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The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005

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ABSTRACT

U.S. educational and occupational wage differentials were exceptionally high at the dawn of the twentieth century and then decreased in several stages over the next eight decades. But starting in the early 1980s the labor market premium to skill rose sharply and by 2005 the college wage premium was back at its 1915 level. The twentieth century contains two inequality tales: one declining and one rising. We use a supply-demand-institutions framework to understand the factors that produced these changes from 1890 to 2005. We find that strong secular growth in the relative demand for more educated workers combined with fluctuations in the growth of relative skill supplies go far to explain the long-run evolution of U.S. educational wage differentials. An increase in the rate of growth of the relative supply of skills associated with the high school movement starting around 1910 played a key role in narrowing educational wage differentials from 1915 to 1980. The slowdown in the growth of the relative supply of college workers starting around 1980 was a major reason for the surge in the college wage premium from 1980 to 2005. Institutional factors were important at various junctures, especially during the 1940s and the late 1970s.

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Chapter 8: *The Race between Education and Technology*

A. Two Tales of the Twentieth Century

1. The "best poor man's country"

In the late eighteenth century America was deemed the "best poor man's country."[1] Land was plentiful, farming provided ample living standards, and wealth was rather equally distributed. But a century later much had changed. As James Bryce remarked in the late 1880s: "sixty years ago [in the time of de Tocqueville] there were no great fortunes in America, few large fortunes, no poverty. Now there is some poverty, many large fortunes, and a greater number of gigantic fortunes than in any other country of the world" (Bryce 1889, p. 600).[2] Bryce was clearly wrong that poverty did not exist in the 1830s.[3] But he was correct that wealth inequality had increased.

Living standards were considerably higher in 1890 than in 1790, but economic inequality had greatly expanded. Although the full distribution of income is hard to pin down before 1940, wealth had become far less equal by 1870 and considerably unequal by the 1920s and the very top of the income distribution was relatively richer in 1913 than at almost any time since.[4] Around the turn of the twentieth century earnings in occupations that required greater levels of schooling were far higher than those that required far less education (see Chapter 2). The economic return to a year of high school or college around 1915 was enormously high and only recently has the college premium approximated its value in 1915. We do not know precisely when in the preceding century the premium to schooling increased and whether it was as high even in 1850, but we do know that by 1900 a year of high school or college was an extremely good investment.

The large premium that accrued to those employed in occupations having substantial educational requirements was observed and commented on by close contemporaries in the early twentieth century. The economist Paul Douglas, for one, noted that "during the nineties [1890s], the clerical class constituted something of a *non-competing group*."[5] Douglas's interest in the wage distribution was sparked by a great wage compression that was apparent by the early 1920s. The astonishing change that took place in his own time prompted his comment: "Gradually the former monopolistic advantages are being squeezed out of white-collar work, and

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[1] The phrase "the best poor man's country" was initially used in the eighteenth century to describe economic conditions in Pennsylvania but was later used to describe the entire northern part of America. See Lemon (1972, p. 229, fn. 1) who took the title of his book on the early history of southeastern Pennsylvania, *The Best Poor Man's Country*, from several contemporary comments about the region. The ideas are similar to those in Tocqueville's *Democracy in America* (1981, orig. publ. 1832).

[2] In his two volume treatise, *The American Commonwealth* (1889), Bryce often commented on Tocqueville's observations.

[3] For example, Bryce considered neither slavery nor the urban poor.

[4] On the trend in the wealth distribution from 1776 to the 1920s (1776, 1850, 1860, 1870, and 1920s), see Wolff (1995) and the compilation of wealth data in Nasar (*New York Times*, August 16, 1992). Piketty and Saez (2003, 2006) contain data on the incomes of the top 1 percent of the distribution from 1913, the beginning of the U.S. income tax, to the early 2000s and for the top 10 percent from 1916.

[5] Douglas (1930, p. 367, italics added).

eventually there will be no surplus left."[6]

According to Douglas several factors acted in concert to compress wages beginning in the late 1910s and early 1920s. One was the deskilling of clerical workers through the substitution of office machinery for skill. Another was the reduction in the flow of immigration, which according to Douglas led to an increase in the earnings of the less educated. Finally, the supply of educated and trained workers qualified to assume various white-collar positions greatly increased thereby depressing their earnings.

Douglas was correct that multiple factors were at work. But the relative increase in the supply of skilled and educated personnel was of far greater importance, we shall soon demonstrate, than were skill reducing factors on the demand side and also more important than the decrease in immigration. The possibility that deskilling led to the large decrease in the relative earnings of the more educated was laid to rest in Chapter 2 when we showed the similarity of wage changes among clerical occupations. Earnings in white-collar occupations that did not undergo much technical change were reduced almost as much as in those that did.

The wage structure began to collapse a short time before 1920 and continued to narrow in various ways until the early 1950s. Earnings of the more educated were reduced relative to the less educated. Those employed in skilled occupations saw their earnings increase less than did those in the lower-skilled jobs. In fact, the wages of every skilled and professional group for which we could uncover consistent time series data declined relative to the wages for lesser skilled workers during first half of the twentieth century. In Chapter 2 we presented relative wage series for professors of all ranks, engineers, office and clerical workers, and craft positions. There was also a substantial compression in the wage distribution of production workers within each of a large group of manufacturing industries. The returns to a year of schooling, not surprisingly, plummeted from 1915 to the early 1950s.[7] The returns to schooling were so high prior to the narrowing that even after the decline in the wage premium education remained a very good investment.

Inequality and the pecuniary returns to education were both exceptionally high at the beginning of the twentieth century. Yet America remained the "best poor man's country" because it had a considerably higher average income than did other nations, as well as an open educational system and more equality of opportunity than existed in Europe.[8] Certain groups, in particular African Americans living in the U.S. South, remained left out for some time. But even they gained access to improved schooling during the mid-twentieth century and moved into higher paying jobs in the 1960s.

2. Integrating the two tales of the twentieth century

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[6] Douglas (1926, p. 719). Paul Douglas was born in 1892 and would have been in his mid-twenties just as the returns to various skills began to be reduced and the wage distribution started to narrow. He was 34 years old when he wrote about the "non-competing" groups that had previously existed.

[7] Our estimates of the decrease in the pecuniary returns to a year of education are robust to the level of schooling as well as to the age and sex of the individuals.

[8] Long and Ferrie (2007) find that intergenerational mobility in the United States was higher than that in Britain in the nineteenth and early twentieth centuries but that it is fairly similar in more recent decades.

By the early 1970s one could say that America "had it all." The U.S. economy had grown at a record pace in the 1960s, when labor productivity expanded at 2.75 percent average annually.[9] The nation's economy was strong. The wage structure widened only slightly from the late 1940s and the income distribution had remained remarkably stable. Americans were sharing relatively equally in prosperity regardless of their position in the income distribution. Recall from Figures 2 and 3 of Chapter 2 that the America economy grew rapidly and its people "grew together" from 1947 to 1973.

Each generation of Americans achieved a level of education that greatly exceeded that of the previous one with typical adults having considerably more years of schooling than their parents. Racial and regional differences in educational resources, educational attainment, and economic outcomes had narrowed substantially since the early twentieth century.[10] Upward mobility with regard to education characterized American society.

But the American economy did not stay the course. Inequality soared from the late-1970s to the early 2000s. Productivity did not continue to advance at the rate it once had, slowing considerably in the mid-1970s and remaining low for about two decades. Although productivity growth eventually resumed its previous rate, rising inequality magnified the impact of the sluggish economy on the vast majority of Americans.

The full twentieth century, therefore, contains two inequality tales—the first tale is one of narrowing differences whereas the second is one of widening differences. These tales can be clearly observed in the almost century-long series for two key components of wage inequality in Figure 1: the college graduate wage premium (relative to those who stopped at high school) and the high school graduate wage premium (relative to those who left school at eighth grade) both from 1915 to 2005. Although it would be best to have the complete income and wage distribution for the entire period, these data do not exist for the pre-1940 period. The returns to education, however, can be analyzed in a consistent manner for the period from 1915 to 2005.

The returns to education and other components of wage inequality do not always move in lock step. But from 1940 to 2005 changes in the wage structure were closely correlated with changes in the premium to college (see Figure 6, Chapter 2, for the college premium and the 90-10 log wage differential). Furthermore, in recent decades the lion's share of rising wage inequality can be traced to an increase in educational wage differentials.[11] We feel confident that

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[9] Growth is given by productivity trends using output per hour in the non-farm business sector from the U.S. Bureau of Labor Statistics (series PRS85006093 from http://www.bls.gov/lpc/home.htm).

[10] The black-white schooling completion gap narrowed from 3.84 years for those born in 1885 (25 years old in 1910) to 1.35 years for those born in 1945 (25 years old in 1970), based on tabulations from the 1940 and 1970 IPUMS. The cross-state standard deviation of mean years of schooling narrowed from 1.60 years for those born in 1885 to 0.62 years for those born in 1945. On the evolution of racial and regional differences in school resources, see Card and Krueger (1992a, 1992b) and Margo (1990); on regional income convergence, see Barro and Sala-i-Martin (1991); and on racial income convergence, see Donohue and Heckman (1991).

[11] Goldin and Katz (2007) find that 65 percent of the growth of overall wage inequality (using the variance of log hourly wages) from 1980 to 2005 for men and women combined can be accounted for by

changes in the premium to education are reasonable proxies to those for wage inequality during the 90 year period we explore.

The college wage premium reveals a sharp decline from 1915 to 1950, jaggedness from 1950 to 1980, and a rapid increase after 1980. The premium to a college education came full circle in the twentieth century and by 2005 had returned to its high water mark at the beginning of the high school movement in 1915. The wage premium for high school graduates shows an equally sharp decrease in the pre-1950 era but less of an increase during the rest of the century.

3. The race

Why did education returns fall in the first half of the twentieth century but rise at the end of the second half? That is the central question we address in this chapter. We analyze changes in the returns to education using the conceptual framework of a race between education (the supply of skill) and skill-biased technological change (the demand for skill).

We use direct evidence on changes in the stock of skill among the U.S. workforce and infer changes regarding skill-biased technological change. That is, we do not use direct evidence on skill-biased technological change but deduce it from estimates of changes in the relative demand for skill. These relative demand change estimates are derived from relative wages by education, relative supply shifts by education, and our estimates of the elasticity of substitution between the education groups. Chapter 3 documented detailed historical evidence of the importance of skill-biased technological change in the evolution of employment opportunities. The evidence includes strong positive relationships throughout the last century between the utilization of new and more capital-intensive technologies and the employment of more highly-educated workers. These findings make us confident that our estimated changes in the relative skill demands are substantially driven by skill-biased technological change.

The concept of a highly-educated worker changed across the period we analyze. A college graduate or possibly one with a post-graduate degree is considered highly educated today. In 1915, however, a high school graduate would have been deemed well educated. For that reason we will use two definitions of a more-educated worker in our analysis, focusing on the college premium for most of the century and the high school premium for the first half.

In the race between technological change and education, we will show that education ran faster during the first half of the century and technology sprinted ahead of limping education in the last 30 years. The race produced economic expansion and also determined which groups received the fruits of growth.

But which of the two factors caused inequality to decline and then to rise? Technological change and an increased demand for skilled and educated workers were common to both periods. There were periods of more rapid increase and some of slower increase. But, by and large, the

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the expansion of educational wage differentials, especially the rise in returns to post-secondary schooling. Lemieux (2006) similarly concludes that increased returns to post-secondary schooling can explain 55 percent of the rise in male hourly wage inequality from 1973 to 2005.

growth rate of the demand for more educated relative to less educated labor was fairly constant over the 1915 to 2005 period.

The major difference across the period was not changes in demand but in supply. Shifts in the rate of growth in the supply of educated labor played a critical role in altering inequality trends. Furthermore, changes in the supply of educated native-born workers have been considerably more important than changes in the stock of immigrants to the overall supply of skill. That is, changes in home-grown education supply have been the most important factor in changing the overall supply of educated Americans. Changes in labor market institutions that have tended to shelter the earnings of low- and middle-wage workers from market forces were key factors during several sub-periods, but most of the variation in educational wage differentials can be well explained by a simple supply and demand framework.

