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Sustaining U.S. Economic Growth

AFTER TWO DECADES in the economic doldrums, the U.S. economy revived strongly in the late 1990s, as the rate of productivity growth doubled. Although continued rapid growth during the next several decades is certainly possible, it is not assured—and the stakes are enormous. This chapter outlines what is known about the sources of U.S. economic growth and describes steps that policymakers—public and private—can take to realize the potential for growth.[1]

Economic Growth: Benefits, Costs, and Uncertainties

Rapid economic growth boosts private incomes and government revenues, and thereby expands options for both private and collective action. Increased output permits people—through their private, individual decisions and through government action—to boost consumption, lower tax rates, extend or enrich schooling, clean up the environment, strengthen national defense, or tackle other goals. In contrast, slow economic growth appears to foster diminished national expectations and political gridlock.[2] From 1973 through the mid-1990s, for example, a lower growth rate in private incomes—and the resulting decrease in the growth rate of tax revenues—constrained the federal government's capacity to undertake costly projects. Advocates of small government may regard such constraints as benign, but it was the relatively conservative president George H. W. Bush who lamented at his inauguration, in 1989, that Americans "have more will than wallet."[3] And it was during his administration and that of his predecessor, Ronald Reagan, that large government deficits diverted private savings from growth-enhancing investments to finance government consumption. Indeed, sluggish revenue growth was among the factors that prevented the Bush administration from constructive responses to the end of the cold war and the fall of communism in Eastern Europe. Whether or not the administration had the will, it did not have the wallet to fund government actions that could have expanded opportunity in America.

Policies to improve economic growth prospects typically involve a tradeoff between known present costs and uncertain future benefits. The investments that contribute to growth come at the price of resources diverted from current consumption. To add to the complexity of the undertaking, contemporary understanding of economic growth—what makes it vary over time and how it is affected by public policy—is quite incomplete.

Beginning in the early 1970s, for example, the growth of U.S. productivity (as measured by output per person-hour worked in nonfarm business) fell by more than half, from an average of 2.8 percent a year between 1947 and 1973 to 1.3 percent a year from 1973 to 1995. If productivity had continued growing from 1973 to 1995 at its previous trend rate, output per worker would have been 38 percent higher in 1995 than it actually was. Although the drop in the productivity growth rate was a watershed event, its causes remain somewhat mysterious and are the subject of continuing dispute.[4] Many analysts believe they have a better fix on why growth rebounded in the second half of the 1990s and resumed its pre-1973 pace. They believe that the cause of speed-up in productivity growth was the technological revolution in data processing and data communications, yet few if any had forecast such a speed-up.[5]

What is fairly certain, however, is that three broad factors have played major roles in long-run American economic growth. Human capital—the combination of the formal knowledge and practical skills acquired by the labor force—is the first. Physical capital—the machines, buildings, and infrastructure that increase productivity and embody much of our collective technological knowledge—is the second. The third is the body of ideas that encompasses modern technology and management techniques. This body of ideas is the principal reason we are so much more affluent than our forebears were. Ideas—and the technology that derives from them—are the primary long-term cause of economic growth. Nevertheless, beyond

maintaining secure property rights, government policy may have its largest effect on economic growth by facilitating additions to human capital—that is, to education and skills.

Human-capital policy represents a crucial lever on growth for three reasons. First, increases in educational investment have been a major source of American economic growth for at least the past century and a principal cause of America's economic edge over other industrial nations in the twentieth century. Second, more is known about the effects of human-capital policies than about the effects of policies intended to increase physical capital investment or the stock of ideas. Third, and probably most important, efforts to upgrade the knowledge and skills of America's workers promise not only to increase output but to lower income inequality. The ultimate goal of economic growth should be not only to expand output but to distribute that output so that as many Americans as possible can lead better lives.

This chapter examines trends for each of the three major drivers of U.S. economic growth—human-capital formation, investment in physical capital, and technological progress—and offers recommendations for encouraging growth in each area.

Investment in Human Capital

Ever since the industrial revolution, "capital" has been central to a nation's economic growth. In the preindustrial age, land and other natural resources largely determined a nation's economic capacity; sometime in the nineteenth century, this role was usurped by physical capital. During the twentieth century, human capital accumulated through formal schooling became a key to economic growth. In determining a nation's success in the increasingly knowledge-driven economy of the twenty-first century, human capital is likely to remain crucial.

