institutional changes may be problematic to the extent evolution of institutions reflects responses to market forces rather than exogenous events. A promising approach is analyze wage structure changes associated with plausibly exogenous changes in institutions (e.g., the differential bite of changes in the Federal minimum wage across U.S. states) or large discrete changes (e.g., deregulation or privatization of an industry or a major change laws affecting unions).[32]

The second related issue concerns the determination of employment when wages deviate from competitive levels. Even if one can adjust observed wage changes for institutional effects, observed employment changes are likely to depend (at least partially) on actual wages rather than on the latent competitive wages. Bound and Johnson (1992) attempt to conceptually escape this problem by assuming employment is set to equate marginal revenue products for each group to the group's underlying competitive wage. This assumption could be justified if deviations from competitive wages arise from union bargaining power and employers and unions negotiate over

[32]See Fortin and Lemieux (1997) and Lee (1998) for recent attempts at using this approach.

wages and employment to reach strongly "efficient bargains" (Farber, 1986). But much evidence suggests that even in union setting employment depends on actual negotiated wages rather than only on opportunity costs (e.g., Card (1990)) and this assumption is much less plausible for deviations from competitive wages caused by minimum wages.

Following Bound and Johnson (1991, 1992), we illustrate the operation of the SDI framework for assessing alternative explanations for between-group wage structure changes using a simple two group example. The work force is assumed to consist of two groups (skilled and unskilled workers). Data are available on actual log relative wages ($\log(w_s/w_u)$) and actual log relative employment ($\log(N_s/N_u)$) for two periods in which the relative wage and employment level of the more skilled group are both assumed to expand (perhaps representing wage structure and employment changes for college and non-college workers in the United States during the 1980s). Figure 6 shows the economy moves from point A to point B. The question is to what extent does this observed change in relative wages and employment reflects the operation of competitive forces as opposed to institutional factors.

The pure supply and demand model assumes relative wages are determined by the intersection of the relative demand and supply curves in each period. Under the assumption of inelastic (predetermined) short-run relative supplies, the increase in the relative employment of skilled workers reflects a rightward shift in the relative supply of skilled workers in Figure 6. If relative demand were stable, the relative wages of skilled workers would have declined. Thus an outward shift in the relative demand for skilled workers (from D_0 to D_1) must have been the driving force behind the rise in relative wage of skilled workers. This pattern leads analysts using a supply and demand model to focus on possible sources of demand shifts for the more-skilled (e.g., skill-biased technological change or product demand shifts across sectors with different skill intensities) and the variation in the rate of growth of relative skill supplies across time periods.

A possible institutional explanation for a rise in the skill differential is a decline in the relative rents of unskilled workers. In this case the rise in the relative wage and employment of the skilled from A to B in Figure 6 could arise even with no shift in the relative demand curve. For example, the relative demand curve could be stable at D_1, but unskilled workers initially received large rents from unions with firms setting employment at the competitive level. In this case, the economy initially operates off the labor demand curve at point A rather than C. The increase in the relative supply of the skilled would have reduced wages to point D, but the complete erosion of rents results in the increased skill premium at point B.

Of course a mixture of both a decline in relative rents and some shift in relative demand favoring the skilled could also be consistent with the observed change in relative wages and employment. Furthermore, the "naive" supply and demand analysis would correctly estimate the effects of demand shifts even in the presence of rents as long as wages are set equal to marginal products. When employment lies on the labor demand curve, wage changes arising from changes in rents affect unemployment (or nonemployment rates). Thus knowledge of the slope of the relative demand and information on observed changes in relative wages and quantities would allow one to uncover relative demand shifts, but this approach could attribute wage changes to relative supply shifts that might reflect changes in relative rents. Information on changes in population shares or labor force shares by skill group potentially can be used to supplement relative employment information to sort out the effects of changes in relative skill supplies from changes in relative rents [e.g., Jackman, Layard, Manacroda, and Petrongolo (1997); Nickell and Bell (1995)].

5. Supply and Demand Factors

This section develops the pure supply and demand approach to analyzing wage structure changes. We begin with a generic supply and demand framework to analyze between-group relative wage changes. We show how this framework can be used to assess whether observed changes in relative wages and relative employment are consistent with stable relative factor demands. We then examine key modeling issues concerning the specific approach to aggregating heterogeneous demographic groups into distinct labor inputs (skill groups) and assumptions concerning market clearing and the exogeneity of relative factor supplies. The framework is used to examine recent U.S. wage structure changes. The importance of between versus within industry demand shifts and the roles of variation in the rate of growth of relative skill supplies, skill-biased technological changes, and globalization factors in changes in wage differentials by education are assessed.

5.1 A Simple Supply and Demand Framework

We begin by examining between-group relative wage changes using a simple supply and demand framework from Katz and Murphy (1992) in which different demographic groups (identified by sex, education, and age/experience) are treated as distinct labor inputs. The relative wages of demographic groups can be thought of as being generated by the interaction of the relative supplies of the groups and an aggregate production with its associated factor demand schedules. The determinants of relative factor supplies are not specified in the initial framework. The key requirement for this approach to be plausible is that observed factor prices and quantities must be "on the demand curve."

The basic framework posits an aggregate production function consisting of K types of labor inputs. We assume the associated factor demands can be written as

(14) $N_t = D(W_t, Z_t)$

where

N_t = Kx1 vector of labor inputs employed in the market in year t

W_t = Kx1 vector of market wages for these inputs in year t

Z_t = mx1 vector of demand shift variables in year t.

The demand shifters, Z_t, capture the effects of technology, product demand shifts, and other non-labor inputs on demands for labor inputs. Since we are concerned with explaining *relative* wage changes as a function of *relative* supply and *relative* demand shifts, we abstract from changes in absolute wages arising from factor-neutral technological change and from neutral demand shifts associated with changes in the scale of the economy. In practice W_t is a vector of relative wages where actual wages have been deflated by a fixed-weighted wage index capturing aggregate wage changes, and N_t is a vector of relative supplies measured as a share of total labor input in the economy in each year measured in *efficiency units*. Actual hours worked for each group are translated into efficiency units by multiplying by the average relative wage for group in some base period.[33]

Under the assumption that the aggregate production function is concave, the (KxK) matrix of cross-price effects on factor demands, D_w, is negative semidefinite. Equation (14) can be written in terms of differentials as

[33]Katz and Murphy (1992) and Murphy and Welch (1992) provide more detailed discussions of alternative approaches to measuring relative wages, relative factor supplies, and defining efficiency units.

(15) $dN_t = D_w dW_t + D_z dZ_t$.

Thus relative wage changes depend on changes in net relative supplies (relative supplies net of relative demand shifts)

(16) $dW_t = [D_w]^{-1}(dN_t - D_z dZ_t)$.

The impact of changes in net relative supplies on relative wages depend on the degree of substitutability and complementarity among different labor inputs in the aggregate production function.

The negative semidefiniteness of D_w implies from equation (15) that

(17) $dW_t'(dZ_t - D_z dZ_t) = dW_t' D_w dW_t \leq 0$.

Changes in factor quantities (net of demand shifts) and changes in wages must negatively covary if observed wages and quantities lie on the factor demand curves. If factor demand is stable (Z_t fixed), equation (17) implies $dW_t' dN_t \leq 0$. Actual changes in relative wages and relative quantities must negatively when factor demands are unchanging. In the case of two inputs, the intuitive basic implication of stable relative factor demand is that an increase in the relative supply of a group must lead to a reduction in the relative wage of that group. Furthermore data on relative factor quantities and wages alone can be used to assess whether observed wage structure changes over any period are consistent with a stable factor demand structure.

This approach can be illustrated using data on recent U.S. relative wage and supply changes. Much early work examining U.S. wage structure changes in the 1970s emphasized the role of "exogenous" relative supply shifts from changing demographics and school completion rates as the driving force behind relative wage changes [e.g. Freeman (1979), Welch (1979)]. This might appear to be a reasonable first approach for this period of the labor market entry of the U.S. baby boom cohorts in which rapid expansions of the relative supply of more-educated and younger workers coincided with declining narrowing educational wage differentials and expanding experience differentials. But an examination of data since the late 1970s or over longer time periods clearly rejects the assumption of stable factor demands and important role of demand shifts especially secularly rising relative demand for more-educated workers [e.g., Autor, Katz, and Krueger (1998), Bound and Johnson (1992), Johnson (1997), Katz and Murphy (1992), and Murphy and Welch (1992)].

Data on relative supply changes for the United States by sex, education, and experience groups for 1963 to 1987 and several sub-periods from the March CPS are illustrated in Table 11. These relative supply changes can be compared to the relative wage changes for the same time periods shown in Table 2. Since the relative supplies and wages of more educated workers and females increased over this 25 year period, it is clear that relative demand shifts are necessary to explain the observed data. Katz and Murphy (1992) divide the labor force into 64 groups (defined by sex, education, and experience) and use estimates of the time series (N_t, W_t) covering the 1963 to 1987 period to assess the stable factor demand hypothesis between any given years t and year τ by evaluating whether

(18) $(W_t - W_\tau)'(N_t - N_\tau) \leq 0.$

Time periods for which the inequality in (18) is satisfied (i.e., the inner product of changes in wages and changes in factor supplies is nonpositive) have the potential to be explained solely by supply shifts. When this inequality is not satisfied, no story relying entirely on supply shifts is consistent with the data.[34] This inequality clearly fails for the entire 1963 to 1987 period as illustrated by the plot in Figure 7.[35] Demand shifts favoring more-educated workers and women are necessary within this framework to explain the pattern of relative wage and quantity changes from 1963 to 1987. Expanding relative wages of more-skilled workers in the face of increased relative supplies of more-educated workers are also apparent in many other OECD nations in the 1980s and 1990s [Gottschalk and Smeeding (1997), OECD(1993, 1996)].

Relative demand shifts favoring more-skilled workers are also essential to understanding longer-run changes in the U.S. wage structure. Table 12 displays the evolution of the educational composition of aggregate U.S. labor input (for those aged 18 to 65 years) measured in full-time equivalents (total hours worked) and of the log college/high school wage differential from 1940 to 1996.[36] The educational attainment of the work force increased rapidly over this fifty-six year period with a more than four-fold increase in the share of hours worked by those with at least some

[34]Murphy and Welch (1992) present a formal statistical framework for testing the stable factor demand hypothesis embodied in equation (18) and implement this framework on U.S. data for men for 1963 to 1989.

[35]But Katz and Murphy (1992) and Murphy and Welch (1992) find that inequality (18) is satisfied for the 1970s.

[36]The large increases in the educational attainment of the U.S. work-force since 1940 may overstate increases in the relative supply of "more-skilled" workers to the extent that the "unobserved" quality of more-educated workers declines with some "re-labeling" of "lower productivity" workers into higher education categories. Juhn, Kim, and Vella [1996] examine this issue using Census PUMS data from 1940 to 1990 and find that conclusions concerning changes in relative supply and implied relative demand shifts are not much affected by adjustments for such re-labeling through controls for cohort-specific college share or mean years of education.

college. Despite the large increase in the relative supply of the more educated, the college/high school wage differential has grown substantially since 1950 suggesting sharp secular growth in the relative demand for the more educated that started well before the rise in wage inequality of the 1980s.[37] But fluctuations in the rate of growth of the relative supply of more-educated workers also appear to have played an important role in the time pattern of changes in educational wage differentials. Tables 11 and 12 illustrate that an increase in the rate of growth in the supply of college workers in the 1970s was associated with a decline in the college wage premium and a decrease in the rate of growth of the supply of college workers in the 1980s was associated with a sharp rise in the college wage premium. A rather smooth trend increase in the relative demand for more-educated workers combined with observed fluctuations in the rate of growth of the relative supply has the potential to explain much of the evolution of U.S. educational wage differentials at least over the past few decades.

The consistency of alternative hypotheses (alternative choices of demand shifters Z_t) concerning the evolution of relative demand with the observed pattern of changes in relative wages and supplies from τ to t can be assessed using a discrete version of equation (17)

$$(19) \qquad (W_t - W_\tau)'[(N_t - N_\tau) - (D(W_\tau,Z_t) - D(W_\tau,Z_\tau))] \leq 0,$$

which involves evaluating the value of the inner product of the change in wages from year τ to year t with the changes in net supplies (equal to the actual change in relative factor supplies less the

[37]Early papers by Griliches (1970) and Welch (1970) inferred substantial relative demand shifts for the more-educated in the 1950s and 1960s to explain the failure of the college wage premium to decline in the face of the rising relative supply of college workers.

change in relative demands that would have happened at fixed factor prices). A particular hypothesis of interest is whether that data are consistent with a stable trend rate of demand change for each labor force group with fluctuations in relative wages about trend driven by detrended relative supply changes. Such trend demand shifts might reflect a rather steady pace of non-neutral technological change or steady shifts in the industrial composition of employment. Katz and Murphy (1992) and Murphy and Welch (1992) find for U.S. data that allowing for trend demand shifts virtually eliminates inconsistencies with otherwise stable demand for the overall period from the early 1960s to the late 1980s, but Katz and Murphy conclude that some acceleration of demand shifts favoring the more-educated and women in the 1980s is required to explain difference among sub-periods in the pattern of relative wage and employment changes.

Analyses of U.S. changes in relative wages and factor supplies over recent decades using a simple supply and demand framework indicate a key role for strong secular shifts in the relative demand favoring the more skilled and decade-to-decade fluctuations in the pace of relative supply changes. An assessment of the quantitative importance for explaining relative wage movements of relative supply and demand shifts and of the underlying sources of the demand shifts requires adding more structure to the framework.

5.2 Some Issues in Supply and Demand Analysis

The assessment of whether economy-wide changes in relative wages and quantities employed are consistent with stable factor demand requires that aggregate factor demand equations (as in equation (14)) satisfy the usual properties of factor demands and that actual wages and employment levels lie on these factor demand equations.[38] No assumptions about the determinants of relative factor supplies are necessary.

Further progress on the contribution of different supply and demand factors to wage structure changes requires additional assumptions about the determinants of factor supplies and the functional form of the factor demand equations. Two key assumptions typically made are that of full-employment (relative wages adjust so that relative supplies equal relative demands) and exogenous (or at least pre-determined) relative supplies. Relative supplies are treated as pre-determined by past educational investment decisions and demographic changes arising from earlier fertility and immigration decisions. Current labor force participation decisions are assumed to be unaffected by current market conditions. Thus the basic model is one of a vertical (inelastic) short-run relative labor supply curve as in Figure 6. Relative quantities employed are determined by pre-determined relative supplies, while both relative demand and supply factor affect relative wages.

The full employment/market clearing assumption may be reasonable for the United States, but it is clearly is problematic for examining European economies over the past two decades. Jackman, Layard, Manacorda, and Petrongolo (1997) have extended the basic model to allow for bargaining factors unemployment under the assumption that relative supply shifts can be measured by exogenous changes in relative labor force sizes by skill group. The well-documented decline in the relative employment/population ratios (through both rising relative unemployment rates and declining relative labor force participation rates) of groups with declining wages in the United States since the 1970s [e.g., Murphy and Topel (1997), Murphy and Welch (1997)] further suggests the assumption of exogenous inelastic relative labor supply curves may also be problematic the United

[38]Thus such assessments may be inaccurate if relative wage changes are driven by institutional factors that force firms off their labor demand curves.

States. Relative population shares of different groups can potentially be used to instrument for relative employment shares to allow for an elastic short run supply curves if relative population shares by sex-education-age groups can plausibly be viewed as pre-determined.

Two other key decisions required to implement a supply and demand analysis are an assumed functional form of the factor demand schedules and a choice concerning how to disaggregate labor input into different skill groups. These decisions involve (explicit or implicit) assumptions about the nature of the aggregate production function.

Many alternative approaches to the aggregation of heterogeneous labor force groups into "appropriate" skill groups have been used in recent research on wage structure changes.[39] One would like to aggregate workers into groups such that workers are much closer substitutes in production within the groups than between the groups. The implicit assumption is that hours of work by different workers are perfect substitutes within a skill group. But the hours of different workers can easily be given different weights in adding up the total supply within a group such as through the approach of measuring labor supplies in efficiency units with each worker's hours weighted by the average wage in a base period of that worker's more detailed sub-group.

A fruitful first- cut approach that is easy to implement is to break up the work force into two groups along the wage structure dimension of particular interest: high-education and low-education to examine educational wage differentials, "young" and "old" to study experience differentials, and men and women to examine gender differentials. The groups can typically be chosen so that the assumption of much greater substitutability within than between groups is plausible and estimates using such an approach are easy to interpret. The disadvantage is one loses much information about

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[39]Hamermesh (1993) provides a detailed and thoughtful discussion of the issues arising in the choice of an aggregation scheme in empirical work on labor demand.

the subtleties of wage structure changes from this extreme approach to aggregation. Examples of this approach include the analyses of relative wage changes for two education groups, skilled (college or more) and unskilled (less than college) by Autor, Katz, and Krueger (1998), Baldwin and Cain (1997) and Krussell et al. (1997). Much research has also analyzed wage structure and relative demand changes for two broad occupation groups such as production and nonproduction workers [e.g., Berman, Bound, and Griliches (1994); Berman, Bound, and Machin (1998)]. Such a broad occupational breakdown is often all that is available for many data sets derived from establishment-based surveys such as the U.S. Annual Survey of Manufactures or cross-country data for manufacturing industries from the U.N. General Industrial Statistics Database. The assumption of pre-determined relative supplies is clearly much less plausible for an occupational grouping than for education or age groupings. But Berman, Bound and Griliches (1994) and Machin and Van Reenan (1997) find that a nonproduction/production worker approach does a reasonable job of matching a high/low education group breakdown in manufacturing for most advanced industrial nations.

A hybrid of the two-group approach is to examine the relative wage of two “pure” skill classes (college graduates and high school graduates) and to relate this relative wage to changes in the relative supply and demands for “equivalents” of these pure skill classes (college and high school equivalents). The aggregation of multiple skill groups into two pure skill classes follows the “linear synthesis” approach developed by Welch (1969) by assuming each skill group is a linear combination of the two pure skill classes with the weights usually based on the extent to which wages of each group tracks those of the pure skill groups [e.g., Katz and Murphy (1992)].

The alternative approach is to specify labor input as consisting of a large number of possible inputs typically defined by sex, education, age/experience groups or with even further differentiation by race and foreign born status. The advantage of this approach is the ability to gain much more information about the nature of wage structure changes (e.g., differences in changes in educational wage differentials for older and younger workers, etc.). But strong assumptions about functional forms and substitution possibilities between groups must be imposed to make this approach feasible. Restrictions on substitution possibilities reduce the number of parameters to be estimated in the factor demand system to a practical number. A breakdown of the work force into K groups implies the matrix of cross-price elasticities among the groups (D_w in equation (15)) as well as the related substitution matrix ($[D_w]^{-1}$) both contain KxK elements implying an enormous number of separate parameters for large K even after imposing symmetry if one does not make further restrictions. The estimation of this many separate parameters for large K is unlikely to be feasible and will more than exhaust the available degrees of freedom when the number of groups is large relative to the time periods or the cross-section units (different regions) being used as the source of identifying variation. For example, Bound and Johnson (1992) examine 32 demographic groups using data from 3 years and Murphy and Welch (1992) examine 188 groups over 27 years.

The first method to addressing this problem is to assume a particular functional form for the production function to limit the number of substitution parameters. Bound and Johnson (1991, 1992) assume a constant elasticity of substitution (CES) production function with each of 32 demographic groups as the inputs and thereby estimate a single intrafactor substitution parameter.[40] The key assumption underlying this approach is that the degree of substitutability in production of between any pair of groups is the same. Thus the degree of substitutability between young male high school graduates and high school dropouts is assumed to be equivalent to the degree of

[40]Card (1997) similarly uses a CES production function with ten skill deciles as the distinct inputs.

substitutability between young male high school dropout and experienced female college graduates. This assumption seems implausible given the similar occupational and industrial distributions of young male high school graduates and dropouts and the quite dissimilar occupational and industrial distributions of young male dropouts and experienced female college graduates (Murphy and Welch (1997)). But Bound and Johnson (1992) show a major advantage of the CES approach is that it can be applied at the sectoral level and provides an interpretable structural framework to analyze between- and within-industry demand shifts for multiple skill groups.

