Educational Attainment as a Constraint on Economic Growth and Social Progress

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Perceptions of the economic problems posed by inadequate educational attainment in the United States have changed over time. During the first part of the past half-century, U.S. educational reforms were driven heavily by political and economic competition with other parts of the world. The National Defense Education Act was passed in 1958 in response to the successful launch of the Soviet Sputnik. This legislation articulated the Cold War education challenge as the need to "develop as rapidly as possible those skills essential to the national security" (Title 1, A). In 1983, the National Commission on Excellence in Education, formed at the behest of the U.S. Secretary of Education, issued its findings on the quality of the education system in *A Nation at Risk*. The report warned of rival nations matching or even surpassing U.S. educational levels and saw the manifestation of a decline in U.S. productivity growth "as one great American industry after another falls to world competition."

In the last several decades of the twentieth century, the focus of national education policy shifted gradually from achieving international prowess to making progress on economic and social equality within the United States. The first major linkage of national education reform to equity concerns came in the Elementary and Secondary Education Act of

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1965, which focused on the needs of low-income children as part of the overall "War on Poverty." With the disintegration of the Soviet Union and the generally good U.S. economic performance in the second half of the 1980s and throughout the 1990s, educational reforms became even further disassociated from the language of international conflict and competition. Although it appeared solid on the whole, America's economic growth offered differential benefits to different groups, as workers with high educational attainment increasingly gained access to relatively higher-paying jobs, while real pay for workers with low educational attainment decreased over time. Thus, the Goals 2000: Educate America Act, passed with bipartisan support in 1994, focused on the problems associated with continuing educational achievement gaps among racial groups and between persons who were proficient in the English language and those who were not. Equalizing opportunity within the United States remained the primary goal behind the landmark No Child Left Behind Act of 2001.

In recent years, technology's importance in economic growth and the need to educate and train a technologically oriented workforce have been increasingly emphasized. Although earlier literature, most notably Richard Freeman's *The Overeducated American* (1976), warned of periodic gluts of college graduates as cycles of labor supply and labor demand did not coincide with one another, recent studies such as the National Research Council's *Building a Workforce for the Information Economy* (2001) have been more inclined to see tightness in scientific and technical fields as a secular feature of the economy.

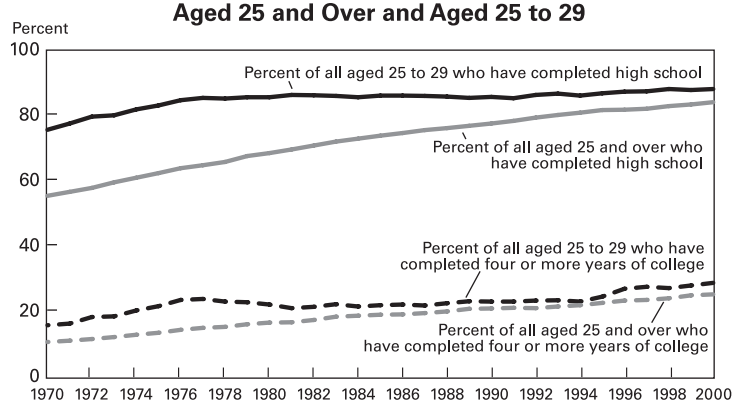
This paper investigates the evidence behind these shifting perceptions of the educational problem. It starts by reviewing the changes in overall educational attainment in the United States during the past several decades and by analyzing the implications for past and future economic growth. The paper then examines the educational attainment of different demographic groups in the population and the ramifications for social progress. Finally, the paper addresses arguments about mismatches in the supply of and demand for technically trained workers.

The paper reaches two broad conclusions. First, a growing body of evidence indicates that improving the quality of U.S. education, both on average and for specific population groups, should be of more concern than increasing the quantity of schooling. Second, as minority racial and ethnic groups account for a growing share of the U.S. population, improving their educational opportunities goes hand in hand with overall economic growth objectives.

The Facts on Overall Educational Attainment

Educational attainment in the United States has changed over the past 30 years. This section discusses whether or not overall educational

Figure 1
High School and College Completion Rates of U.S. Population Aged 25 and Over and Aged 25 to 29



Source: U.S. Census Bureau (March, various years).

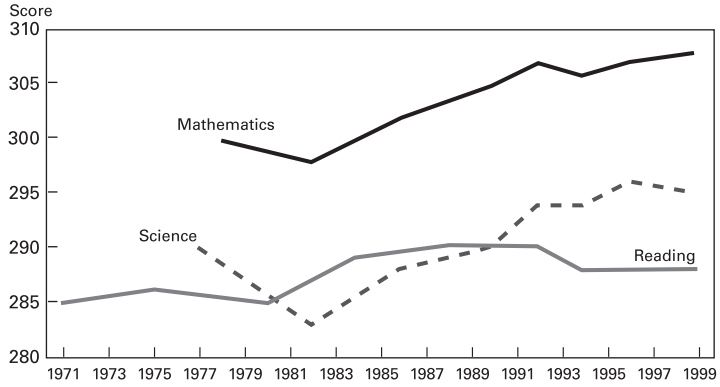
attainment is increasing and reviews the educational rankings of the United States compared to other countries. In examining these issues, the paper uses alternative measures of educational attainment, including both the extent of schooling (quantity) and the amount of knowledge obtained (quality) during these years of schooling.

Overall Trends

The U.S. population has become far more schooled during the past three decades. The share of the population 25 years and over who have completed high school rose from 55.5 percent in 1970 to 84.0 percent in 2000. The share completing four years of college rose from just 11.0 percent to 25.5 percent during this period (Figure 1).

However, much of the increase in schooling since the 1970s is due to the dying out of older generations with comparatively little education, rather than steadily growing educational attainment among younger generations. Individuals who are currently 25 to 29 years old have very similar educational attainment to their predecessors' levels of two decades ago. The share of 25- to 29-year-olds that completed high school increased from about 76 percent in 1970 to 85 percent in 1977 (Figure 1). This percentage stayed virtually constant until 1991 when it began increasing slightly, reaching 88 percent in 2000. Similarly, college completion rates among 25- to 29-year-olds increased in the 1970s but then held steady at around 25 percent throughout the 1980s and early 1990s.

Figure 2
NAEP Long-Term Trend Average Test Scores for 17-Year-Olds



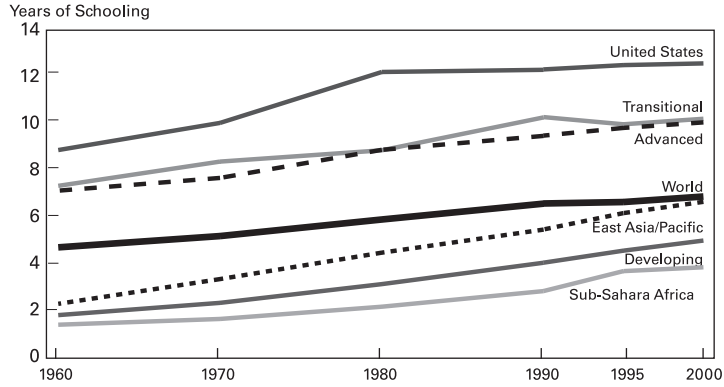
Source: U.S. Department of Education (2000).

College completion rates began to rise again in the second half of the 1990s, reaching about 29 percent by 2000.

While the number of years of schooling provides a rough estimate of the educational levels of the population, examining the knowledge gained during these years provides a useful measure of the quality of educational attainment. Murnane and Levy (1996) identified three categories of basic skills that are increasingly demanded by U.S. employers and that are necessary to earn at least a middle-class income in the United States. The first category includes hard skills such as mathematics, problem-solving, and reading ability. Relying on standardized test scores for these data, the most consistent time series comes from the National Assessment of Educational Progress (NAEP) long-term trend tests. Versions of these tests have been administered to nationally representative samples of 9-, 13-, and 17-year-olds periodically since 1969.[1] The NAEP and other nationwide tests measuring educational achievement trends do not assess the remaining two categories of skill sets identified by Murnane and Levy: "soft" skills such as the ability to work in groups and to make effective oral and written presentations, and the ability to use

[1] The first NAEP long-term trend test in science was administered in 1969. However, the early administrations of this exam are not reliably comparable to later tests because of changes in the questions and methodology. A similar problem exists in mathematics. In order to ensure consistency, only the test scores of the assessments beginning in 1977 for science and 1978 for math were examined.

Figure 3
Average Years of Schooling for Populations Aged 25 and Over, U.S., World, and Regions of the World



Note: Barro and Lee did not make adjustments in the U.S. data to compensate for definitional changes in the CPS from 1992 onwards.
Source: Barro and Lee (2000). Individual country data provided by authors through the Center for International Development at Harvard University.

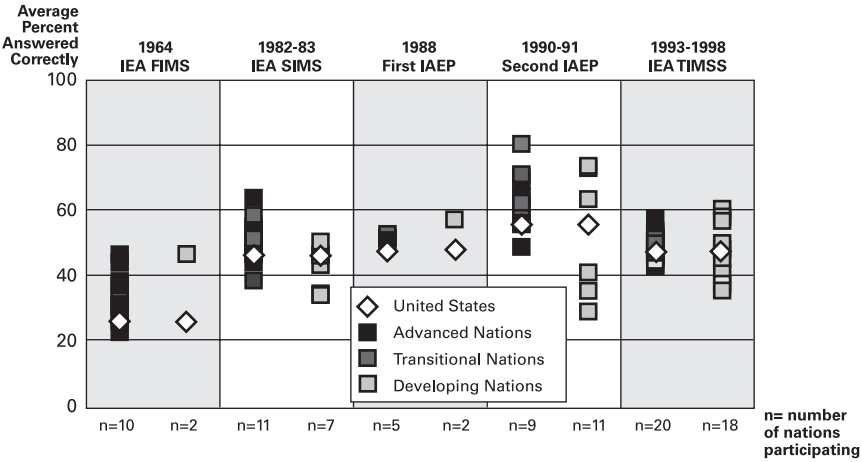
personal computers to carry out simple tasks such as word processing. (Additional information on access to computers is presented later in this paper.)

Figure 2 shows the average NAEP long-term trend test scores of 17-year-olds. Math, science, and reading scores all increased during the 1980s after decreasing in the 1970s. However, the 1990s saw smaller increases and showed some indications that 17-year-olds are losing ground. As of 1999, math scores were only slightly above their previous peak in 1992. Science scores continued to increase in the early 1990s but have retreated since 1996. Reading scores reached a plateau in the late 1980s and early 1990s, fell in the mid-1990s, and are currently holding steady at these lower levels.

International Comparisons: Wide Disparities across Countries and a Mixed Record for the United States

The United States leads the world in the average amount of education received by the population, with 12.2 years of schooling in 2000 (Figure 3). More generally, there exist large and persistent disparities in the educational attainment between advanced and transitional economies and developing economies. In 2000, the population of advanced and

Figure 4
International Math Scores of 13- and 14-Year-Olds



Note: The indicated sample sizes include the United States.
Source: Lee and Barro (1997). Data provided by authors through the World Bank web site, www.worldbank.org.

transitional nations on average had almost 10 years of schooling, while those in developing nations had less than five years. The overall gap has changed very little since 1960. Among the nations classified initially as developing, East Asian and Pacific countries have made substantial improvement over the past 40 years. They lead the developing nations in educational attainment, averaging 6.5 years, which is close to the world-wide average. In contrast, sub-Saharan Africa is at the bottom of the developing countries, with average years of schooling less than four years.

Despite the U.S. lead in having a highly schooled population, the U.S. educational system has not outshone the rest of the world in terms of student achievement at given levels of education. Figure 4 shows U.S. and other countries' scores on five international mathematics tests administered to 13- and 14-year-olds between 1964 and 1998. For each year, the figure shows the U.S. average score compared to advanced and transitional countries on the one hand and developing countries on the other.[2] The different years are not strictly comparable, as the methodologies, the groups of participating countries, and the coverage within

[2] Countries are defined as being in the same categories as in Figure 3.

countries for each test have all varied. Nevertheless, U.S. teens consistently place towards the lower to middle end of nations tested in mathematics, including those nations classified as developing.[3] The general picture for science, not shown, is similar.

The Role of Educational Attainment in Economic Growth

The previous section indicated that the U.S. population has increasingly received more years of schooling, but that the gains have slowed as progress among younger cohorts has diminished. Furthermore, the quality of education in the United States, through high school, is not impressive and is no longer improving for the average student—at least as measured by standardized tests focusing on reading, mathematics, and science. This section explores the impact of educational attainment on U.S. growth, both historically and in the future.