Investments in human capital—including formal schooling, on-the-job training, and opportunities for informal learning—directly contribute to economic growth by increasing the productivity, or "quality," of a nation's work force. (We caution that *quality* used in this sense implies nothing about people's innate characteristics; it refers only to their economic contributions as valued in the marketplace.) Education and training also contribute to technological advance, because scientists, managers, and other highly trained and experienced workers are instrumental to the creation and application of new ideas. A better educated work force, furthermore, facilitates the adoption and diffusion of new technologies.[6]

Although almost all modern governments maintain schools, subsidize educational investments, and mandate some minimum level of education, not all governments have always viewed investments in schooling alike. For example, most of the early twentieth century industrial powerhouses were not favorably disposed to mass education beyond primary schooling. In Europe during the first half of the twentieth century, secondary and postsecondary schooling were either for the elite, as in France and England, or bifurcated, as in Germany, where those who did well or had resources could attend the upper grades and others did apprenticeships.

Not so in America. With few exceptions, schooling in America was for the masses throughout the twentieth century. It was publicly funded by large numbers of fiscally independent districts. In constrast to schooling in other industrialized nations, American public education has historically been open, sex-neutral, primarily academic rather than industrial and vocational, and subject to secular control.[7]

America in the Human-Capital Century

The United States led the world in mass education during the nineteenth century and substantially widened its lead over much of the twentieth century. It forged ahead by instituting mass secondary schooling early in the twentieth century and by establishing a flexible and multifaceted higher education system.[8] And early in the twentieth century, the United States achieved the world's highest per capita income—a position that it maintained for the remainder of that century.[9] The twentieth century can thus be thought of not only as the "American century" but as the "human-capital century."

The twentieth century became the human-capital century because of wide-ranging changes in business, industry, and technology that increased the demand for particular cognitive skills.[10] The early twentieth century rise of big business and of large retail, insurance, and banking operations, for example, generated increased demand for literate and numerate office workers. As technological changes—in industries ranging from petroleum refining to food processing—intensified the use of science in industry, demand increased not only for professionals and office workers but for educated blue-collar workers. The relative value of workers who could read blueprints and knew algebra, geometry, chemistry, and some physics increased enormously with electrification, with the spread of the internal

combustion engine, and with the increased use of complex chemical processes. Farmers who understood chemistry, botany, and accounting had a competitive edge over their less educated neighbors. Education beyond the elementary grades was no longer just for the professionals. It was for all.

Secondary education paid high returns, and youths responded by continuing on to the upper grades. In 1915, the earliest year for which estimates have been made, each additional year of high school increased earnings by about 12 percent.[11] These high returns and the rising need for more educated workers greatly increased the demand for education. But until World War I, more than 50 percent of Americans lived in rural areas. Meeting the increased demand for education required costly investments to build schools and hire teachers—and local governments and school districts, many of them quite small, made these investments. Thus in the United States the highly decentralized system of financing education permitted the diffusion of mass secondary schooling, whereas in Europe centralized school systems were less responsive to local demands for further schooling and hampered the initial spread of mass secondary education.

Greater secondary school completion rates increased attendance at colleges and universities. Higher education in the United States had been a patchwork quilt of public, private, secular, religious, coed, and single-sex institutions from its beginnings in the seventeenth century. But as the demand for higher education increased, the role of the public sector in tertiary schooling expanded: over the course of the twentieth century, the proportion of students enrolled in public four-year schools soared from 20 to 70 percent.[12]

Toward the end of the twentieth century, however, the rate of increase in years of schooling declined substantially in the United States. Beginning with the cohorts born around 1950, the growth in educational attainment for native-born Americans slowed perceptibly (see figure 2-1). By the 1980s, this slowdown had translated into a reduced rate of increase in the educational attainment of the American labor force. Because the increasing quality of the labor force contributed significantly to economic growth in the United States throughout most of the twentieth century, the slowdown in the growth of educational attainment threatens to retard future economic growth. Moreover, because the slowdown has been concentrated among youth from minority and lower-income households, it also threatens to increase economic inequality. The deceleration of growth in educational attainment has occurred despite rising economic returns to education during the past twenty years. Meanwhile, progress in educational attainment elsewhere has continued apace. Among the advanced member nations of the Organization for Economic Cooperation and Development, the level of educational attainment is now increasing more rapidly in nations other than the United States, and the educational attainment of young American adults now lags that of young adults in some other countries.[13]