A second method is to aggregate the number of groups to a smaller feasible number to allow more general patterns of substitution among the groups (such as the three group approach of Jaeger (1995)). The third method is to assume that wages for individual workers depend on their quantities of a smaller number, $k<K$, of (latent) basic skills. The endowments of each of the k underlying skills for K groups vary at a point of time but are assumed to be stable over time. Murphy and Welch (1992) show how this approach greatly reduces the number of parameters to be estimated in the factor demand structure for small k and still allows a rich pattern of substitution possibilities among the K groups.[41]

5.3 Supply and Demand Analysis of Changes in Educational Wage Differentials

Many studies (at least since Freeman (1975)) have used simple supply and demand frameworks to analyze changes in educational wage differentials in the United States and other

[41]Teulings (1997) develops an alternative approach to aggregation allowing for an infinite number of skill classes but adding structure based on an assumption of the comparative advantage of more skilled workers in more complex jobs.

countries. A common approach is to break the work force into two broad educational groups.[42] We illustrate this approach by considering a CES production function for aggregate output Q with two factors, college equivalents (c) and high school equivalents (h):

$$(20) \quad Q_t = [\alpha_t(a_t N_{ct})^\rho + (1-\alpha_t)(b_t N_{ht})^\rho]^{1/\rho}$$

where N_{ct} and N_{ht} are the quantities employed of college equivalents (skilled labor) and high-school equivalents (unskilled labor) in period t, a_t and b_t represent skilled and unskilled labor augmenting technological change, α_t is a time-varying technology parameter that can be interpreted as indexing the share of work activities allocated to skilled labor, and ρ is a time invariant production parameter.

Skill-neutral technological improvements raise a_t and b_t by the same proportion. Skill-biased technological changes involve increases in a_t/b_t or α_t. Following Johnson and Stafford (1998a), one can interpret increases in a_t/b_t as *intensive* skill-biased technological change in which skilled workers get relatively better at their existing jobs more rapidly than do unskilled workers. Increases in α_t can be viewed as *extensive* skill biased technological change or "upskilling" that shifts work tasks from unskilled to skilled workers.[43] The aggregate elasticity of substitution between college and high-school equivalents is given by $\sigma = 1/(1-\rho)$.

Although the single-sector, aggregate production function directly including only labor

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[42]Empirical analyses of more general supply-and-demand frameworks to assess a range of wage structure changes (e.g., education, experience, and gender differentials) include Katz and Murphy (1992) and Murphy and Welch (1992).

[43]Goldin and Katz (1998) model and document this process of upskilling from less-skilled to more-skilled production workers and from production to non-production workers in the U.S. manufacturing sector with the spread of electricity and adoption of continuous process and batch production methods from 1890 to 1929.

inputs given in equation (20) is a well-defined analytical construct, one must be clear about what it means. Such an aggregate production function does not necessarily have any simple interpretation in terms of the production functions of individual firms or even industry-level production functions. The aggregate elasticity of substitution σ reflects not only technical substitution possibilities in firm-level production functions but also outsourcing possibilities and substitution possibilities across goods and services in consumption. Changes in the "technology" indicators a_t/b_t and α_t represent not only true technological changes at the firm level but also the non-neutral effects on skill groups of changes the relative prices or quantities of non-labor inputs (capital, energy) and shifts in product demand among industries with different skill intensities.

Under the assumption that college and high-school equivalents are paid their marginal products, we can use equation (20) to solve for the ratio of marginal products of the two labor types yielding a relationship between relative wages in year t, w_{ct}/w_{ht}, and relative supplies in year t, N_{ct}/N_{ht} given by

(21) $$\log(w_{ct}/w_{ht}) = \log(\alpha_t/[1-\alpha_t]) + \rho\log(a_t/b_t) - (1/\sigma)\log(N_{ct}/N_{ht}),$$

which can be rewritten as

(22) $$\log(w_{ct}/w_{ht}) =(1/\sigma)[D_t - \log(N_{ct}/N_{ht})],$$

where D_t indexes relative demand shifts favoring college equivalents and is measured in log quantity units. The impact of changes in relative skill supplies on relative wages depends inversely on the magnitude of aggregate elasticity of substitution between the two skill groups. The greater is σ, the smaller the impact of shifts in relative supplies on relative wages and the greater must be fluctuations in demand shifts (D_t) to explain any given time series of relative wages for a given time series of relative quantities. Changes in D_t can arise from (disembodied) skill-biased technological change, non-neutral changes in the relative prices or quantities of nonlabor inputs such as computer services, increased outsourcing possibilities that disproportionately affect the two skill groups, and shifts in product demand either from domestic or international sources.[44]

Two approaches can be taken using this framework to assess alternative stories for relative wage changes by skill group consistent with the observed pattern of changes in relative wages and quantities employed. The first is to directly estimate equation (22) after substituting for the unobserved time series D_t with functions of time (e.g., a linear time trend) and/or observable proxies for relative skill demand shifts (such as an index of between-industry demand shifts, cyclical indicators, or measures of international trade). This procedure typically involves OLS estimation of equation (22) using national time series data under the assumption that relative skill quantities employed are pre-determined and yields direct estimates of σ and of the impact of observable demand shifters [e.g., Freeman (1975, 1978), Katz and Revenga (1989)]. The same basic approach can be implemented on panel data on wage structure changes by regions [Juhn (1994), Topel (1993)] or countries. The strong assumption of exogenous relative supply shifts and standard problems of estimation from time series samples with nonindependent observations should introduce a note of caution in interpreting such estimates.

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[44]Thus this simple framework is potentially consistent with capital-skill complementarity. In this case, changes in the relative price (or supply of capital) imply shifts in D_t. For example, the nested CES aggregate production function explicitly allowing for capital-skill complementarity of Krusell et al. (1997) yields a relative wage determination equation that can be written in the same basic form as equation (22).

Katz and Murphy (1992) implement this approach to explain changes in the U.S. college/high school wage differential from 1963 to 1987. The precise relative wage measure used is the ratio of (fixed-weighted) average wages of those with at least a college degree (16 or more years of schooling) relative to those with exactly a high school degrees (12 years of schooling). Katz and Murphy begin with 320 skill groups (defined by sex, education, and experience) and amalgamate them into two labor aggregates: college and high-school equivalents. The basic movements of these relative wage and quantity measures are summarized in Table 13 and the basic pattern of a moderate increase in the college wage premium in the 1960s, a decline in the 1970s, and a sharp increase in the 1980s is apparent in this data. Katz and Murphy assume D_t can be approximated by a simple linear time trend and estimate equation (22) over the 1963-87 period by OLS yielding

$$\text{(23)} \quad \log(w_{ct}/w_{ht}) = \underset{(0.150)}{-0.709} \log(N_{ct}/N_{ht}) + \underset{(0.007)}{0.033} \text{ time} + \text{constant}, \ R^2=0.52,$$

where the numbers in parentheses are standard errors.

The actual time series of college returns and fitted values from the regression are displayed in Figure 8. The model does a reasonable job of explaining movements in the college wage premium over this period but misses the depth of the decline from the mid to late 1970s. The implied estimate of σ, the elasticity of substitution between college and high school labor, from equation (23) is 1.41. The time trend coefficient multiplied by the implied estimate of σ indicates a secular shift in relative demand favoring college workers of approximately 4.6 log points a year over this period in comparison to relative supply growth of 3.9 log points year. The model implies that strong secular relative demand growth for college graduates is necessary to explain the overall rise in the college wage premium in the face of rapid relative supply growth from 1963 to 1987. But fluctuations in the rate of growth of the relative supply of college equivalents helps explain large differences across decades in the behavior of the college wage premium. The log college wage premium decreased by 1.3 log points annually from 1971 to 1979 and then increased by 1.6 log points annually from 1979 to 1987. The estimated model implies that almost half (1.36 log points per year) of the 2.9 log points per year difference in the increase in the log college wage premium in the 1980s from the 1970s is explained by a slowdown in relative supply growth with remaining 1.54 log points being accounted for by unmeasured (residual) increases in relative demand growth.

The limited time series evidence of estimates of equations of the form of equation (22) indicates negative effects of increases in the national relative supply of the more educated on educational wage differentials in other countries including Canada [Freeman and Needels (1993), Murphy, Riddell, and Romer (1998)], Britain [Schmitt, 1995], Sweden [Edin and Holmlund (1995)], the Netherlands [Teulings (1992)], and South Korea [Kim and Topel (1995)]. The estimates suggest (conditional on proxies for demand shifts) that a 10 percent increase in the relative supply of more-educated workers lowers their relative pay 3 to 7 percent in various countries implying aggregate elasticities of substitution in the 1 to 3 range. These findings are consistent with declining educational wage differentials throughout the OECD in the 1970s in the face of rapid supply growth of college graduates.[45] Countries that experienced at least modest increases in educational wage differentials in the 1980s — especially the United States and United Kingdom — tended to

[45]Historical evidence is also consistent with substantial effects of changes in relative skill supplies on relative wages. For example, Goldin and Katz (1995) find that the rapid expansion in secondary schooling during the "high school movement" in the United States from 1910 to 1940 was associated with a substantial narrowing of the relative earnings of white collar workers.

experience a decline in the rate of growth of the supply of college workers in the 1980s. Countries whose educational differentials did not expand in the 1980s — France, Germany, and the Netherlands — essentially maintained their 1970s rate of growth of supply of more-educated workers into the 1980s [Freeman and Katz (1994), OECD (1993)]. Freeman and Needles (1993) and Murphy, Riddell, and Romer (1998) also find that the continued rapid expansion of the relative supply of college equivalents in Canada helps explain the much more modest increase in skill differentials in Canada than in the United States during the 1980s.

A controversial issue concerns the relevant relative supply measure when applying the supply and demand framework embodied in equation (22) in an open economy setting. The integrated equilibrium with incomplete specialization of a standard Hecksher-Olin trade model implies that national relative factor supplies only impact relative wage by changing world relative supplies [e.g., Leamer (1996), Johnson and Stafford (1998b)]. This essentially implies a horizontal relative demand curve at the national level. Single country time-series negative relationships between (detrended) national relative skill supply increases seem inconsistent with this prediction. This could arise if national relative supply changes are highly correlated among internationally integrated advanced economies [Berman, Bound, and Machin (1998)]. But differences across countries in (detrended) relative supply growth also appear to be associated with differences in relative wage behavior even in such tightly linked economies as Canada and the United States. These findings suggests a focus on shifts in relative skill supplies and demand at national level may not be inappropriate. Changes in relative skill supplies in other countries may affect the price of traded goods and show up as a shift in D_t in equation (22). Johnson and Stafford (1998b) provide a comprehensive discussion of deviations from the standard Hecksher-Olin model (such as differentiated products with some home bias in consumption demand and imperfect domestic factor mobility) which lead to a national relative wage determination equation consistent with this (implicitly) closed economy framework.

The second approach to assessing supply and demand stories for changes in the college wage premium is to use outside information to choose a value of σ and then use equation (22) and data on the time series of relative wages and quantities to impute the time series of D_t conditional on the assumed value of σ [Autor, Katz, and Krueger (1998), Johnson (1997), Katz and Murphy (1992), Murphy, Riddell, and Romer (1998)]. An advantage of this approach (conditional on knowledge of reasonable values for σ) is that one can draw inferences about the path of D_t without assuming full employment or the exogeneity of relative supply changes. One can also examine the sensitivity of different stories to "reasonable" choices for σ and determine whether the implied time series for D_t matches well with possible observable measures of demand shifts. Solving equation (22) for D_t and rearranging terms yields

$$(24) \qquad D_t = \log(w_{ct}N_{ct}/w_{ht}N_{ht}) + (\sigma-1)\log(w_{ct}/w_{ht}).$$

Changes in the log relative demand for college equivalents equals the sum of the change in the log relative wage bill and a term that depends positively (negatively) on the change in the log college wage premium when $\sigma>1$ ($\sigma<1$). If $\sigma=1$ (the Cobb-Douglas case), then changes in the relative demand for college equivalents are directly given by changes in the relative wage bill.

This approach requires some knowledge of a plausible range for the elasticity of substitution between high- and low-education workers. The estimate of $\sigma=1.41$ from (23) is in the middle of the range of 0.5 to 2.5 in earlier studies using cross-sectional approaches reviewed by Freeman (1986). Time series studies for different countries suggest a similar range. In an important early study, Johnson (1970) uses cross-state data for 1960 yielding estimates of the elasticity of substitution of college and high school labor of close to 1.5. Krusell et al. (1997) have extended the Katz-Murphy model of equation (23) through 1991 (using a slightly different aggregation scheme into college and high school workers) and find a similar implied estimate of σ of approximately 1.3. Krusell et al. generate a modestly higher estimate of σ=1.67 from a more structural model directly allowing for capital-skill complementarity and replacing the linear time trend proxy for D_t with a measure of the relative supply of capital equipment. Heckman, Lochner, and Taber (1998) develop a distinctive approach to measuring relative skill prices and quantities for two skill groups that allows for movements in wages to deviate from movements in skill prices because of changes in amount of earnings potential devoted to on-the-job training. Heckman, Lochner, and Taber estimate the elasticity of substitution between high and low skill labor to be 1.44 applying OLS to (22) for March CPS data from 1965 to 1990 and find quite similar estimates of σ when instrumenting for relative employment shares with cohort size. In summary much recent evidence suggests the elasticity of substitution between college and non-college workers in the United States is close to 1.4, but a substantial range of uncertainty remains.[46]

Autor, Katz, and Krueger (1998) assess alternative explanations for changes in the U.S. college wage premium from 1940 to 1996 under different assumptions about σ. Autor, Katz and Krueger divide the work force into two groups: college equivalents (college graduates plus half of

[46]Furthermore there is little reason to expect technological changes to leave σ relatively constant and increased openness is likely to imply greater substitutability of domestic and foreign labor and an implied increase in σ. But little direct evidence is available on changes in the aggregate elasticity of substitution.

those with some college) and high school equivalents (half of those with some college plus workers with 12 or fewer years of schooling).[47] Panel A of Table 14 shows decadal changes in the log college/high wage differential and the log relative wage bill and supply of college equivalents. The total wage bills for college equivalents and high school equivalents can be directly calculated from household data on employment and earnings and the college/high school wage premium is estimated in each year from a standard human capital log earnings equation with individual year of schooling dummies. The (composition-adjusted) log relative supply change is calculated simply as the change in log relative wage bill minus the change in the (regression-adjusted) log relative wage: $\log(N_{ct}/N_{ht}) = \log([w_{ct}N_{ct}/w_{ht}N_{ht}]) - \log(w_{ct}/w_{ht})$. The 1970s is clearly the outlier decade in terms of the rapid relative supply growth of college graduates associated with the labor market entry of the baby boom cohorts and possible effects of incentives for college enrollment from the Vietnam War.

The sensitivity of conclusions concerning the implied time path of the growth of relative demand for college workers from (24) under different assumptions about the magnitude of σ is illustrated in panel B of Table 14. The base case assumption of σ=1.4 implies the sharp difference in the behavior of the college wage in the 1970s and the 1980s can be attributed both to slower relative supply growth and faster relative demand growth. An acceleration in relative demand growth is necessary to explain the sharp rise in the college wage premium in the 1980s for estimates of σ in the range of most recent estimates from 1 to 2. A marked decrease in the rate of growth of relative demand is apparent in the 1990s. The compression of educational wage differentials in the 1940s is attributed to slow (and possibly negative) relative demand growth for college workers.

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[47]Johnson (1997) defines college equivalents in the same manner. The findings are quite similar when the more formal approach of Katz and Murphy (1992) is used to allocate different education groups to college and high school equivalents, or when a classification of workers into college graduates and those without college degrees (less than 16 years of completed schooling) is used.

Goldin and Margo (1992) find particularly strong demand growth for unskilled labor during the 1940s, but they also conclude that wage compression in the 1940s was at least partially driven by institutional factors including direct government intervention in wage setting during World War II, the rapid expansion of unions, and possible changes in previous customary wage setting norms.

Overall Table 14 indicates rapid growth in the relative demand for college graduates since 1950 is necessary to reconcile the large increase in the U.S. college wage premium in the face of continuing relative supply increases. Relative supply and demand fluctuations appear to play roles in decadal variations in the change in the college wage premium. The hypothesis of an acceleration in relative demand growth in the 1980s possibly from the computer revolution or globalization factors is supported assuming σ is in the range of recent estimates of 1.3 to 1.7. But the slowdown in demand growth in the 1990s is surprising from this perspective given the continuing spread of computers and more rapid growth of U.S. trade with less-developed countries in the first half of the 1990s than in the 1980s [Borjas, Freeman, and Katz (1997)]. Splitting the full time period roughly in half into the 1940-70 and 1970-96 sub-periods, there is a faster rate in the rate of relative demand growth the second half of the sample suggestive of hypotheses of an increased rate of skill-biased technological change starting in the 1970s [Greenwood and Yorukoglu (1997)]. But evidence of a discrete trend break in the 1970s is not very strong.

These findings indicate the importance of assessing potential sources of trend growth in favor of more-educated workers (such as skill-biased technological changes, capital-skill complementarity, and steady increases in globalization) as well as sources of variation in the rate of demand shifts across periods and the sources of variation in the rate of supply growth (e.g., cohort size, access to higher education, immigration).

5.4 Between- and Within-Industry Shifts in Relative Demand

From the late 1970s to the mid-1990s groups of workers (defined by education and other measures of skill and by sex) with rising relative wages have also tended to have rising relative supplies in most advanced nations [Berman, Bound, and Machin (1998); Katz, Loveman and Blanchflower (1995)]. This pattern is suggestive of pronounced demand shifts favoring the more educated over the less educated and women over men. Substantial shifts in relative demand favoring more-educated workers appear necessary to explain wage structure changes in the United States and other OECD nations both over recent decades and probably over the past century [e.g., Gottschalk and Smeeding (1997); Tinbergen (1974, 1975)].

Changes in product demand ("deindustrialization"), globalization factors, and skill-biased technological change have attracted much attention as possible sources for shifts in relative labor demand. A common approach is to conceptualize relative demand shifts as coming from two types of changes: those that occur within industries (i.e., shifts that change the relative factor intensities within industries at fixed relative wages) and those that occur between industries (i.e., shifts that change the allocation of total labor between industries at fixed relative wages). Sources of within-industry shifts include pure skill-biased technological change, changes in the relative prices (or supplies) of non-labor inputs (e.g., computer services or new capital equipment), and changes in outsourcing activity. Between-industry shifts in relative labor demand may be generated by sectoral differences in productivity growth and by shifts in product demand across industries arising either from domestic sources or from shifts in net international trade which change the domestic share of output in an industry at fixed wages.

This conceptualization has led to the use of decompositions of aggregate changes in the utilization of more-skilled labor into between-industry and within-industry components as a guide to the importance of product demand shifts as opposed to skill-biased technological change (or outsourcing) as sources of relative demand changes [e.g., Autor, Katz, and Krueger (1998), Berman, Bound, and Griliches (1994), Murphy and Welch (1993b)]. Even the most detailed industry classifications available in the standard household and establishment surveys used in such analysis represent aggregate of multiple product markets. Thus, in practice, measured within-industry shifts in labor demand may contain the effects of product demand shifts within the available industry categories. This concern has motivated the use of establishment-level data to decompose changes in the overall employment share (or labor cost share) of more-skilled labor into between- and within-establishment components [e.g., Bernard and Jensen (1997); Dunne, Haltwanger, and Troske (1996)]. Of course, product demand shifts could potentially lead to shifts in product mix, changes in production technology, and changes in the organization of work and relative skill demands at the establishment level. Such decompositions alone clearly can't separate out the exogenous forces driving changes in skill utilization at the plant level. These analyses should be supplemented with case studies and with attempts to examine the correlates of differences across industries and plants of the rate of skill upgrading.

The effect of between-sector shifts in labor demand on the relative demand for different demographic (or skill) groups depends on group differences in industrial employment distributions. Shifts in employment demand between industries with have a larger effect on the relative demands for different labor inputs the greater are the differences in factor ratios (skill intensities) across industries. There exist substantial differences across industries in all advanced nations in employment distributions of different education groups and of men versus women. Changes in the industrial distribution of employment (measured in efficiency units) and variation in the utilization of highly educated (college) labor across broad U.S. industries from 1968 to 1988 are illustrated in Table 15, which uses the college-equivalents aggregation approach of Murphy and Welch (1993b).

The table illustrates large shifts in the industrial employment distribution from 1968 to 1988 out of manufacturing sectors (especially low-skill and medium-skill manufacturing) and into professional services and finance, trade, and education and welfare services. Longer-term shifts in the industrial distribution of employment from 1940 to 1990 also show large shifts towards the more highly-educated sectors [e.g., Juhn (1994)]. Industrial employment shifts since 1960 have favored industries that more intensively utilize college graduates relative to less-educated workers and women relative to men. The industries most intensive in less educated males have seen the largest decline. These patterns are reinforced when one considers occupational shifts as well industrial shifts [Katz and Murphy (1992); Murphy and Welch (1993a)].