We are now ready to offer a fuller analysis of inequality trends in the twentieth century and decompose the change in relative wages by education for the 1915 to 2005 period into its sources. To do so, we construct a framework that contains factors operating on the supply side and the demand side, with changes in wage setting institutions inserted during periods that cannot be fully explained otherwise.

B. The Supply, Demand, and Institutions (SDI) Framework

We construct a formal supply-demand framework that will guide the empirical analysis of the factors that altered the returns to education during the past century. The framework rests on the central finding in Chapter 3 that skill-biased technical change advanced rapidly throughout the twentieth century and thus that the relative demand for skill increased at a fairly steady rate. Our approach is to determine how much of the evolution in educational wage differentials can be explained by fluctuations in the growth rate of the supply of skills combined with smooth trends in relative demand growth.

A large portion of the evolution of wage differentials, we will demonstrate, can be explained using the simple framework. But where supply-demand forces alone fall a bit flat, institutional factors, such as changes in union strength and the effects of war-time wage-setting policies, can reconcile patterns in the skill premium. In that sense we combine the usual supply and demand framework with institutional rigidities and alterations. The broader framework is most important in understanding wage structure changes during the 1940s and in contrasting changes from the mid to late 1970s to those of the early 1980s. The wage compression of the 1940s, it appears, went far beyond what can be accounted for by market forces alone and was driven in part by institutional factors of the World War II era, such as the greatly expanded role of unions and the residual impact of the wartime wage setting policies.

The framework contains two main forces. One is the change in the relative supply of more-educated workers, which has mainly occurred through changes in the schooling of successive cohorts of labor market entrants. The second is the change in the relative demand for more-educated workers, which has been driven largely by skill-biased technological change.

A labor demand framework, in which the aggregate production function depends only on

the quantities of skilled and unskilled workers, guides our analysis. Skilled workers (*S*) are those with some college and the unskilled (*U*) are those without any college. The production function is assumed to be CES (constant elasticity of substitution) in skilled and unskilled labor with an aggregate elasticity of substitution between the two types of labor given by σ_{SU}. Unskilled labor itself is assumed to be a CES sub-aggregate that depends on the number of high school graduates (*H*) and those without a high school diploma (*O*), also called "dropouts," with an elasticity of substitution of σ_{HO}.[12]

The framework is summarized by the following two equations:

$$Q_t = A_t \left[\lambda_t S_t^{\rho} + (1 - \lambda_t) U_t^{\rho} \right]^{\frac{1}{\rho}} \tag{1}$$

$$U_t = \left[\theta_t H_t^{\eta} + (1 - \theta_t) O_t^{\eta} \right]^{\frac{1}{\eta}} \tag{2}$$

where eq. (1) is the aggregate production function and eq. (2) is the sub-aggregate for unskilled labor. In eq. (1) *Q* is output, *A* is total factor productivity, *S* is units of skilled or college labor, and *U* is units of unskilled or non-college labor. In eq. (2) *H* is units of high school graduate labor and *O* is units of high school dropout labor. The parameters λ_t and θ_t give the shares of the different types of labor and are modeled as technology shift parameters.[13] The CES parameters ρ and η are related to the elasticities of substitution, such that $\sigma_{SU} = \frac{1}{1-\rho}$ and $\sigma_{HO} = \frac{1}{1-\eta}$.

Wages for the three skill groups of workers (*S*, *H*, *O*) are derived using the familiar condition that a competitive equilibrium occurs when wages equal marginal products. Relative wages for college to high school workers and for high school graduates to dropouts are given by:

$$\log\left(\frac{w_{S_t}}{w_{U_t}}\right) = \log\left(\frac{\lambda_t}{1-\lambda_t}\right) - \frac{1}{\sigma_{SU}} \log\left(\frac{S_t}{U_t}\right) \tag{3}$$

and

$$\log\left(\frac{w_{H_t}}{w_{O_t}}\right) = \log\left(\frac{\theta_t}{1-\theta_t}\right) - \frac{1}{\sigma_{HO}} \log\left(\frac{H_t}{O_t}\right) \tag{4}$$

Thus, relative wages depend on the demand shifters (λ_t and θ_t), the relative supply of the more and less educated groups, and the relevant elasticity of substitution between the two groups (σ_{SU} and σ_{HO}). Equations (3) and (4) are the main estimating equations of the model.

A key assumption in our empirical implementation of the framework is that relative skill supplies are predetermined and thus that, in the short run, labor supply for each skill group is

[12] We use the term "dropout" for individuals who did not graduate from high school even though some individuals, early in our period, did not drop out since there was no four-year high school in their locale.

[13] Differential effects of changes in the prices or quantities of other production inputs (e.g., capital and energy) on the demands for different types of labor are subsumed into λ_t and θ_t. The total factor productivity parameter A_t implicitly includes technological progress and physical capital accumulation.

completely inelastic.[14] In addition, the framework assumes that a change in the relative supply of college to non-college labor does not affect the premium to high school graduates relative to high school dropouts. The restriction does not imply that college supplies are unimportant in the determination of unskilled wages, but it does mean that the supply of more educated labor equally affects the wages of the high school graduates and the dropouts.

The framework allows for heterogeneity in worker productivity (efficiency) within each skill aggregate (college, high school graduate, and dropout labor), but it assumes that different workers are perfect substitutes in production within each skill aggregate. The implication is that skill supplies (*S*, *U*, *H*, and *O*) must be measured in efficiency units (productivity-adjusted hours worked) rather than by hours worked. We measure skill supplies in efficiency units taking into account systematic differences in wages by age, sex, and education and adjusting for changes in the age-sex-education group composition of hours worked within each skill aggregate.[15]

Figure 2 is a graphical depiction of how the framework can be used to analyze changes in the wage structure. It is drawn with estimates for the 1960 to 2005 period that we will shortly describe. The SS* lines give the annualized percentage change in the relative supply of educated workers (college educated relative to non-college workers, in this case) for the period noted. The estimation of eq. (3) produces the elasticity of substitution, σ_{SU}, between college and non-college workers and thus the wage elasticity of demand. Given that estimate and the rate of change in the wage premium to college workers, the demand function in rate of change form, DD*, can be identified. The point at which the DD* function crosses the X axis gives the change in the relative demand for college workers.

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[14] Heckman, Lochner and Taber (1998) find that relaxing the assumption of predetermined relative skill supplies and using youth cohort size and military requirements to instrument for relative skill supplies yields estimates similar to those from OLS for the aggregate elasticity of substitution between college and non-college workers for U.S. national time series data. Ciccone and Peri (2005) instrument for relative skill supplies in state-level panel data for 1950 to 1990 using measures of state compulsory schooling and child labor laws. Their instrumental variable estimates of σ_{SU} cluster around 1.5, almost identical to our implied estimates of σ_{SU} given in Table 2.

[15] We follow two complementary approaches to measuring skill supplies in efficiency units. The first approach, following Autor, Katz, and Krueger (1998), starts with information on the total wage bill in each skill group and on composition-adjusted prices (wages) based on our estimated educational wage differentials. The wage bill (prices × quantities) for each skill group is then adjusted for changes in wages (prices) to get a pure composition-adjusted quantity (supply) measure. The details of the approach are given in the notes to Table 1. The second approach, following Katz and Murphy (1992), starts with hours worked and wages for detailed age-sex-education groups. Efficiency units are then computed by weighting the hours worked of each age-sex-education group by the relative wage of that age-sex-education group in a base period. The first approach can be thought of as a chain-weighted price index that adjusts raw labor inputs into efficiency units, whereas the second approach uses a fixed-weighted price index. For comparability with the existing literature, we use the wage-bill based approach for measuring broad long-run supply and demand shifts by skill groups in Tables 1 and 3. We also follow the literature in using the fixed-weighted approach for time series regressions to explain the evolution of educational wage differentials (Tables 2 and 4) and for the decomposition of skill supply shifts into different components (e.g., U.S. born vs. immigrant labor inputs in Tables 5 and 6). We have checked the robustness of the findings in each case to using the alternative approach to measuring skill supplies. The answers are similar in all cases using both approaches.

We now take the framework to the data and measure the relative roles of supply forces, demand factors, and institutional changes in affecting the wage premium. We begin with the college wage premium.

C. Why the Premium to Skill Changed: 1915 to 2005

1. College wage premium

a. Applying the framework

The facts that any framework of the college wage premium must explain and reconcile are given in Table 1 (see also Figure 1). They are easily summarized. The college wage premium (col. 1) collapsed from 1915 to 1950 but subsequently increased, especially after 1980. By 2005 the college wage premium was back at its 1915 level. As we noted in describing Figure 1, the returns to college have come full circle. The relative supply of college workers (Table 1, col. 2) grew rapidly for much of the period, although a slowdown of critical importance is apparent toward the end, particularly from 1990 to 2005. For the full period, the growth in relative supply of college workers occurred at a fairly rapid clip—on the order of 2.87 percent per annum.

Because the premium to education at the end of the century was approximately equal to its level at the start, our supply-demand framework implies that the relative demand for skill across the entire century must have grown at about the same rate as the relative supply of skill. Even though the race between technology and education was about even over the long haul, the long run conceals crucial short run changes. What caused the returns to education to decline and then rise across the past century? We will demonstrate that fluctuations in the relative supply of college workers together with stable demand growth go far to explain the higher-frequency movements in the college premium.

We estimate a version of eq. (3) across the 1915 to 2005 period using data for all the available years: 1915, 1940, 1950, 1960, and annually from 1963 to 2005.[16] The dependent variable is the wage premium of those with at least a college degree (16 or more years of schooling) relative to those with exactly a high school degree (12 years of schooling). The premium is the log of the ratio of the wages for the two education groups. The relative skill supply measure is that of efficiency units of college equivalents (those with a college degree plus half of those with some college) to efficiency units of high school equivalents (those with 12 or fewer years of schooling plus half of those with some college).[17]

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[16] The wage and skill supply data are actually for the years 1914, 1939, 1949, and 1959 but for simplicity of presentation we will refer to these dates as 1915, 1940, 1950, and 1960, which are the years of the censuses (state and federal) from which these data were collected. See Acemoglu (2002) for a related time series analysis of the college wage premium and the relative supply of college skills using data for 1939 to 1996 (1939, 1949, 1959, and 1963 to 1996).

[17] Our empirical specification and measurement choices follow Katz and Murphy (1992) and Autor, Katz, and Kearney (2005, 2008). The empirical findings are similar for alternative measures of the skilled-unskilled wage premium, such as a fixed-weighted average of wages of all workers with some college or

A linear time trend allows for secular growth in the relative demand for college workers. Interactions with specific years enable demand trend changes. Consistent with our earlier findings concerning the slowdown in demand growth beginning in the early 1990s (see Chapter 3), we add a term in most specifications to allow the demand trend to change in 1992.[18] The results are provided in Table 2 and graphed in Figure 3.

The most important result from the estimation is that changes in the relative supply of college workers had a substantial and economically significant negative impact on the college wage premium across the entire period. Most of the specifications yield similar coefficients for the relative supply variable (Table 2, line 1). That for col. (3), our preferred specification, implies that a 10 percent increase in the relative supply of college equivalents reduces the college wage premium by 6.1 percent and translates into an elasticity of substitution between the skilled and unskilled, σ_{SU}, of 1.64 (= 1/0.61, see eq. 3). The rapid growth of the supply of college equivalents from 1915 to 1980 operated to depress the college wage premium despite strong secular growth in the relative demand for college equivalents. The sharp slowdown in the growth in the supply of college workers since 1980 has been a driving force behind the rise in the college wage premium.

Overall, simple supply and demand specifications do a remarkable job explaining the long-run evolution of the college wage premium. The predictions from specifications (2) and (3), graphed in Figure 3 alongside the actual values for the college wage premium, show that most of the shorter-run fluctuations can be tracked as well. Two short-run fluctuations, however, are more complicated. One is the 1940s and the other is the mid to late 1970s.