Causes of Growth in the United States

The most detailed accounting of the role of educational attainment in U.S. growth is found in a series of papers by Dale Jorgenson and various co-authors. These studies conclude that increases in labor quality via rising educational attainment have had a measurable effect on economic growth in recent decades.

As detailed initially in Jorgenson, Gollop, and Fraumeni (1987), the studies analyze the contributions to U.S. economic growth from capital and labor inputs and productivity. Labor's contribution comes from both increases in work hours and increases in the quality of the workforce. In the most recent of these studies, Jorgenson, Ho, and Stiroh (2002) estimate that increases in labor quality, via a more highly educated workforce, contributed an average of 0.3 percentage point per year during the period 1958–99. Overall economic growth (value added) during this period was 3.4 percent per year, and growth in output per hour worked was 1.8 percent per year.

Of the subperiods highlighted by Jorgenson, Ho, and Stiroh, the highest contribution of labor quality was in the first half of the 1990s (0.4 percent per year), and the lowest contribution was in the second half of the 1990s (0.2 percent per year).[4] The reason for the drop in the most

[3] Admittedly, developing countries are likely to administer the test to only a small fraction of 13- and 14-year-olds, since the average years of schooling in these countries is low.

[4] A related paper by Oliner and Sichel (2000) estimated that growth in labor quality contributed 0.22 percentage point to annual economic growth from 1974 to 1990, 0.44 percentage point from 1991 to 1995, and 0.31 percentage point from 1996 to 1999. They

recent five-year period is that as the unemployment rate fell in the late 1990s, many workers with relatively less education and experience entered the ranks of the employed labor force.

As valuable as the calculations of Jorgenson and his co-authors are, they may possibly understate the overall importance of education in U.S. economic growth in recent years. The neoclassical framework used in these studies measures the contribution of education to workers' productivity, but it does not attempt to quantify the role of rising educational attainment in making capital more productive. An increase in the supply of educated workers increases the market size for technologies that are complementary to educated labor and may induce the use of such technologies (Acemoglu 1998). This relationship is illustrated by comparing recent information technologies with older inventions: It takes more education to use a computer than to turn on an electric light switch or to drive an automobile. Thus, some of the growth that Jorgenson and his co-authors attributed to the greater use of information technologies (0.5 to 1 percent in the 1990s) might not have come about were it not for the education of the labor force.[5]

Projections of Stagnating Labor Force Quality

In concert with the analysis in the prior section of this paper, Ho and Jorgenson (1995) noted that the educational attainment of the 25- to 34-year-old age group has changed relatively little since the early 1980s.[6] Accordingly, they predicted that this relatively small increase in educational attainment will translate into gradually diminishing educational attainment increases for the workforce as a whole as these young workers account for a growing share of the overall U.S. labor force. Thus, the contribution of labor quality to growth is likely to be smaller in coming decades compared to what it was in the 1960s through the mid-1990s.

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estimated the following annualized growth rates in real nonfarm business output: 3.1 percent in 1974–90, 2.8 percent in 1991–95, and 4.9 percent in 1996–99. Thus, Oliner and Sichel are in general agreement with Jorgenson, Ho, and Stiroh about the relative importance of improvements in labor quality in overall economic growth. Unlike Jorgenson, Ho, and Stiroh, Oliner and Sichel do not view the latter part of the 1990s as being a period of low growth in labor quality, but they agree that the first part of the 1990s saw higher growth in labor quality.

[5] Similarly, Oliner and Sichel estimated that greater use of information technologies contributed 0.5 percentage point to annual economic growth from 1991 to 1995 and 1.1 percentage point from 1996 to 1999.

[6] This is especially true at the low end of the educational distribution. In 1982, 10.3 percent of 25- to 34-year-olds in the workforce had not completed high school. This share was 9.8 percent in 1999. At the high end, the share completing four or more years of college was fairly stable at about 27 percent between 1982 and 1994, but according to Ho and Jorgenson's updated tables (1999), it increased another 4 percentage points between 1995 and 1999.

A separate set of projections by Ellwood (2001) underscores this point. Both the overall size of the labor force and the share with a college degree are expected to show much smaller increases between 2000 and 2020 than between 1980 and 2000. The total U.S. labor force grew from 79.8 million in 1980 to 118.5 million in 2000, nearly 50 percent. Given the age mix of the current population and reasonable assumptions about immigration, the labor force is expected to expand by no more than 19 million, or 16 percent, between 2000 and 2020. The fraction of the labor force with a college degree increased from 21.6 percent in 1980 to 30.2 percent in 2000. If subsequent cohorts have the same education at age 25 as the 25-year-old cohort of 2000, the share of the labor force with a four-year college degree would increase only to 31.7 percent by 2020. Even under optimistic assumptions about rising educational attainment, the college share would increase only to 35.2 percent.[7]

Despite the strong presumption that the share of the labor force that is college-educated is likely to stagnate in the next two decades, the implications for U.S. economic growth are unclear. Under one view, this would constrain growth both through slowing worker quality (as in the Jorgenson studies) and by retarding the development and dissemination of new technologies. Under another view, the mix of contributions to future growth may be different from what it has been in the past, but the high number of years of education of the current and entering workforces may be sufficient to assure undiminished growth.[8] The remainder of this section reviews studies that cast further light on these predictions.

The Links between Education and Productivity

An article by Lucas (1988) set out to explicate the "mechanics of economic development" by focusing on the potential importance of human capital in enhancing the productivity of an economy's labor and physical capital. Inspired by this largely conceptual study, a series of subsequent empirical papers on "endogenous growth" investigated whether the average level of educational attainment, measured at a certain point in time, has a positive effect on a nation's per capita income growth in *subsequent* years. Some of these studies also examined whether increases in educational attainment have a contemporaneous effect on the

[7] Ellwood's "high-growth" scenario assumes that graduation rates from high school rise 0.25 percentage point per year over the next 20 years, the entry rate from high school into some college rises by 1 percentage point per year, and the entry rate from some college to college graduation rises by 1 point per year.

[8] For example, technological development might be redirected toward technologies that are less dependent on rising educational attainment for their adoption. Additionally, investment in physical capital might conceivably accelerate to offset slowing human capital investment.

rate of growth.[9] All the empirical studies conclude that there is a positive association between education and growth. However, because of measurement issues inherent in comparing countries with different educational systems and economies, disagreement continues to exist about how strongly and quickly education *causes* growth.[10]

On the whole, the endogenous growth literature to date has more definitive implications for developing countries than for developed countries such as the United States. Benhabib and Spiegel (1994) and Krueger and Lindahl (2001) found that countries with very low levels of educational attainment tend to grow slowly, all else equal. One explanation, supported in the former study, is that these countries lack the know-how to adopt the more productive technologies that are available elsewhere. This conclusion provides a pessimistic view of the growth prospects of the least educated of the developing countries.

Despite disagreements about the magnitude of the effect, the literature provides new evidence that quality of education may have an impact on economic growth, independent of quantity of education. Hanushek and Kimko (2000) examined the relationship between cross-country growth rates from 1960 to 1990 and average scores on various international math and science tests. In a closely related study, Barro (2001) studied per capita growth across countries in three time periods—1965–75, 1975–85, and 1985–95—along with the students' science scores from each country. Both studies found that quality of education, as measured by standardized tests, had more explanatory power than years of schooling. (While intriguing, these studies suffer from a comparatively limited amount of international test score data, so they should not be used too literally for policy analysis.)

All in all, the empirical literature since Lucas offers guidance to the United States while stopping short of a definitive conclusion about whether future per capita income growth will slow. It suggests that future growth would be higher if the average quality of schooling were higher and if the nation continued to make progress in raising the average number of years of schooling.

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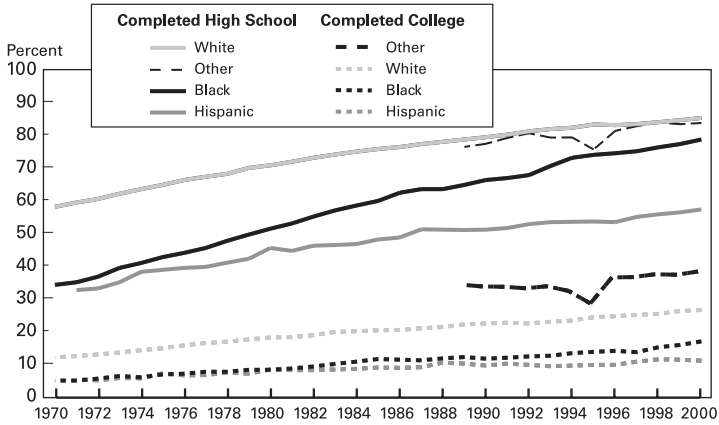
[9] This would flow out of the neoclassical growth model if labor were measured in efficiency units (as in Jorgenson's and related empirical work). It also flows out of aggregating the most commonly used microeconomic model of wage determination. The individual studies are discussed in Appendix A.

[10] Additionally, some attempts have been made to study these issues by comparing metropolitan areas within the United States (which reduces some of the measurement problems). This within-country literature has not reached consensus about which level of education, secondary or post-secondary, matters more. See Appendix A.

Figure 5
High School and College Completion Rates of U.S. Population Aged 25 and Over, by Race/Ethnicity



Note: Persons who are Hispanic are allocated to two categories: Hispanic (an ethnic designation) and either white or black (a racial designation). Beginning in 1996, the Census Bureau changed how it processed "Other" responses.
Source: U.S. Census Bureau (March, various years).

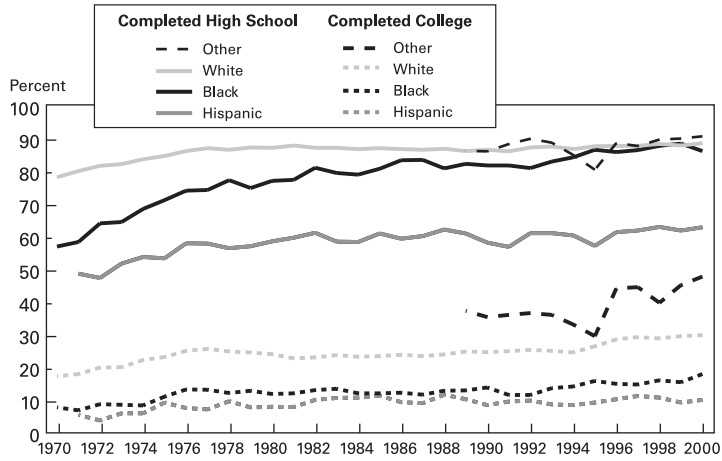
Continuing Racial and Ethnic Disparities in Educational Attainment

Perhaps more striking than the recent stagnation in educational attainment of the young, both in terms of years of schooling and knowledge acquired, is the growing gap among distinct population groups within the United States. Most notably, racial and ethnic inequalities persist in the educational attainment levels of Americans, with blacks and Hispanics continuing to be less educated, on average, than their white counterparts.

Examining the population age 25 years and older, blacks and Hispanics lag behind in both high school and college completion rates (Figure 5).[11] In 2000, about 85 percent of white adults had completed high school, compared to 78 percent of blacks and only 57 percent of Hispanics. The high school completion rate for "other" races—chiefly Asians—was very similar to that of whites. Twenty-six percent of white

[11] To ensure a consistent time series going back to 1970, the data on Hispanics from the Current Population Survey include both white and black Hispanics. The "white" and "black" categories shown here include Hispanics. The category marked "other" includes Asians, American Indians, and additional races.

Figure 6
High School and College Completion Rates of U.S. Population Aged 25 to 29, by Race/Ethnicity



Note: Persons who are Hispanic are allocated to two categories: Hispanic (an ethnic designation) and either white or black (a racial designation). Beginning in 1996, the Census Bureau changed how it processed "Other" responses.
Source: U.S. Census Bureau (March, various years).

adults and 38 percent of the "other" racial group had completed four years of college, compared to only 17 percent of blacks and 11 percent of Hispanics. The gaps for blacks and Hispanics are not just vestiges of past social inequality; they persist among the 25- to 29-year-old age group, especially with regard to college completion (Figure 6).