If within-industry relative factor demand is stable so that changes in the wage structure are entirely explained by between-industry shifts in labor demand and relative supply changes, then the shares of industrial employment of groups whose relative wages have increased should tend to fall inside every industry. Thus the hypothesis of stable within-industry demand implies that the share of college equivalents should have declined in all U.S. industries over the past few decades. In fact, Table 15 illustrates strong within-sector upgrading occurred from 1968 to 1988 with the share of college equivalents increasing in every broad industry. Similar patterns of substantial skill upgrading are observed in the examination of changes in labor utilization within more disaggregate industries [Berman, Bound, and Griliches (1994), Autor, Katz, and Krueger (1998)] and at the establishment level [Bernard and Jensen (1997); Doms, Dunne, and Troske (1997); Dunne, Haltiwanger, and Troske (1996)].[48] This finding indicates that within-industry demand shifts favoring these groups must have occurred. On the other hand, the finding does not rule out the possibility that the between-industry shifts have also played a significant role in relative wage changes. But Murphy and Welch (1993) and Autor, Katz, and Krueger (1998) find that the vast majority of the increased utilization (measured by employment or labor cost) of college graduates in recent decades can be accounted for by within-industry changes. And Dunne, Haltiwanger, and Troske (1996) find with plant-level data for manufacturing that aggregate changes in skilled labor employment and labor cost share are dominated by within-plant changes.

How does one quantitatively assess the contributions of different sources of relative labor demand shifts? This is a difficult issue often requiring strong assumptions about sectoral production functions and the consumer preferences [Bound and Johnson (1992)]. One widely used measure of the effect of between-sector demand shifts on relative labor demands is the fixed-coefficient input requirements index introduced by Freeman (1975). This index measures the percentage change in the demand for a demographic group as the weighted average of percentage employment growth by industry where the weights are the industrial employment distribution for the demographic group in a base period. This proxy for the percentage change in demand for demographic group k can be written as

$$(25) \qquad \Delta DEM_k = \Sigma_j \lambda_{jk}(\Delta E_j/E_j)$$

[48]Berman, Bound and Machin (1998) document a similar pattern of within-industry skill upgrading (shifts to nonproduction workers) in the manufacturing sectors of all advanced countries in the 1970s and 1980s even during period of sharply rising relative wages for more-skilled workers.

where j indexes industry, E_j is total employment in industry j, $\lambda_{jk} = E_{jk}/(\Sigma_j E_{jk})$ in a base year, and E_{jk} is the employment of group k in industry j. Katz and Murphy (1992) provide a formal justification for ΔDEM_k as a between-industry demand shift index when employment is measured in efficiency units (value-weighted labor inputs), when industry technologies are held fixed except for factor-neutral technological change, and when relative wages are unchanging. Since changes in relative wages can directly affect the distribution of industrial outputs (and employments), ΔDEM_k will not measure the effects on relative labor demand of changes in the allocation of employment across sectors at fixed wages when relative wages are changing. These demand shifts indices will tend to understate the "true" between-industry demand shift favoring groups with rising relative wages and overstate demand shifts for groups with falling relative wages [Katz and Murphy (1992)]. Murphy and Welch (1993a) and Juhn (1994) propose and implement adjustments for this bias under the strong assumption of unit own-price and zero cross-price elasticities of consumer demand.

Empirical analyses of the magnitude of between-industry and between-occupation shifts in relative labor demand using (adjusted and unadjusted) versions of ΔDEM_k indicate strong and rather steady between-industry and between-occupation demand shifts favoring more-educated workers and high-wage workers from 1950 to the present [Juhn, Murphy and Pierce (1993); Juhn (1994); Katz and Murphy (1992); Murphy and Welch (1993a)]. Between-industry demand shifts actually appear to be larger in magnitude in the 1960s, a period of the rapid expansion of employment in government and education-intensive service sectors, than in the period since 1970 [Katz and Murphy (1992); Autor, Katz, and Krueger (1998)]. The direction of demand shifts in the 1940s are less clear [e.g., Goldin and Margo (1992)]. But the magnitudes of measured demand shifts for more-educated labor between industries or between occupations are consistently much smaller than the growth of the relative supply of more-educated workers [Katz and Murphy (1992); Murphy and Welch (1993a)]. Thus substantial within-industry and within-occupation demand shifts favoring the more-skilled are a key driving force in the large secular increase in the relative demand for more-educated workers documented in Table 14. Similar patterns are apparent in other OECD countries [e.g., Katz, Loveman, and Blanchflower (1995)]. These patterns are strongly suggestive of an important role of skill-biased technological change.[49]

When within-sector factor-biased technological changes are allowed, the interpretation of ΔDEM_k as a measure of the impact of product demand shifts on relative labor demand becomes more tenuous and the nature of the bias is more complicated [Bound and Johnson (1992)]. In this case, one needs to add more structure (i.e., assumptions concerning sectoral production functions and consumer preferences) to develop measures of the contribution of product demand shifts and skill-biased technological change as sources of changes in relative labor demand. We illustrate these issues using a simplified version of the model developed by Bound and Johnson (1992) with two inputs college equivalents (c) and high school equivalents (h). Under the rather strong assumptions of Cobb-Douglas industry production functions and Cobb-Douglas consumer preferences, we find that a standard shift-share decomposition of the growth of the aggregate college wage-bill share (share of college equivalents in total costs) can be used to directly measure the extent to which the growth in the relative demand for college equivalents reflects skill-biased technological change as opposed to product demand shifts.

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[49]An alternative possibility for large within-industry (and within-plant) shifts in relative labor demand favoring skilled workers is increased foreign outsourcing of less-skilled jobs [Feenstra and Hanson (1996)]. Berman, Bound, and Griliches (1994) and Berman, Bound, and Machin (1998) conclude that (at least through the 1980s) the amount of such foreign outsourcing is too small for it to be the driving force behind within-industry skill upgrading.

Following Bound and Johnson [1992], we assume the economy consists of J industries and the output of each industry j (Q_j) depends on the employment of college and high school equivalents according to a CES production function of the form of equation (20) with a common elasticity of substitution ($\sigma = 1/[1-\rho]$) and with the other technology parameters (α_{jt}, a_{jt}, and b_{jt}) allowed to vary by industry and time. The relative demand for the output of industry j relative to a reference industry r in period t is assumed to be given by

$$(26) \quad Q_{jt}/Q_{jt} = \theta_{jt}(P_{jt})^{-\epsilon}$$

where P_{kt} is the price of Q_{kt} relative to Q_{rt} and θ_{kt} is a parameter that reflects consumer tastes and other factors (such a foreign competition) affecting relative product demand for the output of industry k in year t.

We consider the special case of a Cobb-Douglas economy: $\sigma = \epsilon = 1$. The production function for industry j can now be written as:

$$(27) \quad Q_{jt} = A_{jt} N_{cjt}^{\alpha_{jt}} N_{hjt}^{1-\alpha_{jt}}$$

where A_{jt} indexes the level of productivity in industry j in year t. We assume the aggregate labor supplies of college equivalents (N_{ct}) and of high school equivalents (N_{ht}) are exogenous and full employment prevails so that the entire labor force of each group is allocated across the J industries: $N_{ct} = \Sigma_j N_{cjt}$ and $N_{ht} = \Sigma_j N_{hjt}$. Workers are assumed to be mobile across industries so that wages are equalized across industries. These assumptions imply (using equation (A8) of Bound and Johnson

(1992)) that the log ratio of the competitive wage for college equivalents to that of high school equivalents is given by

$$(28)\qquad \log\left(\frac{w_{ct}}{w_{ht}}\right) = \log\left(\frac{\Sigma_j \alpha_{jt}\theta_{jt}}{\Sigma_j (1-\alpha_{jt})\theta_{jt}}\right) - \log\left(\frac{N_{ct}}{N_{ht}}\right) = D_t - \log\left(\frac{N_{ct}}{N_{ht}}\right).$$

Equation (28) is of the same form as equation (22) with an aggregate elasticity of substitution between college and high school equivalents of 1 and with the demand shift term D_t now directly related to industry technology and product demand shift parameters.[50]

Under these Cobb-Douglas assumptions the aggregate log relative demand for college equivalents (D_t) can be decomposed into a between-industry component that depends only on product demand shifts (changes in the θ_{jt}'s) and a within-industry component that depends only on the pace of skill-biased technological change (changes in the α_{jt}'s). These between- and within-industry demand shift components can also be directly measured with data on industry shares of the aggregate wage bill and on the share of the college wage-bill share in each industry. The Cobb-Douglas production function assumption implies that α_{jt}'s are directly measured by the share of the total wage bill accounted for by college equivalents in each industry:

$$(29)\qquad \alpha_{jt} = (w_{ct}N_{cjt})/Y_{jt}$$

[50]The common industry-level elasticity of substitution and the aggregate elasticity of substitution are only equal when $\sigma = \epsilon$ or all industries have the same factor intensities or both.

where $Y_{jt} = w_{ct}N_{cjt} + w_{ht}N_{hjt} = P_{jt}Q_{jt}$, with the last equality arising from constant returns to scale in a model with only two labor inputs. The assumption of $\epsilon = 1$ in equation (26) means that the relative product demand shift for industry j ($\theta_{jt}/[\Sigma_j\theta_{jt}$) can be directly measured by its share of aggregate revenues or by Y_{jt} (its share of the aggregate wage bill) under the normalization of $\Sigma_j Y_{jt} = 1$.

Differentiating the expression for D_t in equation (28) yields an expression for the (instantaneous) rate of change in log relative demand for college equivalents that can be written as

$$(30) \quad dD_t = dD_t^w + dD_t^b$$

where

$$(31) \quad dD_t^w = \frac{\Sigma_j d\alpha_{jt} Y_{jt}}{Y_{ct}} + \frac{\Sigma_j d\alpha_{jt} Y_{jt}}{1 - Y_{ct}}$$

and

$$(32) \quad dD_t^b = \frac{\Sigma_j \alpha_{jt} dY_{jt}}{Y_{ct}} + \frac{\Sigma_j \alpha_{jt} dY_{jt}}{1 - Y_{ct}}$$

and $Y_{ct} = \Sigma_j\alpha_{jt}Y_{jt} = w_{ct}N_{ct}/(w_{ct}N_{ct} + w_{ht}N_{ht})$, the aggregate college wage-bill share. The numerator of equation (31) is simply the within-industry growth component of the growth of the aggregate college-wage bill share, and the numerator of equation (32) is simply the between-industry component.

Thus a standard shift-share decomposition of the growth of the wage-bill (labor-cost) share of more-skilled workers [Berman, Bound and Griliches (1994), Berman, Bound, and Machin (1998), and Autor, Katz, and Krueger (1998)] can be used to directly measure the effects of skill-biased technological change (within-industry demand growth) and product market shifts (between-industry demand growth) on overall relative demand growth. Autor, Katz, and Krueger (1998) have implemented this approach on data for three-digit industries for the 1960 to 1996 period. They find rate of within-industry relative demand growth for college graduates appears to have increased from the 1960s to the 1970s and remained at a higher level in the 1980s and 1990s. This restrictive Cobb-Douglas framework suggests a larger impact of skill-biased technological change on the growth in the relative demand for college workers from 1970 to 1996 than in the 1960s. These results highlight the importance of more directly examining evidence on the role of skill-biased technological change in the recent widening of the wage structures of many OECD nations.

5.5 Skill-Biased Technological Change

The deteriorating labor market outcomes of less-educated workers in most OECD economies over the past two decades despite their increasing relative scarcity strongly implies a strong decline in the relative demand for less-skilled workers. Skill-biased (or unskilled labor saving) technological change and increased exposure to international competition from less developed countries (Stolper-Samuelson effects) have been offered as the leading candidate explanations for this demand shift. Much indirect evidence suggests a dominant role for skill-biased technological change (associated with changes in production techniques, organizational changes, and reductions in the relative prices of computer services and new capital equipment) in the declining relative demand for the less skilled. First, as discussed in section 5.4, the magnitude of employment (or wage bill) shifts to skill-intensive industries as measured by between-industry demand shift indices is too small to be consistent with explanations giving a leading role to product demand shifts, such as induced by greater trade with developing countries, or Hicks-neutral, sector-biased technological change. Estimates of between-industry demand shifts also show little evidence of acceleration in recent decades. Second, despite increases in the relative wages of more-skilled workers, the composition of U.S. employment continues to shift rapidly towards more-educated workers and higher-skill occupation within detailed industries and within establishments [Autor, Katz, and Krueger (1998), Berman, Bound and Griliches (1994); Dunne, Haltiwanger, and Troske (1996)]. A rise in the relative cost to firms of skilled labor should have led to within-industry and within-establishment shifts in employment towards unskilled labor in the absence of skill-biased technological change. Third, within-industry skill upgrading despite rising or stable skill premia is apparent in found in almost all industries in many other developed economies in the 1980s. Furthermore the cross-industry pattern of the rate of skill upgrading in manufacturing industries appears to be quite similar among advanced nations [Berman, Bound, and Machin (1998)]. These findings are consistent with an important role for *pervasive* skill-biased technological change throughout developed countries and concentrated in similar industries in each country as a major source of changes in relative skill demands. The potential impact of skill-biased technological change on the wage structure is likely to be greater the more pervasive it is across countries [Berman, Bound, and Machin (1998), Johnson and Stafford (1998b), Krugman (1995)].[51]

[51]The degree to which technological changes are pervasive across countries or localized within a single country is an important issue in assessing the likely impact on relative wages in increasingly open economies. It is the sector bias rather than the factor bias of localized technological change that determines its impact on relative wages in a small open economy operating under incomplete specialization in a standard Hecksher-Ohlin [Leamer

More direct evidence also suggests that (broadly interpreted) skill-biased technological change is an important source of shifts in relative labor demand. Much econometric and case study evidence indicates that the relative utilization of more-skilled workers is positively correlated with capital intensity and the implementation of new technologies both across industries and across plants within detailed industries [e.g., Bartel and Lichtenberg (1987); Doms, Dunne, and Troske (1997); Griliches (1969); Levy and Murnane (1996); Mark (1987)]. These patterns indicate that physical capital and new technologies appear to be relative complements with more-skilled workers. Thus secular increases in the capital/labor ratio could be a source of secular growth in the relative demand for skilled labor.[52] Krusell et al. (1997) present suggestive evidence that the rapid increase in the (quality-adjusted) stock of capital equipment since the early 1960s combined with strong complementarity between capital equipment and skilled labor can "account" for the trend growth in the relative demand for skills.[53]

There also appear to be strong correlations between industry-level indicators of technological change (computer investments, the growth of employee computer use, research and development (R&D) expenditures, utilization of scientists and engineers, changes in capital intensity measures)

(1996)]. Haskell and Slaughter (1998) provide an intriguing initial attempt to empirically examine whether differences across countries in the pattern of the sector-bias of (localized) technological change can help explain differences in changes in the relative wages of skilled workers in the 1980s. But the factor bias of technological change is often the crucial determinant of the relative wage impact in a closed economy setting. For example, the factor bias alone matters for how technological changes affect relative wages in a closed economy model with Cobb-Douglas sectoral production functions and Cobb-Douglas consumer preferences as indicated by equation (28). The factor bias re-emerges as an important factor in an open economy setting when technological change is pervasive across countries (since the integrated international economy as a whole can be viewed as a closed economy) and for localized technological change for a large open economy (so that the world prices of tradeables are affected by localized technological change).

[52]Such a conjecture partially motivated Griliches (1969, 1970) early seminal work on capital-skill complementarity.

[53]Their measure of the capital-skill complementarity effect on relative wages evolves similarly to a linear time trend. Thus the aggregate time series model of Krusell et al. (1997) attributes variations in changes in the skill premium around trend (such a sharp decline in the skill premium in the 1970s and sharp rise in the 1980s) to variations in the rate of growth of the relative skill supplies and to unobserved demand shocks (the residual).

and the within-industry growth in the relative employment and labor cost share of more-skilled workers [Allen (1997); Autor, Katz, and Krueger (1998); Berman, Bound, and Griliches (1994); Berndt, Morrison, and Rosenblum (1994); Machin and Van Reenen (1997), Wolff (1996)]. Technology indicators, particularly computer investment or employee computer usage, also appear to be more powerful explanatory variables for differences among industries in the pace of skill upgrading than are indicators of outsourcing activity, import pressures, or changes in export activity [Autor, Katz, and Krueger (1998)].[54] The causal interpretation of contemporaneous correlations of technology indicators such as R&D intensity and computer use with skill upgrading since R&D activities directly used highly-educated workers and since other sources of changes in the use of skilled workers could drive variation across industries in purchases of computers. But Autor, Katz, and Krueger (1998), Machin and Van Reenen (1997), and Wolff (1996) find that lagged computer investments and R&D expenditures predict subsequent increases in the pace of skill upgrading. This pattern is consistent with a recent survey of U.S. human resource managers indicating that large investments in information technology lead to changes in organizational practices that decentralize decision-making, increase worker autonomy, and increase the need for highly-educated workers [Bresnahan, Brynholfsson, and Hitt (1998)].

Plant-level studies of U.S. manufacturing by Bernard and Jensen (1997) and Doms, Dunne, and Troske (1997) similarly find strong positive relationships between within-plant skill upgrading and both R&D intensity and computer investments. But Doms, Dunne, and Troske (1997) find little relationship between a plant -level indicator of the number of new factory automation technologies

[54]But the change in export intensity does seem to have a robust positive relationship to within-industry skill upgrading even conditional on measures of computer investments [Bernard and Jensen (1997); Autor, Katz, and Krueger (1998)].

being used and within-plant skill upgrading. In contrast, case studies by the Bureau of Labor Statistics indicate large production labor saving production innovations were adopted in the 1970s and 1980s in the electrical machinery, machinery, and printing and publishing sectors, three manufacturing industries that are among the leaders in the rate of skill upgrading in most developed countries [Berman, Bound, and Machin (1998); Mark (1987)].

The diffusion of computers and related technologies has attracted much attention as a possibly important measurable source of recent changes in the relative demand for skills. The share of U.S. workers using computers on the job, an extremely crude measure of the diffusion of computer-based technologies, increased from 25 percent in 1984 to 47 percent in 1993 [Autor, Katz, and Krueger (1998)] The rapid spread of computers appears to have occurred at a similar pace in other OECD countries. For example, Card, Kramarz, and Lemiuex (1996) report similar levels of employee computer usage in Canada, France, and the United States circa 1990. Krueger [1993] and Autor, Katz, and Krueger [1997] document a substantial log wage premium associated with computer use (conditional on standard controls for observed worker characteristics) that increased from 0.17 in 1984 to 0.20 in 1993. The extent to which this computer wage premium represents a measure of the true returns to computer skills (the treatment effect of computer use) or largely reflects omitted characteristics of workers and their employers is a subject of much debate (see, for example, Bell (1996) and DiNardo and Pischke (1997)). But the resolution of this debate does not directly address the issue of whether the spread of computer technologies has significantly changed organizational practices and altered relative skill demands.[55]

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[55]The existence of a positive computer wage differential is neither a necessary nor a sufficient condition for the diffusion of computers to have induced a shift in the relative demand for more-skilled workers and to have affected the wage structure. If computer technologies are more complementary with highly-skilled than less-skilled workers, a decline in computing costs and spread of computers could generate an increase in the relative demand for

Computer technology may influence relative labor demand in several ways.[56] Computer business systems often involve the routinization of many white-collar tasks. Simple, repetitive tasks have proved more amenable to computerization than more complex and idiosyncratic tasks [Bresnahan (1997)]. Microprocessor-based technologies have similarly facilitated the automation of many production processes in recent years. Thus direct substitution of computers for human judgement and labor is likely to have been more important in clerical and production jobs than in managerial and professional jobs. Computer-based technologies may also increase the returns to creative use of greater available information to more closely tailor products and services to customers' specific needs and to develop new products. Bresnahan (1997) posits such an organizational complementarity between computers and workers who possess both greater cognitive skills and greater "people" or "soft" skills.

The direct substitution and organizational complementarity channels both predict that an increase in the relative demand for highly-educated workers should be associated with computerization. These predictions are consistent with the findings of Autor, Katz, and Krueger (1998) that increased computer intensity is associated with increased employment shares of managers, professionals and other highly educated workers, and with decreased employment shares of clericals, production workers, and less educated workers. Bresnahan, Brynjolfsson and Hitt (1998) similarly find in firm-level data that greater use of information technology is associated with

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and relative wages of more-educated (and more-skilled) workers. Labor market competition could require firms both with and without computer technologies to pay equal wages to attain equally able employees. In this case a cross-section wage regression with sufficient controls for worker skills would yield no computer wage premium even though computers may have greatly raised the relative wages of the more-skilled and widened the wage structure.

[56]Bresnahan (1997) provides a descriptive theory of and illuminating historical evidence on how computers affect labor demand and organizational practices. Sichel (1998) provides a thoughtful analysis of the overall impact of the computer revolution on the U.S. economy.

the employment of more-educated workers, greater investments in training, broader job responsibilities for line workers, and more decentralized decision-making.