Each of the specifications in cols. (1), (2), and (3) uses a different method to account for the 1940s within our general framework. The col. (1) specification allows trend demand to differ between the first and second halves of the twentieth century by including an interaction with a post-1949 dummy variable. The trend estimates show slow demand growth for college workers in the first half of the twentieth century, a sharp acceleration after 1949, and a somewhat slower change after 1992. The model over-predicts the decline in the college wage premium from 1915 to 1940 and under-predicts the sharper decline in the 1940s. The specification in col. (2) allows the demand trend shift to occur after 1959, rather than 1949.

Figure 3 shows that the col. (2) specification does a fine job fitting the 1915 to 1940 decline but not the sharp decline in the college premium of the 1940s and the strong rebound of the 1950s. The difficulty in predicting the short-run changes for the 1940s and 1950s probably stems from institutional and cyclical factors. These include the residual effects from World War II wage policies, industrial union strength that increased the bargaining power of the lower-educated, the strong demand for war production workers, and the post-war boom in consumer durables, all of which acted to reduce the relative wage of college workers below the long-run

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more to all workers with no college. The basic results are also robust to the use of different relative supply measures (such as workers with any college versus those with no college) and to adding controls for cyclical factors (such as the unemployment rate).

[18] See also Autor, Katz, and Krueger (1998) and Autor, Katz, and Kearney (2005, 2008).

market equilibrium value of 1950.[19]

The decrease in the college wage premium of the 1940s overshot the decrease predicted by changes in the fundamentals, and the increase of the 1950s may have brought the system back into sync. We explore that possibility by including a dummy variable for 1949 to allow temporary institutional factors to impact wage setting in the 1940s (Table 2, col. 3). The estimation implies that institutional factors, or temporary demand factors, lowered the college wage premium by 14 log points in 1949. As shown in Figure 3, the col. (3) estimation fits the data extremely well and provides our preferred specification. The flexible time trend given by the col. (4) specification demonstrates the robustness of the coefficient on relative labor supply across the entire period.

Another brief period that is not captured well by the specifications in Table 2 is the decline in the college wage premium in the mid to late 1970s. The period was complicated by the post-1973 productivity slowdown and severe oil price and inflation shocks. Many unions, such as in steel and automobiles, whose members were disproportionately in the non-college group had wage contracts that were fully indexed to inflation and geared to provide real wage increases that tracked expected national productivity growth. Union settlements in the late 1970s were not yet adjusted to slower productivity growth and, in consequence, they led to a relative increase in the wages of the non-college workers. But the deep recession of the early 1980s and changes in employer attitudes towards unions, particularly following Reagan's stand-off with air traffic controllers, led to concession bargaining in the early 1980s and set the stage for the spectacular rebound of the college wage premium. The continued decline of unions and the erosion of the real value of the federal minimum wage in the 1980s may have increased the college wage premium by more than market factors alone would have predicted.[20]

Demand growth for college workers appears to have slowed in the 1990s, as indicated by the negative coefficient on the trend interacted with 1992. Given the rapid spread of information technology in the 1990s and beyond, the finding would appear to be at odds with the skill-biased technological change explanation. But a resolution exists.

Computerization prior to the 1990s largely substituted for non-college clerical and production tasks. More recent advances in information technology have increasingly led to organizational changes that eliminate many lower- and middle-paid college jobs but greatly complement top-end managers and those with strong problem-solving skills. Demand for those who graduated from more selective institutions as well as those with post-B.A. degrees is still soaring and they are doing spectacularly well. But demand for many other college workers is less strong and their earnings have not risen as much relative to non-college workers since 1990.[21] Nevertheless, the college wage premium (even for those with only a B.A.) remains at a historically high level and even "marginal" college graduates earn a very high return to college.[22]

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[19] See Goldin and Margo (1992) for a detailed analysis of these factors in the 1940s wage compression.
[20] On union wage developments in the 1970s and early 1980s see Mitchell (1980, 1985). On the role of institutions in the growth of wage inequality in the 1980s see DiNardo, Fortin, and Lemieux (1996).
[21] Autor, Katz, and Kearney (2006, 2008) discuss the "polarization" of the U.S. labor market since 1990, by which they mean that the two ends of the distribution are doing better than the middle. The top is doing well, the middle is doing poorly, and the bottom is doing fairly well. Their explanation is that

b. Computing supply and demand shifts

The estimated coefficients on college relative supply (that is σ_{SU}) are used to compute changes in relative demand, as depicted in Figure 2. The demand shifts are given in the last three columns of Table 1 for three values of σ_{SU}: 1.4 (a consensus estimate from the past literature); 1.64 (our preferred estimate from col. 3 of Table 2); and 1.84 (implied by col. 1 of Table 2). The results are fairly robust to the choice of parameter values.

On average from 1915 to 2005 supply and demand forces kept pace with each other, as we noted before. Neither education nor technology won the race in the long run. The same was true for the 1960 to 1980 period.[23] But for other periods it was not. Across the earliest periods listed, 1915 to 1940 and 1940 to 1960, supply ran ahead of demand by about 1 percent average annually.[24] For the most recent period, 1980 to 2005, demand outstripped supply. Most important is that for both the early and late sub-periods educational supply changes have been the tail wagging the wage-premium dog. Supply variations were far more important in changing relative wages than were differential demand changes across periods.

That supply factors and not demand factors were the culprits in changing inequality can be seen in Figure 2. The relative supply of college workers increased at 3.77 percent per annum from 1960 to 1980 but at just 2 percent per annum from 1980 to 2005. Relative demand, on the other hand, was considerably more stable over the period. Had the relative supply of college workers from 1980 to 2005 expanded at the rate it did from 1960 to 1980, the relative wage of college workers would have *fallen* (the intersection of $DD^*_{1980\text{-}2005}$ with $SS^*_{1960\text{-}80}$), and not risen at 0.9 percent per annum. Thus, the slowdown in the growth of educational attainment since 1980 is the most important factor in the rising college wage premium of the post-1980 period.

Technology has been racing ahead of education in recent decades because educational growth has been sluggish, not because skill-biased technical change has accelerated. To be sure,

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demand is soaring for those who have analytical and "people" skills and is strong, as well, for those who have lower-skilled jobs in the service sector. Computers substitute for routine manual and cognitive tasks, thus reducing demand for many high-end jobs taken by high school graduates and low-end jobs taken by those with any college. But new information technologies complement the non-routine analytic and interactive tasks of those with post-college training and have relatively little impact on non-routine manual tasks of many lower-skilled service sector jobs. The growth of international outsourcing (also known as offshoring) appears to have had similar impacts on labor demand. See also Autor, Levy, and Murnane (2003), Goldin and Katz (2007), and Levy and Murnane (2004).

[22] See Card (2001) on the high returns to college for "marginal" college enrollees whose college attendance decisions are impacted by changes in public tuition and geographic access to college.

[23] The 1970s contain similarities to the 1940s, as we noted in the text, in the overshooting of the reduction in the college wage premium due to institutional factors. Thus the 1950s and the 1980s contain increases in the college wage premium that overshot market forces because of the erosion of the institutional factors that had protected lower- and middle-wage workers in the 1940s and 1970s.

[24] We use the entire 1940 to 1960 period rather than the two sub-decades for the reasons provided in the text. The college wage premium in the 1940s, in would appear, decreased more than justified by fundamentals and the increase in the 1950s brought it back to its equilibrium value.

relative demand growth for college workers was more rapid in the second half of the twentieth century, particularly in the 1980s, than in the first half, but demand has not been growing rapidly since 1990.[25] We summarized the point in Chapter 3 with the quip: "it's not technology – stupid." We will soon demonstrate that the inequality culprit is also "not immigration." Relative supply changes can be affected by changes in the stock of domestically-produced workers or by an influx of workers from abroad. The former, it will be shown, was far more important in all periods we examine.

College workers were the most important well-educated group in the second-half of the twentieth century. But in the first-half of the twentieth century college workers were not the only well-educated group and were not the most important quantitatively. A high school diploma was the mark of a well-educated individual in the early part of the twentieth century just as a college diploma has been from the mid-point onward. We now turn to an understanding of movements in the high school wage premium.

2. High school wage premium

a. Applying the framework

The high school wage premium collapsed from 1915 to 1950, in an almost identical manner to the college wage premium (Figure 1 and Table 3).[26] But the high school wage premium then remained flat from 1950 to 1980 whereas the college wage premium rose, albeit with some jaggedness. The big difference in the two series begins after 1980 when the payoff to college soared and that to high school increased only slightly. The high school wage premium at the end of the century was far lower than it was in 1915.

The primary reason for the collapse of the high school wage premium from 1915 to 1950 was the enormous growth in the relative supply of high school graduates created by the high school movement. From 1915 to 2005 the supply of high school graduates increased at 4.25 percent annually more than the supply of those without a high school diploma (called "dropouts" here) and at 5.54 percent annually more during the high school movement years, 1915 to 1940 (see Table 3). The only years of marked slowness in the relative supply of high school graduates are those in the most recent period, 1990 to 2005.

To obtain estimates of the elasticity of substitution between high school graduates and

[25] The rapid relative demand growth we estimate in Table 1 for college workers from 1980 to 1990 may have been due to the computer revolution but may also be an overshooting due to institutional factors (declines in both union strength and the real minimum wage).

[26] We use the wage differential between those with exactly a high school degree (12 years of schooling) and those with 8 years of schooling. Those margins are the most relevant ones for measuring the full returns to high school in the first-half of the century since the majority of workers had 8 or fewer years of schooling in 1915. In contrast, almost no U.S.-born workers today have fewer than 9 years of schooling (under 1 percent in 2005) and the more meaningful margin is between those with a high school degree and high school dropouts (those with 9 to 11 years of schooling). Empirically, the distinction does not matter much for the time series path of the high school wage premium or for our analytic conclusions. These two measures of the high school wage premium are compared in Appendix Table A8.1.

dropouts (σ_{HO}), we estimate a version of eq. (4) for the high school wage premium, similar to the analysis for the college wage premium (see Table 4). In the analysis of the college wage premium, the elasticity of substitution (σ_{SU}) was stable throughout the period varying from 1.6 to 1.8. But, in the case of high school graduates versus dropouts, the elasticity of substitution (σ_{HO}) shifted substantially around 1950.

The shift can be seen by adding an interaction between the relative supply term and a dummy variable for the post-1949 period (Table 4, col. 4). In the absence of the interaction the elasticity of substitution is substantial in magnitude (around 5) for the entire period. But the interaction reveals that the elasticity of substitution is large only in the post-1949 period and far smaller (around 2) in the previous decades.[27]

The results imply that high school graduates and dropouts are far closer substitutes today than they were prior to the 1950s. Therefore, changes in the relative supply of high school graduates to dropouts today will have smaller effects on the high school wage premium than in the past. High school graduates were once distinctly more skilled than those without a diploma and many positions were reserved for them. Thus the vast increase in high school graduation throughout much of the twentieth century served to reduce the high school wage premium by increasing the relative supply of high school graduates to dropouts.

Earlier in the century firms sought high school graduates as office workers and as blue-collar production workers in many of the high-tech industries of the day. Those hiring employees described certain jobs as requiring a high school diploma or particular high school courses and they viewed high school graduates as vastly superior to those without secondary school training. But today's high school graduates and dropouts are perceived by employers as being close substitutes. The historical facts and our estimates speak to a change in the distinction between a worker with a high school degree and one who is a high school dropout.[28]

There appears to have been some overshooting of the high school premium in the 1940s with a catch-up in the 1950s, as was the case with the college premium. But institutional factors appear far less important than for the college wage premium. The 1949 year dummy, for example, is insignificant in the high school wage premium regression (Table 4, col. 3).

b. Computing supply and demand shifts

We calculate the relative impact of supply and demand forces in changing the high school wage premium using three values of the elasticity of substitution (2, 3, and 5) that span our estimates (see Table 3). Our preferred elasticities are 2 for the pre-1950s and 5 for the post-

[27] The large and significant coefficient on the interaction of the high school relative supply and the post-1949 dummy variable should be contrasted with that for the college wage premium analysis for which there is virtually no impact of adding a similar term (Table 2, col. 5).

[28] The specifications in Table 4 that do not allow for a break in the elasticity of substitution in 1949 (cols. 1, 2, and 3) produce the implausible result that there was essentially no trend increase in the demand for high school graduates relative to dropouts during the pre-1950 period.