The trends in black and Hispanic high school completion rates are different from one another. By 1999, black 25- to 29-year-olds had successfully reached the high school completion rates of their white cohorts (88 percent).[12] Hispanics have remained far behind as a result of

[12] Past studies have shown that much of the racial gap in high school attainment has been closed by blacks via high school equivalency certificates (chiefly the GED, or General Educational Development). Differential use of the GED among racial and ethnic groups may be a source of concern if, as some studies have found, the payoff to a GED is not as high as the payoff to a regular high school diploma, exacerbating racial and ethnic inequalities. In fact, the share of GEDs among all high school finishers has risen since the 1970s, but the differences across blacks and whites have narrowed. In 1971, the number of GEDs equaled about 7 percent of all high school degrees. This share rose to about 14 percent by 1980 and hovered around 16 percent throughout the 1990s. According to Cameron and Heckman (1993), among 25-year-old males between 1979 and 1987, blacks were almost twice as likely to earn their degree via the GED than whites (13.3 percent versus 6.8 percent). However,

relatively stagnant attainment levels since the early 1980s. In 2000, 63 percent of 25- to 29-year-olds of Hispanic origin had completed high school; this was barely greater than the 61 percent rate that existed in 1982. Much of this disparity is the consequence of large influxes of relatively poorly educated Hispanic immigrants.[13] The U.S.-born Hispanic population in this age group shows a high school completion rate around 80 percent, much closer to the rates of their black and white peers.

Despite gains in high school degrees among the black population, black–white differences in four-year-college completion rates have not diminished over time. In fact, the black–white gap is slightly greater among young adults than in the adult population as a whole. Between 1970 and 2000, the college-completion rate among 25- to 29-year-old whites increased from about 17 percent to almost 30 percent (an increase of 13 percentage points). For young black adults, the rate increased from 7 percent to almost 18 percent (an increase of 11 percentage points). Gains in college completion rates for Hispanics over this entire 30-year period have been far more modest than both white and black gains and have been virtually nonexistent since the late 1980s.

The racial gap in educational attainment is less severe among persons who live in the suburbs, where the population has higher average educational attainment than the urban or rural populations. In 2000, 22.9 percent of black adults living in the suburbs had completed four years of college, close to the population-wide average of 25.5 percent and 5.7 percentage points below the suburban white average.[14] Among urban dwellers, 31.1 percent of whites had college degrees versus only 15.7 percent of blacks, for a gap of 15.4 points. Additionally, all suburban 17-year-old groups outperformed their urban and rural counterparts on NAEP tests, suggesting variance in school quality by location. The bulk of blacks continue to live in urban areas (53 percent), but an increasing share is living in suburban areas (34 percent in 2000). This location shift may possibly help raise black educational attainment in the future.

Since both young blacks and young whites have increased their rates

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Current Population Survey data from 1999 indicate that among the population aged 18 to 29, 9.8 percent of blacks (males and females) received their high school degree via the GED compared to 8.6 percent of whites. Thus, while the GED has played an important role in increasing relative high school attainment levels of blacks in the past, its importance appears to have diminished over time. However, the increasing reliance on the GED for high school attainment levels is likely associated with the observed slowing effect in overall college completion rates, as those who get a GED are less likely to go on to complete higher education than those who receive a traditional high school diploma. See Boesel, Alsalam, and Smith (1998).

[13] See Little and Triest (2002) and Clark and Jaeger (2002) for analyses of the role of Mexican immigration in the educational attainment of U.S. Hispanics.

[14] Overall high school completion rates have become more similar over time for dwellers in urban, suburban, and rural areas, but a growing gap has appeared between rural and metropolitan populations in their shares of college-educated.

of high school and college degree completion over time, the more stagnant patterns for young adults as a whole shown in Figure 1 must be attributable to the changing composition of the U.S. population. Indeed, the total (white plus black) Hispanic share of 25- to 29-year-olds is estimated to have risen dramatically, from 5.0 percent in the early 1970s to 15.5 percent in 2000.[15] The relatively low educational gains of this group over time have contributed significantly to the overall stagnation for young adults. Whites' overall population share has fallen, which also serves to depress overall educational gains, but this has been partly offset by the rising share for Asian Americans. In 1970, the 25- to 29-year-old age group was 88.2 percent white, 10.6 percent black, and 1.2 percent "other." In 2000, this group was 79.7 percent white, 13.8 percent black, and 6.5 percent "other." Breakdowns of "other," available since 1989, show that the Asian-origin share is now over 5 percent.[16]

Differences in Academic Achievement, Access to Information Technology, and Literacy

Knowledge assessment measures also indicate continuing racial and ethnic disparities. Differences in the white, black, and Hispanic test scores of 17-year-olds narrowed somewhat during the 1980s but many of these gains were lost in the 1990s.[17] The black–white gap in NAEP reading scores (Figure 7) narrowed from 52 points in 1971 to 21 points in 1988, but widened again to 31 points by 1999. The Hispanic–white gap was 41 points in 1975, 22 points in 1990, and 24 points in 1999. The basic patterns for math and science (not shown) are similar. These growing differences in the 1990s are not characterized by faster gains by white students, but rather represent declining scores among blacks and Hispanics.

These test-score differences represent real disparities in academic knowledge among groups. Using standards set in the NAEP "main" tests (a set of tests that are updated periodically to allow for change in pedagogy), the latest average scores for twelfth-grade whites in all three subject areas fall between "basic" and "proficient" (Table 1).[18] The average 1998 reading scores for blacks and Hispanics are in this same band, but the 2000 mathematics and science scores fall short of the "basic"

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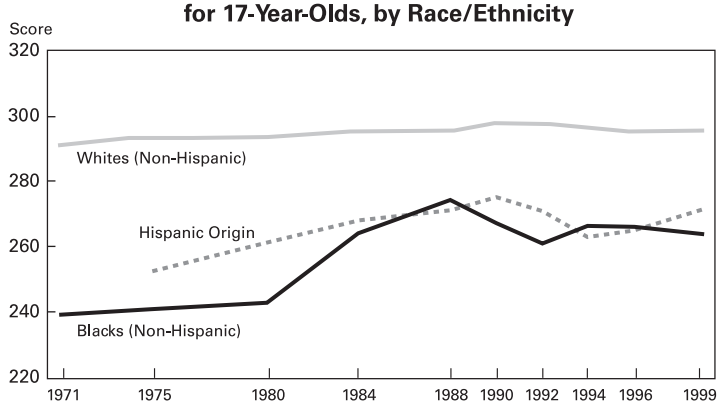
[15] As with the data on educational attainment, these numbers come from the Current Population Survey. Results based on the latest decennial Census (2000) are somewhat different because of its much greater coverage of the population, but they also show sharp changes in the composition of the population by race and ethnicity.

[16] The share for American Indians and Aleut Eskimos is about 1 percent; this group continues to have low average educational attainment.

[17] For the NAEP scores, the white, black, and Hispanic categories are mutually exclusive.

[18] More recent NAEP "main" tests have moved towards a greater degree of open-ended questions versus multiple choice and allow greater use of calculators for math problems.

Figure 7
NAEP Long-Term Trend Reading Test Scores for 17-Year-Olds, by Race/Ethnicity



Source: U.S. Department of Education (2000).

Table 1
Average Twelfth-Grade NAEP Scores by Race, Hispanic Origin, and Parental Education, versus Standards

	Reading (1998)	Mathematics (2000)	Science (2000)
Race/Ethnicity:			
Whites	298	308	154
Blacks	270	274	123
Hispanics	275	283	128
Parental Education:			
Graduated from college	301	313	157
Some education after high school	292	300	146
Graduated from high school	280	288	135
Did not finish high school	268	278	126
Standards:			
Advanced	346	367	204
Proficient	302	336	170
Basic	265	288	138

Source: U.S. Department of Education (1999c, 2001b, and 2003).

achievement level.[19] Indeed, on the four administrations of the mathematics tests given between 1990 and 2000, average black and Hispanic twelfth-grade scores almost always fell short of the basic achievement score of 288.[20] According to the NAEP, this meant that these students did not have a high probability of being able to determine the cost of renting a car given the per-day and mileage charges, nor were they able to apply the concept of perimeter.

To some extent, the test score differences for white, black, and Hispanic high school students reflect differences in family circumstances, such as the disparate educational attainment of their parents' generation. Higher (lower) parental education is associated with higher (lower) student test scores on the NAEP (Table 1). In the 1998 reading test and the 2000 mathematics and science tests, students whose parents had received some education beyond high school had average scores above the "basic" achievement standard. Students whose parents' highest education was a high school degree had average math and science scores that either just barely met the "basic" standard or fell short of it. In light of the differences in schooling completion rates among racial and ethnic groups over the past three decades, a higher percentage of black and Hispanic students are likely to have less-educated parents, which contributes to continuing gaps in NAEP test scores.

Achievement differences in NAEP scores resulting from family background call into question the equalizing effect of public schools. Nevertheless, data on school resources, specifically computer and Internet access, indicate that schools tend to equalize access to information technology compared to what white, black, and Hispanic students have at home.[21] In 2000, Hispanic children aged 6 to 17 were only one-half as likely as whites to have access to a computer at home—38 percent, versus 79 percent (Figure 8). However, 70 percent of Hispanic children reported being able to use a computer at school, compared to 84 percent for whites (Figure 9).

While smaller than the disparities in homes, the school disparities have remained fairly persistent over time. The 14-point gap between white and Hispanic-origin students in computer access at school is similar to the 13-point gap in school use as of 1984. While still below that of white students, black school-age children's recent rates of computer

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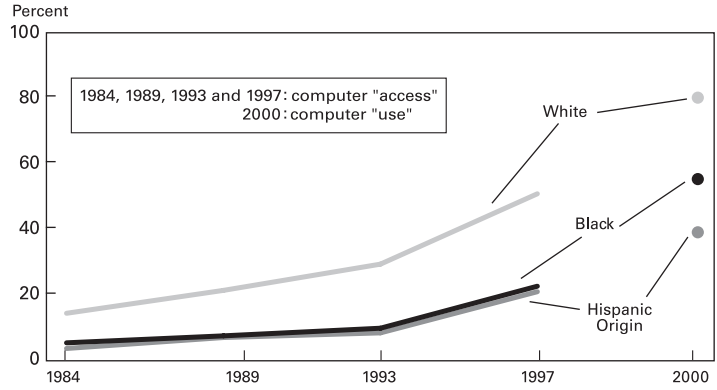
[19] Admittedly, a National Research Council committee concluded that the NAEP cutoffs for "proficient" have been set too high, but they did not draw a similar conclusion with respect to the definition of the "basic" standard (National Research Council 1999).

[20] The one exception was Hispanics in 1996, whose scores were just higher than this standard.

[21] Supplements to the Current Population Survey in October 1984, 1989, 1993, and 1997 provide information about school-aged children's use of computers, and the supplement in August 2000 provides an update on access (but not actual use). The 2000 data on blacks and whites define these categories exclusive of Hispanics.

Figure 8
Home Computer Use among Children Aged 6 to 17, by Race/Ethnicity



Note: Data for 2000 for "whites" and "blacks" do not include Hispanics; in all other years, "whites" and "blacks" include Hispanics.
Source: U.S. Census Bureau (October 1984, 1989, 1993, 1997; August 2000).

usage and access have been slightly above the rates for Hispanics. The 1997 survey shows noticeable convergence between black and white computer usage, but the 2000 survey suggests renewed divergence.

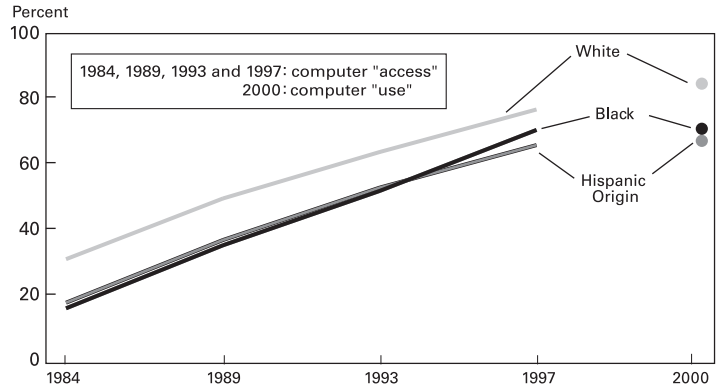
The ongoing computer-access gap in schools among whites, blacks, and Hispanics seems to contradict the widespread publicity over the major strides made in hooking schools up to the Internet since the 1996 "E-rate" legislation.[22] Indeed, 96 percent of public schools with 50 percent or more minority enrollment had Internet access in 2000, more than a 30 percentage point increase since 1997 and not much below the 100 percent rate for schools with very few minority students (Figure 10).[23] However, the percentage of instructional rooms with Internet access has continued to differ sharply across schools with different racial compositions. In 2000, schools with the largest minority enrollments had only 64 percent of instructional rooms wired to the Internet, while schools with little minority representation had 85 percent of rooms hooked up (Figure 11).