Educational Advance in the Twentieth Century

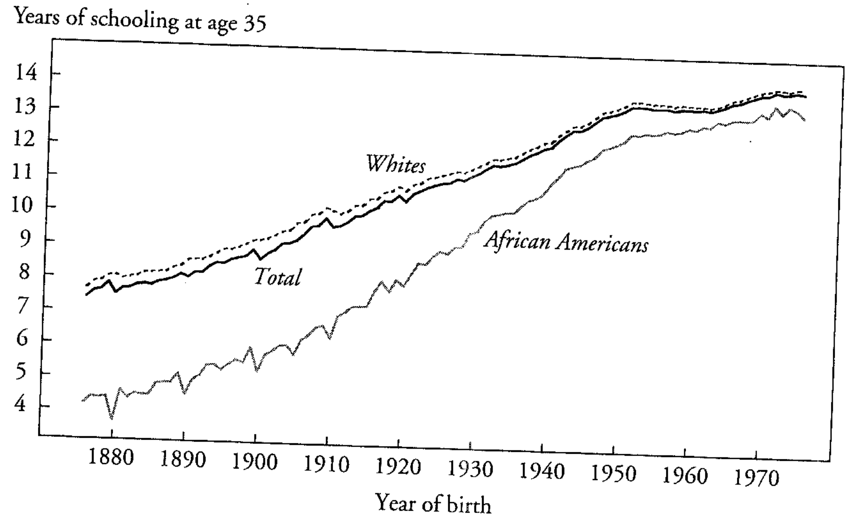
An ideal measure of human capital would not be limited to formal schooling. It would also include parental and other child care during the preschool years, training in commercial and vocational institutions, on-the-job training, and learning in informal settings. But because such an ideal measure does not exist, we measure human capital by the number of years of formal schooling or the highest grade attained.[14]

Americans born in 1975 spent nearly twice as many years in school—14.1 years versus 7.4 years, an increase of 6.7 years—as did Americans born a century earlier (see figure 2-1).[15] For cohorts born between 1876 and 1951, the increase was 6.2 years, or 0.82 years a decade. Educational attainment was then roughly constant for cohorts born between 1951 and 1961, and it increased by only 0.5 years for cohorts born between 1961 and 1975.

About one-half of the overall increase in educational attainment over the twentieth century is attributable to the increase in high school attendance and graduation, and about one-quarter is attributable to the increase in college and postcollege education. Thus the spread of mass secondary schooling, a movement that began in earnest around 1910, was responsible for much of the increase in the educational attainment of native-born Americans in the twentieth century.

At the start of the period for cohorts born in the late 1870s, the gap in educational attainment between whites and African Americans was 3.6 years; and on average white students spent nearly twice as long in school as did black students. Beginning with the cohorts born around 1910, the gap began to close (figure 2-1). The convergence slowed for cohorts born between 1940 and 1960 and slowed further for those born since 1960. The black-white schooling gap for recent cohorts (those born in the 1970s) is 0.6 years—one-sixth of what it was a century ago. The current gap in educational attainment between non-Hispanic whites and Hispanics—2.3 years for those born 1970 to 1975—is nearly four times larger than that between whites and blacks.[16] Because Hispanics are a large and

Figure 2-1. *Years of Schooling by Birth Cohort, U.S. Natives by Race, 1876–1975*[a]