1950s. The central finding is that the decrease in the high school wage premium from 1915 to 1940 was due mainly to the rapid growth in relative supply.

Relative demand increased greatly from 1915 to 1940, but it grew at a slower pace than supply and the wage premium declined. Relative supply also increased at a rate exceeding demand from 1940 to 1960. The size of the difference will depend on whether one uses the larger elasticity value or the smaller one, since the period spans the shift we observe in the substitution parameter.[29] Also of importance is the moderate increase in the high school wage premium from 1980 to 2005. Although relative demand growth moderated, the relative supply of high school graduates slowed considerably more.

In the analyses we have done, supply factors were shown to have been more important than demand factors in altering the premium to education in the twentieth century. Changes in the relative supply of educated labor can arise from several sources. We have emphasized changes in the educational attainment of successive cohorts of native-born Americans. But the foreign born may have been an important contributing force.

Immigration may have greatly increased the supply of those without a high school diploma in the 1980 to 2005 period, thus reducing the relative supply of high school graduate labor. Immigration may also have reduced the relative supply of college workers, thus serving to increase the premium to college in the post-1980s. Earlier in the twentieth century legislative restrictions that greatly reduced immigration flows could have increased the relative supply of more educated workers. In all cases, immigration forces could have acted in concert with education forces to change the premium to skill. We turn now to a direct estimate of the influence of immigration on skill supplies and the premium to skill from 1915 to 2005.

3. Immigration and demographics

a. Immigration and the labor force

In the early years of the twentieth century immigrants were a substantial part of labor force growth. By 1915 the foreign born share of the U.S. labor force (18 to 65 years old) exceeded 21 percent.[30] After the immigration restrictions of the 1920s the foreign born share of the labor force declined, and by 1970 it was just 5.4 percent.[31] More recently, and especially after the 1965 immigration legislation ended national-origins quotas, the inflow surged again. By 2005 the foreign born share rose to 15 percent. The national-origin composition of immigration also shifted in recent decades and the share of immigrants coming from Asia and Latin America (especially Mexico) has increased. In our exploration of the impact of immigration on the skill premium we will concentrate on the earlier (1915 to 1940) and the later decades (1980 to 2005) when the contribution of immigration to labor force growth was large.

Because immigrants, on average, have been less well educated than U.S. natives, large

[29] The decrease in the wage premium from 1940 to 1950 was even larger than from 1915 to 1940. But institutional factors of the 1940s make analyzing the longer 1940 to 1960 period more sensible.
[30] The 21 percent figure is an average from the 1910 and 1920 U.S. population censuses.
[31] On immigration restriction in the early twentieth century see Goldin (1994).

changes in immigration flows during the twentieth century altered relative skill supplies. Changes in relative skill supplies, in turn, could have potentially impacted the premium to education. In the first period we consider, 1915 to 1940, the slowdown in immigration would have served to *increase* relative skill supplies. Had immigration continued at its previous rate, there would have been a larger supply of those with less education since the United States was then undergoing its high school movement but Europe, the largest source of immigrants, had not yet done so. In the most recent period, 1980 to 2005, immigration is presumed to *decrease* relative skill supplies. Immigration today, it is often claimed, is flooding America with workers who compete for jobs with the native born at the bottom of the education and skill ladder.

The question we ask is how much of the change in skill supplies have come from changes in immigration and how much from changes in the education of the native-born population. The presumption of many commentators is that immigration greatly increases the premium to skill. But does it?

Our answer will be that immigration has had a smaller effect on relative skill supplies than is generally presumed in all periods we examine and that immigration has had only a relatively modest impact on changes in the premium to education. The impact of immigration from 1980 to 2005 was larger than during earlier periods. But our estimates are that immigration was responsible for only 10 percent (about 2.4 log points) of the post-1980s increase in the college to high school wage premium (which was 23 log points). Immigration can explain a considerably large share (43 percent) of the rise in the high school graduate wage premium, but the domestic education slowdown accounts for more (57 percent).

The reason that immigration is responsible for only a small fraction of the post-1980s increase in the college wage premium concerns the educational distribution of recent immigrants. Many of the foreign born occupy the very bottom of the education ladder, but some are found at the top with college and graduate degrees. In 2005, 17 percent of the foreign born population had fewer than nine years of schooling whereas less than 1 percent of native-born Americans did. At the other end of the spectrum, immigrants in 2005 were more likely to have an advanced (post-college) degree and had about the same likelihood of having at least a four-year college degree as did native-born Americans.[32]

Immigrants in 1915 expanded the labor supply of dropouts by 22 percent, as compared with 6 percent for those with exactly a high school degree, and by 20 percent for high school equivalents, as compared with 11 percent for college equivalents (Table 5 col. 1a). These 1915 data come from our Iowa sample and figures for the entire United States, if we had them, would probably reveal a somewhat larger immigrant share of employment in each skill group. The differential impact of immigration on labor supply across education groups, however, is likely to have been similar for Iowa and the nation as a whole.[33] In 1940, after immigration restrictions

[32] These estimates are based on tabulations from the 2005 CPS MORG sample for those aged 18 to 65 years in the civilian work force.

[33] Immigrants were 15.6 percent of employment in 1915 Iowa (Table 5) but 21 percent for the entire United States. The data on educational attainment in 1940 of older immigrant birth cohorts (those who arrived by 1915) and the U.S. born in the same cohorts confirms that the contribution of immigration to skill supply gaps for the United States in 1915 is well-approximated by our direct estimates for Iowa.

were in place for nearly two decades, the fraction of the foreign born in each education group had declined substantially.

For much of the post-World War II period, the foreign born remained a small fraction of the workforce and the distribution of their years of schooling was similar to that of the native-born. In more recent years, however, immigrants have had a much larger impact on skill supplies. In 1990 they increased the number of dropouts by 29 percent, but they increased the number of high school graduates by just 7.5 percent. In 2005 they increased the number of dropouts by an astounding 76 percent and increased the supply of high school graduates by almost 15 percent. The increases in the immigrant share for high school and college equivalents are substantial, but the two are fairly balanced.

b. Immigration and the education gap

The contribution of the foreign born to the gap in the supply of more and less educated groups is given in Table 5. The "immigrant contribution" gives the fraction of the log difference between the supplies of the unskilled and skilled accounted for by the presence of immigrants.[34] For high school dropouts relative to high school graduates, the fraction is 14.4 percent in 1915, decreases to 2.9 percent in 1970, and then increases for the remainder of the period. In 2005 immigrants expanded the dropout to high school graduate ratio by 43 percent (log points). But the immigrant contribution to the ratio of high school to college equivalents is modest in all years and is greatest for 1915.

We previously noted that there was a large slowdown in the growth of the relative supply of the college educated in the post-1980s. Furthermore much of the increase in the college wage premium was accounted for by the education slowdown. But how much of the slowdown in skill supplies was due to the increase in immigration?

The answer is that just 14 percent of the college supply slowdown was due to the increase in the foreign born. The relative supply of the college educated expanded at 3.89 percent per year from 1960 to 1980 but at 2.27 from 1980 to 2005, resulting in a decrease of 1.62 percent per year (see Table 6). Of that decrease, 1.40 percentage points (= 3.83 – 2.43) or 86 percent of the total (= 1.4/1.62) was due to the slowdown in the relative supply of the college educated among native-born Americans, and so 14 percent was due to immigration.

But how much of the increase in the college wage premium was due to immigration? Immigration decreased the relative supply of college equivalents by 3.9 log points from 1980 to 2005 (col. 3b of Table 5). Using our preferred estimate of σ_{SU} (= 1.64), the change in relative supply implies an increase in the college wage premium of 2.4 log points or only 10 percent of the overall increase, a fact we noted earlier. Thus, the slowdown in the growth of relative college supply from the native-born was *nine* times more important than was immigration in explaining the rise of the college wage premium from 1980 to 2005.[35]

[34] The derivation of the "immigrant contribution" is provided in the notes to Table 5.

[35] Our implicit assumption that immigrants and the native-born are perfect substitutes within education groups may slightly overstate the impact of immigration on the wages of the U.S. born. Estimates of the wage impacts of immigration also tend to be smaller in local labor market analyses than using our

Not surprisingly, the impact of immigration on the supply of high school graduates relative to dropouts is larger than for the college group,. Immigrants were a substantial fraction of all dropouts in 2005, although they were far less important before 1980. But even in the case of the less-educated groups, the impact of immigration on relative skill supply was of less quantitative significance than was the slowdown in high school graduation among the native-born population.[36]

The relative supply of high school graduates increased by a staggering 5.61 percent per year from 1960 to 1980 but then at a sluggish 2.49 percent per year from 1980 to 2005, for a decrease of 3.12 percent per year. Of that rather large decline, 1.79 percentage points (= 5.74 – 3.95) or 57 percent of the total (= 1.79/3.12) was due to the slowdown in the relative supply of U.S. high school graduates. The increase in the foreign born concentrated in the low-end of the education distribution contributed the remaining 43 percent of the change.

What about the impact of the curtailment of immigration in the earliest of the periods examined, 1915 to 1940, on the relative supply of educated labor? The sharp reduction in immigration starting in the mid-1910s increased the relative supply of educated workers. But the increased schooling of the native-born was by far the more important factor in the rapid relative growth of skill supplies and thus in the decrease in the skill premium. Of the 4.8 percent annual growth in the relative supply of high school graduates to dropouts from 1915 to 1940, 4.41 percent was from the increased educational attainment of the native-born and just 0.39 percent was from the decline in immigration (see Table 6). Therefore, the curtailment of immigration accounted for less than 10 percent of the expansion of the relative supply of high school graduates to dropouts during the period. Similarly less than 9 percent of the increase in the ratio of college to high school equivalents from 1915 to 1940 was due to immigration restrictions.

The main conclusion of this section is that immigration had only a minor impact on the growth in the relative supply of the college educated and a moderate effect on the supply of high school graduate workers relative to dropouts during the 1980 to 2005 period. The slowdown in the growth of educated Americans, domestically produced, was of far greater consequence. As a result immigration played only a modest role in the surge in the college skill premium in the post-1980s. Similar conclusions were drawn for the earliest of the periods considered, 1915 to 1940, when immigration was sharply curtailed.

c. Cohort change

Now that we have shown that changes in relative skill supplies were determined primarily by domestic educational forces, we are led to a question concerning demographics. How much of the variation in the growth of relative skill supplies of the U.S. born, shown in Table 6, was driven by changes in the growth of educational attainment of successive birth cohorts and how much to changes in the size of entering cohorts arising from baby booms and

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approach of looking at skill supplies at the national level. See Borjas (2003), Borjas, Freeman, and Katz (1997), Card (2009), and Ottaviano and Peri (2008) on alternative approaches and estimates of the impact of immigration on recent U.S. labor market outcomes.

[36] The slowdown in the U.S. high school graduation rate will be discussed in Chapter 9.

busts? We can answer the question by decomposing the growth of relative skill supplies of the U.S. born into educational attainment growth across cohorts and changes in cohort size.[37]

We find that changes in the growth rate of educational attainment *across* successive cohorts of the U.S. born were far more important than were changes in cohort size in altering the growth rate of home-grown relative skill supplies. A few examples will make the point clear.

Consider first the rapid growth rate of the relative supply of college equivalents of 3.83 percent per year from 1960 to 1980 for the native born. Of the total, 3.51 percent was due to educational upgrading across cohorts and 0.32 came from the increasing size of younger and more educated cohorts who entered the labor force with the baby boomers of the 1960s and 1970s. That is, fully 92 percent of the total was due to the educational advancement of successive cohorts. Consider next the slower growth in domestic college supply of 2.43 percent per year from 1980 to 2005. Of the total, 2.54 percent arose from cohort educational upgrading and -0.11 percent from smaller entering cohort sizes.

Of the total decline in the growth rate of the domestic college supply of 1.4 percent per year (3.83 – 2.43) from 1960-80 to 1980-2005, almost 70 percent (0.97 percent per year) was due to the slowdown in the growth of educational attainment across successive birth cohorts. In fact, the deceleration in the growth rate of educational attainment of the U.S. born explains a 0.59 percent per year increase in the college wage premium (assuming σ_{SU} = 1.64) out of the actual increase of 0.90 percent per year from 1980 to 2005.