The gaps in school and home resources as indicated by technology access and manifested in student test-score data have a lasting effect on the relative achievement levels of whites, blacks, and Hispanics. Post high

[22] Officially known as the Universal Service Order provision of the 1996 Telecommunications Act.

[23] Minorities include all groups except non-Hispanic whites.

Figure 9
School Computer Use among Children Aged 6 to 17, by Race/Ethnicity



Note: Data for 2000 for "whites" and "blacks" do not include Hispanics; in all other years, "whites" and "blacks" include Hispanics.
Source: U.S. Census Bureau (October 1984, 1989, 1993, 1997; August 2000).

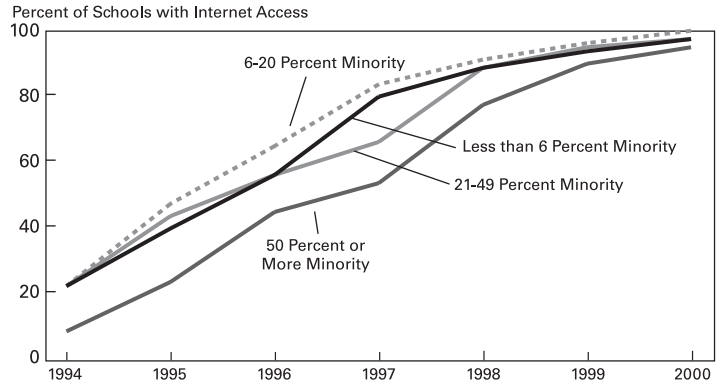
school education and training do not counteract these effects, as racial achievement differences exist even among persons with similar years of schooling. In 1992, the U.S. Department of Education administered the National Adult Literacy Survey to some 13,500 persons 16 years of age and older.[24] The survey tested respondents on reading comprehension, the ability to use documents such as tables and forms, and the ability to use printed materials to perform computations or other quantitative analysis. The resulting scores were translated into five levels of literacy. No dividing line has been established between literate and illiterate, but income and employment are strongly and positively correlated with literacy scores. Moreover, individuals who demonstrate only level-one or level-two literacy are much more likely to be receiving food stamps and living below the poverty line.[25]

Not surprisingly, average proficiency increased with years of education. However, within each educational attainment category, literacy scores also varied among whites, blacks, and Hispanics, reflecting

[24] This test was re-administered in 2002 with a greater attempt to link demographic and background information with literacy levels. Results are not yet available.

[25] Over 40 percent of adults scoring in levels one and two live in poverty, compared to 4 to 8 percent of adults scoring in the highest two levels. Further, 17 to 19 percent of adults in levels one and two receive food stamps, compared to only 4 percent for individuals in levels four and five.

Figure 10
Internet Access in Public Schools, by Percent Minority Enrollment

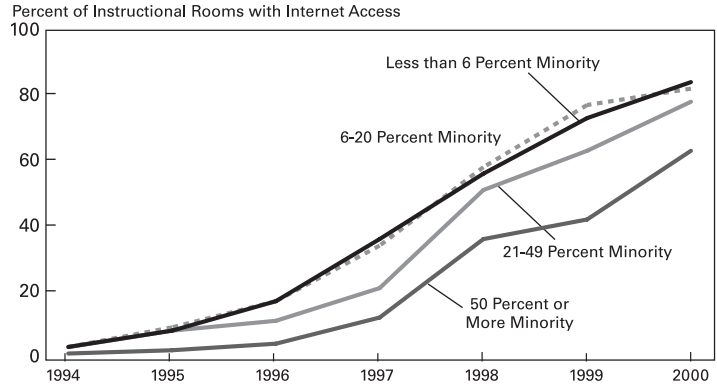


Source: U.S. Department of Education (2001a).

a persistency in the achievement patterns seen among teenagers (Figure 12).[26] Among "terminal" high school graduates, the average white literacy score was considerably higher than that of blacks, putting the average white adult at literacy level three, while blacks and Hispanics remained at level two. The score gap remained similar between blacks and whites with some college, and increased among college graduates. The average white college graduate was at level-four literacy, while among blacks and Hispanics, only college graduates demonstrated average literacy above the lowest two categories. According to the U.S. Department of Education, these literacy scores imply that the average black and Hispanic adult with less than four years of college has a low probability of being able to use a bus schedule for a given set of conditions and is not likely to be able to interpret instructions for an appliance warranty (1993).

[26] For the National Adult Literacy Survey, "white" and "black" include persons of Hispanic origin. Some of the reported gaps for people not currently in high school may include the effects of poorer education for older cohorts of minorities, since they are not broken down by age.

Figure 11
Internet Access in Public-School Instructional Rooms, by Percent Minority Enrollment



Source: U.S. Department of Education (2001a).

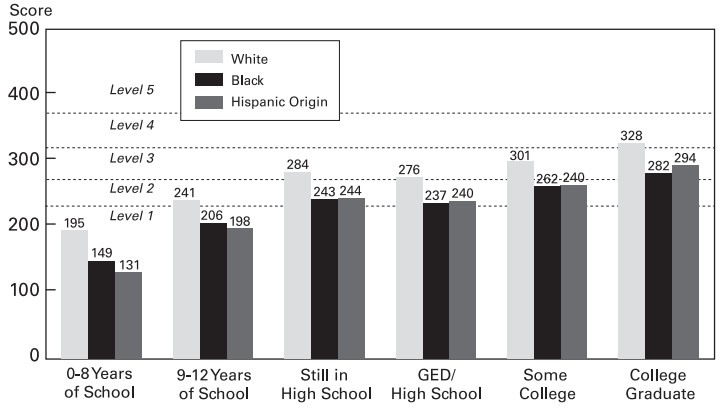
Educational Attainment by Sex: Persistent Differences in Subject Area Test Scores

In contrast to the patterns among whites, blacks, and Hispanics, male–female differences in educational attainment have largely disappeared over time. At least since 1970, adult women and men have demonstrated equal high school completion rates (Figure 13). Although college completion rates differed greatly for men and women in the 1970s, over the past 30 years this gap has shrunk as a result of steeper increases in college graduation rates among women. By 2000, in the population aged 25 years and older, almost 28 percent of males had completed four years of college compared to 24 percent of women.

The remaining gap in college completion is due to differences between males and females within the white population. Black women's college completion rates traditionally have been on par with black men's, and Hispanic women had matched Hispanic male completion rates by the late 1990s.

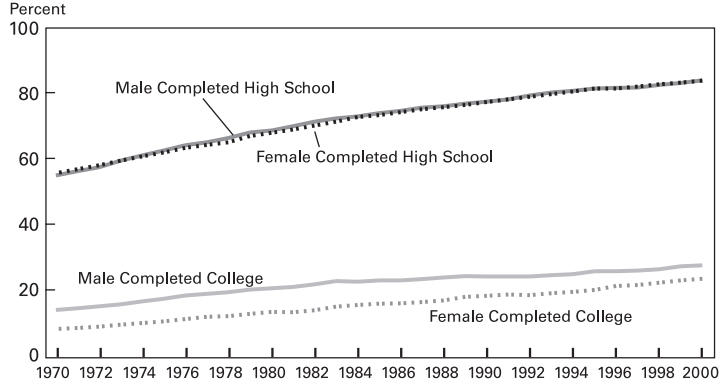
Focusing on the younger generation shows that since the mid-1990s, a slightly higher percentage of all women than men in the age group 25 to 29 have completed four years of college (Figure 14). Thus, the gaps remaining in the adult population likely will evaporate over time—or even reverse—as younger women continue to match or exceed younger men in educational attainment.

Figure 12
Average Literacy Proficiency Scores, by Education and Race/Ethnicity



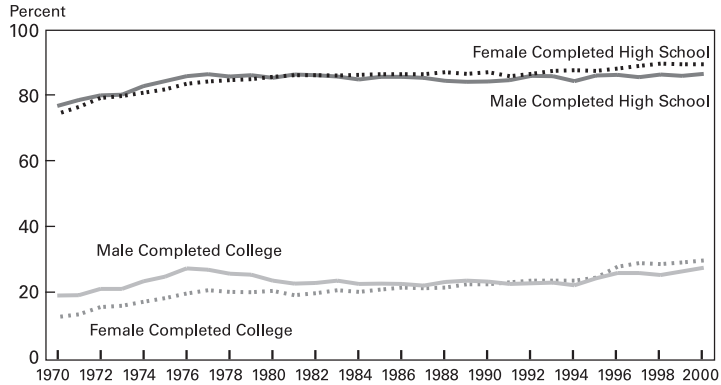
Source: U.S. Department of Education (1999a).

Figure 13
High School and College Completion Rates, U.S. Population Aged 25 and Over, by Sex



Source: U.S. Census Bureau (March, various years).

Figure 14
High School and College Completion Rates, U.S. Population Aged 25 to 29, by Sex



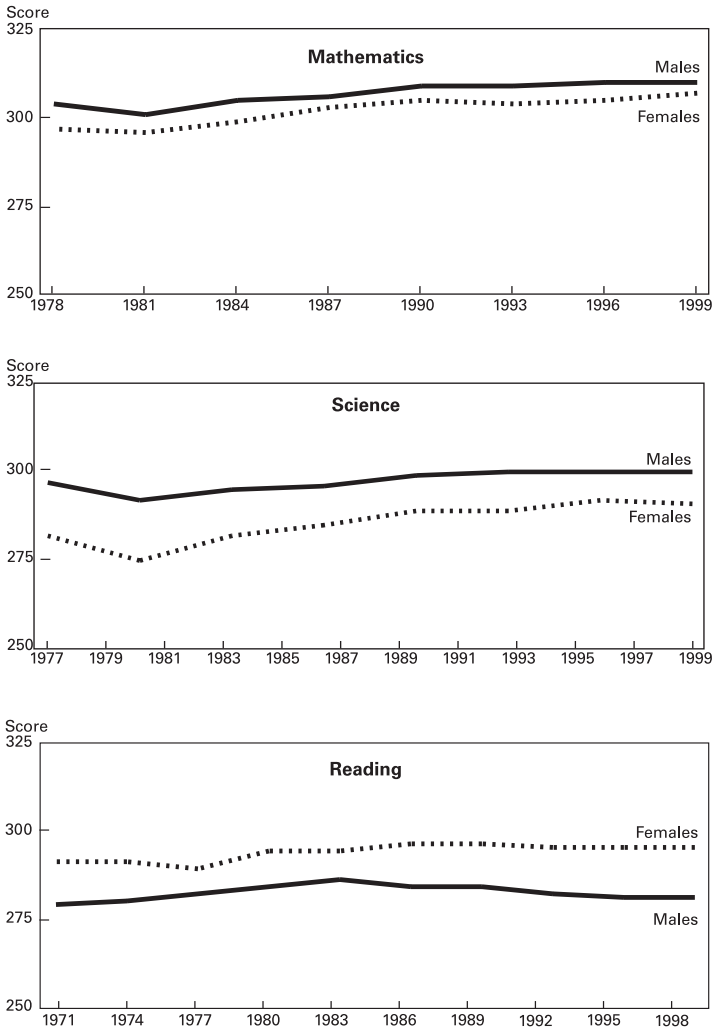
Source: U.S. Census Bureau (March, various years).

Although men and women are becoming equal in their likelihood of completing college, differences still exist in assessment test scores by different subject areas. On the NAEP, 17-year-old boys performed better than girls on the math and science tests, while girls outperformed boys on the reading test (Figure 15). The gender gap is no longer considered statistically significant in mathematics, but a meaningful difference continues to exist in science. The gender gap has widened in reading as male scores worsened throughout the 1990s. These persistent achievement differences suggest that men and women may continue to choose different mixes of occupations in future years. These choices may imply different incomes, if mathematical and scientific skills are compensated more or less highly than language skills.

Occupations: Limited Opportunities for High School Dropouts, Growing Opportunities for College Graduates

Educational attainment is strongly linked to employment opportunities. The past and present inequality in educational attainment and achievement between demographic groups has contributed to differences in the occupational mix of these groups. This, in turn, creates income and employment gaps by race, ethnicity, and gender. Studying changes in the educational attainment levels of workers in major occupation groups suggests that opportunities for high school dropouts are disappearing

Figure 15
NAEP Long-Term Trend
Test Scores for 17-Year-Olds, by Sex



Source: U.S. Department of Education (2000).

throughout the economy. While high school graduates still comprise the majority of workers in most major occupational categories, they do not dominate the fastest-growing occupations. Instead, college graduates are increasingly dominating the fastest-growing fields.