A summary interpretation of the evidence on the impact of skill-biased technological change on recent wage structure changes is illuminated by distinguishing between two distinctive hypotheses that are sometimes confused.[57] The first is that skill-biased technological change (broadly conceived to also include capital deepening and skill-biased organizational innovations) is an important (and probably the most important) driving force behind long-run secular increases in the relative labor demand more-educated and more-skilled workers. The widespread direct evidence of capital-skill and technology-skill complementarity and indirect evidence of strong within-industry and within-plant increases in the relative demand for skill are strongly consistent with this first hypothesis. In fact, the introduction of new production technologies and increases in physical capital intensity appear to have been typically associated with increased demand for more-skilled workers throughout the twentieth century.[58]

The second hypothesis is that the impact of technological change on the relative demand for more-skilled workers *accelerated* recently (possibly in the 1980s), and this acceleration can account for the particularly large increases in wage inequality and educational wage differentials in the 1980s.

The available evidence is less definitive with respect to this hypothesis. A simply supply-and-demand analysis for the United States (such as in Table 14) indicates a particularly rapid rate of

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[57]See Autor, Katz, and Krueger (1998), Mishel, Bernstein, and Schmitt (1997b), and Gottschalk and Smeeding (1997) for further discussion of these issues.

[58]For example, Goldin and Katz (1998) show that capital-deepening, the diffusion of purchased electricity, and the introduction of continuous-process and batch methods of production greatly increased the relative demand for nonproduction workers and more-educated production workers in manufacturing from 1909 to 1929

relative demand growth in the 1980s under our preferred values for the aggregate elasticity of substitution between college and non-college labor. In contrast, implied relative demand growth is much slower in the 1990s a period a continuing rapid spread of computers. But Autor, Katz, and Krueger (1998) find that within-industry demand growth accelerated from the 1960s to the 1970s and then stayed at this higher level through the mid-1990s. This provides some indirect evidence that the impact of skill-biased technological change on relative skill demands accelerated starting in the 1970s. Autor, Katz, and Krueger also provide some more direct evidence that the increase in rate of within-industry skill upgrading from the 1960s to the post-1970 period is concentrated in the most computer intensive sectors of the economy. The exceptionally rapid increase in the relative supply of college graduates in the 1970s from the labor market entry of the baby-boom cohorts delayed the impact of this demand shift on wages until the 1980s. A deceleration of relative skill supply growth from the 1970s to the 1980s and 1990s appears to be a crucial part of differences in U.S. wage structure behavior in the 1970s and the period since the 1979.

Several conceptual issues concerning the nature of skill-biased technological change merit further consideration. One possibility is that skilled workers are more flexible and facilitate the adoption of new technologies so that all technological change increases the relative demand for more-skilled labor over some transitional period [Bartel and Lichtenberg (1987); Greenwood and Yorukoglu (1997); and Welch (1970)]. As technologies diffuse and become routinized the comparative advantage of the highly skilled declines. In this case the level of demand for skilled labor depends on the rate of innovation. Periods of large increases in the skill premium correspond to technological revolutions.[59] But an ever increasing rate of innovation seems to be necessary to

[59]Recent models of how periods of rapid technological change affect the labor market include Caselli (1997), Greenwood and Yorukoglu (1997), and Helpman and Rangel (1998).

generate persistent secular growth in the relative demand for more-educated workers. Furthermore the apparent slowdown in growth of the relative demand for skill in the 1990s could reflect the maturing of the computer revolution. An alternative (but potentially complementary) hypothesis is that distinctive technological innovations may have different factor biases. Some of the main technological changes of the twentieth century associated with electrification and computerization may have been skill-biased, but other innovations need not be. Mechanization in the nineteenth century associated with the movement from artisanal production (intensive in skilled craft workers) to factory production (intensive in unskilled labor) appears to have been largely deskilling even though more flexible workers were likely to have been necessary to assist in the introduction of factory methods [Goldin and Katz (1998)]. Under this scenario the inherent skill-biased nature of twentieth century innovations rather than an accelerating rate of innovation is the source of secular within-industry growth in the relative demand for skill.

An important further issue concerns the extent to which the rate of technological change and its direction (i.e., the extent to which technological change is skill-biased) are exogenous or are affected by changes in relative skill supplies. Acemoglu (1998), following a substantial earlier literature on induced innovation, has developed an interesting model in which increases in the proportion of skilled workers affect R&D efforts and can direct technological change in a skill-biased. Acemoglu finds it is possible for the "induced" increase in the relative demand for skills to even overshoot the increase in the relative supply of skills.

5.6 Globalization and Deindustrialization[60]

A popular culprit for rising labor market inequalities in developed countries is the increased globalization of economic activity arising from reductions in barriers to trade and reduced costs to international economic transactions. Increased trade with developing countries is commonly viewed as a driving force behind "deindustrialization" (a sharp decline in the share of employment in production jobs in manufacturing) and the woes of less-skilled workers in advanced economies [e.g., Wood (1994, 1995, 1998)]. U.S. manufacturing imports from less-developed countries (LDCs) increased from 0.8% of GNP in 1970 to 2.3% in 1980 to 2.8% in 1990 to 4.1% in 1996 [Borjas, Freeman, and Katz (1997)]. Increased international capital mobility, reduced costs of international technology transfer, and greater foreign outsourcing opportunities also may increase the effective elasticity of demand facing workers in bargaining, erode their bargaining power, and reduce the extent to which internal labor markets insulate them from product market and labor market shocks [e.g., Bertrand (1998); Borjas and Ramey (1995); Rodrik (1997)].

A common (but controversial) method for estimating the effects of trade on labor markets is *factor content analysis* [Borjas, Freeman, and Katz (1992, 1997); Lawrence (1996); Sachs and Shatz (1994); Wood (1994, 1995)]. The basic approach is to determine how much of different types of labor (e.g., skilled and unskilled labor) are used to produce a country's exports, and how much would have been used in produce its imports (or the domestic goods that would have been produced in the absence of imports). The difference between the supplies of labor used in exports and imports provides an estimate of the implicit change in the relative supply of unskilled labor from trade, or,

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[60]A comprehensive treatment of theoretical and empirical issues related to assessing the impacts of international trade on the labor market is contained in the chapter by Johnson and Stafford (1998b). The chapter by Borjas (1998) contains a detailed analysis of immigration and the wage structure. Thus we present only a brief treatment of issues concerning the role of globalization factors in recent changes in the wage structure.

equivalently, the impact of trade on the relative demand for the unskilled. An estimate of the aggregate elasticity of substitution between skilled and unskilled labor can then be used to simulate the impact of the implicit change in relative skill supplies from trade. Increased trade will tend to have an adverse effect on less-skilled workers to the extent that import-competing industries disproportionately employ less-skilled workers and export sectors are relatively more skill-intensive. This pattern is strongly present for U.S. trade with LDCs, but the characteristics of workers in industries with high imports and exports with other developed countries are fairly similar [Borjas, Freeman, and Katz (1997); Sachs and Shatz (1994)].

The factor content of observed changes in net exports can provide an accurate input to assessing how changes in trade affect relative wages in limited circumstances [Johnson and Stafford (1998b)]. If one begins in autarky, then allows for trade, and trade is a modest proportion of the national economy, the change in national endowments due to the factor content of trade measures the pressure of trade for changes in relative wages [Deardorff and Staiger (1988); Krugman (1995)]. More generally, if the changes in net exports being examined are caused by external factors (e.g., reductions in trade barriers or reductions in transportation costs, changes in factor endowments abroad), then factor content analysis may be sensible. If changes in net exports result from domestic sources (e.g., an increase in the relative supply of skilled labor leading to greater net exports of high-skill goods and lower net exports of low-skill good), then factor content analysis can be quite misleading [Leamer (1996)].

A further practical issue in factor content analysis is the how to estimate the hypothetical factor content of the domestic production that would arise to replace imports from LDCs. The standard approach is to assume LDC imports would be replaced by domestic production in the closest import-competing industry using the contemporaneous average factor proportion in the domestic import-competing industry [e.g., Sachs and Shatz (1994)]. But Wood (1994, 1995) has argued persuasively that within each sector there is a wide distribution of factor proportions and labor productivity, and that LDC imports are likely to be most directly competing with the segment of an industry using the most unskilled-labor intensive production techniques. The issue is somewhat more complicated since some LDC imports may not closely compete with any domestic industry so that their absence might expand domestic demand for goods or services with quite different (and possibly even higher) skill intensities than in the assumed "import-competing" sector.

Borjas, Freeman, and Katz (1997) examine the factor content of the growth of U.S. trade with LDCs from 1980 to 1995. They examine the robustness of the conclusions to a wide range of assumptions concerning the factor ratios that would have been used in U.S. industries to replace LDC imports. They find that the growth of trade with LDC's from 1980 to 1995 to a 1.4 log point increase in the implicit relative supply of high school equivalents relative to college equivalents assuming U.S. manufactures would use the same factor ratios that prevailed in their industries in 1980 (prior to the change in LDC trade being assessed) in the absence of LDC imports. Under our preferred estimate of σ=1.4, this implies that growth of trade with LDCs can account for only 1 log point out of a 19 log point increase in the college wage premium from 1980 to 1995. Thus demand shifts from skill-biased technological change and domestic sources of changes in relative skill supplies appear to be much more significant factors in the recent expansion of the U.S. college wage premium than trade's impact as measured by factor contents. The impact is relatively larger if one focuses on the impact of trade on the high school dropouts. But Borjas, Freeman, and Katz also find that increased unskilled immigration had a much larger impact on changing the implicit relative supply of the least skilled U.S. workers than did LDC trade from 1980 to 1995.

The factor content approach may understate the effects of globalization pressures on relative wages when the threat of trade, outsourcing, or plant relocation can lead to wage changes even in the absence of new trade flows [Rodrik (1997)].[61] Borjas and Ramey (1995) explore the contribution of the erosion of industry wage differentials in trade competing durable goods manufacturing industries to increased U.S. educational wage differentials and find it to be quite modest.

Product-price studies attempt to more directly assess the implication of the Stolper-Samuelson theorem that impacts of trade on relative wages operates through changes in the relative product price of more- and less-skill intensive. Product-price studies suffer from similar practical limitations to factor-content studies both arising from data quality issues in price data (the difficulty of separating true price from quality changes) and difficulties in trying to isolate product-price changes driven by exogenous trade-related forces rather than other sources. Slaughter (1998) provides a nice a review of the emerging literature in this area and concludes that these limitations combined with a wide range of somewhat conflicting results make it difficult to draw strong conclusions from the price studies concerning the impact of international trade on wage inequality. Attempts to isolate "exogenous" international components of changes in product prices and trade flows (possibly by examining the consequences of changes in trade policy and explicit trade barriers) could be a more fruitful research strategy than standard approaches to factor content analysis and product price studies.

[61]The rate of skill-biased technological change may also be affected by globalization factors both through lower costs of technology transfer (lower cooperation costs) and through threats of foreign competition inducing "defensive innovation" [Wood (1994, 1998)].

"Deindustrialization" (a substantial decline in manufacturing employment) is also often identified as a leading cause of poor labor market performance of less-skilled workers in advanced countries. And international trade is often viewed as the major driving force behind deindustrialization [e.g., Wood (1994, 1995, 1998)]. Between-industry demand shift indices (Section 5.4) do indicate that shifts out of manufacturing to more-skill intensive sectors have played some role in the decline in the relative demand for less-skilled workers. But the overall rate of between-industry demand shifts does not appear to be any larger in the period of sharp increases in wage inequality in the 1980s than in other recent decades. Nevertheless, it is striking that much of the recent increase in U.S. wage inequality and educational wage differentials is concentrated in the period from 1979 to 1985 centered on a deep recession and containing a large appreciation of the U.S. dollar and large decline in manufacturing employment. And the periods of extremely tight labor markets and strong demand for production workers in manufacturing during the two World Wars are the two periods of large compressions in the U.S. wage structure during the twentieth century.[62] Furthermore studies using geographic variation across U.S. states and metropolitan areas consistently find that larger declines in manufacturing employment are strongly positively associated (at least in the short-run) with larger increases in overall wage inequality [Juhn (1994)], residual wage inequality [Bernard and Jenson (1998)], and educational wage differentials [Borjas and Ramey (1995); Bound and Holzer (1997)].

5.7 Summary

Supply and demand models provide a useful organizing framework for understanding

[62]The 1980s were also a period of a substantial decline in unions and erosion of the minimum wage, and the two World Wars are periods of growing union power and government intervention in the economy.

important aspects of between-group wage structure changes.[63] Supply and demand factors (the determinants of competitive wages in the SDI framework of section 4) are important determinants of wage structure changes. Substantial secular increases in the relative demand for more-educated and more-skilled workers appear necessary to explain observed patterns of the evolution of the wage structure in developed countries over most of the last century. Shifts in the industrial and occupational distribution of employment to more skill-intensive industries and occupations can account for a significant minority of this growth in the relative demand for skills. But within-industry growth in relative labor demand favoring the more educated (within-industry skill upgrading) appears to be the major driving force in the rise in the relative demand for the more skilled. This pattern suggests a key role for skill-biased technological change in explaining relative demand shifts. Strong positive cross-industry correlations of indicators of technological change (especially indicators of the usage of computer-based technologies) and the rate of skill upgrading provides more direct evidence on the importance of skill-biased technological change. Technology factors appear to be somewhat more important than international trade changes as a source of relative demand shifts favoring the more-skilled.

Variations in the rate of growth in the relative supply of more-educated workers (college workers) appear to a be an important determinant of variations in the rate of change of educational and occupational wage differentials. Changes in cohort size, incentives for educational investments,

[63]We focus on applications of supply and demand models to explaining changes in educational wage differentials in this chapter. Similar models have proved useful for examining changes in relative wages by age or experience [e.g., Freeman (1979); Katz and Murphy (1992); Welch (1992)]. Supply and demand models are more-difficult to apply to changes in within-group (residual) inequality that are a key component of rising U.S. wage inequality over the last two decades. See Juhn, Murphy, and Pierce (1993) for an interesting attempt to measure between-industry and between-occupation shifts in relative demand for observed and unobserved skills based on the assumption that skills are measured by one's position (percentile) in the wage distribution.

changes in female labor force participation, and international immigration appear to be important sources of variations in relative skill supplies.[64] Detrended skill supply growth helps predict detrended changes in the college wage premium in the United States and other advanced nations. A deceleration in the rate of growth of the relative supply of college workers appears to be an important determinant of the sharp increase in U.S. educational wage differentials in the 1980s, and especially rapid growth in relative skill supply a key determinant of the narrowing of the college wage premium in the 1970s. Countries with decelerations in relative supply growth in the 1980s are those with the largest increase in educational wage differentials.

The data are less clear on whether the recent widening of the wage structure is largely driven by an acceleration in relative demand shifts favoring the more-skilled. For the United States, the pace of within-industry skill upgrading does appear to have increased since 1970, and the 1980s do appear to be a period of particularly rapid relative demand growth. But institutional factors (the erosion of unions and the minimum wage and loss of industry rates) operating in the 1980s combined with supply growth deceleration can potentially explain the observed patterns even when combined with smooth trend growth in the relative demand for more-educated workers. We next turn to an examination of how changes in labor market institutions affect the wage structure.

6. Labor Market Rents and Labor Market Institutions

Large and persistent wage differentials are present across industries and establishments even

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[64]See Topel (1997) for a more thorough analysis of the impacts of alternative sources of changes in relative factor proportions. See Macunovich (1998) for an interesting and more expansive analysis of how changes in relative cohort size affect the wage distribution both through standard effects of changes in factor proportions and through changes in the level and composition of aggregate labor demand through differences over the life-cycle in consumption behavior.

after conditioning on observed measures of worker characteristics, working conditions, and non-wage employee benefits and even after controlling for (time-invariant) worker unobserved ability through individual fixed effects [e.g., Gibbons and Katz (1992); Groshen (1991); Krueger and Summers (1988)]. Positive inter-industry wage differentials are associated with lower employee quit rates and longer queues of job applicants [Holzer, Katz, and Krueger (1991); Katz and Summers (1989)]. Thus industry and establishment wage differences appear to partially reflect variation in relative rents such as predicted by models emphasizing efficiency wage considerations and worker bargaining power [e.g, Katz (1986); Lindbeck and Snower (1988)]. Differences across countries in wage setting institutions (union and government roles in wage setting) appear to be strongly related to differences in levels of wage inequality among advanced nations especially in the lower half of the wage distribution and to differences in the magnitude of educational wage differentials [Blau and Kahn (1996, 1998); Freeman (1993, 1996)].

The apparent importance of labor rents and institutional interventions in cross-section wage distributions suggest that these factors may also matter for changes in the distribution of wages. The same labor market shocks (e.g., from skill-biased technological change, globalization factors, or changes in skill supplies) may have different impacts on the wage structure depending on how unions and government regulations affect wage setting. Changes in labor market institutions and the incidence of labor market rents may directly lead to wage structure changes.

In this section, we first explore the role of institutional factors on recent U.S. wage structure changes. We examine the existing research on impacts of changes in industry rents, changes in the unionization, and changes in the "bite" of the Federal minimum wage. We then briefly discuss the overall roles of supply, demand, and institutional factors in differences in wage structure changes among advanced nations. An interesting and rather unexplored topic for further research is the impact of changes in ideology and norms of fairness on wage setting [e.g., Rotemberg (1996)]. The large wage structure changes in most countries during the two World Wars clearly indicate the possible importance of large shocks that change wage setting norms.

6.1 Industry Rents

The large variation across industries in wages for workers with the same observed characteristics suggests that differences across groups in shifts in the industrial distribution of employment may help explain changes in the wage structure by affecting the average industry wage premium earned by different groups. The share of less-educated U.S. employees working in high-wage durable goods manufacturing fell dramatically in the 1980s, while the share of college graduates working durable goods changed very little and the share in high-wage service industries (e.g., financial and professional services) increased substantially. Furthermore the share of female college graduates working in the low-wage education and welfare service industries declined substantially in the 1980s. These patterns are most pronounced for young workers (those with up to 9 years of potential experience) [Katz and Revenga (1989)]. Changes in industry wage effects may also have differential effects across demographic and skill groups given their quite distinctive industrial employment distributions (e.g., a decline in the wage premium to construction workers has a larger effect on less-educated workers who are disproportionately employed in construction).

Much research documents that changes in the U.S. wage structure by education, experience, and gender over the past several decades largely reflect within-industry changes rather than changes in the incidence of industry rents [e.g., Bound and Johnson (1992); Murphy and Welch (1993b)].

But changes in average industry rents do appear to have significantly contributed to widening educational wage differentials in the 1980s. For example, Murphy and Welch (1993b) find, using a 49 (approximate two-digit industry) decomposition, that the U.S. college/high school wage differential increased 16.2 percent overall and 12.0 percent within industries. Large changes in the college wage premium occur within essentially every industry, although the changes are much more moderate in industries with large shares of public employees.[65] Thus changes in relative labor rents from differential shifts in the industrial composition of employment by education group could explain up to one-fourth of the rise in the college wage premium in the 1980s. The implied estimate should be reduced proportionately to the extent industry wage differentials represent differences in unobserved ability as opposed to "true" wage differentials from labor market rents. Bound and Johnson (1992) find similar impacts of changes in the magnitude of industry rents accruing to college and high school workers in the 1980s. The impact of a declining employment share of the less-educated in high-wage industries (durable goods manufacturing) appears to be especially important for young workers in the 1980s. Murphy and Welch (1993b) estimate that the college/high school wage differential increased by 26.3 percent for workers with 1 to 10 years of experience and by 20 percent within industries. But differences in the behavior of educational wage differentials for young workers in the 1970s and the 1980s are strikingly driven by within industry changes (a changes of 33.8 percent overall versus 29.2 percent within industries). The growth of within-group (residual) wage inequality in the 1970s and 1980s is also dominated by the within-

[65]Changes in U.S. wage inequality and educational wage differentials in the 1980s are much smaller in the public sector than in the private sector [Katz and Krueger (1991)]. These public/private differences are suggestive of the importance of how differences in wage setting institutions and political pressure on wage setting can lead to quite different relative wage responses to similar labor market shocks. The rising level of unionization in the public sector since the early 1970s as compared to substantial deunionization in the private sector may also have played a role in the smaller growth in inequality among public sector workers [Card (1998)].

industry component [Juhn, Murphy, and Pierce (1993)].[66]

The recent widening of the U.S. wage structure also provides a potential laboratory for assessing alternative interpretations of measured inter-industry wage differentials. If industry wage differentials largely reflect differences across industries in average unobserved ability [e.g., Abowd, Kramarz, and Margolis (1998); Murphy and Topel (1990)], then a sharp rise in the returns to skill should lead to a widening of measured inter-industry wage differentials in the 1980s and 1990s. Widening industry wage differentials in the 1970s [Bell and Freeman (1991)] are consistent with this hypothesis given the rise in within group inequality in the 1970s suggests a rise in the price of unobserved skills. Krueger (1998) presents a preliminary exploration of this issue for the more recent period (using data from the CPS ORG file) and finds little evidence that the dispersion of inter-industry wage differentials (the standard deviation of estimated industry wage differentials for men conditional on education and experience) increased from 1979 to 1993. Krueger finds the (adjusted) standard deviation of industry wage differentials (at the approximately two-digit level) increased sharply from 0.147 in 1979 to 0.173 in 1983 and then declined rather steadily back to 0.149 in 1993.