D. Non-competing Groups: 1890 to 1930

1. The premium to skill and the relative supply of educated workers

We had previously selected 1915 as the starting date to analyze changes in the premium to education because we were able to compute reasonably comparable estimates of relative skill supplies and skill returns from 1915 to 2005. But an earlier period is of sufficient importance in the history of relative skill supplies that we will make do with a somewhat different measure of skill returns. The period includes the years from 1890 to 1915, termed by Paul Douglas as the era of non-competing groups, as well as the years from 1915 to 1930 when non-competing groups began to fade.

The measure of skill returns that we will use is one that we introduced in Chapter 2—the ratio of the wage in an occupation that required some secondary school or higher to the wage in an occupation that did not. We can more finely track the movement of occupational wage ratios prior to 1930 than the returns to education. We showed in Chapter 2 that the premium to various types of office and professional work declined starting around 1914 to the early 1920s. Although the ratio for some of the series increased a bit at the end of the 1920s, the wage premium for white collar work never returned to the levels that existed before 1914. What factors were

[37] We use a methodology analogous to that described in Tables 5 and 6 for decomposing overall relative skill supply growth into immigrant and native-born components.

responsible for the substantial premiums to skill and education in the period of non-competing groups and for the sharp and persistent erosion of the premiums after 1914?

We must first provide estimates of the change in wage ratios by skill and supplies of educated workers. To make comparisons over time, we divide 1890 to 1930 into two periods of equal length: 1890 to 1910 and 1910 to 1930. We aggregate the various skill premium series presented in Chapter 2 using employment weights.[38] The wage premium for white-collar work computed in this fashion was fairly steady during the first two-decade period but decreased by 25.7 log points (or about 23 percent) during the second two-decade period. That is, from 1910 to 1930 the skill premium fell by 1.28 percent per year on average.

The stock of high school graduates prior to 1940 must also be constructed. Our preferred approach is to use the administrative data presented in Chapter 6 on the annual flow of new high school graduates at the national level. In constructing the stocks of high school graduates in each year from 1890 to 1930 using the administrative data, we assume that the high school graduate share of the work force was 4 percent in 1890 and add the flows of new high school graduates each year to the existing stock in the work force.[39] We adjust our measure of the stock of high school graduates in the work force in each year to account for differences in labor force participation rates between high school graduates and other adults. Based on tabulations from the 1915 Iowa State Census and the 1940 IPUMS for the relevant cohorts, we take the labor force participation rate for male high school graduates to have been the same as the overall male participation rate and that it was 40 percent higher for female high school graduates than for those who had not completed high school.[40]

The implied estimates from the administrative data of the high school graduate share of the U.S. labor force are presented in col. (1) of Table 7. The stock of high school graduates in the United States increased slowly to 1910, when they were 5.4 percent of the U.S. labor force. But after 1910 the stock increased far more rapidly, not a surprise given the high school movement. From 1890 to 1910 the change in the relative supply of high school graduates to those with less than a high school degree in the labor force was 31.5 log points and from 1910 to 1930 it was 89.9 log points, almost three times as large. These data translate into a 1.57 percent

[38] We use the following four groups to measure the white collar wage premium with the 1910-30 change in the log wage premium and the weight for each group given in parentheses: male clerks (-0.379, 0.3), female clerks (-0.229, 0.2), associate professors (-0.247, 0.25), and starting engineers (-0.143, 0.25). The rationale for the weights is that white-collar work was about 50 percent clerical at the time and males were about 60 percent of clerical workers. See Goldin and Katz (1995, tables 1 and 10).

[39] Our assumption about initial conditions—that high school graduates were 4 percent of the work force in 1890—is a compromise between historical administrative data on the high school graduation rate (which increased from 2 percent in 1870 to 3.5 percent in 1890) and the higher estimate for 1890 of a 6.3 percent share of high school graduates implied by "backcasting" household survey data from the 1915 Iowa Census and 1940 IPUMS. Modest changes in the assumed 1890 initial conditions do not substantially change our conclusions.

[40] See Goldin and Katz (1995, table 8) for further details on the methodology and a discussion of how accounting for immigration and differential mortality by education could affect our series on the high school graduate share of the labor force for 1890 to 1940 derived from administrative data.

average annual increase in the relative supply of high school graduates from 1890 to 1910 and 4.49 percent per year from 1910 to 1930.[41]

The census and administrative estimates imply similar growth rates in the relative supply of high school graduates from 1910 to 1930, but the census estimates of relative supply growth are considerably faster for 1890 to 1910. Both approaches imply a sharp acceleration in the growth of the relative supply of high school graduates after 1910. We place more confidence in the administrative estimates for the period prior to 1910 and we will use them in the analysis to follow.[42]

2. Explaining the skill premium decline: education, immigration, and demand

Douglas had suggested several possible factors that could account for the decrease in the skill premium beginning in the late-1910s: a relative increase in educated workers; a decrease in immigration (thus fewer less-educated workers); and a decrease in the relative demand for skill due to the "deskilling" of various office positions. We assess each of these explanations using the aggregate measure of the change in the skill premium, changes in the stock of educated workers including immigrants, and our estimate of the elasticity of substitution between skilled and unskilled workers, σ_{SU} (which yields the wage elasticity of demand for skill = $-1/\sigma_{SU}$).[43]

Because there was no change in the premium to skill from 1890 to 1910, relative supply and demand must have increased at the same rate. The relative supply of high school graduates increased by 1.6 percent annually (31.5 log points) during those decades (using the administrative data estimates in col. 1 of Table 7) and thus demand must have increased at the same rate. But during the next decades, from 1910 to 1930, relative supply grew at an astounding 4.5 percent annually (by 89.9 log points) and the premium to skill decreased by 1.3 percent annually (25.7 log points).

Given our preferred estimate of σ_{SU} = 1.64, relative demand grew at 2.4 percent annually (47.8 log points) from 1910 to 1930. Our estimates imply that the relative demand for high school graduates accelerated after 1910. Demand grew at a rate that was 0.8 percent more per year from 1910 to 1930 compared with 1890 to 1910.[44]

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[41] An alternative approach is to use data on educational attainment by birth cohort from the 1915 Iowa State Census and the 1940 U.S. population census. Estimates of the high school graduate share of the labor force using this method are shown in col. (2) of Table 7.

[42] One reason to prefer the administrative data is that high school graduation rates probably advanced faster in Iowa than in the rest of the United States in the late nineteenth and early twentieth centuries. The census-based estimates of the high school graduate share in col. (2) of Table 7 are much higher than the administrative-based estimates in every year from 1890 to 1930. See Goldin (1998) on the overstatement of high school graduation rates of older cohorts in the 1940 census.

[43] Recall that the inverse of the elasticity of substitution, $-1/\sigma_{SU}$, is $\partial \log(w_S/w_U)/\partial \log(S/U)$, the slope of the relative demand curve.

[44] If we assume, instead, an elasticity of substitution of 2 (our preferred estimate between high school graduates and dropouts in the early period), then we conclude that demand grew at 1.9 percent annually (38.5 log points) from 1910 to 1930, which also some demand acceleration after 1910.

Thus the large decrease in the wage premium to educated workers was caused by the enormous increase in the supply of educated workers. Relative demand, rather than slowing, had actually accelerated. But the increase in high school graduates to dropouts could have been caused by immigration restrictions as well as by the high school movement. What was the role of immigration restriction, as opposed to schooling advances, in this early period?

The foreign born were almost 22 percent of the U.S. workforce between 1890 and 1910. With the passage of immigration restrictions in the 1920s, and the substantial cessation of international labor mobility during World War I, the foreign born became a smaller fraction of the labor force. By 1930 they were about 16 percent of the labor force. The decrease in immigration would have served to increase the fraction of the labor force with high school education since immigrants were less well-educated than the native-born workforce. But what was the actual impact? The actual impact of the large change in immigration was much smaller than one might have expected.

We simulate the impact of immigration on the supply of high school graduates from 1910 to 1930 by asking what would have happened if the immigrant share remained constant at 22 percent from 1910 to 1930 rather than declining to 16 percent. We use data from our 1915 Iowa sample showing that immigrants had, on average, one-third the high school graduation rate of the U.S. born. We find that the high school graduation expansion of the native-born was more than ten times as important as was immigration in explaining the growth of the high school graduate share of the workforce from 1910 to 1930. Using our administrative data the immigrant decline can explain only a 0.5 percentage point increase in the growth of the high school graduate share of the workforce from 1910 to 1930 as compared with a 5.9 percentage point increase from the rising educational attainment of the U.S. born.[45]

The increase in the education of native-born workers was so great after 1910 that even had the foreign born remained at their 1910 level from 1910 to 1930, the relative supply of educated workers would have increased by 85.2 log points as compared with its actual increase of 89.9 log points. Thus, schooling gains among the U.S. born were more than *eleven* times more important than immigration in explaining the faster skill supply growth after 1910 and were consequently the major reason for the collapse in the white collar wage premium from 1910 to 1930.[46]

E. Recapitulation: Who Won the Race?

Technological change can create winners and losers. Distributional problems are more likely when technological change is skill biased, that is when new technologies increase the relative demand for more educated, skilled, and advantaged workers.

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[45] Our census-based estimates of the labor force share of high school graduates (col. 2 of Table 7) imply that immigration accounts for a 0.9 percentage point increase in the high school graduate share of the labor force from 1910 to 1930 as compared with a 10.1 percentage point contribution from the U.S. born.

[46] More precisely, the growth in the relative supply of high school graduates increased by 58.4 log points from 31.5 log points for 1890-1910 to 89.9 log points for 1910-30. The rising high school graduation rate of the U.S. born accounts for 53.7 log points of the acceleration and declining immigration explains the remaining 4.7 log points.

A nation's economy will expand as technology advances, but the earnings of some may advance considerably more than the earnings of others. If workers have flexible skills and if the educational infrastructure develops sufficiently, then the supply of skills will expand as their demand increases. Growth and the premium to skill will be balanced and the race between technology and education will not be won by either side and prosperity will be widely shared. External factors can also alter the demand and the supply of skills. The immigration of workers who are disproportionately at the bottom of the skill distribution could greatly impact the earnings of those who are their closest substitutes. Changes in international trade patterns and off-shoring opportunities can also alter skill demands.

We began this chapter with a summary of the returns to skill and education first developed in Chapter 2. The premium to education and skill was extremely high in the late nineteenth century but decreased at several junctures until the 1940s. By the 1960s America was growing rapidly and the fruits of economic growth were being shared fairly equally across the income scale. But the story quickly and abruptly changed in the late 1970s and early 1980s when rapidly rising inequality took hold and productivity growth was sluggish at best. The twentieth century contains two inequality tales. This chapter has been a search for an explanation.

The estimates of relative skill supplies provided in Chapter 1 have been used in the quest to uncover why the relative premium to skill changed. We did so by estimating the elasticity of substitution between various groups of workers by skill or education. We then used these estimates to compute the degree to which relative labor demand and supply shifted.

The supply and demand framework we employed does an extremely good job in explaining changes in the premium to skill. There were times when we appealed to institutional changes and rigidities. But, by and large, the framework allows us to tell a consistent and coherent story to reconcile the two inequality tales of the twentieth century. We will summarize the major findings of that analysis and begin with the college wage premium.

The college wage premium ended up in 2005 at about the place it had been in 1915. Thus over the very long run the relative supply for skilled workers grew at the same rate as did demand. But that does not help us understand the two tales. Only a detailed analysis of the sub-periods will. From 1915 to 1980 education raced far ahead of technology and that served to reduce skill premiums and to lessen the economic power of what Paul Douglas termed non-competing groups. From 1915 to 1940 supply outstripped demand by 1.41 times (3.19 percent average annually versus 2.27); from 1940 to 1960 it did so by 1.47 times (2.63 percent average annually versus 1.79). In both periods supply increased by about 1 percent per year more than demand. In Section II we discussed the many reasons for the surge in education including the high school movement in the pre-1940 era and the increase in college going in the post-World War II period.