The educational attainment levels of workers in every major occupational category have increased over the past 30 years. In 1970, only a minority of service workers, machine operators, assemblers, inspectors, farm workers, and laborers had completed high school. Now, high school completion is the norm across the board. In each of the nine major occupation groups, 70 percent or more of the workforce has at least a high school diploma (Figure 16). This implies that a high school diploma is a common requirement for most types of jobs.

The percentage of college degrees has also increased within occupational groups, but typical increases have been modest (Figure 17).[27] As recently as 2000, only professional and technical occupations employed a majority of workers with four years of college. The next closest categories were executive, administrative, and managerial (49 percent) and sales (32 percent). Each of the other categories had 15 percent or fewer workers with four years of college. Thus, the workforces across different occupations have remained very different in the prevalence of a college degree.

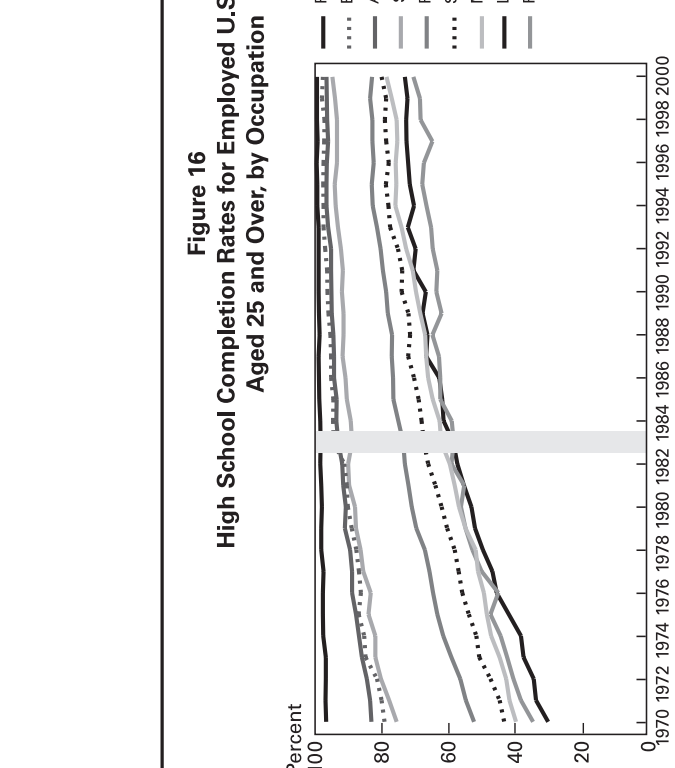
However, as is well known, the fastest-growing occupations have been the ones that employ college-educated workers most intensively (Figure 18). Professional and technical occupations employed 16.7 percent of the workforce just after a major classification break in 1983 and 19.8 percent in 2000. Executive, administrative, and managerial occupations increased from 11.8 percent to 16.1 percent over this same period. The largest decline was in machine operators and related professions, which have traditionally had a low representation of educated workers whether measured by either high school or college completion. The expansion of occupational fields that employ larger shares of college graduates indicates the growing importance of these degrees. This evidence coupled with the growing necessity of a high school degree illustrates the potential future limits on occupational opportunities for groups who lag behind in educational attainment.

Educational Attainment and Earnings Equality

The last section detailed the lingering inequalities in educational attainment in the United States, especially among whites, blacks, and persons of Hispanic origin, and to a much more limited degree between men and women. This section explores the quantitative impacts of these differences on earnings inequality. To what extent do blacks' and His-

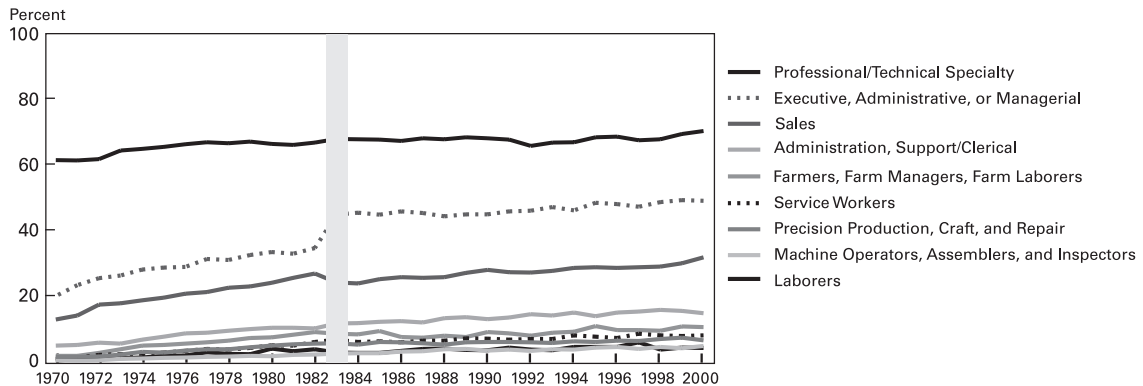
[27] The classification change in 1983 appears to have been quite significant for changing the percentage with a college degree in some occupations. In particular, executive, administrative, and managerial occupations had a greater presence of college graduates after the classification change than before. As seen later, the sales category grew considerably as a result of reclassification, but its share with a college degree decreased only modestly.

Figure 16
High School Completion Rates for Employed U.S. Population Aged 25 and Over, by Occupation



Note: In 1983, the Census Bureau changed the classification of several occupations, moving them from one occupational group to another. The largest impact was in the Executive, Administrative, Managerial group. Several occupations in this category were reassigned to the Administrative Support/Clerical, Sales, Machine Operators, and Service Workers categories. Additionally, several occupations that were previously in the Professional/Technical Specialty group were reassigned to the Executive, Administrative, Managerial Position group. Other minor changes in classification occurred in 1971 and 1992.
Source: U.S. Census Bureau (March, various years).

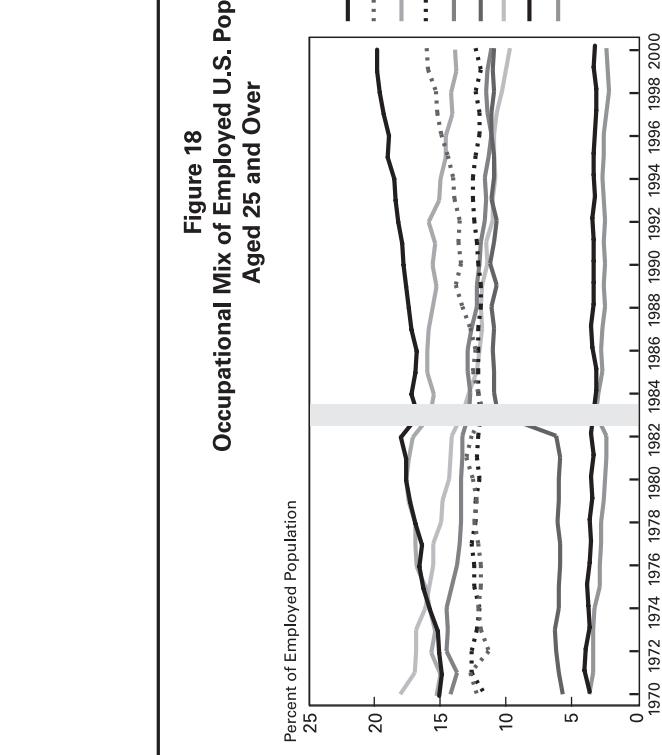
Figure 17
College Completion Rates for Employed U.S. Population Aged 25 and Over, by Occupation



Note: In 1983, the Census Bureau changed the classification of several occupations, moving them from one occupational group to another.The largest impact was in the Executive, Administrative, Managerial group. Several occupations in this category were reassigned to the Administrative Support/Clerical, Sales, Machine Operators, and Service Workers categories. Additionally, several occupations that were previously in the Professional/Technical Specialty group were reassigned to the Executive, Administrative, Managerial Position group. Other minor changes in classification occurred in 1971 and 1992.

Source: U.S. Census Bureau (March, various years).

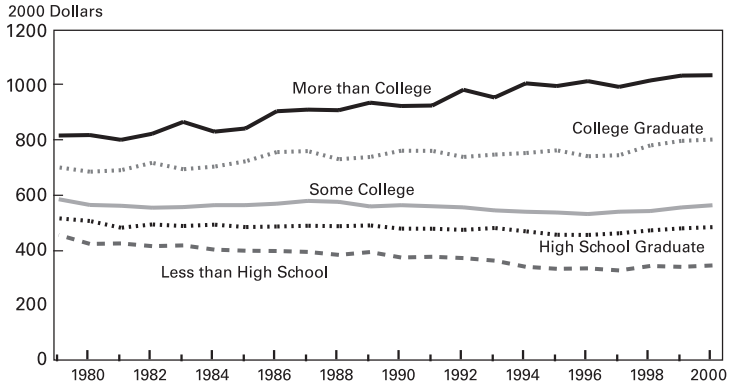
Figure 18
Occupational Mix of Employed U.S. Population Aged 25 and Over



Note: In 1983, the Census Bureau changed the classification of several occupations, moving them from one occupational group to another. The largest impact was in the Executive, Administrative, Managerial group. Several occupations in this category were reassigned to the Administrative Support/Clerical, Sales, Machine Operators, and Service Workers categories. Additionally, several occupations that were previously in the Professional/Technical Specialty group were reassigned to the Executive, Administrative, Managerial Position group. Other minor changes in classification occurred in 1971 and 1992.

Source: U.S. Census Bureau (March, various years).

Figure 19
Median Weekly Earnings of Full-Time Workers by Educational Attainment



Note: Wages are converted to 2000 dollars using the CPI-U-XI.
Source: U.S. Census Bureau (2000), Outgoing Rotation Earner Study.

panics' lower educational attainment account for their lower economic status? To what extent can male–female income differences be explained by educational differences?

The Rising Penalties to a Lack of Education

As has been widely acknowledged and analyzed, educational attainment has been of growing importance in determining income, particularly in the United States, which has relatively little regulation or centralized coordination of pay scales compared to most other nations. Less-educated persons tend to be out of work more frequently than highly educated persons. Moreover, during the past couple of decades, even full-time employment has been associated with declining real earnings over time for the less educated. Meanwhile, college graduates have enjoyed a growing payoff to their education.

Figure 19 illustrates the growing earnings differences associated with different levels of educational completion among full-time workers. Among those with less than a four-year college degree, median real earnings fell almost continually from 1979 to the mid-1990s. Adjusted for inflation, median earnings dropped 27.4 percent for those with less than a high school education, 11.7 percent for those with only high school, and 8.3 percent for those with some college. The increases in the late 1990s still

leave these workers' median weekly earnings in 2000 below what they were a decade earlier.

By contrast, pay generally has increased over time for those with a college degree or more, albeit at different rates in different time periods. As a result, in 2000, the median full-time worker with a four-year college education earned 67 percent more than one with only a high school diploma. In 1980, this differential had been 36 percent, or roughly one-half of its current spread.

Differential Payoffs to Education: An Important Source of Earnings Inequality

The sharp earnings penalty for a lack of education, combined with the growing payoff to completing college, suggests that the lingering differences in college completion rates between whites and blacks, and the growing differences between whites and Hispanics, could have major ramifications for economic inequality. This section will attempt to quantify this effect. To do so, this paper relies heavily on the insights and numerical findings of a recent study by Bradbury (2002).

Bradbury's contribution is to point out that the typical payoffs to further education have varied among demographic groups in the United States. Based on regression analysis using the Current Population Survey, she finds that blacks and Hispanics did not see as steep an increase in the educational wage premium between 1980 and 2000 as their nonblack or non-Hispanic counterparts. Thus, minorities' earnings were held back, not just because they had lower educational attainment levels, but because the payoff to education was not as great as for majority earners.

Although Bradbury focused on changes in the educational wage premium over time, her data and estimated coefficients can be used to answer the following questions: How much of the earnings gap between blacks and nonblacks would be closed if blacks completed the various levels of schooling at the same rates as nonblacks? How much do differences in educational attainment account for earnings differences between Hispanics and non-Hispanics and between women and men?

As detailed below, it turns out that "simply" equalizing years of schooling would close only one-fifth to one-third of the observed earnings gaps between minority and majority men who work full time, and roughly one-half of the earnings gap between minority and majority women who work full time. The remaining earnings gaps result from non-Hispanic whites earning much more for any given level of education than Hispanics or blacks. This suggests that there are earnings penalties associated with a lower-quality education and the other characteristics of minority neighborhoods, or that labor markets discriminate by race and ethnicity, or that some combination of these various factors leads to earnings gaps across groups.