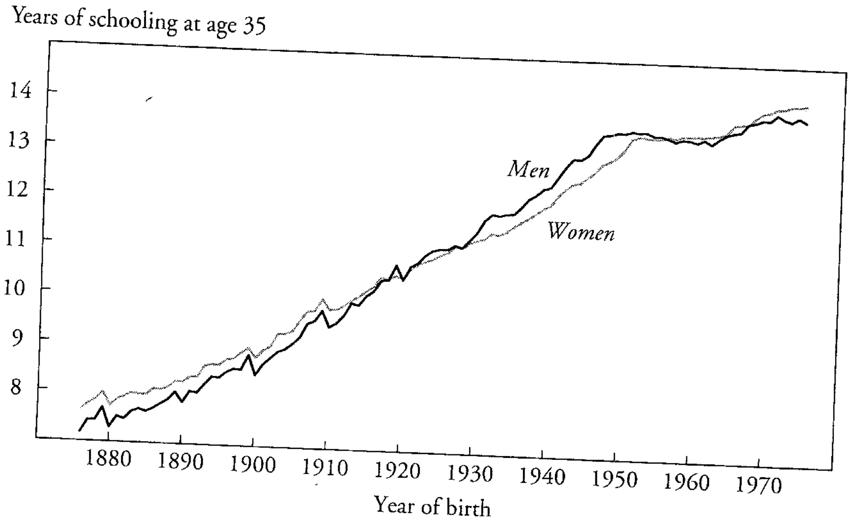


Sources: 1940–90 Integrated Public Use Microsamples (IPUMS) of the U.S. federal population censuses; 1999 and 2000 Current Population Survey (CPS) Merged Outgoing Rotation Group (MORG) samples.

a. Figure plots mean years of completed schooling for native-born residents by birth cohort at thirty-five years of age (data for cohorts not observed at exactly this age were adjusted to age thirty-five). For the 1940–80 samples, years of schooling are given by the highest grade completed, top coded at eighteen years. Those with seventeen years of schooling in 1940 and 1950 (the highest category in those years) were assigned 17.6 years of schooling (the mean for those with seventeen or eighteen years of schooling in 1960). The categorical education variable for the 1990, 1999, and 2000 samples was converted to years of completed schooling. Categories covering more than a single grade were translated as follows: 2.5 years for those in the first through fourth grade category; 6.5 years for those in the fifth through eighth grade categories; twelve years for those with twelve years of schooling, a general equivalency diploma, or a high school diploma; fourteen years for those with some college or an associate's degree; sixteen years for those with a bachelor's degree; 17.6 years for those with a master's degree; and eighteen years for those with a professional or doctoral degree.

To age-adjust reported years of schooling, we used the proportional life-cycle change in reported years of schooling for U.S. birth cohorts from 1876 to 1975. Specifically, we collapsed the data into birth cohort-year cells. We then ran a regression of log mean years of schooling on a full set of birth cohort dummies and a quartic in age, pooling all the samples from 1940 to 2000 for native-born residents aged twenty-five to sixty-four (covering birth cohorts from 1876 to 1975). The age coefficients from this regression were used to create age-adjusted measures of schooling evaluated at age thirty-five. For birth cohorts observed at age thirty-five in one of our sample years, we used actual mean years of schooling at that age. For cohorts not observed in our samples at exactly age thirty-five, we adjusted to that age the mean years of schooling for the observed year closest to age thirty-five (or to the average of the closest pair of years in the case of a tie). The results are quite similar if we average the age-adjusted years of schooling of a birth cohort across all the years we observe the cohort.

Figure 2-2. *Years of Schooling by Birth Cohort, U.S. Natives by Sex, 1876–1975*[a]



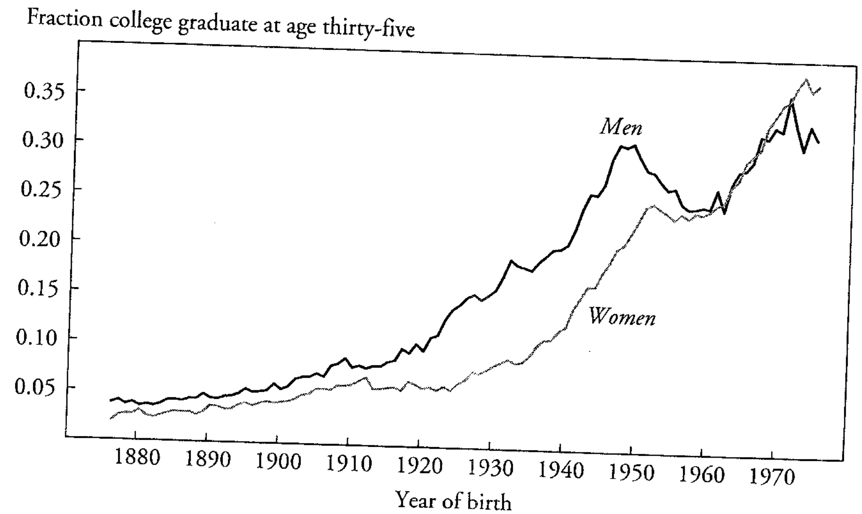
Sources: 1940 to 1990 IPUMS of the U.S. population censuses; 1999 and 2000 CPS MORG samples.