But a big reversal occurred around 1980. Had the relative supply of college workers increased from 1980 to 2005 at the same rate that it had from 1960 to 1980, the college premium, rather than rising, would have fallen. Education lost the race to technology.

Similarly for the high school graduate premium, we found that from 1915 to 1940 supply raced ahead of demand, again by about 1 percent per year (5.54 percent average annually versus 4.79 with $\sigma_{HO} = 2$) and considerably more from 1940 to 1960 (3.55 percent average annually versus 1.79 with $\sigma_{HO} = 3$). The rapid increase in high school graduates caused the high school graduate premium to plummet in the pre-1950 period.

We questioned whether some of the supply changes we measured were really due to changes in immigration rather than to changes in domestically supplied schooling. The issue is most important for the earliest of the periods we studied, when immigration was high and then became restricted, and also for the most recent period, when immigration surged again.

We noted that during the critical period 1980 to 2005, when the college premium increased by an astonishing 25 percent, immigration could account for only 10 percent of the surge or just 2.4 percent. Most of the increase was due, instead, to the slowdown in college going among the native-born population. In fact, educational changes to the native-born population were nine times more important than was immigration in explaining the rise in the college wage premium.

Immigration was more important for the relative decline in supply at the bottom end of the skill distribution. But even in that case, educational slowdowns among the U.S. born were more important quantitatively.

Earlier in the century, the high school movement was considerably more important than immigration restrictions to the reduction in the skill premium. Had the fraction foreign born in the labor force remained at its high early twentieth century level but the high school movement had occurred, as it did, the relative supply of educated workers would have grown at 95 percent of its actual rate (85.2 versus 89.9 log points) from 1910 to 1930.

We noted that the wage structure and the returns to skill have exhibited important discontinuities. Most of the narrowing in wage differentials, for example, took place in the 1910s and the 1940s, periods close to or coinciding with the two world wars. They were times of increased demand for the lower skilled, great innovation, and union activity. But although the discontinuities in the wage structure suggest structural change, the fact that the wage structure remained in place though the institutions changed suggests the importance of fundamental changes in both education and technology.

Our central conclusion is that when it comes to changes in the wage structure and returns to skill, supply changes have been critical, and changes in the educational attainment of the native born have driven the supply side. The fact was true in the early years of our period when the high school movement made Americans educated workers and in the post-World War II decades when high school graduates became college graduates. But the same is also true today when the slowdown in education at various levels is robbing Americans of the ability to grow strong together.

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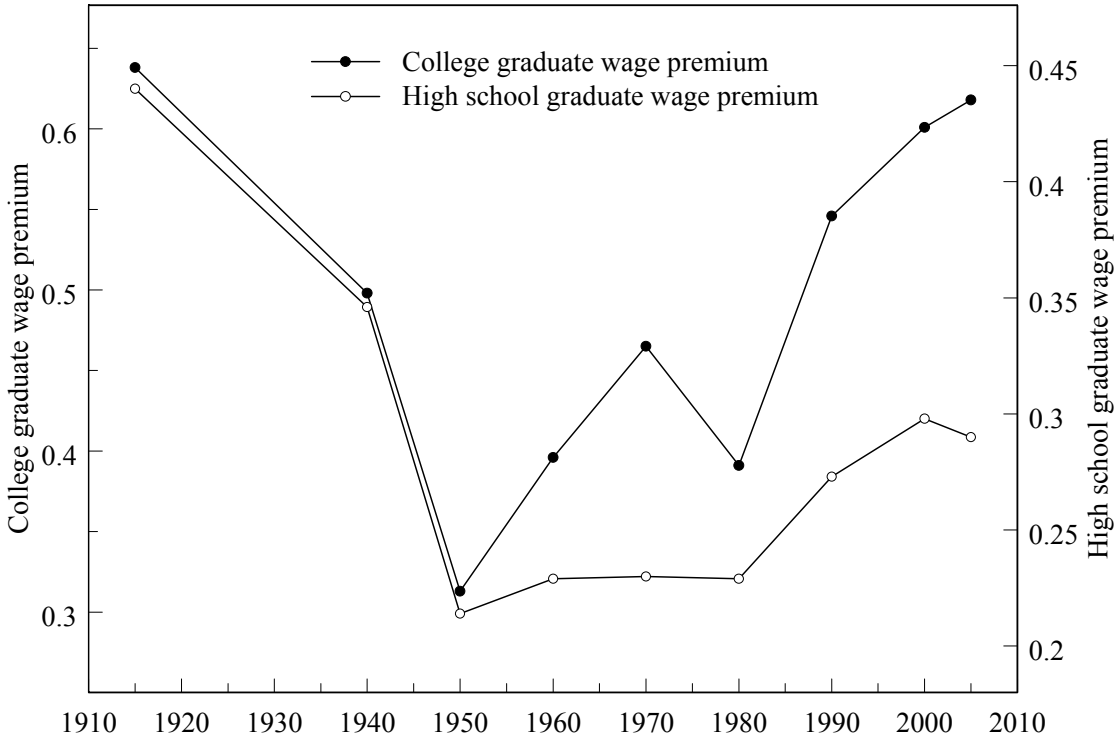
Figure 1
College Graduate and High School Graduate Wage Premiums: 1915 to 2005



Sources and Notes:
College Graduate Wage Premium: The plotted series is based on the log college/high school wage differential series in Appendix Table A8.1. We use the 1915 Iowa estimate and the 1940 to 1980 census estimates for the United States. We extend the series to 1990, 2000, and 2005 by adding the changes in the log (college/high school) wage differentials for 1980 to 1990 for the CPS, 1990 to 2000 from the census, and 2000 to 2005 from the CPS to maintain consistency in the coding of education across pairs of samples used for changes in the college wage premium.

High School Graduate Wage Premium: The plotted series is based on the log (high school/eighth grade) wage differential series in Appendix Table A8.1. We use the 1940 to 1980 Census estimates for the United States. To maintain data consistency, we then extend this series backwards to 1915 using the1915 to 1940 change for Iowa and forward to 2005 using the 1980 to 1990 change from the CPS, the 1990 to 2000 change from the February 1990 CPS to the 2000 CPS, and the 2000 to 2005 change from the CPS.

Figure 2
The Supply and Demand Framework

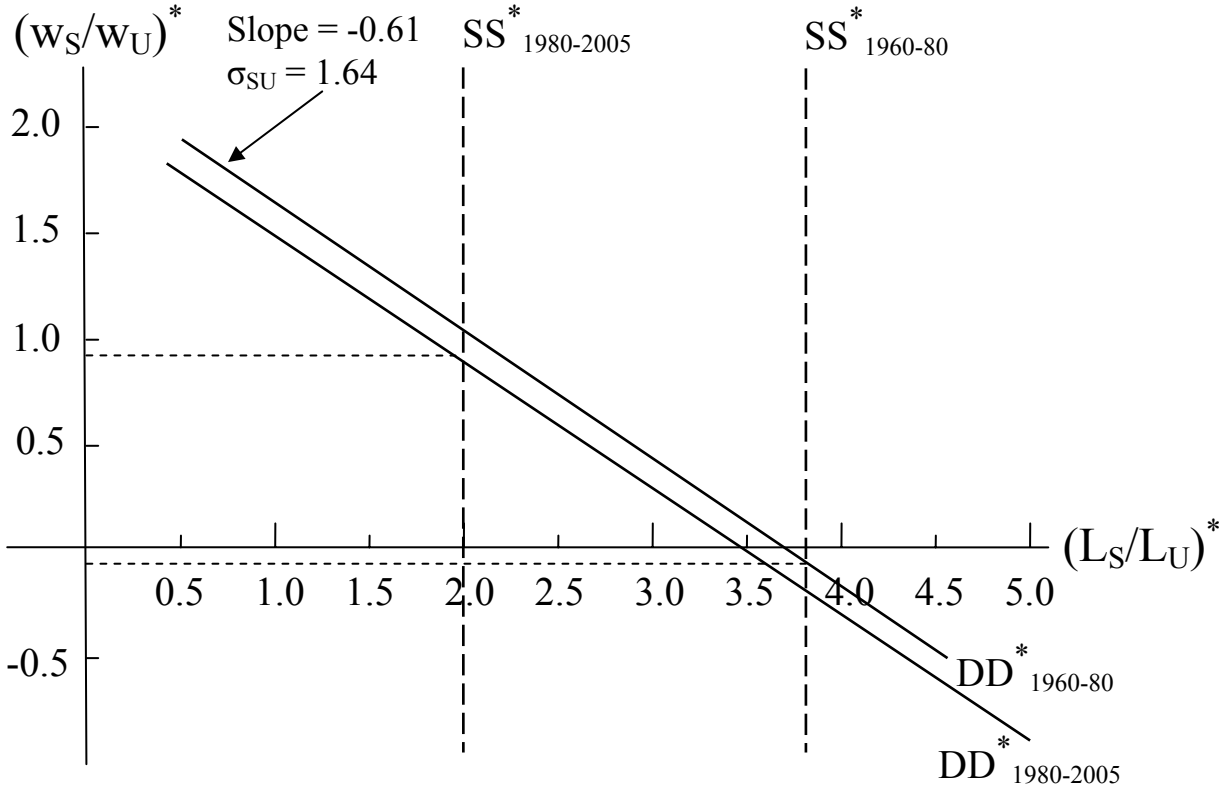
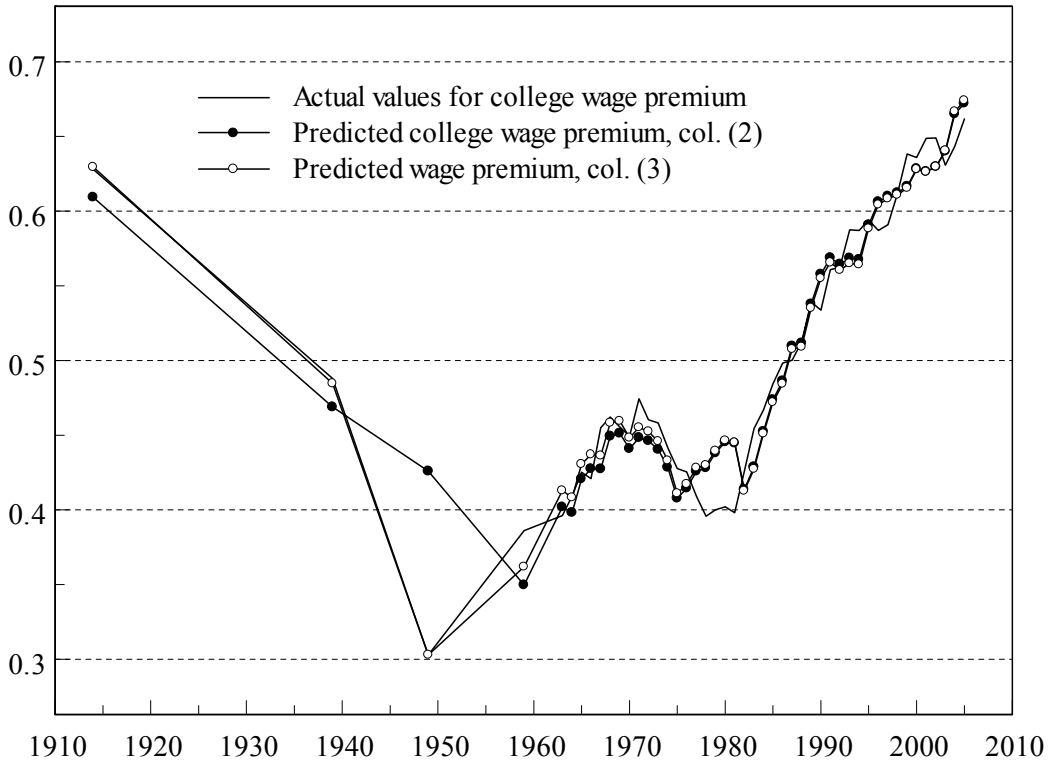


Figure 3
Actual versus Predicted College Wage Premium: 1915 to 2005



Sources and Notes: The actual values for the college wage premium are from the series used in the regressions in Table 2 and documented in the notes to Table 2. The two series for the predicted college wage premium are the values of the college wage premium predicted from the regressions in col. (2) and col. (3) of Table 2, as noted in the figure.