Table 2
Sources of Weekly Earnings Differences for Men
Constant 2000 Dollars

	1979–1980	1999–2000
Black Men versus Nonblack Men		
Actual Difference	148.81	138.13
Simulated difference if blacks given nonblacks' characteristics and:		
If each group's education mix and returns to education kept at actual values	156.20	148.91
If blacks given nonblack education mix	119.61	122.82
If blacks given nonblack returns to education	41.68	34.11
Hispanic Men versus Non-Hispanic Men		
Actual Difference	147.59	237.72
Simulated difference if Hispanics given non-Hispanic characteristics and:		
If each group's education mix and returns to education kept at actual values	236.33	282.73
If Hispanics given non-Hispanic education mix	172.77	181.78
If Hispanics given non-Hispanic returns to education	64.49	121.51

Source: Author's estimates and Bradbury (2002) using "upper-bound" coefficient estimates that exclude occupation and industry from the equations.

Table 2 summarizes the evidence for men, by different racial and ethnic groupings. In 1979–80, the average real weekly wage was $478 for black full-time male workers and $627 for nonblack full-time male workers, for a difference of $149. (These earnings are expressed in 2000 dollars.) Part of this wage difference is associated with factors not directly linked to education, such as usual work hours per week, marital and family status, potential years of work experience, and region of the country. According to Bradbury's regressions, equalizing these other factors produces a slightly larger wage difference, $156.[28]

To determine the share of the wage difference caused by educational

[28] The simulations reported here use Bradbury's "upper-bound" estimates for education. Occupation and industry mix are omitted from the independent variables in the regressions. Thus, whatever added differences in earnings may be attributable to occupation and industry are subsumed in the other coefficients, and the simulations do not explicitly equalize the mix of occupations and industries. Bradbury's "lower-bound" estimates include occupation and industry as separate regressors. Using these results and equalizing occupation and industry choices across groups changes the numerical conclusions somewhat for minority versus majority women, but hardly at all for men. Nor does this assumption matter in analyzing overall male–female differences. Appendix B presents the full details of the two sets of estimates.

differences, a new set of calculations was performed in which black men were assigned the same educational attainment patterns as nonblack men. The percentage of black men completing less than high school dropped dramatically in this simulation, while the percentages completing only high school, some college, college, and more than college were each increased. The new educational attainment rates were multiplied by the estimated payoffs for black men from completing each level of education, as estimated in Bradbury's regressions. The increase in black men's years of schooling lifted their weekly earnings by about 8 percent, or $37. However, this increase was only 23 percent of the simulated earnings gap in 1979–80. Similarly, when the same exercise was done using the 1999–00 observations on educational attainment and payoffs to education, black men's weekly earnings rose about 6 percent. The weekly earnings gap narrowed by $26, only 18 percent of the $149 simulated earnings gap between black and nonblack men.

In a second new simulation exercise, black men retained their actual composition of educational attainment, but each educational attainment level was assumed to earn the same return in the labor market as that experienced by white men. In her paper, Bradbury found that, holding constant a range of other attributes, nonblack high school graduates currently earn about 20 percent more than black high school graduates, while nonblack college graduates earn 23 percent more than black college graduates. She found similar differences in 1979–80.[29] Not surprisingly then, giving black men the nonblack earnings at each level of education would raise their simulated earnings considerably. Indeed, black men's real weekly earnings were raised by about $115 in both 1979–80 and 1999–00. This amounted to roughly three-quarters of the observed earnings gap between the two groups, holding non-education factors constant.

Performing the simulation exercises for Hispanic versus non-Hispanic males yields broadly similar results. Because Hispanics have fallen further behind non-Hispanics in their average years of schooling, raising their years of schooling closes more of the earnings gap than is the case for blacks. However, the shortfall in quantity of schooling still does not account for the bulk of their shortfall in earnings. If Hispanic men had achieved the non-Hispanic men's educational mix, the size of their simulated real earnings gaps would have been reduced from $236 to $173, or by 27 percent, in 1979–80. In 1999–00, 36 percent of their earnings gap would have been closed. As in the case of black men, a far larger share of

[29] See Bradbury's Figure 12 for differences in payoffs for blacks and nonblacks and Figure 13 for Hispanics and non-Hispanics. The numbers cited rely on the "lower-bound" estimates, but the "upper-bound" estimates are not very different.

Table 3
Sources of Weekly Earnings Differences for Women
Constant 2000 Dollars

	1979–1980	1999–2000
Black Women versus Nonblack Women		
Actual Difference	27.93	62.94
Simulated difference if blacks given nonblacks' characteristics and:		
If each group's education mix and returns to education kept at actual values	34.93	58.07
If blacks given nonblack education mix	19.56	33.77
If blacks given nonblack returns to education	14.70	25.55
Hispanic Women versus Non-Hispanic Women		
Actual Difference	53.82	131.45
Simulated difference if Hispanics given non-Hispanic characteristics and:		
If each group's education mix and returns to education kept at actual values	73.31	131.77
If Hispanics given non-Hispanic education mix	32.46	54.28
If Hispanics given non-Hispanic returns to education	33.01	80.26
All Women versus All Men		
Actual Difference	207.53	141.03
Simulated difference if women given men's characteristics and:		
If each group's education mix and returns to education kept at actual values	159.45	86.13
If women given men's education mix	159.56	98.70
If women given men's returns to education	−3.26	−13.29

Source: Author's estimates and Bradbury (2002) using "upper-bound" coefficient estimates that exclude occupation and industry from the equations.

the earnings gap is accounted for by lower labor market returns from completing given amounts of education.

Turning to women who work full time, the earnings differences between blacks and nonblacks and between Hispanics and non-Hispanics are much smaller—on the order of one-half of those among men in 1999–00 (Table 3). Additionally, the returns to education are more similar among women of different racial and ethnic groups than among men. For example, black (Hispanic) female high school graduates working full time earn roughly one-tenth less than nonblacks (non-Hispanics); the

percentage gaps are similar among college graduates.[30] As a result, providing black women with the same number of years of schooling as nonblack women closes their current earnings gap by 42 percent, while providing them the same rates of return for a given number of years of education closes the gap by about 56 percent. For Hispanics versus non-Hispanics, the percentages are roughly the reverse: Raising the number of years of schooling for Hispanics would reduce their earnings gap by more than half.[31]

Finally, a similar exercise was conducted for comparing women and men. These two groups' years of schooling are quite similar. As discussed earlier, women lag behind men somewhat in four-year college completion. However, among full-time workers, greater shares of women than men complete high school and get some education beyond high school. Not surprisingly then, all of the earnings difference between men and women who work full-time can be attributed to differences in the returns from completing a given level of education (after equalizing weekly hours of work, the influences of family and marital status, and the other variables used to produce simulated earnings).

Implications for Policy

Trying to attribute the observed earnings gaps among whites, blacks, and Hispanics into separate portions categorized by differences in years of schooling and differences in returns to completing a given number of years of schooling is somewhat artificial. If blacks and Hispanics were able to earn the same amount upon completion of high school or college as whites, they would likely stay in school longer.[32] Moreover, the analysis in Bradbury's study and this paper considered only full-time workers. Persons who receive little education are less likely to be in the workforce and less likely to be employed, relative to their more-educated peers. Thus, raising the years of schooling for blacks and Hispanics would tend to have an additional equalizing effect on earnings by raising their likelihood of being employed, which is not measured here.

Nevertheless, the analysis strongly suggests that, to combat the earnings gap, more emphasis should be put on policies that raise the payoff to education for minority groups. The first step in this process is developing an understanding of why returns from completing the same number of years of schooling differ across population groups. After

[30] These percentages are from Bradbury's "lower-bound" estimates shown in her Figures 12 and 13; the simulations reported here use the "upper-bound" estimates.

[31] Hispanic women's educational attainment levels are further below non-Hispanic women's than is the case for black women relative to nonblack women.

[32] See Cameron and Heckman (2001) for further discussion of incentive effects and barriers to educational attainment for blacks and Hispanics.

reviewing a variety of empirical studies, Bradbury concludes that the differentials reflect a combination of influences. First, institutional factors, such as labor market discrimination, create distinctions between groups. Second, "differences exist in the quality of education obtained by different groups, implying that individuals with similar 'educational attainment' do not actually have the same education, and, by implication, job skills" (p. 41). Indeed, this paper has shown evidence of differences in school resources, standardized test scores, and literacy among racial and ethnic groups. An additional problem is likely to be geographic segregation by income and race, which leaves many minority households living in neighborhoods without established job networks and far away from fast-growing suburban employers (Bradbury, Kodrzycki, and Mayer 1996). Since white women tend to live in the same locations and attend the same schools as white men, the earnings differences associated with similar educational attainment are likely reflective of differences in career paths.

Shortfalls of Technical Talent and Their Implications

A final set of concerns for the United States is that the skill mix of the educated labor force may be suboptimal in some sense. If the mix of knowledge embodied in workers is out of line with the demands of employers, economic growth may be curtailed in the affected industries, perhaps enough to spill over to the economy as a whole.

Although these concerns have waxed and waned over time, they keep reemerging and usually focus on scientific and technological skills. For example, as early as the 1950s, studies appeared on engineering shortages in the United States, and in the late 1980s, projections for a shortfall of engineers during the 1990s became commonplace. More recently, in the second half of the 1990s, employers perceived a shortage of information technology workers, not only in the United States but worldwide, prompting the National Research Council to commission a detailed, high-level study of these issues (National Research Council 2001).

The focus of concerns on technical occupations is, in part, a consequence of their perceived importance in overall economic growth and in achieving additional national objectives. For example, a study issued by the U.S. Bureau of Labor Statistics (Braddock 1992) began as follows:

> Our Nation's economic progress and general well-being depend in considerable measure on the work of scientists, engineers, and technicians. These men and women contribute to the development of new products, improvements in productivity, enhanced defense capabilities, environmental protection, and advances in communications and health care (p. 28).

If anything, this perception has increased as technology's role in recent economic growth has been emphasized:

> It is important to the nation that there be an adequate number of scientists and engineers. Industries that rely on scientific and technical research and development are increasingly important in both the global and American economies. If there are too few scientists and engineers, the economy and its competitive position, both now and in the future, are put at risk (National Research Council 2000, p. 15).

Supply or Demand?

From the standpoint of economic theory, a shortage can develop in the short run as the relative demand for different skills shifts and the supply of appropriately skilled workers does not match the demand. In response, wages or other aspects of compensation for these skills increase so that shortages tend to be eliminated over time.[33] However, the mismatch of skills may pose a longer-term problem if demand spikes unexpectedly for skills that are acquired only over a lengthy period of education or training, or if market barriers prevent wages from adjusting.[34] It is important to examine the mechanics of technical labor markets to assess the potential danger of longer-term shortages.

Little if any evidence exists that shortages of scientific and technical workers are a permanent feature of advanced economies such as the United States. For this to be true, the private return (that is, wages and other forms of compensation) in these occupations would have to fall short of the productive contributions of the workers on a continual basis. Despite the acknowledgement of the importance of scientific and technical innovations, no study has yet indicated that market failures cause these workers to be underpaid.[35] Developing countries, by contrast, may face a chronic "brain drain" problem as skilled professional and technical workers migrate to more advanced countries, where pay tends to be higher.

Instead, tightness in scientific and technical fields tends to be episodic. Demand for these skills, on occasion, has shifted abruptly and for an unpredictable period of time as a result of policy or technological

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[33] The other aspects of compensation may include monetary benefits or nonmonetary amenities such as improved working conditions or enhanced prestige.

[34] Another possible problem might be if demand for certain skills somehow chronically increases too much for supply to adjust. This possibility has been modeled theoretically, but it has not received empirical support.