6.2 Unions

Unions play an important role in wage determination in all advanced nations both directly through collective bargaining and union threat (or spillover) effects on wages and indirectly by affecting government policies (e.g., minimum wages and other product and labor market

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[66]But Davis and Haltiwanger (1991) and Dunne, Haltiwanger, and Troske (1997) find with plant-level data that growing between-plant wage differentials are an important component of increased wage dispersion for manufacturing employees in the 1980s and early 1990s.

regulations). Lewis (1986) concludes from a thorough review of the enormous literature on U.S. union relative wage effects that the average treatment effect of union coverage on individual earnings (holding the locus of unionization fixed) was approximately 15 percent (15 log points) in the 1970s. More recent studies using longitudinal data to control for selectivity on unobserved ability into the union sector reach a similar conclusion and find a much larger union wage effect for low-skill and less-educated workers than for high-skill and more-educated workers [e.g., Card (1996)]. Thus traditionally higher unionization rates among less-educated and blue-collar males are likely to have tended to serve to reduce educational and occupational wage differentials. Unions also tend to reduce wage inequality within the union sector by compressing wage differentials and standardizing wages between jobs and between establishments. Freeman and Medoff (1984) conclude for the United States that the inequality reducing effects of unions (standardizing wages among jobs and narrowing the white collar/blue collar wage differential) have tended to be larger than the inequality increase effect of unions by creating a union/nonunion wage differentials among workers who otherwise would receive similar wages.

Thus the sharp U.S. decline in unionization over the past two decades concentrated among less-educated males could be an important source of expanding educational wage differentials and overall wage inequality for males.[67] Card (1997) estimates that the U.S. union membership for males declined from 30.8 percent in 1973-74 to 18.7 percent in 1993. The overall decline masks substantial differences by education. Among U.S. males, the unionization rate fell from 1973-74 to 1993 by 20.8 percentage points for those with less than 12 years of schooling, 14.8 percentage points for those with exactly 12 years of schooling, and actually increased slightly for college

[67]The decline in U.S. union density began in the mid-1950s, but the 1980s are the period of most precipitous decline.

graduates.

A simplified version of the group wage determination model of equation (12) can be used to make a first-cut assessment of how changes in unionization affect between-group wage differentials. We assume the mean log wage for group k (Y_k) is the sum of the competitive wage for group k (Y_{kc}) and the product of the fraction of group-k workers that are unionized (U_k) and the union wage premium for group k (λ_k): $Y_k = Y_{kc} + \lambda_k U_k$. This approach ignores any impact of unions on non-union wages either through union threat effects or through spillover effects in which workers displaced by higher union wages increase the supply of workers to the nonunion sector. The change in wages for group k is then given by a simplified version of equation (13):

$$(33) \qquad dY_k = dY_{kc} + d\lambda_k U_k + \lambda_k dU_k.$$

Differences among groups in their changes in unionization rates and in changes in their union wage premia can affect their relative wages. Bound and Johnson (1992) implement this approach assuming a 15 percent union wage effect for all groups ($\lambda_k = 0.15$ for all k). Bound and Johnson find the unionizaton rate for male high school graduates fell by 11.5 percentage points from 1979 to 1998 as compared a decline of 2.8 percentage points for male college graduates. Under these assumptions the larger union decline for high school than college graduates accounted for a 1.3 log point expansion in the college wage premium for males from 1979 to 1988, or 8 percent of overall increase of 16.3 log points. Freeman (1993) does a full shift-share decomposition using equation (33) and allowing for differences in the union wage premium among education (and occupation) groups and over time. Freeman finds that de-unionization can explain a 1.5 log point increase in the male college wage premium from 1978 to 1988, but had a much larger impact (4 log points) on the expansion of the college wage premium for younger males (those aged 25 to 34).

DiNardo, Fortin and Lemiuex (1996) and Card (1997) examine the effects of deunionization on overall wage inequality for U.S. men and women, and Freeman (1993) examine the effects on male wage variance. DiNardo, Fortin and Lemieux use a semiparametric procedure to simulate the effects of changes in union density on the full distribution of wages of both men and women. The driving force in their results is the much more compressed wage distribution for nonunion males than for union males. Their approach essentially attributes the differences in wage distributions by union status to the effects of unions on the wages of union workers. The impacts of nonrandom selection of workers into the union sector and of the general equilibrium effects of unionization are not explicitly considered. The key identifying assumption is that wage densities conditional on union status and observable covariates do not depend on the unionization rate. This may be a problematic assumption to the extent changes in the unionization rate affect the degree of nonrandom selection by unobservables into the union sector and have general equilibrium effects on the union and nonunion wage distributions through changes in union power, union threat effects, and union spillover effects.

DiNardo, Fortin and Lemieux simulate the effect of the decline in unionization from 1979 to 1988 on the wage distribution in 1988 by reweighting the actual 1988 union and nonunion wage densities using the 1979 unionization rate rather than the 1988 unionization rate (i.e., giving larger weight to the more compressed wage distribution for nonunion workers). They find that the decline in unionization from 1979 to 1988 can account for 10.7 percent (0.021 log points) of the 0.195 log point rise in the 90-10 log wage differential for males and has almost no effect on changes in wage inequality for females. DiNardo, Fortin and Lemieux's results suggest the decline in unionization contributed to a "declining middle" of the male wage distribution and can "explain" one-third of the increase in the 90-50 wage differential and actually partially offset other forces towards a widening of the 50-10 differential.

Freeman (1993) attempts to estimate the effects of deunionization on the change in the variance of log earnings of U.S. males from 1978 to 1988. He decomposes the effects of deunionization into changes in three components of the impact of unions on the variance of male log earnings: (1) the dispersion reducing effect of union among blue-collar union workers; (2) the dispersion increasing effect of unionism on the earnings of blue collar worker due to the union wage differential; and (3) the dispersion-reducing effect of unionism due to the union-induced reduction in the white collar/blue collar wage differential. Standard cross-section based estimates of each of these union effects are used in these calculations. Freeman concludes that the decline in union density can explain approximately 20 percent of the rise in male earnings inequality from 1978 to 1988 through these three mechanisms. Card (1997) generalizes Freeman's approach to account for non-random selection of workers into the union sector on estimates of union wage differentials and union effects on wage dispersion within the union sector. Card's adjusted estimates suggests somewhat more modest effects than those using standard cross-section estimates of union impacts. Card concludes that declining unionization can explain about 12 percent of the rise in male wage inequality (variance in log wages) from 1973-74 to 1993 and essentially none of the increase for females.

In summary, the existing literature suggests both differential declines in industry rents by skill groups and the concentration of deunionization on the less-educated contributed to the enormous increase in educational wage differentials and overall male wage inequality in the 1980s. Key outstanding issues in the assessment of the effects of deunionization on wage structure are the importance of unmeasured general equilibrium effects of unions on the wage structure and the extent to which union density changes are endogenous responses to other labor market forces. A further open question is whether one should adjust the observed changes in wage differentials used in supply and demand analyses for the effects of changes in industry rents and unionization. If these changes don't affect relative group employments (the economy moves off the labor demand curve), then the apparent acceleration of relative demand growth for college workers in the 1980s (e.g., as shown in Table 12 for σ=1.4) might actually reflect the erosion of the relative labor rents of less educated workers.

6.3 Minimum Wage

Direct government intervention in wage setting may also be a key factor in shaping the wage structure. The Federal minimum wage potentially may have significant effects in reducing wage inequality by raising wages in the lower end of the U.S. wage distribution as well as adverse effects on the employment of low-wage workers.[68] The nominal Federal minimum wage was fixed at $3.35 an hour from 1981 to 1990 so that the real Federal minimum wage declined throughout this period.

The minimum wage relative to the median wage declined by almost 40 log points from 1979 to 1989 [Lee (1998)]. Visual inspection of U.S. wage distributions for men and women in 1979 and the late 1980s show substantial bunching around the (relatively high) minimum wage in 1979 (especially

[68]Th e recent literature suggests rather modest effects of changes in the Federal minimum wage on the employment of low-wage workers [Card and Krueger (1995)].

for women) and much less bunching around the relatively low minimum wage in the late 1980s. These patterns are suggestive of a substantial possible role for the erosion of the relative (and real) value of the Federal minimum wage on the widening of the lower half of the U.S. wage distribution in the 1980s.

DiNardo, Fortin and Lemieux (1996) simulate the effects of restoring the 1988 minimum wage to its 1979 real value under the assumptions of no disemployment effects of such a 27 percent increase in the minimum wage and no spillovers of the minimum wage onto the distribution of wages above the minimum wage. They find that the decline in the real value of the minimum wage from 1979 to 1988 can account for most of the increase in the 50-10 log wage differential for both men and women and 17 to 25 percent of growth in the standard deviation of log hourly wages for men and 25 to 30 percent of the increase for women. The effects of the decline in the minimum wage on the college wage premium are somewhat more modest.

The interpretation of these minimum wage impacts depends on whether it is reasonable to assume a constant real minimum wage from 1979 to 1988 would imply a constant "bite" of the minimum wage. The erosion of the real and relative minimum in the 1980s could be a political response to changes in market force that reduced the relative shadow competitive wage of less-skilled workers and increased the adverse employment effects of minimum wage increases. The declining relative employment of workers with low-predicted wages in the 1980s [e.g., Juhn, Murphy and Topel (1991); Murphy and Topel (1997)] despite a declining minimum wage suggests other market forces were serving to reduce the labor market opportunities of low-wage workers. The strong correlations of a declining relative minimum wage with declining relative earnings of low-wage workers appear consistent with either direction of causation.

Lee (1998) attempts to address this issue by looking at cross-state differences in the impact of the Federal minimum wage given substantial differences in wage levels across U.S. states. Lee's approach also allows for spillover effects of the minimum wage on wages up to the median of the wage distribution. He uses state panel data and finds strong effects of the minimum wage (relative to the median wage) on lower part of state wage distributions both using cross-section (between state variation) and panel data models with state and year effects. Cross-state differences in the "effective minimum wage" and observed state wage distributions are used to estimate effect of changes in the minimum wage on wage distribution. The key identifying assumption is that the "underlying" dispersion in a state's wage distribution is orthogonal to the state's effective minimum wage. Low-wage states must not have inherently lower wage dispersion in the bottom half of the wage distribution than high-wage states for this approach to be valid (since the cross-state uniformity of the Federal minimum wage implies a higher effective minimum wage in low-wage states). Lee finds a strong relationship across states (especially in 1979) between the effective minimum wage and compression of the lower half of wage distribution, but little systematic relation with dispersion in the upper half suggesting no inherent differences in wage dispersion by state wage levels.

Lee's (1998) estimates using cross-state variation in the effective minimum to estimate how the effective minimum effects the lower half of state wage distributions implies essentially all of the increase in the 50-10 wage differential from 1979 to 1988 is driven by the decline in the effective Federal minimum wage. Furthermore the rise in the minimum wage from 1989 to 1991 is associated with a narrowing of wage dispersion in the lower half of the wage distribution. Lee concludes that the erosion of the minimum wage can account for much of the increase in residual wage inequality in the 1980s and a modest proportion of increases in educational wage differentials. Teulings (1998) finds even larger minimum wage impacts examining differences across four U.S. regions and allowing for minimum wage spillovers to spread throughout the wage distribution. The large magnitudes of spillover effects of the minimum wage in the studies of Lee (1998) and Teulings (1998) studies are important issues for further scrutiny as well as the possible impacts of alternative assumptions about employment effects of the minimum wage.

6.4 The SDI Model and Cross-Country Differences in Wage Structure Changes

The pattern of demand shifts for more-skilled workers appears relatively similar in advanced nations, but not all OECD nations have experienced sharp increases in wage dispersion and educational wage differentials similar to the United States since the end of the 1970s. Differences in the growth of relative skill supplies appear to be an important factor in cross-country differences. Decelerations in the growth in the relative supply of skills in the 1980s seem more pronounced in the countries with the largest expansions in educational wage differentials and overall wage inequality (the United States and the United Kingdom). Differences in labor market institutions among countries and changes in those institutions influenced the recent pattern of wage inequality changes among OECD countries [Freeman and Katz (1994, 1995)]. Countries where unions, employer federations, and government agencies play a larger role in wage determination had smaller increases in inequality than in the United States. The comparison of Canada and the United States is instructive since the labor market shocks from technology and trade are likely to have been fairly similar. Yet differences in the pattern of relative skill supply growth (a deceleration in the United States but not in Canada) and wage setting institutions (much greater deunionization in the United

States) appear to greatly account for larger increases in educational wage differentials and overall wage inequality in the United States ([Freeman and Needles (1993); DiNardo and Lemieux (1997)].

Countries with declining influences of wage setting institutions also tend to experience larger increases in wage inequality. For example, increased wage inequality appears to coincide with declining unionization in Britain in the 1980s, with Sweden's move from peak-level bargaining to more company- and industry-based settlement in the mid-1980s, with the ending of the greater government intervention in wage setting through the *scala mobile* in Italy in the early 1990s.

A key difficultly in the separation of the effect of supply and demand factors from those of institutional factors is the usual interpretation of institutional change as an outside force that affects labor market outcomes. But institutions are not immune to market forces. Shifts in supply and demand that raise relative wage differentials will reduce the strength of centralized collective bargaining and lower union influence on wage setting [e.g., Freeman and Gibbons (1995)]. Institutions that go strongly against market forces face a difficult task. The fact that unionization fell in most countries in the 1980s, when market forces appear to have favored greater inequality, may be no accident. Italy's dropping of the *scala mobile*, Sweden's move away from peak-level bargaining, and the 1980s' trend toward more plant- or firm-level arrangements in France partially reflect responses to a changing economic environment, not just random variations in modes of pay setting. A better understanding of the endogenous determinants of institutional changes is a crucial issue for future work on wage structure changes.

7. Conclusions

The existing research on changes in wage structures and earnings inequality suggest several directions for future research. In particular, researchers should consider the roles of changes in labor market institutions (the incidence of labor market rents) as well as changes in competitive supply and demand factors in assessing changes in the wage structure. A key issue in such analyses that use a full supply-demand-institutions model is how to model the effects of institutions on employment rates and composition as well as on wages. And the extent to which institutional changes reflect exogenous political events as opposed to responses to market forces is also a major factor to assess in any attempt to sort out the effects of institutions from supply and demand factors.

Analyses of wage structure changes also can benefit from taking somewhat of a longer-term historical perspective then just examining the most recent decade of data. For example, an analysis focusing on U.S. wage structure changes in the 1980s alone would conclude little effect of supply factors since groups with rising relative wages have rising relative supplies (the more-educated, older workers, women) indicating demand shifts are the driving force. An analysis of just the 1970s might find that demographic factors (the baby boom and a rising supply of college graduates) can explain rising experience differentials and narrowing educational wage differentials even with stable demand. But a consideration of a longer horizon might (e.g., the 1960s to the 1990s) actually indicates that relative supply shifts (e.g., the growth in the relative supply of college workers) actually slowed down in the 1980s and were exceptionally fast in the 1970s and that strong secular demand shifts favoring the more-educated a key element on any explanation. The importance of factors such as skill-biased technological change and globalization pressures in the 1980s and 1990s also look different went viewed through a longer-term perspective. Cross-country comparative work and differences across regions within a country may also provide useful variation in demand and supply shocks and institutional factors.

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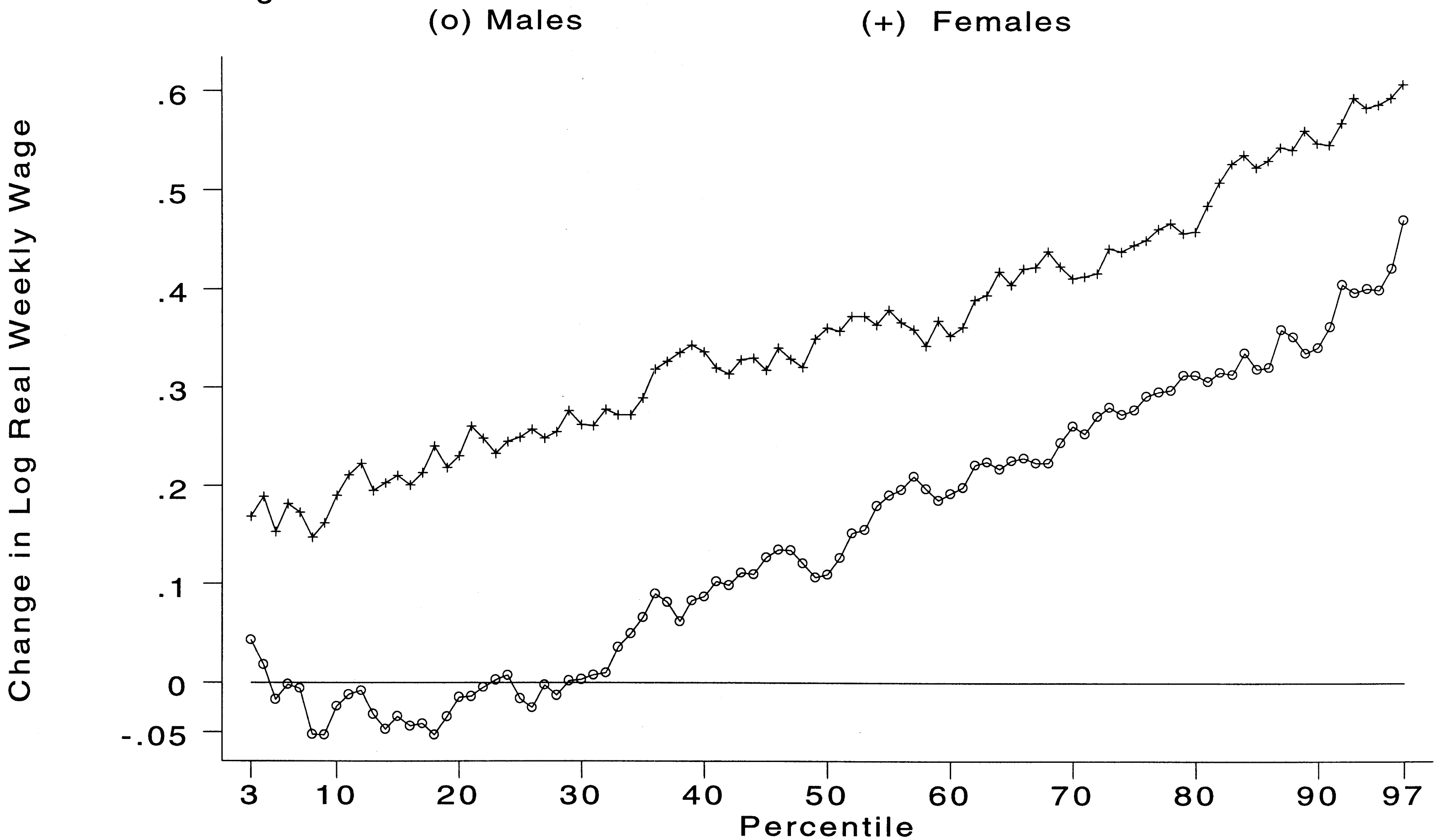
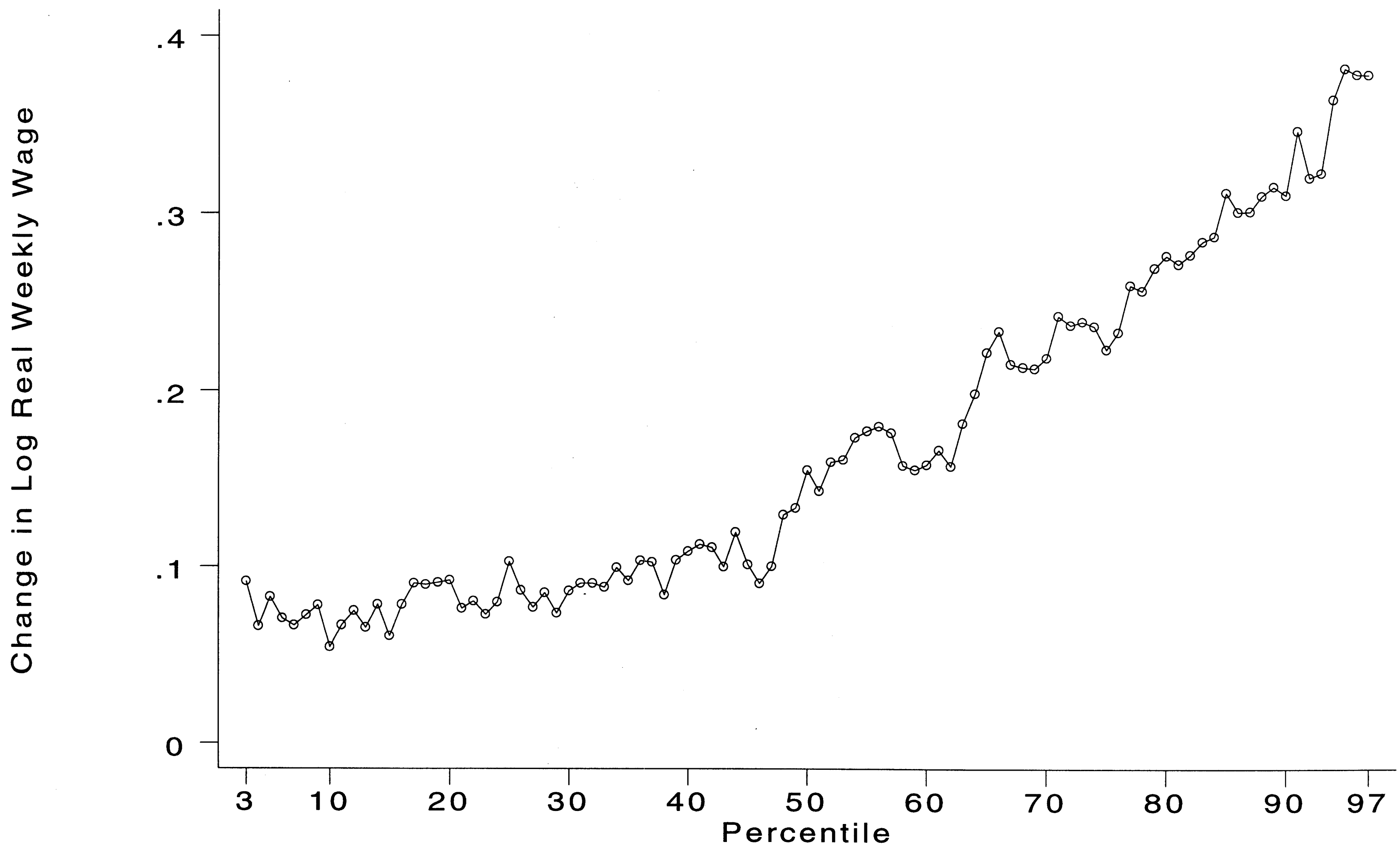
Figure 1