Table 1
Changes in the College Wage Premium and the Supply and Demand for College Educated Workers: 1915 to 2005 (100 × Annual Log Changes)

	Relative Wage	Relative Supply	Relative Demand ($\sigma_{SU} = 1.4$)	Relative Demand ($\sigma_{SU} = 1.64$)	Relative Demand ($\sigma_{SU} = 1.84$)
1915-40	-0.56	3.19	2.41	2.27	2.16
1940-50	-1.86	2.35	-0.25	-0.69	-1.06
1950-60	0.83	2.91	4.08	4.28	4.45
1960-70	0.69	2.55	3.52	3.69	3.83
1970-80	-0.74	4.99	3.95	3.77	3.62
1980-90	1.51	2.53	4.65	5.01	5.32
1990-2000	0.58	2.03	2.84	2.98	3.09
1990-2005	0.50	1.65	2.34	2.46	2.56
1940-60	-0.51	2.63	1.92	1.79	1.69
1960-80	-0.02	3.77	3.74	3.73	3.73
1980-2005	0.90	2.00	3.27	3.48	3.66
1915-2005	-0.02	2.87	2.83	2.83	2.82

Sources: The underlying data are presented in Appendix Table A8.1 and are derived from the 1915 Iowa State Census, 1940 to 2000 Census IPUMS, and 1980 to 2005 CPS MORG samples.

Notes: The "relative wage" is the log (college/high school) wage differential, which is the college wage premium. The underlying college wage premium series is plotted in Figure 1. The relative supply and demand measures are for college equivalents (college graduates plus half of those with some college) relative to high school equivalents (those with 12 or fewer years of schooling and half of those with some college). The log relative supply measure is given by the log relative wage bill share of college equivalents minus the log relative wage series:

$$\log\left(\frac{S}{U}\right) = \log\left(\frac{w_S S}{w_U U}\right) - \log\left(\frac{w_S}{w_U}\right)$$

where S is efficiency units of employed skilled labor (college equivalents), U is efficiency units of employed unskilled labor (high school equivalents), and w_S and w_U are the (composition-adjusted) wages of skilled and unskilled labor. The log relative wage bill is based on the series for the wage bill share of college equivalents in Appendix Table A8.1. The relative demand measure $\log(D_{SU})$ depends on σ_{SU} and follows from equation (3) in the text:

$$\log(D_{SU}) = \log\left(\frac{S}{U}\right) + \sigma_{SU} \log\left(\frac{w_S}{w_U}\right)$$

To maximize data consistency across samples in the measurement of education changes from 1980 to 1990 use the CPS, changes from 1990 to 2000 use the census, and changes from 2000 to 2005 use the CPS. The changes for 1915 to 1940 are for Iowa. See Autor, Katz, and Krueger (1998) for details on the methodology for measuring relative skill supply and demand changes.

Table 2
Determinants of the College Wage Premium: 1915 to 2005

	(1)	(2)	(3)	(4)	(5)
(College/high school) supply	-0.544	-0.595	-0.610	-0.579	-0.618
	(0.079)	(0.093)	(0.065)	(0.099)	(0.079)
(College/high school) supply × post-1949					0.0078
					(0.0420)
Time	0.00378	0.00970	0.00991	0.00973	0.0103
	(0.00200)	(0.00243)	(0.00171)	(0.00545)	(0.0028)
Time × post-1949	0.0188				
	(0.0013)				
Time × post-1959		0.0156	0.0154		0.0150
		(0.0012)	(0.0009)		(0.0022)
Time × post-1992	-0.00465	-0.00807	-0.00739		-0.00742
	(0.00227)	(0.00279)	(0.00196)		(0.00199)
1949 Dummy			-0.137		-0.143
			(0.021)		(0.036)
$Time^2 \times 10$				-0.00342	
				(0.00203)	
$Time^3 \times 1000$				0.105	
				(0.034)	
$Time^4 \times 10{,}000$				0.00664	
				(0.00186)	
Constant	-0.493	-0.645	-0.656	-0.587	-0.674
	(0.168)	(0.197)	(0.138)	(0.210)	(0.079)
R^2	0.934	0.917	0.960	0.928	0.960
Number of observations	47	47	47	47	47

Sources and Notes: Each column is an OLS regression of the college wage premium on the indicated variables using a sample covering the years 1914, 1939, 1949, 1959, and 1963 to 2005. Standard errors are given in parentheses below the coefficients. The college wage premium is a fixed weighted average of the estimated college (exactly 16 years of schooling) and post-college (17+ years of schooling) wage differential relative to high school graduates (those with exactly 12 years of schooling). (College/high school) supply is the log supply of college equivalents to high school equivalents both measured in efficiency units. "Time" is measured as years since 1914. The data for 1963 to 2005 are from the 1964 to 2006 March CPS samples. The college wage premium and relative supplies in efficiency units for 1963 to 2005 use the same data processing steps and sample selection rules as those described in the data appendix to Autor, Katz, and Kearney (2008). The college wage premium for 1963 to 2005 uses the log weekly earnings of full-time, full-year workers. The college wage premium observations for 1914, 1939, 1949, and 1959 append the changes in the college wage premium series from 1915 to 1970 (actually 1914 to 1969) plotted in Figure 1 to the 1969 data point from our March CPS series. The log relative supply observations for 1914 to 1959 similarly append changes in the relative supply of college equivalents from 1914 to 1939 for Iowa and for the United States from 1939 to 1949, 1949 to 1959, and 1959 to 1969 from the Census IPUMS samples using the efficiency-units measurement approach of Tables 5 and 6.

Table 3
Changes in the High School Wage Premium and the Supply and Demand for High School Educated Workers: 1915 to 2005 (100 × Annual Log Changes)

	Relative Wage	Relative Supply	Relative Demand ($\sigma_{HO} = 2$)	Relative Demand ($\sigma_{HO} = 3$)	Relative Demand ($\sigma_{HO} = 5$)
1915-40	-0.38	5.54	4.79	4.41	3.66
1940-50	-1.32	4.38	1.74	0.42	-2.22
1950-60	0.15	2.72	3.02	3.17	3.47
1960-70	0.01	5.31	5.33	5.34	5.36
1970-80	-0.01	5.65	5.63	5.62	5.60
1980-90	0.44	4.04	4.92	5.36	6.24
1990-2000	0.25	1.87	2.37	2.62	3.12
1990-2005	0.11	1.52	1.75	1.86	2.09
1940-60	-0.59	3.55	2.38	1.79	0.62
1960-80	0.00	5.48	5.48	5.48	5.48
1980-2005	0.24	2.53	3.02	3.26	3.75
1915-2005	-0.17	4.25	3.91	3.75	3.41

Sources: The underlying data are presented in Appendix Table A8.1 and are derived from the 1915 Iowa State Census, 1940 to 2000 Census IPUMS, and 1980 to 2005 CPS MORG samples.

Notes: The relative wage is the log wage differential between those with 12 years and 8 years of school, adjusted for demographic factors. This high school wage premium series is plotted in Figure 1. The relative supply and demand measures compare exact high school graduates (those with exactly a high school degree or 12 years of completed schooling) to those without a high school diploma (0 to 11 years of schooling). The methodology for constructing the supply and demand measures is the same as described in the notes to Table 1 with high school graduates (H) replacing college equivalents (S) and high school dropouts (O) replacing high school equivalents (U). Thus, the log relative supply measure is given by the log relative wage bill share of high school graduates to dropouts minus the log high school wage premium. The log relative demand measure $\log(D_{HO})$ is based on eq. (4) in the text and given by:

$$\log(D_{HO}) = \log\left(\frac{H}{O}\right) + \sigma_{HO}\log\left(\frac{w_H}{w_O}\right)$$

To maximize data consistency across samples in the measurement of education, changes from 1980 to 1990 use the CPS MORG, changes from 1990 to 2000 use the February 1990 CPS and the 2000 CPS MORG, and changes from 2000 to 2005 use the CPS MORG. The changes for 1915 to 1940 are for Iowa.

Table 4
Determinants of the High School Wage Premium: 1915 to 2005

	(1)	(2)	(3)	(4)	(5)
(High school/dropout) supply	-0.180	-0.193	-0.193	-0.512	-0.352
	(0.059)	(0.039)	(0.039)	(0.071)	(0.137)
(High school/dropout) supply × post-1949				0.322	
				(0.054)	
(High school/dropout) supply × time					0.00496
					(0.00218)
Time	-0.00084	0.00239	0.00235	0.0171	0.0308
	(0.00278)	(0.00179)	(0.00176)	(0.0037)	(0.0100)
Time × post-1949	0.0132			-0.0032	
	(0.0011)			(0.0029)	
Time × post-1959		0.0117	0.0116		
		(0.0006)	(0.0006)		
Time × post-1992	-0.00753	-0.0109	-0.0107	-0.0106	
	(0.00386)	(0.0026)	(0.0026)	(0.0029)	
1949 Dummy			-0.0278		
			(0.0192)		
$Time^2 \times 10$					-0.0084
					(0.0012)
$Time^3 \times 1000$					0.113
					(0.025)
$Time^4 \times 10{,}000$					-0.0055
					(0.0015)
Constant	0.088	0.049	0.053	-0.579	-0.282
	(0.118)	(0.078)	(0.077)	(0.142)	(0.271)
R^2	0.897	0.953	0.956	0.944	0.971
Number of observations	47	47	47	47	47

Sources and Notes: Each column is an OLS regression of the high school wage premium on the indicated variables using a sample covering the years 1914, 1939, 1949, 1959, and 1963 to 2005. Standard errors are given in parentheses below the coefficients. The high school wage premium is the (composition-adjusted) wage differential between those with exactly a high school degree (12 completed years of schooling) and those with 8 completed years of schooling. (High school/dropout) supply is the log supply of those with 12 completed years of schooling to those with 0 to 11 years of schooling measured in efficiency units. "Time" is measured as years since 1914. The data for 1963 to 2005 are from the 1964 to 2006 March CPS samples. We use the same data processing steps and sample selection rules as those described in the data appendix to Autor, Katz, and Kearney (2008) in constructing wage series for high school graduates and dropouts and the relative supply measure in efficiency units for 1963 to 2005. The high school wage premium for 1963 to 2005 is for the log weekly earnings of full-time, full-year workers and compares workers with exactly 12 years of schooling to all dropouts. We multiply this high school wage premium series for 1963 to 2005 by 1.44 to make it comparable to a series for the log wage gap between those with 12 and 8 years of schooling. The multiplier of 1.44 is the mean

ratio of the log (high school/eighth grade) to the log (high school/dropout) wage differential series in Appendix Table A8.1 for 1915 to 1980. The high school wage premium observations for 1914, 1939, 1949, and 1959 append the changes in the high school wage premium series from 1915 to 1970 (actually 1914 to 1969) plotted in Figure 1 to the 1969 data point from our March CPS series. The log relative supply observations for 1914 to 1959 similarly append changes in the relative supply of college equivalents from 1914 to 1939 for Iowa and for the United States from 1939 to 1949, 1949 to 1959, and 1959 to 1969 from the Census IPUMS samples using the efficiency-units measurement approach of Tables 5 and 6.

Table 5
Immigrant Contribution to Labor Supply by Educational Attainment: 1915 to 2005

	Ratio of Immigrants to U.S. Born Workers						
	High School Dropouts versus High School Graduates			High School Equivalents versus College Equivalents			
Year	(1a) Dropouts	(2a) Graduates	(3a) Immigrant Contribution	(1b) High School	(2b) College	(3b) Immigrant Contribution	Immigrant Employment Share
Iowa							
1915	0.223	0.059	0.144	0.198	0.114	0.073	0.156
1940	0.084	0.035	0.046	0.067	0.056	0.010	0.058
U.S.							
1940	0.169	0.075	0.084	0.140	0.088	0.047	0.111
1950	0.124	0.071	0.048	0.103	0.074	0.026	0.086
1960	0.086	0.044	0.039	0.067	0.062	0.005	0.062
1970	0.071	0.040	0.029	0.054	0.063	-0.009	0.054
1980	0.118	0.049	0.065	0.068	0.075	-0.006	0.067
1990	0.291	0.075	0.183	0.106	0.096	0.009	0.093
2005	0.762	0.146	0.430	0.190	0.151	0.033	0.151

Sources: 1915 Iowa State Census, 1940 to 1990 Census IPUMS, and 2005 CPS MORG. The samples include civilian employed workers from 18 to 65 years old.