[35] Within the U.S. context, it may plausibly be argued that teachers currently are underpaid, since this field has been dominated by women, whose professional opportunities have been limited historically as a result of sex discrimination and social norms. See Temin (2002).

change. For example, the demand for engineers and other technical workers rose considerably from the late 1970s to the late 1980s as U.S. defense procurement outlays doubled as a share of GDP. Recently, demand for information technology (IT) workers rose sharply as real investment in information processing equipment and software went from 3 percent of real GDP in early 1995 to almost 7 percent by the end of 2000.[36] The college labor market as a whole is not faced with such sharp swings in demand. As noted by Ryoo and Rosen (2001), most other types of college-educated workers tend to be employed in relatively stable services industries.[37]

These sudden demand shifts combine with slow supply adjustment to create potential problems in technical fields. Engineers and computer scientists must receive appropriate education and training. This requires not only a significant amount of time, but also flexibility within educational institutions to adjust their instructional staff and facilities. However, it is not clear that this slow supply adjustment is unique to technical fields. At a first approximation, the adjustment periods for these fields are likely similar to those for other occupations that are dominated by a highly educated workforce.[38]

It is plausible that the historic volatility of demand in technical fields may lead prospective workers to discount wage and salary signals, slowing the supply adjustment relative to workers in other steadier fields. Following the defense buildup of the 1980s, demand for engineers and technical workers was halted by the end of the Cold War and the resulting dramatic declines in defense procurement. The boom of spending on IT in the late 1990s was followed by a dramatic bust that brought on a national recession and resulted in lower demand for IT workers.[39]

However, contrary to ex post evidence concerning demand volatility in technical occupations, the National Research Council's report, issued

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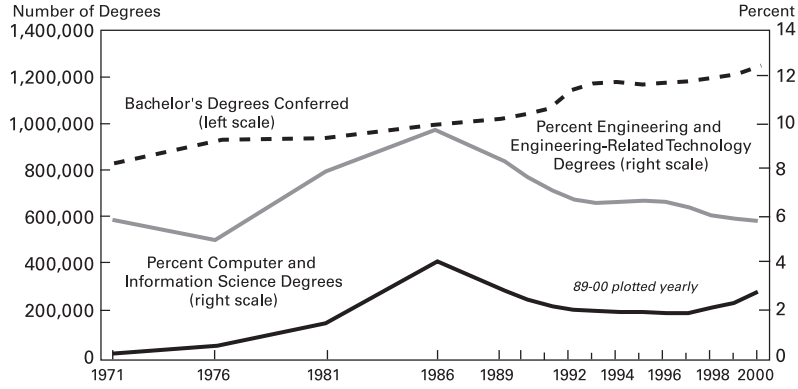
[36] Admittedly, these statistics on expenditures are not indicative of demand alone, but also reflect the supply of workers in the industries producing these goods and services.

[37] Moreover, because the upswings in demand for technical workers have been so strong on occasion, they have contributed significantly to national economic growth. Thus high demand for engineers in the late 1980s and high demand for IT workers in the late 1990s coincided with periods of low overall unemployment, which compounded the recruitment and retention of these workers.

[38] Moreover, many positions in technical fields can be filled with persons with a limited period of formal education. The National Research Council estimated that about one-half of the five million positions in information technology fields involve the application, adaptation, configuration, support, or implementation of IT products designed or developed by others. These positions do not require lengthy formal education and training periods. Of the higher-level positions involving development of IT products, about two-thirds of the workers have at least a bachelor's degree, but in many cases their university degrees were in fields other than computer science, which suggests that graduates in other fields were able to retrain for IT (National Research Council 2001).

[39] For example, Internet advertisements for high-technology workers in New England fell 75 percent between early 2001 and early 2002 (*Mass High Tech* 2002).

Figure 20
Total Bachelor's Degrees Conferred and Shares in Engineering and Computer Sciences



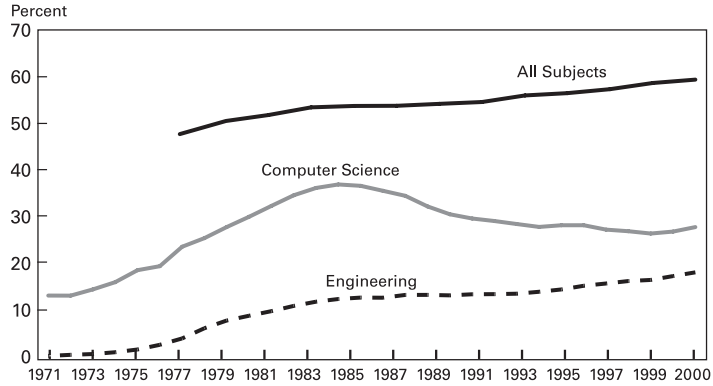
Source: U.S. Department of Education (2002).

before the downturn was evident, surmised that "there is some historical precedent for thinking that the IT sector might be affected less severely than other sectors by an overall downturn and even that IT growth can continue during an overall downturn" (2001, p. 119). Thus, volatility could have dissuaded students from pursuing IT-related degrees only if they were more farsighted than objective experts were.

Moreover, a look at recent trends in college majors suggests that escalating salaries for IT specialists have elicited a supply response. The share of U.S. bachelor's degrees awarded in computer and information sciences rose from about 2 percent in the mid-1990s to about 3 percent in 2000 (Figure 20). Conversely, engineering's share of bachelor's degrees has fallen continuously since the late 1980s, despite Ryoo and Rosen's estimate that "the speed of response in this market to changing conditions is rapid" (p. 2).

One problem, identified by Romer (2000), may be that engineering schools do not advertise engineering salaries to their prospective students to the same extent that business and law schools do. If prospective students do not realize that the relative pay for engineers has risen, this would tend to lengthen the adjustment period following an increase in demand for engineers. By contrast, the abundance of Internet-based salary information for IT positions may lead to a relatively faster

Figure 21
Share of Bachelor's Degrees Conferred to Women in All Subjects, Computer Sciences, and Engineering



Source: U.S. Department of Education (2002).

adjustment to changes in pay.[40] In addition, however, the rates of increase in IT salaries, at least in the late 1990s, appear to have been higher than for engineers (National Research Council 2001).

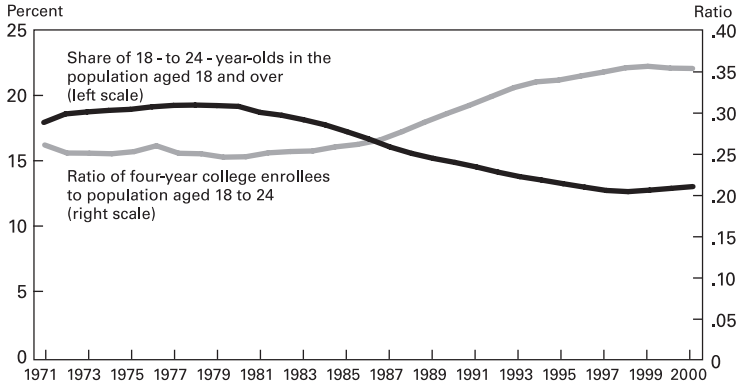
Another barrier to increasing the share of college students completing engineering degrees may be the continuing under-representation of young women. Even as the share of all U.S. bachelor's degrees awarded to women approaches 60 percent, the share of engineering bachelor's degrees awarded to women remains under 20 percent (Figure 21). Although computer science also has a preponderance of male majors, its female share has been considerably higher than that in engineering. The continuing weaker performance of high school girls than boys on science tests may exacerbate the challenge of shifting a greater share of college students into technical fields.

Demographics as a Current Complication for Supply

This study has argued that, given the mixed evidence on supply adjustment, it is the sudden demand shifts relative to other sectors that

[40] See National Research Council (2001) for examples of web sites.

Figure 22
Share of 18- to 24-Year-Olds in U.S. Adult Population and Ratio of Four-Year College Enrollees to Population Aged 18 to 24



Source: U.S. Department of Education, (2002).

are especially important in creating periodic tightness or shortages in scientific and technical fields. However, the upsurge in demand for IT workers in the 1990s took place against a backdrop of constraints on supply that appear to be both predictable and longer-lasting.

One constraint has been the slowing increase in college attendance among the young. Another constraint has been slow population growth among the age group that typically attends college. Because of the maturing of the baby boom, the share of 18- to 24-year-olds in the total U.S. population 18 years and over fell from about 19 percent in the late 1970s to about 13 percent in the late 1990s (Figure 22).

As discussed above, demographically based projections call for only modest increases in the number of college graduates during the next two decades (Ellwood 2001). To the extent that projections of a reemergence of growth in demand for IT workers come to pass, the anticipated overall slow growth in supply of college-educated workers would tend to constrain the ability to fill positions—*even if* choices of college majors are responsive to market signals. Thus, mechanisms to retrain the adult workforce as demand for technical skills increases appear to deserve even greater attention than in the past.

Summary and Conclusions

This study provides support for the view that the existing patterns of educational attainment in the United States threaten social progress. The Hispanic share and, to some extent, the black share of the population have risen over time. Yet not only do blacks and Hispanics complete fewer years of schooling than whites, but more important for their economic status, their educational resources and achievement lag behind at each level of schooling. Some of these gaps, particularly performance on standardized tests, have widened in the past decade. Moreover, newer educational initiatives, such as providing access to information technology in the classroom, have been introduced less widely in schools with higher proportions of minority students. These apparent differences in the quality of schooling received by whites, blacks, and Hispanics, as well as likely differences in non-school inputs and access to jobs, account for a greater share of earnings differences observed among full-time workers in these groups than differences in their years of schooling.

Because children's educational achievement has been closely linked to the levels of education completed by their parents, raising educational achievement for racial and ethnic minorities will take a sustained effort. By contrast with the differences by race and ethnicity, differences in the economic status between men and women are no longer attributable to differential rates of access to higher education. Instead, they are likely associated with continuing differences in the fields of work that men and women pursue.

Unless new policies offset the effects of existing demographic and educational patterns, improvements in labor quality are likely to contribute less to economic growth in the United States in the coming two decades than has been the case since the 1960s. The key reasons for this projection are the relatively slow increase in years of schooling obtained by young adults and the relatively low share of the population in the age group when labor market entry typically occurs. Furthermore, international test scores indicate a continuing mediocre performance for U.S. students on average. These trends suggest that capital formation or technology development would have to provide an offset in order to keep per capita income growth from slowing in coming decades. They also suggest that surges in demand for educated labor, as have occurred periodically in scientific and technical fields, will be challenging to accommodate.

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Appendix A: Education as an Explanation for Why Countries Grow at Different Rates

This Appendix provides a more detailed review of the approaches and findings of the endogenous growth literature.

Education as a Precursor to Growth

Barro (1991) tested the endogenous growth model in a study of growth rates in per capita GDP for a sample of 98 countries for the period 1960 to 1985. He explored the relationship of per capita GDP growth to initial levels of per capita GDP and human capital, controlling also for a range of other economic and political variables such as the ratio of government consumption to GDP, the degree of political instability, and economic distortions.[41]

Barro concluded that higher human capital levels (holding initial GDP and other variables fixed) are strongly positively related to subsequent growth. Barro also explored the mechanisms by which higher human capital may lead to higher growth. He found, empirically, that countries with high human capital have low fertility rates and high rates of physical investment, both of which tend to raise per capita income growth. He indicated that the regressions help account for the high rates of economic growth in Pacific Rim countries, which had relatively high levels of human capital compared to initial GDP. However, the model fails to account for much of the relatively weak performance over this period for countries in sub-Saharan Africa and Latin America.

A shortcoming of the study is the crude measurement of human capital. Barro used primary and secondary school enrollment rates—that is, total numbers enrolled in school relative to the population size of the relevant age groups. At best, this measure approximates the rate of investment in human capital; it does not indicate the stock of human capital embodied in the working-age population.[42]

Since the publication of Barro's 1991 study, Barro and Lee (2000) have collaborated on improving the measurement of human capital. The newer data are based on combining periodic census or survey measures of the education levels of the adult population and measures of new school entrants, which affect adult education with the appropriate time lags. Representative results presented in Barro and Sala-i-Martin (1995) indicate that average years of secondary and higher schooling have positive impacts on a country's subsequent growth.

The Barro-type analysis has been extended to U.S. cities and metropolitan areas by Glaeser, Scheinkman, and Shleifer (1995) and by Simon (1998). These authors found that areas with higher initial education tended to show higher rates of growth in per capita income and/or population in subsequent decades. Glaeser, Scheinkman, and Shleifer found the presence of high school graduates to be more important than college graduates, whereas Simon attached greater importance to the college-educated labor pool.

Human Capital: Analogies to Physical Capital

The main purpose of Mankiw, Romer, and Weil (1992) was to test the endogenous growth model (as supported empirically by the Barro studies) against the neoclassical growth model. Mankiw, Romer, and Weil amended the traditional neoclassical growth model by adding the stock of human capital as a separate factor of production. Thus, physical capital, human capital, labor (measured essentially as the number of workers), and

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[41] Barro's 1991 study is explicitly empirical. He does not specify a theoretical model of growth. The macro growth literature tends to include initial per capita income in order to test theories about income convergence across countries; these tests are not the focus of this current review of the literature.