a. Using the approach described in the notes to figure 2-1, the figure plots the mean years of completed schooling for native-born residents by birth cohort and sex, adjusted to age thirty-five.

rapidly growing share of the U.S. labor force, their level of educational attainment is critically important for future American productivity.[17]

Men and women spent similar amounts of time in school *on average* over the twentieth century (figure 2-2), but men born before about 1955 were more likely to graduate from college (figure 2-3). Male college graduation rates surged for the peak World War II draft cohorts, born from the early 1920s, and continued to grow rapidly for the Korean War draft cohorts. The expansion in college graduation rates reflects, in part, the educational benefits provided by the G.I. Bill, which were available to the (mostly) male veterans of World War II and the Korean War.[18] College graduation rates for men again soared during the Vietnam War, as young men sought to avoid the draft through student deferments. When the draft ended, in 1973, the rate at which men graduated from college plummeted, only to rise again in the face of rising labor market returns to education in

Figure 2-3. *Graduation from College by Birth Cohort, U.S. Natives by Sex, 1876–1975*[a]



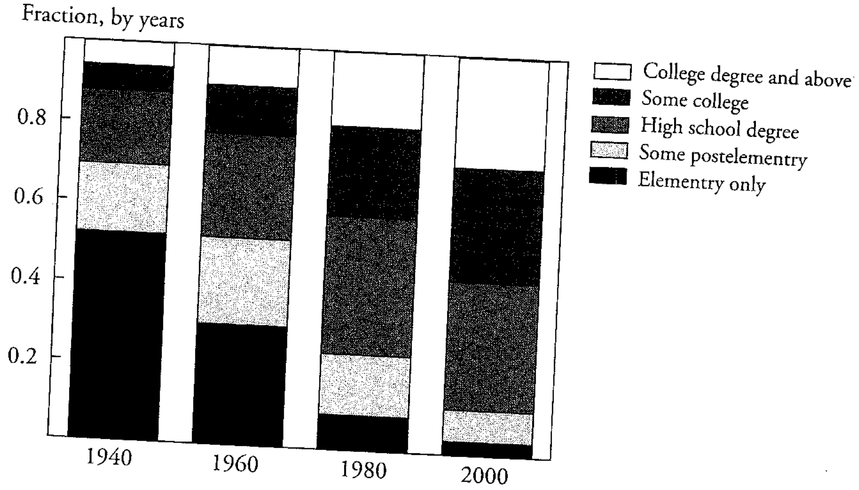
Sources: 1940 to 1990 IPUMS of the U.S. population censuses; 1999 and 2000 CPS MORG samples.

a. The figure plots the fraction of native-born college graduates by birth cohort and sex adjusted to age thirty-five. For the 1940–80 samples, college graduates were defined as those who had completed sixteen or more years of schooling; for the 1990–2000 samples, college graduates were defined as those who had a bachelor's degree or higher. The log of the college graduation rate for a birth cohort-year cell is the dependent variable in the age-adjustment regressions. The adjustment approach was the same as that described in the notes to figure 2-1.

the 1980s (which were apparent for cohorts who had been born in the early 1960s). Women's rates of graduation closely follow those of men, with some exceptions, such as for the World War II and Korean War cohorts. For cohorts born since the early 1960s, the women's college graduation rate exceeds that of men.

Differences in educational attainment by race and socioeconomic status have persisted and in some cases increased over the past two decades. For cohorts born since 1960, the rate at which African Americans graduated from college increased less rapidly than the rate at which whites did. Moreover, during the period of sharply rising educational wage differentials in the 1980s, differences in the rate of college attendance and graduation by family income increased.[19]

Figure 2-4. *Educational Attainment of the Work Force, 1940–2000*



Source: Table 2A-1.