Notes: The "immigrant contribution" calculation follows the approach of Borjas, Freeman, and Katz (1997) and is derived as follows. The ratio of unskilled (*U*) to skilled (*S*) workers can be decomposed as follows:

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

where L_{j_t} = supply of workers in skill group *j* in year *t*, and N_{j_t} (M_{j_t}) = supply of U.S. born (immigrant) workers in skill group *j* in year *t*, such that $L_{j_t} = N_{j_t} + M_{j_t}$. The first term of the right side of the equation is the native contribution to the ratio. The second term, in brackets, is the immigrant contribution. We call this term the "immigrant contribution" and it is given in the table in cols. (3a,b). The components of the "immigrant contribution" are given in cols. (1a,b), $\frac{M_{U_t}}{N_{U_t}}$, and cols. (2a,b), $\frac{M_{S_t}}{N_{S_t}}$. The "skilled" groups in the table are high school graduates and college "equivalents"; the "unskilled" groups are dropouts and high school "equivalents," respectively. College equivalents are those with 16 or more years of schooling plus half of those with some college. High school equivalents are those with 12 or fewer years of schooling plus half of those with some college. Worker supplies in cols. (1) to (3) are measured in efficiency units: the sum of hours of work weighted by the relative wage of each individual's demographic group in a base year (the average of 1940, 1960, and 2005). We use 60 demographic groups (6 education groups × 5 age groups × 2 sexes). The last column presents the immigrant employment share using raw employment counts not efficiency units.

Table 6
Contribution of Immigrants and the U.S. Native-Born to the Growth of Relative Skill Supplies: 1915 to 2005 (100 × Annual Log Changes)

	High School Graduates/ High School Dropouts			College Equivalents/ High School Equivalents		
Period	Total	Immigrant	Native-Born	Total	Immigrant	Native-Born
1915-40	4.80	0.39	4.41	2.82	0.25	2.57
1940-60	3.49	0.22	3.26	2.96	0.21	2.75
1960-80	5.61	-0.13	5.74	3.89	0.06	3.83
1980-2005	2.49	-1.46	3.95	2.27	-0.16	2.43

Sources: See Table 5.

Notes: Each cell in the table is the annualized percentage change, from the beginning to the end of the period, of relative skill supplies measured in efficiency units. The "total" column gives the overall growth in relative skill supply. The immigrant and native-born columns decompose the overall relative skill supply growth into the immigrant and native contributions defined in the notes to Table 5. The immigrant column can be computed from the data in Table 5 cols. (3a.b) "immigrant contribution," which is the immigrant contribution to the relative skill supply. For example, from 1980 to 2005 the "immigrant contribution" for high school dropouts versus high school graduates went from 0.065 to 0.430 (Table 5, col. 3a). If there had been no foreign born in 1980, the log ratio of high school graduates to dropouts would have increased by 6.5 log points and in 2005 it would have increased by 43 log points. Thus, the annualized contribution of immigrants to changes in log(H/O) from 1980 to 2005 is given by $[(0.065 - 0.430) \times 100/25] = -1.46$. See the notes to Table 5 for the definitions of college and high-school equivalents and efficiency units. It should be noted that the relative supply numbers given here differ slightly from those in Table 1 for (college/high school) equivalents in efficiency units and Table 3 for (high school graduates/dropout) equivalents in efficiency units. To compute the impact of immigration we used a somewhat different method of computing efficiency units. In Table 6 we employ a set of fixed weights (see Table 5) but in Tables 1 and 3 we use different weights for each year.

Table 7
High School Graduates as a Share of the Labor Force (≥ 14 years old)

	Administrative Records (1)	Census (2)
Year		
1890	0.040	0.063
1900	0.044	0.080
1910	0.054	0.102
1920	0.079	0.150
1930	0.123	0.212
Change in high school graduate share		
1890 to 1910	0.014	0.039
1910 to 1930	0.069	0.110
Change in log relative supply		
1890 to 1910	0.315	0.523
1910 to 1930	0.899	0.857
Annualized log relative supply change × 100		
1890 to 1910	1.57	2.62
1910 to 1930	4.49	4.28

Sources: The estimates in col. (1) are from Goldin and Katz (1995, table 8). The estimates in col. (2) use the 1915 Iowa State Census and the 1880 to 1940 Census IPUMS.

Notes: The relative supply measure is the ratio of high school graduates to those with less than 12 years of schooling. The col. (1) estimates use the administrative data on flows of new high school graduates from Figure 1, Chapter 6 to build up stocks of high school graduates following the methodology described in the notes to table 8 of Goldin and Katz (1995).

The col. (2) estimates use individual-level data on all labor force participants (those reporting a gainful occupation) aged 14 years or older in each Census IPUMS from 1880 to 1930. We impute the probability that a labor force participant in the 1880 to 1930 Census IPUMS is a high school graduate based on high school graduate shares by birth cohort and sex in the 1915 Iowa State Census (for pre-1890 birth cohorts) and the 1940 Census IPUMS (for 1890 to 1916 birth cohorts). The Iowa estimates for pre-1890 birth cohorts are multiplied by 0.8, the mean ratio of the high graduate share for the overall U.S. to Iowa residents for 1870 to 1890 birth cohorts in the 1940 IPUMS. We assume that labor force participation rate from 1880 to 1930 was the same for male high school graduates and less-educated males. We assume that the labor force participation rate of adult female high school graduates (those 21 years and older) was 1.4 times the rate of less-educated adult females for 1880 to 1930. These assumptions are based on the labor force participation rates by education, sex, and cohort in the 1915 Iowa sample and 1940 IPUMS. We adjust downward the high school graduation rates of those 14 to 19 years old to reflect the lower labor force participation rates of those continuing in school. The 1890 estimate of the high school graduate labor force share is the average of the 1880 and 1900 estimates since there is no 1890 Census IPUMS sample.

Appendix to Chapter 8 (Appendix 8): *Construction of Wage Bill Shares and Educational Wage Differentials, 1915 to 2005*

Table A8.1
Wage Bill Shares and Educational Wage Differentials: 1915 to 2005

	Wage Bill Shares (percent)			Educational Wage Differentials		
	High School Dropouts	High School Graduates	College Equivalents	College/ High School	High School/Eighth Grade	High School/ Dropout
Iowa						
1915	80.9	9.1	7.4	0.638	0.370	0.243
1940	58.1	23.9	13.4	0.498	0.276	0.185
United States						
1940 Census	58.3	20.6	16.7	0.498	0.346	0.242
1950 Census	52.1	25.0	17.4	0.313	0.214	0.149
1960 Census	42.4	27.1	23.4	0.396	0.229	0.159
1970 Census	29.7	32.3	29.7	0.465	0.230	0.167
1980 Census	17.0	32.5	39.3	0.391	0.229	0.179
1980 CPS	15.4	34.2	39.5	0.356	0.223	0.170
1990 Feb. CPS	7.8	29.8	50.0	0.540	0.349	0.243
1990 CPS	8.6	29.9	49.4	0.508	0.267	0.207
1990 Census	8.0	26.8	51.0	0.549	0.284	0.213
2000 CPS	5.4	25.5	56.1	0.579	0.374	0.285
2000 Census	5.4	22.7	57.4	0.607	0.309	0.255
2005 CPS	5.0	24.4	57.6	0.596	0.366	0.286

Sources: 1915 Iowa State Census; 1940 to 2000 U.S. Census IPUMS; 1980, 1990, 2000, and 2005 CPS MORG samples; and February 1990 CPS.

Notes:
Wage Bill Shares: Wage bill shares, defined as the share of total labor earnings paid to each education group, are calculated for samples that include all individuals 18 to 65 years old employed in the civilian work force at the survey reference date. Since employment at the survey reference date is not available in the 1915 Iowa State census, we include all individuals with occupational earnings in 1914 in our calculations of wage bill shares for Iowa in 1915. The earnings of wage and salary workers and the self-employed are included in calculating wage bill shares in all years and samples. In those samples for which the earnings for the self-employed are not available (the 1940 Census IPUMS, the CPS MORG samples, and the February 1990 CPS), we impute the hourly earnings of the self-employed using the average earnings of wage and salary workers in the same industry-education-year cell following the approach of Autor, Katz, and Krueger (1998). High school dropouts are those with 0 to 11 years of completed schooling. High school graduates are those with exactly 12 years of completed school and no college. College equivalents include all of those with at least a four-year college degree (16 or more years of completed schooling) plus one-half of those with some college.

Educational Wage Differentials: The log college/high school wage differential is a weighted average of the estimated college (exactly 16 years of completed schooling or bachelor's degree) and post-college (17+ years of schooling or a post-baccalaureate degree) wage premium relative to high school graduates (those with exactly 12 years of completed schooling or a high school diploma) for the year given. The weights are the employment shares of college and post-college workers in 1980.

The log (high school/eighth grade) wage differential is the estimated wage premium for those with exactly a high school degree (12 years of completed schooling) and those with exactly 8 years of completed schooling. Changes in education coding in the census and CPS lead us to include workers with 5 to 8 years of completed schooling in the eighth grade category for the 1990 and 2000 Census, February 1990 CPS, and the 2000 and 2005 CPS MORG samples.

The log (high school/dropout) wage differential is a weighted average of the estimated wage premium for those with exactly a high school degree (12 years of completed schooling) relative to 4 groups of "dropouts," those with exactly 8, 9, 10, and 11 years of completed schooling. The weights are the employment shares in 1980 of dropouts with 8, 9, 10, and 11 years of completed schooling.

Educational wage differentials for the United States for 1940 to 2005 are estimated in each sample using a standard cross-section regression of log hourly earnings on dummies for single years of schooling (or degree attainment) categories (some schooling categories contain multiple years with education coding changes in 1990), a quartic in experience, three region dummies, a part-time dummy, a female dummy, a nonwhite dummy, and interaction terms between the female dummy and quartic in potential experience and the nonwhite dummy. The educational wage differentials are directly taken from the coefficients on the dummy variables for schooling categories. The regression samples include civilian employees from 18 to 65 years old. The regression specification and the specific data processing steps follow the approach of Autor, Katz, and Krueger (1998, table 1).

Estimates of educational wage differentials for Iowa from 1915 to 1940 required a different treatment based on our concerns with the meaning of college education for older cohorts in the 1915 Iowa state census, and difficulties in measuring the returns to education for women in the early twentieth century given the potential importance of unpaid family work. These issues are discussed in detail in Goldin and Katz (2000).

We use our preferred estimates of the returns to a year of college for young men (18 to 34 years olds) in 1914 and 1939 from Chapter 2, Table 7 to estimate the change in the log college high school wage differential from 1915 to 1940. The return to a year of schooling for young men decreased by 0.033, from 0.148 in 1915 to 0.115 in 1940, which implies a decline in the log (college/high school) wage differential of 0.140 from 1915 to 1940 after proportionally scaling up the 1940 return to a year of college for young men by a factor of 4.307 to equal the 1940 national (college/high school) wage differential of 0.498 for all workers aged 18 to 65 years.

The log (high school/eighth grade) and (high school/dropout) wage differentials for Iowa in 1915 and 1940 are estimated from samples of non-farm, full-year male civilian workers aged 18 to 65 years in the 1915 Iowa State Census and from those residing in Iowa in the 1940 Census IPUMS. These measures of the high school wage premium are taken from cross-section regressions of log annual earnings on dummy variables for single year of schooling categories, a quartic in potential experience, and dummy variables for nonwhites and for foreign born status. Hours and weeks of work are not available in the 1915 Iowa State Census but information on months of unemployment in 1914 is available. Full-year workers for 1915 are those with earnings in 1914 but no unemployment in 1914. Full-year workers in 1940 are those who worked at least 50 weeks in 1939.