[42] Basic problems include possible measurement errors in enrollments as well as the ambiguous definition of the denominator, especially for developing countries where students frequently intersperse periods of school attendance with extended periods of absence from school. Nonetheless, Barro's fundamental results held even when the sample was restricted to the 55 countries that had per capita GDP above $10,000 in 1960.

an exogenously determined level of technology determine the level of output. Using an assumed Cobb-Douglas production technology and making use of steady-state properties of the neoclassical growth model, Mankiw, Romer, and Weil showed that the major determinants of a country's growth in output per capita are its initial per capita output level and the rates of accumulation of physical and human capital.[43] Using the same 98 countries and 1960–1985 time period as Barro (1991), Mankiw, Romer, and Weil concluded that per capita GDP growth varies positively with investments in both human and physical capital. They proxied human capital accumulation by the ratio of secondary school enrollment to the working-age population. In a follow-up to the Mankiw, Romer, and Weil paper, Bernanke and Gürkaynak (2001) rejected certain key findings of the neoclassical model, but concluded nevertheless that a country's rate of economic growth is correlated with its rate of human capital accumulation.

Who Is Correct: Barro, or Mankiw, Romer, and Weil?

Benhabib and Spiegel (1994) set out to test the competing views of how human capital affects growth. Is human capital an "ordinary" input akin to labor and physical capital, as in Mankiw, Romer, and Weil, or does it induce growth by facilitating the development or adoption of technology, as in Barro (1991)?

Benhabib and Spiegel started by positing an aggregate Cobb-Douglas production function with physical capital, human capital, labor, and technology as inputs. They estimated the level of human capital of the labor force as a function of 15-year lags of the enrollment rate in primary schools and five-year lags of the enrollment rates in secondary schools and higher education (derived from Kyriacou 1991). The model was estimated for per capita income growth from 1965 to 1985 using a sample of up to 78 countries. Whether measured by the new Benhabib and Spiegel variable or by the cruder variables used in Barro (1991), human capital was found to be insignificant in determining per capita growth (and, in fact, entered negatively).

In another exercise, Benhabib and Siegel tested whether human capital facilitates technological progress (rather than serving as a separate input into production) through two separate mechanisms. Their regressions included the level of human capital as an indicator of a country's capacity for innovation. To indicate the country's capacity for technological catch-up, they also included an interaction term between the level of human capital and the gap between a country's per capita income and that of the leading nation.[44] The results supported the view that human capital is a determinant of growth through the latter mechanism, technology catch-up. By splitting the sample into three separate groups of countries, Benhabib and Spiegel found that this channel is especially important for countries at low levels of economic development. Krueger and Lindahl (2001), discussed below, also concluded that "the positive effect of the initial level of education on growth seems to be a phenomenon that is confined to low-productivity countries" (p. 1130).

Measurement Can Make the Difference

Krueger and Lindahl injected a microeconomics perspective into the debate. They noted that the microeconomic (or "Mincer") model of earnings determination posits that an individual's wage is a positive function of years of schooling. This model has been shown to provide a good description of wage differences across individuals in a variety of studies using data for many different nations.[45] Aggregating over individuals within a country and differencing across years yields a macroeconomic version of the Mincer model in which the

[43] More precisely, the model determines output per effective worker, which is a function of the number of workers and the level of technology. In their empirical work, Mankiw, Romer, and Weil use output per person of working age.

[44] In the discussion of the structural model presented in their Table 5, Benhabib and Spiegel are not clear as to whether human capital and the income gap are measured at the beginning of the sample period.

[45] These studies also control for individual differences in labor market experience, sex, and race.

growth in average earnings depends on the change in average education. If the rate of return increases secularly over time, initial education also will enter positively.[46]

Given the apparent success of the Mincer model, Krueger and Lindahl found it puzzling that influential macroeconomic studies conclude that the change in a country's human capital does not matter in determining income growth. One possible explanation is that the degree of education an individual receives is merely an indicator of the individual's (unobserved) ability, rather than something that adds to his or her productive capacity. However, Krueger and Lindahl cited a series of microeconomic studies rejecting the view that education is principally a signaling device.

An alternative explanation, which Krueger and Lindahl support, is that measurement problems prevent schooling changes from entering significantly. They showed that the schooling data developed in Kyriacou and used in studies such as Barro and Lee are poorly correlated when expressed as changes in educational attainment within countries over intervals of time. Furthermore, these data sets appear especially deficient in measuring the amount of secondary and higher education, when compared to the recent World Values Survey. Krueger and Lindahl questioned the inclusion of physical capital formation in growth regressions, preferring a more parsimonious specification.[47] When capital is omitted from the regression, they found that the change in schooling is more likely to be significant. Furthermore, its significance was greater when the time period analyzed is increased from five years to 10 or 20 years, which the authors interpret as further evidence of measurement error. Over short periods of time, variations in average schooling data for a country are likely to reflect measurement problems more than true changes in schooling.

In their study, de la Fuente and Doménech (2000) also developed evidence that measurement error has biased the findings of previous studies. The authors constructed new data on educational attainment in the 21 OECD countries for the period 1960–1990, making use of a greater amount of national information and fixing artificial breaks in the series caused by changes in classification criteria.

Additionally, de la Fuente and Doménech posited an aggregate production function in which the output per employed worker depends on the stock of physical capital and the average number of years of schooling of the adult population. They used pooled data at five-year intervals and estimated the equation in both levels and changes. They allowed for time and country dummies. In the equations for the growth rate of per-worker output, the growth in schooling has a significant positive effect when measured by the revised de la Fuente and Doménech data but not when measured according to Barro and Lee.

Allowing for Quality Differences in Education

The literature summarized so far has made use of human capital stock measures based on cumulating historical data on school enrollments. Since years of schooling are likely not to be comparable across countries, some very recent studies have made attempts to measure the quality of education received. These studies may be of particular interest to developed nations that have well-educated workforces as measured conventionally but that are increasingly concerned with improving academic achievement.

Hanushek and Kimko (2000) construct composite measures of labor force quality for 31 countries based on six mathematics and science tests administered between 1965 and 1991 by the International Association for the Evaluation of Educational Achievement (IEA) and the International Assessment of Educational Progress (IAEP). They extended the analysis to a sample of about 80 countries by constructing labor force quality measures via

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[46] Macroeconomic studies use the change in log GDP per capita as the dependent variable, not the change in the mean of log earnings. Krueger and Lindahl indicate that if income has a lognormal distribution over time, and if labor's share is constant, the results from these two alternative dependent variables should be the same.

[47] One issue is endogeneity: Fast growing countries may have greater access to capital. Another issue is artificial correlation with growth, since capital formation is derived from data on investment, which is a component of GDP. Barro (1991) did not include capital formation among the independent variables.

regression analysis using the limited test scores for some countries, along with additional indicators such as family characteristics and school resources.

Hanushek and Kimko performed regression analysis to explain differences in cross-country growth rates during the period 1960 to 1990. They found that the quantity of schooling (as measured by Barro and Lee) becomes insignificant when the labor force quality measures are added. Furthermore, the inclusion of labor force quality substantially boosts the explanatory power of the regressions.

A closely related panel study by Barro (2001) examined per capita GDP growth for 100 countries in three time periods: 1965–1975, 1975–1985, and 1985–1995. Quality is measured by science, mathematics, and reading scores, although for some countries test scores are available only for the 1990s. In this study, Barro found that both the quantity of schooling and the quality as measured by science scores have an effect on growth, with quality being more important than quantity. Thus far, owing to a lack of good data, the literature has not investigated the effects of changes in school quality over time.

Reverse Causality and Omitted Variables

The authors of most of the recent studies have noted that education seems to have an implausibly large effect on economic growth (in addition to the cited studies, see Bils and Klenow 2000). This may be a result of either reverse causality or omitted variables. Reverse causality occurs as individuals anticipate that higher societal school enrollment will lead to greater economic growth. This causes them to anticipate greater wage gains from investments in education, which in turn affects their schooling decision. As Hanushek and Kimko argued, however, reverse causality is less plausible for the quality of schooling than for the quantity. The thornier problem is omitted variables: Countries that are committed to higher economic growth are likely to undertake a range of pro-growth policies, some of which may be hard to quantify. The education variable will pick up the effect of these other policies. More fundamentally, as Krueger and Lindahl pointed out, macroeconomic studies tend to treat schooling decisions as exogenous; they do not investigate why students in some countries enroll more in school, or learn more from school, than students in other countries.

Appendix B: Simulations of Changes in Educational Attainment and Returns to Education

Appendix Table 1 shows the simulations of changing educational attainment and earnings for given levels of educational attainment for black men, black women, Hispanic men, and Hispanic women. Separate simulations were performed using 1979–1980 and 1999–2000 worker characteristics and Bradbury's "lower-bound" and "upper-bound" regressions. Appendix Table 2 presents the analogous simulations for women versus men.

In the simulations examining the wage gap between the sexes, men and women were given the mean characteristics of both sexes for all explanatory characteristics except for educational attainment. However, the coefficients—which represent the effects of these characteristics on wages—were taken from Bradbury's regressions looking at only the male population.

Appendix Table 1
Results of Simulation Exercises Regarding the Racial and Ethnic Wage Gaps

		Simulations					
		Educational attainment mix and the returns to education for each group, equalizing all other explanatory variables		Each group's educational attainment mix and the non-minority returns to education		Non-minority educational attainment mix and each group's returns to education	
Panel A 1979–1980	Actual weekly earnings	lower-bound	upper-bound	lower-bound	upper-bound	lower-bound	upper-bound
Black Men	478.44	484.96	461.11	582.71	575.64	513.23	497.71
Nonblack Men	627.25	614.46	617.31	614.46	617.31	614.46	617.31
Difference	*148.81*	*129.50*	*156.20*	*31.74*	*41.68*	*101.22*	*119.61*
Black Women	380.14	368.98	371.34	395.87	391.57	376.97	386.72
Nonblack Women	408.07	404.00	406.27	404.00	406.27	404.00	406.27
Difference	*27.93*	*35.02*	*34.93*	*8.13*	*14.70*	*27.03*	*19.55*
Hispanic Men	474.79	393.25	381.77	567.41	553.60	442.98	445.33
Non-Hispanic Men	622.38	617.18	618.09	617.18	618.09	617.18	618.09
Difference	*147.59*	*223.93*	*236.33*	*49.77*	*64.49*	*174.21*	*172.77*
Hispanic Women	353.81	342.50	330.21	385.51	370.51	368.77	371.06
Non-Hispanic Women	407.63	402.32	403.52	402.32	403.52	402.32	403.52
Difference	*53.82*	*59.82*	*73.31*	*16.81*	*33.01*	*33.55*	*32.46*
Panel B 1999–2000							
Black Men	496.72	490.19	466.33	586.22	581.13	510.85	492.42
Nonblack Men	634.86	613.55	615.24	613.55	615.24	613.55	615.24
Difference	*138.13*	*123.37*	*148.91*	*27.33*	*34.10*	*102.70*	*122.82*
Black Women	425.47	414.33	425.25	463.54	457.78	430.51	449.55
Nonblack Women	488.41	482.44	483.32	482.44	483.32	482.44	483.32
Difference	*62.94*	*68.11*	*58.07*	*18.89*	*25.55*	*51.93*	*33.77*
Hispanic Men	420.90	382.40	364.24	543.29	525.46	464.33	465.19
Non-Hispanic Men	658.61	643.82	646.97	643.82	646.97	643.82	646.97
Difference	*237.72*	*261.43*	*282.73*	*100.53*	*121.51*	*179.50*	*181.78*
Hispanic Women	363.83	379.09	356.60	427.77	408.12	432.65	434.09
Non-Hispanic Women	495.29	484.73	488.38	484.73	488.38	484.73	488.38
Difference	*131.45*	*105.64*	*131.77*	*56.96*	*80.26*	*52.08*	*54.28*

Source: Author's estimates and Bradbury (2002).

Appendix Table 2
Results of Simulation Exercises Regarding the Wage Gaps by Sex

		Simulations					
		Educational attainment mix and the returns to education for each group, equalizing all other explanatory variables		Each group's educational attainment mix and the male return to education		Male educational attainment mix and each group's returns to education	
Panel A 1979–1980	Actual weekly earnings	lower-bound	upper-bound	lower-bound	upper-bound	lower-bound	upper-bound
Women	404.62	428.07	424.20	570.88	586.92	429.03	424.31
Men	612.15	567.79	583.65	567.79	583.65	567.79	583.65
Difference	*207.53*	*139.72*	*159.45*	*−3.08*	*−3.26*	*138.76*	*159.34*
Panel B 1999–2000							
Women	479.41	489.67	501.29	590.39	600.71	481.55	488.73
Men	620.44	579.82	587.43	579.82	587.43	579.82	587.43
Difference	*141.03*	*90.15*	*86.13*	*−10.58*	*−13.28*	*98.27*	*98.70*

Source: Author's estimates and Bradbury (2002).