Change in Log Real Weekly Wage by Percentile, 1963-95

Figure 2: Change in Log Real Weekly Wage by Percentile,All,1963-95



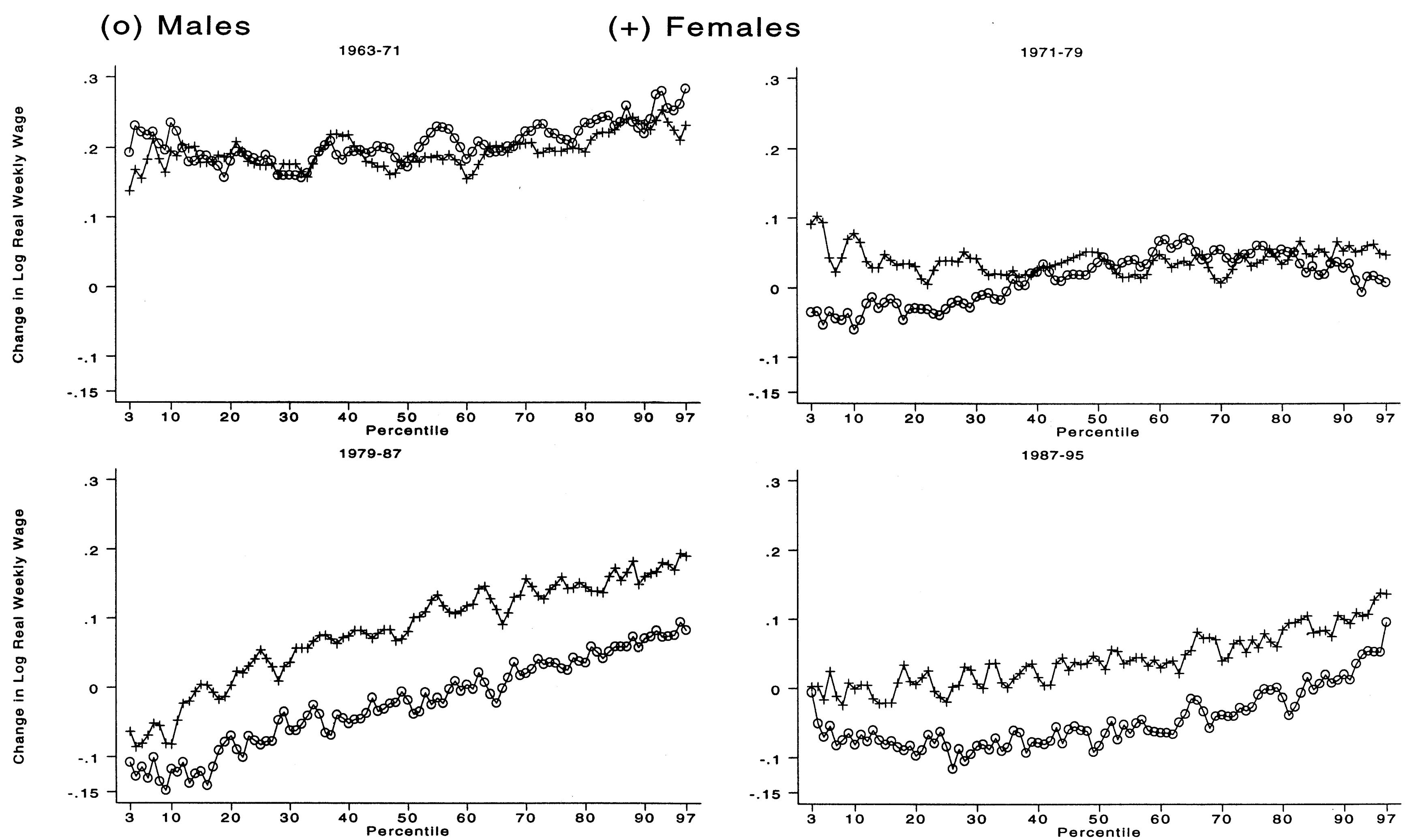


Figure 3: Change in Log Weekly Wage by Percentile

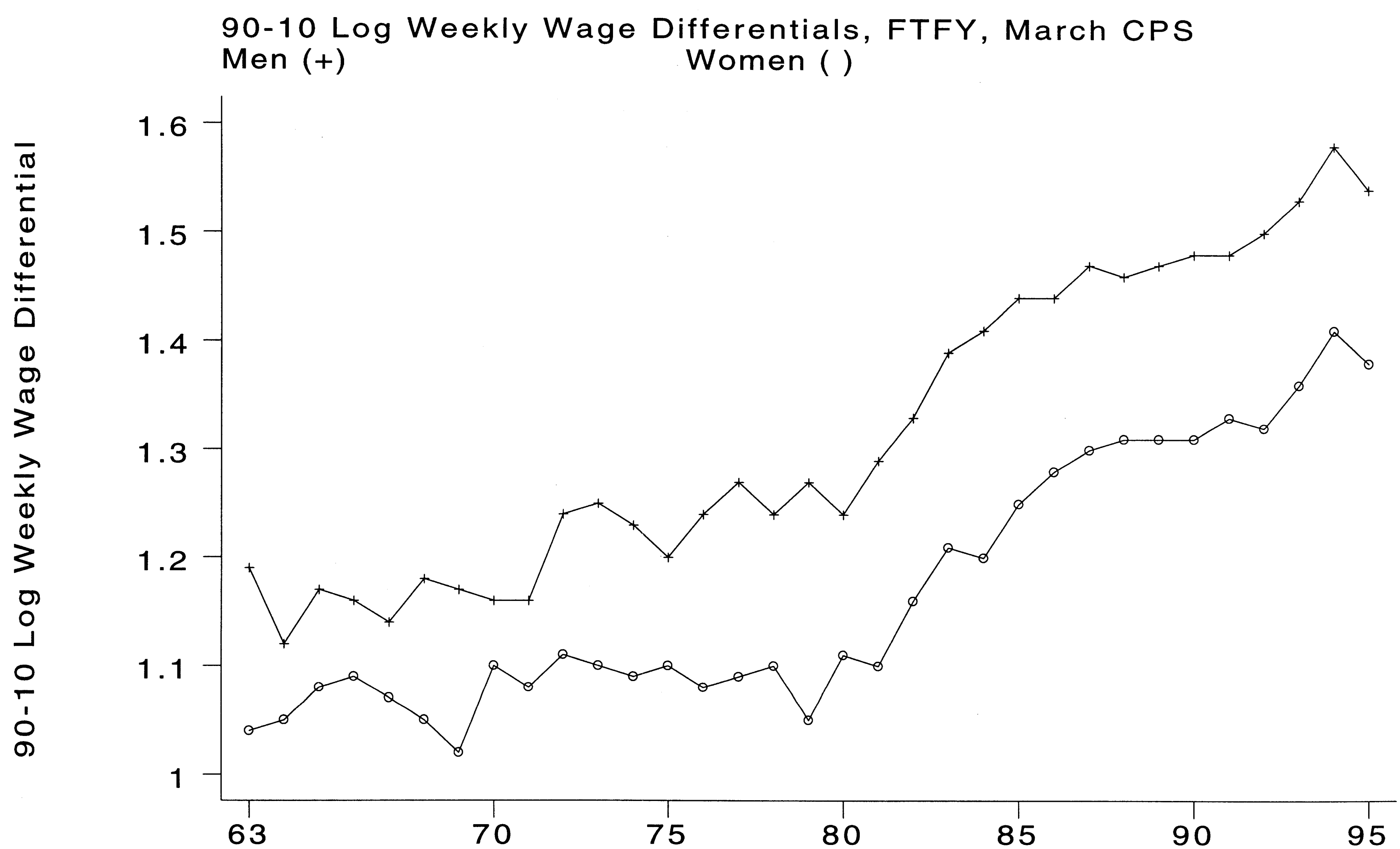
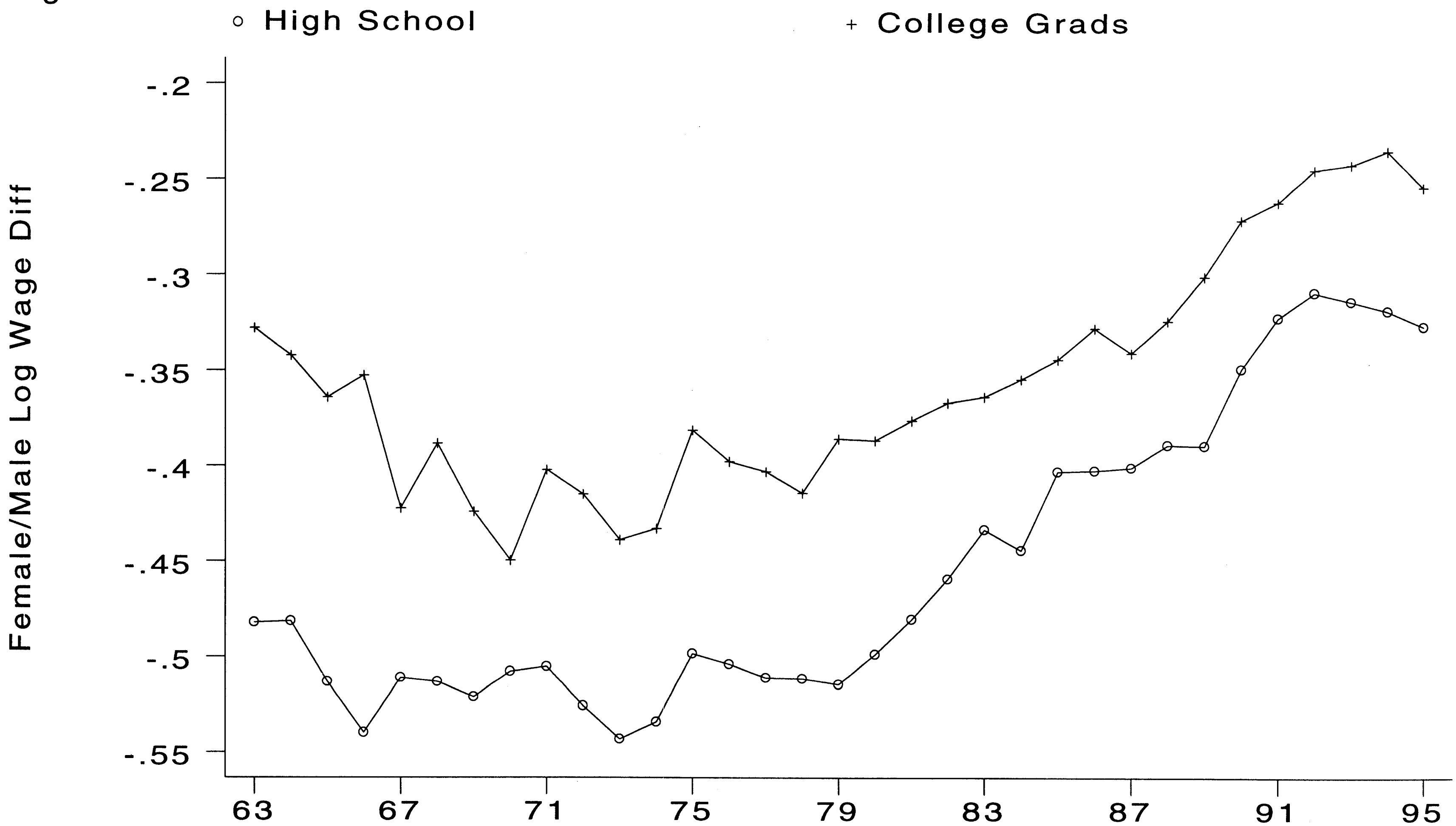


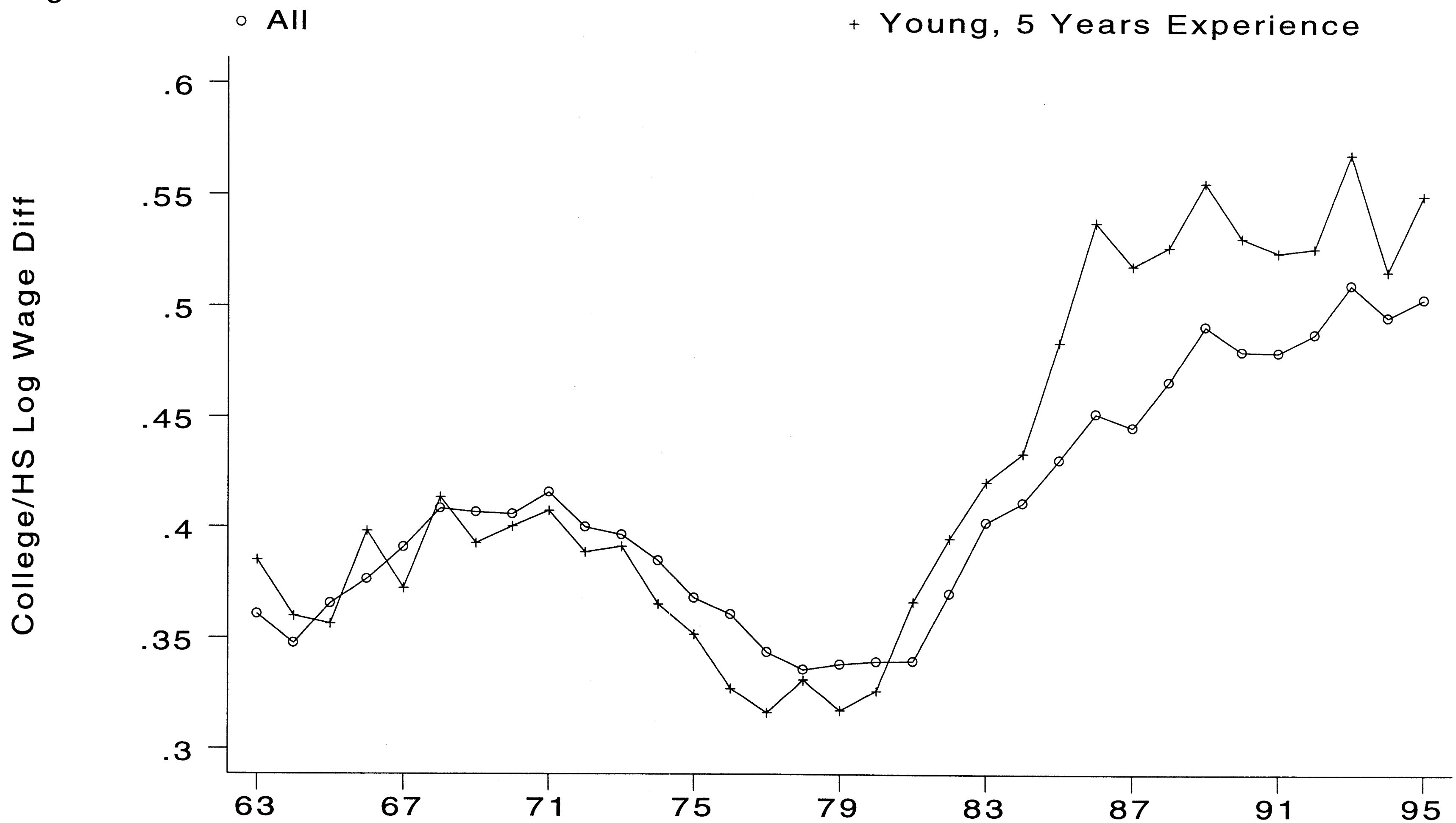
Figure 4: Overall U.S. Wage Inequality, 1963-95

Figure 5A



Female/Male Log Weekly Wage Differential, 1963-95

Figure 5B



College/HS Log Weekly Wage Differential, 1963-95

Figure 5C

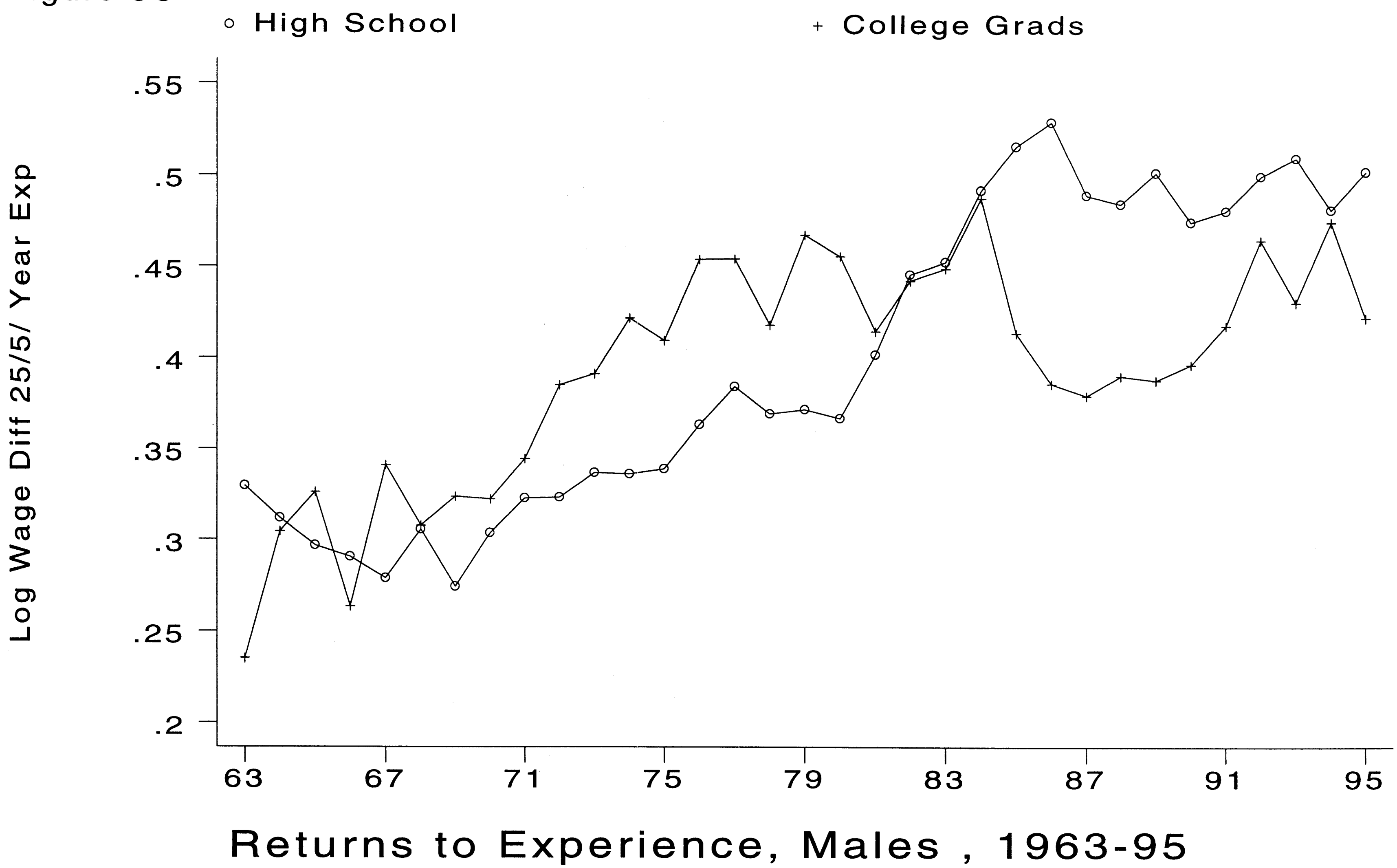

○ High School
+ College Grads
Log Wage Diff 25/5/ Year Exp
.55
.5
.45
.4
.35
.3
.25
.2
63
67
71
75
79
83
87
91
95
Returns to Experience, Males , 1963-95