Educational Attainment of the Work Force and Educational Wage Differentials

To measure the impact of human-capital accumulation on economic growth, we must measure the educational attainment of the work force and the economic returns to educational investments. Behind the large contribution made by human capital to U.S. economic growth in the twentieth century lies a spectacular increase in the educational attainment of American workers (see figure 2-4; for more detailed information, see appendix 2A).[20]

Between 1940 and 2000, the average number of years of schooling for members of the work force increased by 4.4 years: from 9 to 13.4 years. In 1940, only 30 percent of U.S. workers had graduated from high school and fewer than 6 percent had a college degree. By 2000, 89 percent had graduated from high school and 28 percent had a college degree. During the first half of the twentieth century, the major change in educational attainment in the labor force was the replacement of workers who had less than a high school education by workers who had completed high school. Late in the twentieth century, the major change was the influx of workers with at least some college education. The educational attainment of the

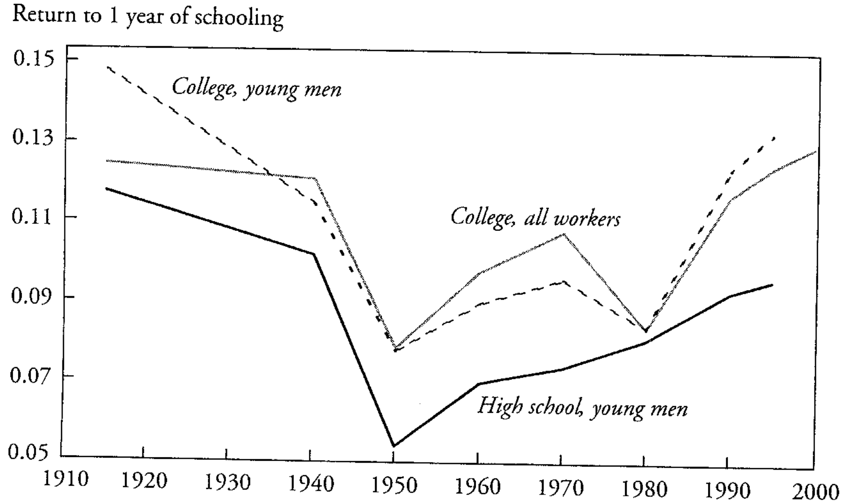
American work force increased particularly rapidly from 1940 to 1980, as better educated young people replaced less educated older cohorts in the work force.[21] Progress slowed thereafter.

How have the private economic returns to education, as measured by educational wage differentials, evolved? Even as early as 1915, the private economic return to a year of either high school or college was substantial. Those returns likely helped to spur the rapid increases in educational attainment that characterized the era of the high school movement, from around 1910 to 1940. Educational wage differentials narrowed substantially from 1915 to 1950, then expanded modestly for several decades before narrowing again in the 1970s. Significant increases occurred again in the 1980s, and some modest advances continued in the 1990s (figure 2-5).

Changes in the wage structure are largely shaped by a race between the rising demand for skills, which is driven by technological changes and industrial shifts in employment, and the increasing supply of skills, which is driven by immigration, demographic shifts, and changes in educational investment across cohorts.[22] Throughout the twentieth century, demand shifted toward industries and occupations that employed workers with higher than average levels of education. At the same time, technological change also increased the demand for well-educated workers, both within industries and within occupations.[23] From 1915 to the 1970s, when increasing supply more than offset the added demand for skilled workers, educational wage differentials narrowed. Since 1980, demand for well-educated workers has outpaced supply, and educational wage differentials have been rising in consequence.

Countries in which increases in educational attainment have recently slowed—including the United States, the United Kingdom, and Canada—have experienced greater increases in educational wage differentials, especially for younger cohorts, than have countries where educational attainment has continued to expand rapidly, such as France, Germany, and the Netherlands.[24] Since about 1980, several factors have boosted education returns and wage inequality in the United States. The growth in the supply of college-educated workers has slowed, and the demand for better educated workers has risen—a change that has been driven, in part, by technological and organizational changes. Unions have lost membership. Compensation for the top achievers in many fields, including business, sports, and entertainment, has greatly increased. The real value of the minimum wage has fallen. Beginning in 1995, tight labor markets, an increase in the real minimum wage, and rapid growth in productivity helped spur

Figure 2-5. *Educational Wage Differentials for All Workers and Young Male Workers, 1915–2000*