Figure 5D

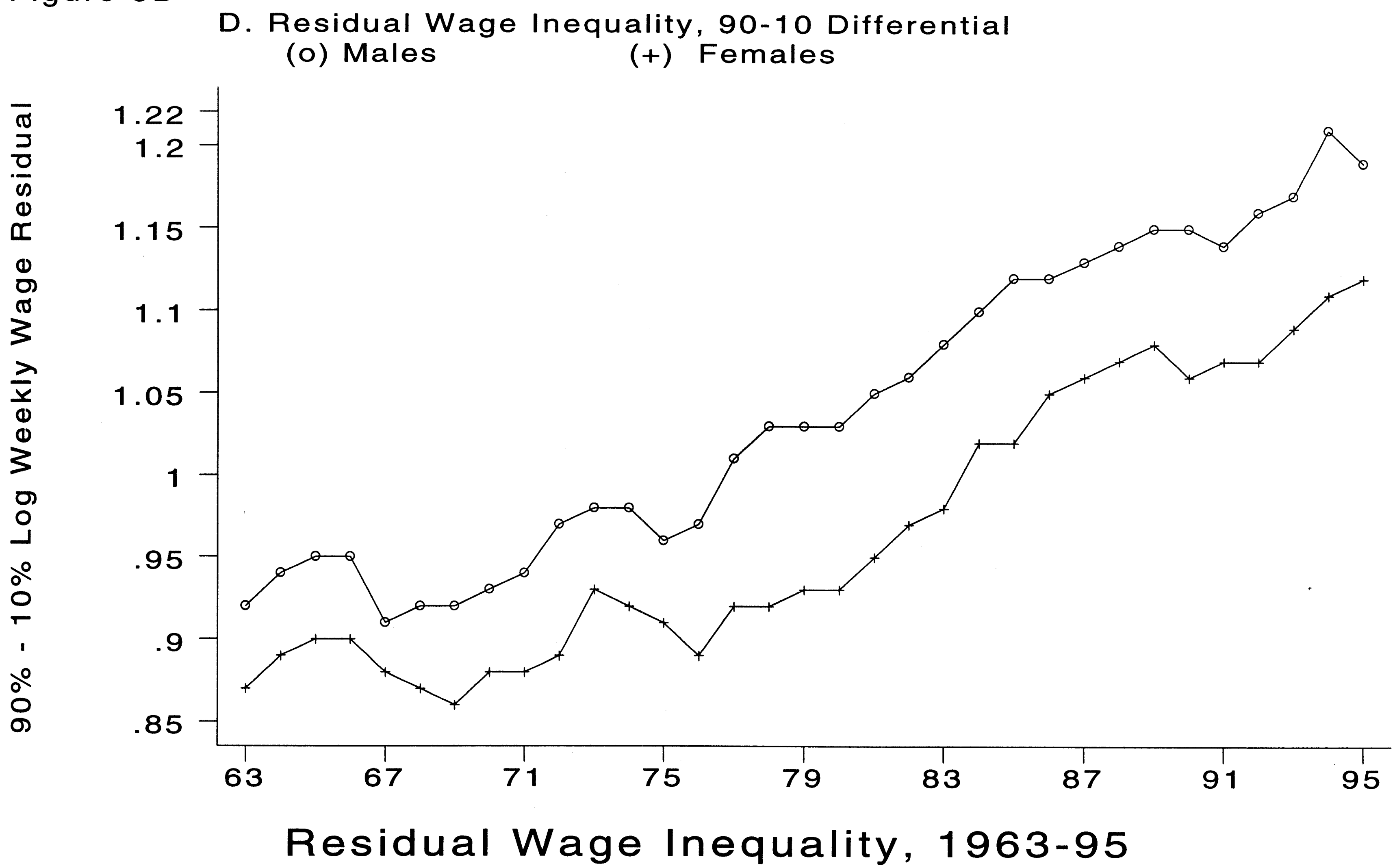

D. Residual Wage Inequality, 90-10 Differential
(o) Males
(+) Females
90% - 10% Log Weekly Wage Residual
1.22
1.2
1.15
1.1
1.05
1
.95
.9
.85
63
67
71
75
79
83
87
91
95
Residual Wage Inequality, 1963-95

Figure 6 : SDI Model

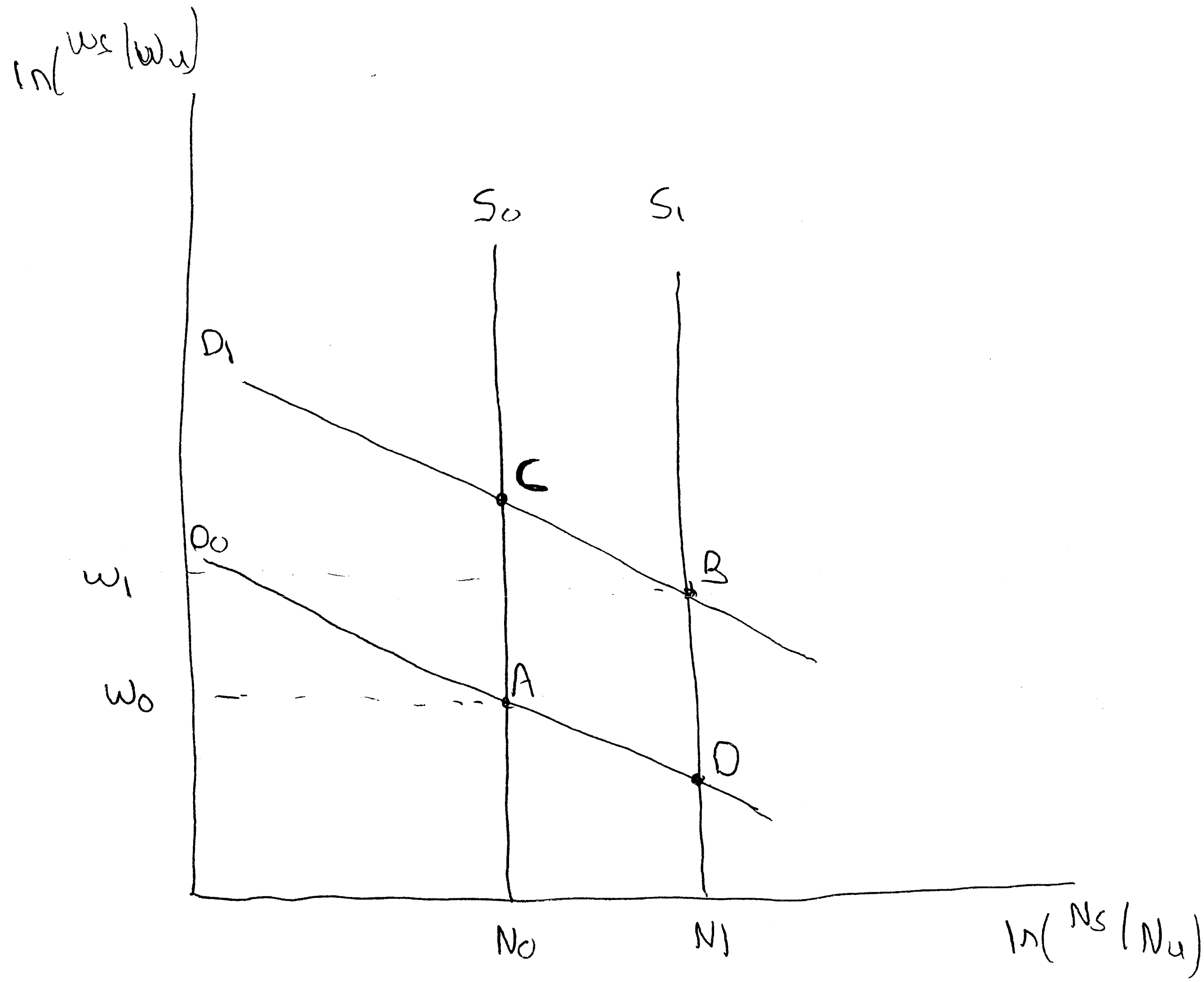


Figure 7: Price and Quantity Changes for 64 Groups, 1963-87
1963 - 1987

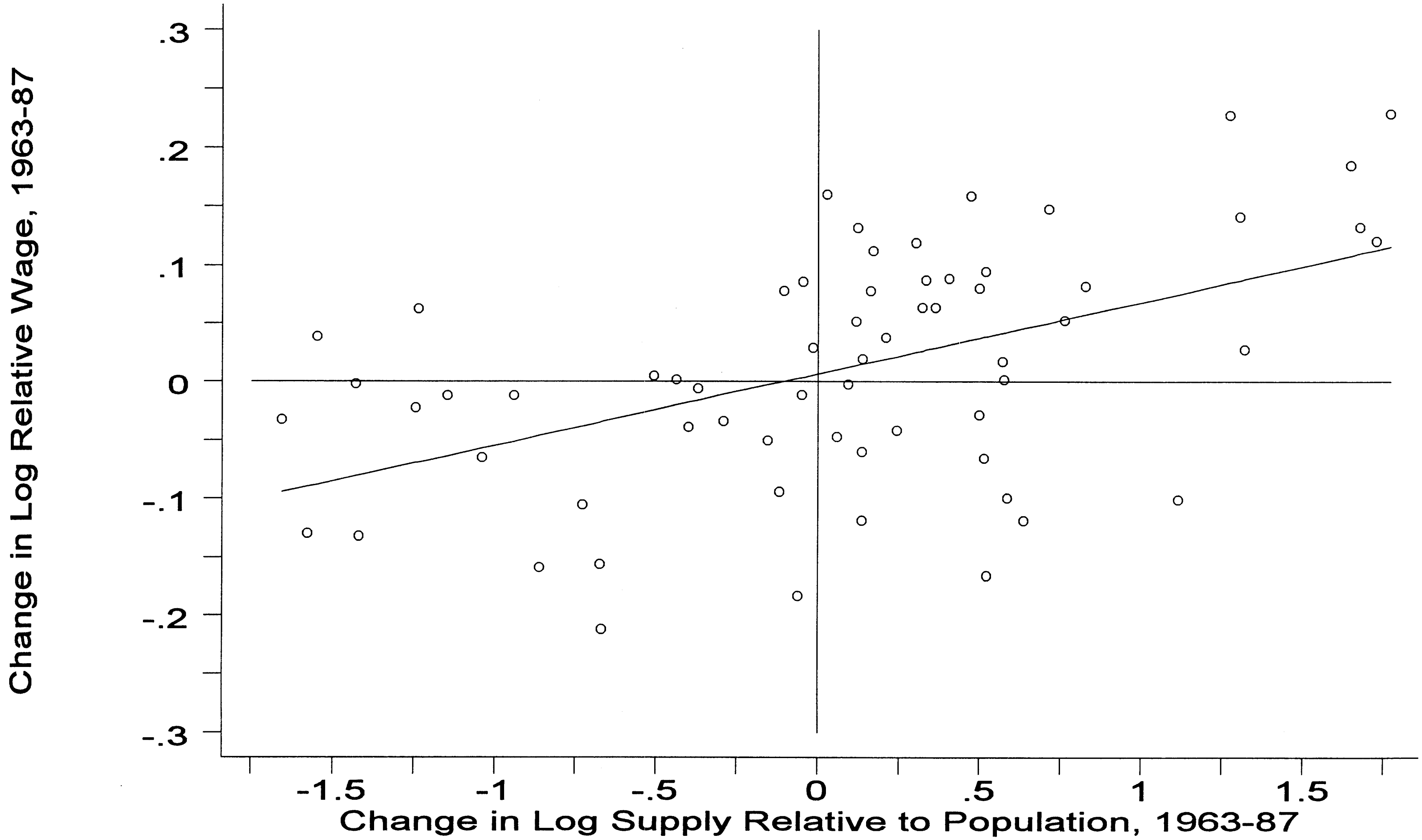


Figure 8

Actual vs. Predicted Log College Wage Premium
(o) Actual (+) Predicted

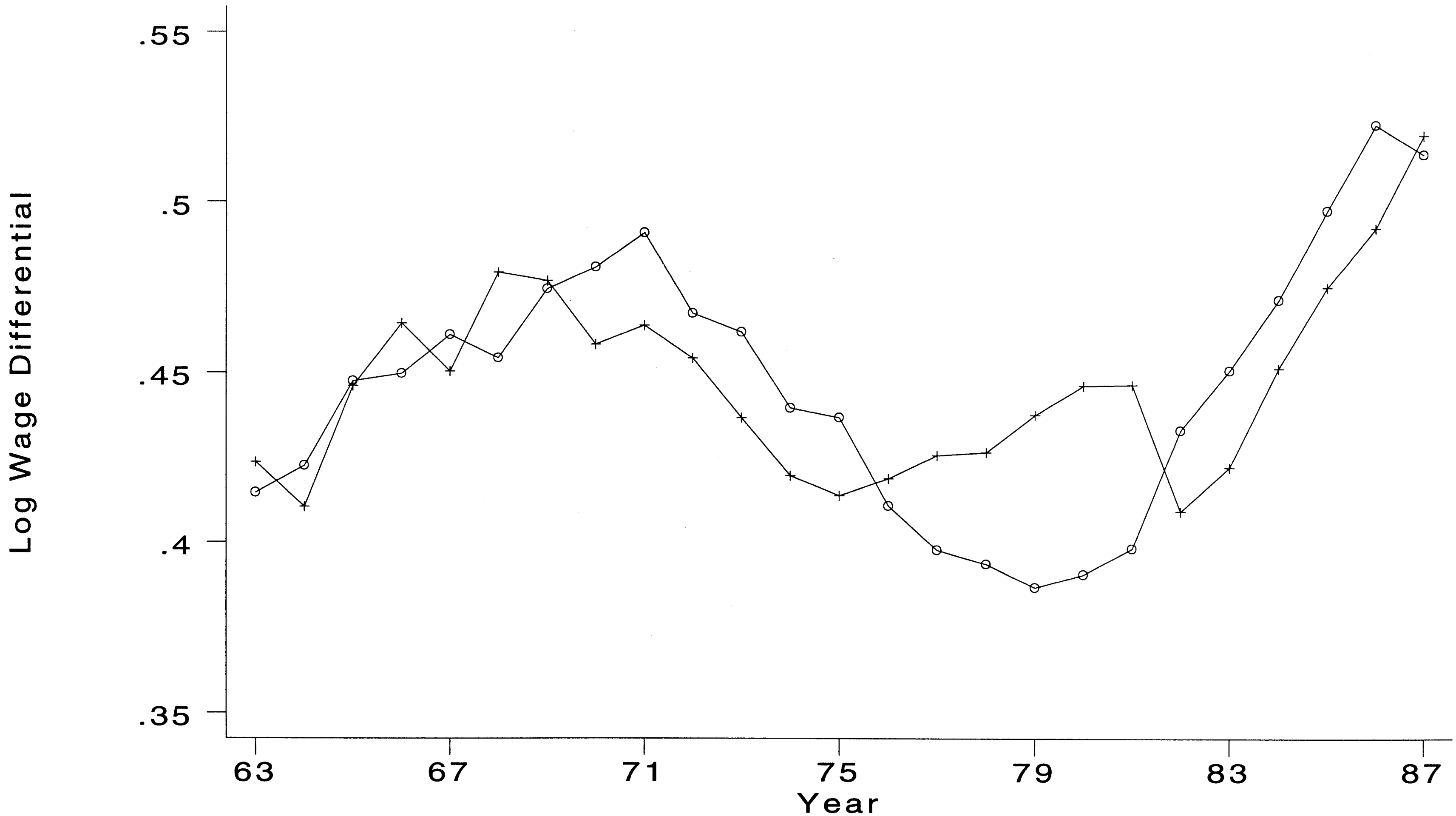


Table 1
Measures of Wage Inequality for Weekly Wages of Full-Time, Full-Year Workers
March CPS, 1963-95

	Standard Deviation of Log Wage	Percentiles of Log Wage Distribution 90-10	90-50	50-10	Gini Coefficient
A. Males					
1963	0.469	1.19	0.51	0.68	0.250
1971	0.495	1.16	0.55	0.61	0.270
1979	0.517	1.27	0.55	0.72	0.277
1987	0.579	1.47	0.65	0.82	0.313
1995	0.616	1.54	0.74	0.79	0.343
B. Females					
1963	0.406	1.04	0.50	0.54	0.223
1971	0.430	1.08	0.54	0.55	0.238
1979	0.432	1.05	0.54	0.51	0.243
1987	0.506	1.30	0.61	0.69	0.281
1995	0.544	1.38	0.68	0.70	0.304
C. All Males and Females					
1963	0.502	1.27	0.57	0.70	0.272
1971	0.530	1.31	0.62	0.68	0.293
1979	0.539	1.35	0.66	0.69	0.299
1987	0.580	1.44	0.70	0.74	0.320
1995	0.603	1.54	0.76	0.78	0.340

Table 2
U.S. Real Weekly Wage Changes for Full-Time, Full-Year Workers
March CPS, 1963-1995

	Change in Mean Log Real Weekly Wage (multiplied by 100)				
Group	**1963-71**	**1971-79**	**1979-87**	**1987-95**	**1963-95**
All	19.1	−1.4	−4.0	−7.2	6.6
Sex:					
Men	20.4	−2.1	−7.3	−10.1	0.9
Women	16.9	−0.1	1.5	−2.5	15.8
Education (years of schooling):					
0-11	15.6	1.6	−10.8	−9.4	−4.5
12	17.5	1.3	−6.3	−7.1	5.5
13-15	18.6	−1.9	−2.2	−10.2	4.4
16+	26.0	−7.1	5.3	−1.8	22.4
16-17	23.0	−7.4	3.9	−2.9	16.6
18+	32.3	−6.5	8.1	5.9	34.5
Experience (Men)					
5 years	19.9	−5.8	−9.7	−9.7	−5.3
25-35 years	20.1	1.4	−4.7	−10.5	6.4
Education and Experience					
Education 12					
Experience 5	19.1	−0.8	−18.3	−10.7	−10.7
Experience 25-35	16.8	4.5	−4.6	−6.6	10.1
Education 16+					
Experience 5	24.2	−12.7	7.8	−8.0	11.2
Experience 25-35	34.8	−0.3	3.5	−2.0	32.9

Table 2: continued

Notes: The numbers in the table represent changes in the (composition-adjusted) mean log wage for each group, using data on full-time, full-year workers from the March CPS covering calendar years 1963 to 1995. The data were sorted into sex-education-experience groups based on a breakdown of the data into 2 sexes, 8 education categories (0-8, 9, 10, 11, 12, 13-15, 16-17, and 18+ years), and 4 potential experience categories (1-10, 11-20, 21-30, and 31+ years). Log weekly wages of full-time, full-year workers were regressed in each year separately by sex on the dummy variables for the 8 education categories, a quartic in experience, 3 region dummies, black and other race dummies, and interactions of the experience quartic with 3 broad education categories (high school graduate, some college, and college plus). The (composition-adjusted) mean log wage for each of the 64 groups in a given years is the predicted log wage from these regressions evaluated for whites, living in the mean region based on the 1980 Census distribution of employment, at the relevant experience level (5, 15, 25 or 35 years depending on the experience group). Mean log wages for broader groups in each year represent weighted averages of the relevant (composition-adjusted) cell means using a fixed set of weights (the 1980 share of total hours worked from the 1980 Census PUMS). All earnings numbers are deflated by the chain-weighted (implicit) price deflator for personal consumption expenditures.

TABLE 3
Comparison of Annualized Changes in Educational Wage Differentials among CPS and Census Data Sources: 1959 - 1996
(10 * Annualized Log Changes)

	Males			Females			Males & Females		
	Clg-Plus/ High Schl	Some Clg/ High Schl	High Schl/ 9^{th} Grd	Clg-Plus/ High Schl	Some Clg/ High Schl	High Schl/ 9^{th} Grd	Clg-Plus/ High Schl	Some Clg/ High Schl	High Schl/ 9^{th} Grd
				A. Full-Time Weekly Earnings					
1960s									
March CPS	0.149	-0.006	0.032	0.047	0.069	0.020	0.127	0.015	0.027
Census PUMS	0.056	-0.003	0.018	0.071	0.021	0.008	0.063	0.005	0.018
1970s									
March CPS	-0.061	-0.029	0.043	-0.028	-0.028	-0.015	-0.053	-0.026	0.022
Census PUMS	-0.027	-0.017	0.029	-0.046	0.007	-0.014	-0.026	-0.008	0.016
May CPS	-0.073	-0.007	0.004	-0.144	-0.021	-0.050	-0.102	-0.012	-0.016
1980s									
March CPS	0.167	0.065	0.068	0.139	0.064	0.083	0.158	0.065	0.072
Census PUMS	0.159	0.060	0.032	0.159	0.064	0.035	0.159	0.060	0.033
CPS ORG	0.168	0.067	0.042	0.133	0.075	0.098	0.156	0.070	0.061
1990s									
March CPS	0.142	0.039	0.038	0.088	0.035	0.089	0.120	0.037	0.057
CPS ORG	0.109	-0.002	0.161	0.138	-0.012	0.056	0.122	-0.007	0.126
				B. All Hourly Earnings (Weighted by Hours Worked)					
1960s									
March CPS	0.116	-0.018	0.016	0.003	0.072	0.045	0.090	0.010	0.020
Census PUMS	0.063	-0.011	0.017	0.069	0.024	-0.011	0.071	0.001	0.008
1970s									
March CPS	-0.059	-0.032	0.007	-0.038	-0.008	-0.021	-0.045	-0.018	-0.007
Census PUMS	-0.039	-0.019	0.024	-0.105	-0.003	-0.021	-0.054	-0.011	0.009
May CPS	-0.055	0.001	-0.016	-0.119	-0.022	-0.076	-0.079	-0.007	-0.040
1980s									
March CPS	0.166	0.065	0.065	0.117	0.044	0.080	0.150	0.056	0.072
Census PUMS	0.144	0.054	0.035	0.135	0.059	0.027	0.144	0.057	0.031
CPS ORG	0.151	0.063	0.028	0.134	0.076	0.081	0.147	0.069	0.046
1990s									
March CPS	0.076	0.002	0.060	0.095	0.028	0.015	0.086	0.014	0.043
CPS ORG	0.093	-0.012	0.142	0.113	-0.015	0.055	0.102	-0.014	0.111

Table 3 notes:

Numbers above are 10 * annualized log changes in estimated log earnings differentials. Samples are: 1960s - March 1963-69 CPS and Census PUMS 1959-69; 1970s - March 1969-79 CPS, Census PUMS 1969-79, and May 1973-79 CPS; 1980s - March 1969-79 CPS, Census PUMs 1979-89, and CPS ORG 1979-89; 1990s - March 1989-95 CPS and CPS ORG 1989-96. All wage differentials are estimated using seperate cross-sectional log earnings regressionsin each sample and year that include 10 education category dummies corresponding to years of school or highest degree completed (0, 1-4, 5-6, 7-8, 9, 10, 11, some college, college graduate, post-college), a quartic in potential experience, a non-white dummy, a part-time dummy (if applicable), and three region dummies. Pooled-gender earnings regressions include a female dummy, and interactions between female and the experience quartic, part-time dummy, non-white dummy, and region dummies. All samples exclude allocated observations (except the May CPS), those whose earnings are below the lowest one-percent of earners in the full sample, and those whose hourly wage exceeds the top-coded value for full-time earners. March samples are limited to those earning at least 1/2 the real value of the 1982 minimum wage converted from nominal dollars using the PCE deflator. Hourly samples include both full- and part-time workers. Weekly earnings samples are limited to full-time workers and, in the March CPS and Census PUMS, those working 40-plus weeks. Sample weights are used in all estimates and are multiplied by weekly hours in hourly wage samples or, in Census hourly samples, by weeks worked in the previous year. Earnings are imputed for top-coded observations by multiplying the value of the top code by 1.5. The college-plus/high school differential is a weighted average of the exactly college/high school differential and the post-college/high school differential where the weights are the relative employment shares of those with exactly a college education and those with post-college education from the 1980 Census PUMS (for Census samples) and the 1980 CPS ORG (for CPS samples).

TABLE 4
Annualized Changes in Overall and Residual Inequality Measures: 1960 - 1996
(10 * Annualized Changes)

	Males						Females						Males & Females					
	Overall			*Residual*			*Overall*			*Residual*			*Overall*			*Residual*		
	90-10	50-10	Var	90-10	50-10	Var	90-10	50-10	Var	90-10	50-10	Var	90-10	50-10	Var	90-10	50-10	Var
A. Full-Time Weekly Earnings																		
1960s																		
March CPS	-0.03	-0.11	0.02	-0.01	-0.01	0.01	-0.03	-0.03	0.02	-0.02	-0.03	0.01	0.02	-0.03	0.03	-0.01	-0.02	0.01
Census PUMS	0.10	0.03	0.03	0.03	0.01	0.02	0.05	0.00	0.03	0.01	-0.03	0.02	0.07	-0.02	0.04	0.02	0.01	0.02
1970s																		
March CPS	0.10	0.11	0.03	0.11	0.08	0.03	0.03	-0.01	0.01	0.07	0.01	0.02	0.06	0.00	0.02	0.09	0.05	0.02
Census PUMS	0.10	0.11	0.05	0.09	0.05	0.04	-0.03	-0.11	-0.02	-0.03	-0.06	-0.02	0.07	0.02	0.02	0.05	0.01	0.01
May CPS	0.01	0.10	0.03	0.11	0.08	0.03	-0.12	-0.12	-0.02	0.01	-0.08	0.00	0.02	0.05	0.01	0.07	0.01	0.02
1980s																		
March CPS	0.20	0.09	0.08	0.12	0.06	0.05	0.25	0.16	0.08	0.15	0.10	0.05	0.14	0.09	0.05	0.13	0.07	0.04
Census PUMS	0.17	0.06	0.03	0.07	0.02	0.00	0.16	0.10	0.04	0.09	0.05	0.01	0.08	0.02	0.01	0.08	0.03	0.00
CPS ORG	0.26	0.10	0.09	0.15	0.08	0.05	0.30	0.19	0.08	0.18	0.12	0.05	0.17	0.08	0.06	0.16	0.10	0.05
1990s																		
March CPS	0.11	-0.03	0.05	0.07	0.03	0.02	0.12	0.04	0.05	0.07	-0.01	0.02	0.09	-0.01	0.03	0.07	0.01	0.02
CPS ORG	0.05	0.00	0.05	0.06	0.02	0.03	0.12	0.04	0.06	0.07	0.02	0.03	0.07	0.03	0.04	0.06	0.02	0.03
B. All Hourly Earnings (Weighted by Hours Worked)																		
1960s																		
March CPS	-0.01	-0.05	0.02	-0.01	-0.03	0.00	0.02	-0.01	0.00	-0.01	-0.02	0.00	0.04	-0.04	0.02	-0.02	-0.04	0.00
Census PUMS	0.04	-0.03	0.02	-0.01	-0.03	0.01	-0.01	-0.07	0.01	-0.01	-0.05	0.01	0.03	-0.03	0.02	-0.01	-0.03	0.01
1970s																		
March CPS	0.08	0.07	0.03	0.07	0.04	0.01	0.03	-0.03	0.01	0.05	0.00	0.01	0.04	-0.01	0.01	0.05	0.02	0.01
Census PUMS	0.08	0.05	0.04	0.05	0.03	0.02	-0.11	-0.12	-0.06	-0.09	-0.10	-0.05	0.02	-0.04	-0.01	0.00	-0.02	-0.01
May CPS	0.06	0.06	0.01	0.09	0.05	0.01	-0.11	-0.12	-0.03	-0.01	-0.08	-0.01	0.02	-0.04	-0.01	0.05	-0.01	0.00
1980s																		
March CPS	0.19	0.09	0.07	0.10	0.06	0.04	0.20	0.15	0.07	0.13	0.09	0.04	0.12	0.06	0.05	0.11	0.07	0.04
Census PUMS	0.14	0.05	0.03	0.07	0.02	0.00	0.17	0.11	0.03	0.10	0.07	0.00	0.10	0.06	0.01	0.08	0.04	0.00
CPS ORG	0.17	0.08	0.07	0.12	0.07	0.04	0.28	0.19	0.07	0.18	0.13	0.05	0.14	0.08	0.05	0.15	0.10	0.04
1990s																		
March CPS	0.12	0.00	0.04	0.05	-0.01	0.03	0.16	0.01	0.07	0.08	0.02	0.05	0.08	0.03	0.04	0.06	0.00	0.03
CPS ORG	0.07	-0.03	0.05	0.09	0.03	0.04	0.08	0.03	0.06	0.09	0.05	0.05	0.10	0.02	0.05	0.09	0.04	0.04

Table 4 notes:

Numbers above are 10 * annualized changes in earnings inequality metrics. See the notes to Table 3 for details on sample criteria and use of weights. Residuals are estimated from separate log earnings regressions in sample and year which include 9 education category dummies corresponding to years of school or highest degree completed (0, 1-4, 5-8, 9, 10, 11, some college, college graduate, post-college), a quartic in experience, and interactions between the experience quartic and dummies for less than high school, some college, and college or greater education. Pooled gender models also include a female dummy and interactions between female and the experience quartic and experience-education interaction terms.

Table 5
Between- and Within- Group Components of Changes in the Variance of Log Weekly Wages, Full-Time, Full-Year Workers, March CPS 1963-1995

	Changes in the Variance Components				
	Total Change	Between-Group Change	Within-Group Change	% Explained	% Residual
A. Males					
1963-95	.159	.067	.092	42	58
1963-79	.047	.014	.033	33	67
1979-95	.112	.053	.059	47	53
B. Females					
1963-95	.131	.048	.083	37	63
1963-79	.022	-.001	.023	-5	105
1979-95	.109	.049	.060	45	55
C. Males and Females					
1963-95	.111	.028	.083	25	75
1963-79	.037	.010	.027	27	73
1979-95	.074	.018	.056	24	76

The between-group components (predicted values) and within-group components (residuals) of the variance of log weekly wages are based upon separate regressions by sex in each year of log weekly wages on 8 education dummies, a quartic in experience, 3 region dummies, black and other race dummies, and interaction between the experience quartic and 3 broad education category dummies. The regressions for males and females combined include the same covariates, plus a female dummy, and interactions of the female dummy with all other covariates.

Table 6
Observable and Unobservable Components of Changes in the 90-10 Log Wage Differential
White Males, March CPS, 1964-1988

	Total Change	Observed Quantities	Observed Skill Returns	Unobservables
1964-88	.373	.035	.128	.208
1964-79	.165	.029	.014	.119
1979-88	.208	.006	.114	.089

Source: Juhn, Murphy, and Pierce (1993, Table 4).

Table 7
Variances of Permanent and Transitory Log Earnings, 1970-87

Sample Definition	Permanent Variance 1970-78	Permanent Variance 1979-87	Permanent Variance Change	Permanent Variance Percent Change	Transitory Variance 1970-78	Transitory Variance 1979-87	Transitory Variance Change	Transitory Variance Percent Change
Log Annual Earnings								
All	0.201	0.284	0.083	41	0.104	0.148	0.044	42
Years of Completed Education								
Fewer than 12	0.175	0.272	0.097	55	0.106	0.208	0.102	96
12 or more	0.161	0.216	0.055	34	0.081	0.123	0.042	52
16 or more	0.184	0.200	0.016	9	0.065	0.093	0.028	43
Log Weekly Earnings								
All	0.171	0.230	0.059	35	0.075	0.101	0.026	35

Source: Gottschalk and Moffitt (1994, Table 1).

Table 8
U.S. Wage Structure Changes, 1940-1990
Full-Time, Full-Year Non-Agricultural Workers
Census PUMSs

	Males 90-10 Diff.		Females 90-10 Diff.		All College/HS Diff.
Sample:	1%	MW	1%	MW	1%
1940	1.47	1.41	1.79	1.32	0.427
1950	1.00	1.00	1.10	1.06	0.303
1960	1.09	1.10	1.13	1.02	0.367
1970	1.18	1.16	1.18	1.02	0.409
1980	1.32	1.28	1.15	1.10	0.365
1990	1.48	1.52	1.30	1.33	0.501

Note: All estimates are for log weekly wages of full-time, full-year workers not employed in agriculture. The 1% sample deletes the lowest 1% of workers sorted by log weekly wage. The MW sample deletes all workers earning less than ½ of the contemporaneous Federal minimum wage. The college/high school wage differential is the (adjusted) differential in log weekly wages of workers with exactly 16 years of schooling (or only a bachelor's degree in 1990) to those with exactly 12 years of schooling in regression of log weekly wages on 8 education dummies, a quartic in experience, 3 region dummies, a non-white dummy, a female dummy, and interactions of the female dummy with all other covariates except the education dummies.

TABLE 9

Changes in Educational/Occupational Skill Differentials in Selected Countries

COUNTRIES THAT EXPERIENCED:	1970s	1980s
LARGE FALL IN DIFFERENTIALS	Australia Canada France Germany Italy Japan Netherlands Sweden South Korea United Kingdom United States	Korea
MODEST CHANGES IN DIFFERENTIALS		
MODEST FALL IN DIFFERENTIALS		Netherlands
NO NOTICEABLE CHANGE IN DIFFERENTIALS		France Germany Italy
MODEST RISE IN DIFFERENTIALS		Australia Canada Japan Sweden
A LARGE RISE IN DIFFERENTIALS		United Kingdom United States

SOURCE: Freeman and Katz (1994, 1995)

TABLE 10
Trends in Wage inequality for Males, Selected OECD countries, 1979 to 1994[a]

Log of ratio of wage of 90th percentile earner to 10th percentile earner

Country	1979	1984	1989	1994	Change from earliest to latest year
Australia	1.01	1.01	1.03	1.08	0.07
Austria[b]	0.97		1.00		0.03
Canada[c]	1.24	1.39	1.38	1.33	0.09
Finland[d]	0.89	0.92	0.96	0.93	0.04
France	1.22	1.20	1.25	1.23	0.01
Germany[e]		0.87	0.83	0.81	-0.06
Italy	0.83	0.83	0.77	0.97	0.14
Japan	0.95	1.02	1.05	1.02	0.07
Netherlands[f]		0.92	0.96	0.95	0.03
New Zealand[g]		1.00	1.12	1.15	0.15
Norway[h]	0.72	0.72	0.77	0.68	-0.04
Sweden[i]	0.75	0.71	0.77	0.79	0.04
United Kingdom	0.90	1.02	1.12	1.17	0.27
United States	1.16	1.30	1.38	1.45	0.29

SOURCE: OECD (1996), Table 3.1, pp. 61-62.

NOTES:

[a] The samples generally consist of full-time workers, with the exceptions of Austria, Italy, and Japan. See OECD (1996, pp. 100-103) for details on the samples and earnings measures.

[b] Data for Austria in the 1979 column are for 1980.
[c] Data for Canada are for 1980, 1986, 1990, and 1994
[d] Data for Finland are for 1980, 1983, 1989, and 1994.
[e] Data for Germany are for 1983, 1989, and 1993.
[f] Data for the Netherlands are for 1985, 1989, and 1994.
[g] Data for New Zealand are for 1984, 1990, and 1994.
[h] Data for Norway are for 1980, 1983, 1987, and 1991.
[i] Data for Sweden are for 1980, 1984, 1989, and 1993.

Table 11
U.S. Relative Supply Changes, 1963-1987

Group	Change in log share of aggregate labor input (multiplied by 100)			
	1963-71	1971-79	1979-87	1963-87
Gender:				
Men	-2.9	-4.9	-4.2	-12.0
Women	11.2	15.7	11.2	38.2
Education (years of schooling):				
8-11	-35.2	-48.6	-41.9	-125.7
12	7.6	-4.8	-4.8	-2.0
13-15	20.3	23.3	6.7	50.3
16+	17.8	24.1	15.6	57.5
Experience (men):				
1-5 years	30.3	16.3	-27.9	18.6
6-10 years	14.2	19.5	-10.4	23.4
11-15 years	-4.3	6.9	17.5	20.1
16-20 years	-17.8	-6.6	22.7	-1.7
21-25 years	-15.5	-16.9	0.0	-32.3
26-35 years	-5.5	-23.8	-17.4	-46.7
Education 12				
Experience 1-5	16.2	18.7	-40.9	-6.0
Experience 26-35	4.0	-26.9	-10.9	-33.8
Education 16+				
Experience 1-5	52.7	17.1	-12.7	57.1
Experience 26-35	19.8	18.9	-5.8	32.9

Notes: The numbers in the table represent log changes in each group's share of total labor supply measured in efficiency unites (annual hours times the average relative wage of the group for the 1963-1987 period) using data from the March Current Population Surveys for 1964-1988.

Source: Katz and Murphy (1992, Table 2)

Table 12
Educational Composition of Employment
and the College+/High School Wage Premium, 1940-1996

	Full-Time Equivalent Employment Shares by Education Level (in percent)				
	High School Dropouts	**High School Graduates**	**Some College**	**College Graduates**	**Log College+/ HS Wage**
1940 Census	67.9	19.2	6.5	6.4	.498
1950 Census	58.6	24.4	9.2	7.8	.313
1960 Census	49.5	27.7	12.2	10.6	.396
1970 Census	35.9	34.7	15.6	13.8	.465
1980 Census	20.7	36.1	22.8	20.4	.391
1980 CPS ORG	19.1	38.0	22.0	20.9	.356
1990 CPS ORG	12.7	36.2	25.1	26.1	.508
1990 Census	11.4	33.0	30.2	25.4	.549
Feb. 90 CPS	11.5	36.8	25.2	26.5	.533
1996 CPS ORG	9.4	33.4	28.9	28.3	.557

Source: Autor, Katz, and Krueger (1998, Table 1).

Table 13
College/High School Relative Wage and Quantity Movements, 1963-1987

	Log Change (multipied by 100)			
	1963-71	**1971-79**	**1979-87**	**1963-87**
College/High School Weekly Wage Ratio	7.7	-10.4	12.8	10.0
Relative Supply of College to High School Equivalents	31.4	40.8	25.5	97.6

Source: Katz and Murphy (1992, Table 8).

Table 14
College Equivalent Wage-Bill Shares, Supply and Demand Shifts, 1940-1996

A. Changes in College-Plus/Non-College Log Relative Wages, Wage Bill, and Supply (100 * Annual Log Changes)

		College Equivalents	
	Relative Wage	Relative Wage Bill	Relative Supply Change
1940-1950	-1.86	0.50	2.35
1950-1960	0.83	3.75	2.91
1960-1970	0.69	3.25	2.55
1970-1980	-0.74	4.25	4.99
1980-1990	1.51	4.05	2.53
1990-1996	0.40	2.81	2.41

B. Impllied Relative Demand Shifts Favoring College-Equivalents (100 * Annual Log Changes)

	College Equivalents		
	$\sigma=1$	$\sigma=1.4$	$\sigma=2$
1940-1950	0.50	-0.25	-1.36
1950-1960	3.75	4.08	4.58
1960-1970	3.25	3.52	3.94
1970-1980	4.25	3.95	3.50
1980-1990	4.05	4.65	5.56
1990-1996	2.81	2.97	3.21

Source: Autor, Katz, and Krueger (1998, Table 2).

Table 15
U.S. Employment Shares and Percentage College Labor by Industry

	Employment Shares			Percentage College Labor		
Industry	**1968**	**1988**	**Percent Change 1968-88**	**1968**	**1988**	**Percent Change 1968-88**
Agriculture and Mining	4.8	3.3	-32.5	12.7	29.4	16.7
Construction	6.8	7.1	5.1	12.5	22.2	9.8
Low-Skill Manufacturing	4.4	2.7	-39.5	9.4	17.1	7.7
Medium-Skill Manufacturing	13.0	8.0	-38.1	14.8	25.9	11.1
High-Skill Manufacturing	13.1	10.3	-21.6	27.7	44.8	17.0
Transportation and Utilities	7.6	7.3	-3.9	15.4	34.9	19.5
Wholesale	3.9	4.6	15.4	26.7	41.8	15.0
Retail	11.8	12.2	3.5	15.7	29.9	14.2
Professional and Financial	13.5	22.3	65.2	42.8	58.8	15.9
Education and Welfare	9.0	10.3	13.9	73.1	75.8	2.7
Government	7.1	6.8	-4.4	30.8	50.7	19.9
Other Services	5.0	5.3	5.3	12.8	27.7	14.9
All Industries	100.0	100.0	0.0	26.7	43.6	16.9

Notes: All quantities refer to fixed-wage weighted aggregates of annual hours across experience, sex, and education. Industry shares refer to the percentage of aggregate fixed-wage weighted labor hours employed in the industry. The percentage college labor refers to the percent of fixed wage weighted labor accounted for by the college wage aggregate. See Murphy and Welch (1993b) for details of the aggregation scheme.

Source: Murphy and Welch (1993b, Table 3.4)