Sources: Returns to a year of high school and a year of college for young men are from Claudia Goldin and Lawrence F. Katz, "Decreasing (and Then Increasing) Inequality in America: A Tale of Two Half-Centuries," in F. Welch, ed., *The Causes and Consequences of Increasing Income Inequality* (University of Chicago Press, 2001), table 2.4 and figure 2.6, and are based on data from the 1915 Iowa State Census, the 1940–70 IPUMS of the U.S. population censuses, and the 1970 to March 1996 CPSs. The samples include full-year nonfarm workers with zero to nineteen years of potential experience. Returns to a year of college for all workers are based on data from the 1915 Iowa State Census, the 1940–80 IPUMS of the U.S. population censuses, and 1980–2000 CPS MORG samples. The return to a year of college equals the regression-adjusted wage differential between a worker with exactly sixteen years of schooling (or a bachelor's degree) and with exactly twelve years of schooling (or a high school degree), divided by 4. The college returns for 1940 to 2000 were derived from log hourly wage regressions for samples of all workers (men and woman) aged eighteen to sixty-five, using the same specifications and data-processing procedures as David H. Autor, Lawrence F. Katz, and Alan B. Krueger, "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics*, vol. 113, no. 4 (1998), table 1. The 1915 to 1940 change in the college wage premium uses samples of full-year workers from Iowa and the methods of Claudia Goldin and Lawrence F. Katz, "Education and Income in the Early Twentieth Century: Evidence from the Prairies," *Journal of Economic History*, vol. 60, no. 3 (2000), pp. 782–818.

wage growth among low earners. These developments slowed the trend toward increasing wage inequality—and in the late 1990s even narrowed wage inequality among workers whose earnings were below the median. In the United States, current economic returns to a college education are at least as high as they have been in sixty years. An increase in the ranks of

college-educated workers should boost economic growth and reduce wage inequality.

Education, Labor Quality, and Economic Growth

For nearly fifty years, economic analysis has shown that an increase in the quality of the labor force will boost output. The differences in the wages paid to workers with differing characteristics reflect the quality—or market value—of those characteristics.

Analysts disagree on the precise importance of the different channels by which education affects economic growth, but they concur that the overall effect of education on growth is large.[25] Research comparing economic growth among different countries has found that per capita output increases more rapidly in nations that have both a high level of educational attainment and rapid growth in educational attainment.[26]

The direct contribution to economic growth of increases in the educational attainment of the U.S. labor force can be estimated through standard "growth-accounting" methods.[27] The procedures involved are straightforward. The key assumption is each factor of production is paid a price—wages, profits, or rents—that equals the value of its contribution to production. The first step, then, is to measure the change in the quantity of each measurable factor of production. The proportionate change in the quantity of a measurable input, multiplied by its share of national product, measures its contribution to the rate of economic growth. Usually, changes in the directly measurable factors of production do not account for the entire change in output. The residual is referred to as the change in total factor productivity. In the next two sections we measure the contributions of improvements in the education, work experience, and other characteristics of the labor force to U.S. economic growth from 1915 to 2000. We also consider the implication of recent demographic and educational trends for future U.S. economic growth.

EDUCATION. Compensation of labor—wages plus fringe benefits—accounts for approximately 70 percent of production. Assuming labor is paid its marginal contribution to output and that output is proportional to inputs, a 1 percent increase in effective labor, occurring through an increase in the average human capital of the work force, directly boosts output by 0.7 percent.[28]

On average, from 1915 through 2000, increases in educational attainment boosted the effective size of the work force by 0.5 percent a year

Table 2-1. *Educational Growth Accounting, Chain-Weighted Indexes, 1915–2000*[a]

Period	*Annual percent change in educational productivity*		*Change in educational attainment of work force (years)*
	Employment	*Hours*	
1915–40	0.52	0.50	1.38
1940–60	0.50	0.49	1.52
1960–80	0.61	0.59	1.93
1980–2000	0.35	0.35	0.86
1915–2000	0.50	0.48	5.69

Sources: 1915 Iowa State Census sample; 1940, 1960, and 1980 IPUMS of the U.S. federal population censuses; 1980 and 2000 CPS MORG samples.

a. Details of the construction of the educational productivity indexes are given in appendix 2B. The indexes cover the civilian work force (aged sixteen or older) in each year. The reported educational productivity changes are based on chain-weighted prices. (Fixed-weighted prices give similar results.) Changes from 1915 to 1940 are for Iowa; changes for the other periods cover the entire United States. The education groups used are 0–4, 5–6, 7–8, 9–11, 12, 13–15, and 16 or more years of schooling. The chain-weighted index covering years t to t' uses the average educational wage differentials for t and t'. The employment-based indexes weight workers by their sampling weights; the hours-based indexes weight workers by the product of their sampling weight and their hours worked in the survey reference week.

(table 2-1).[29] Thus education contributed an average of 0.35 percentage point a year to economic growth (0.7 x 0.5) over an eighty-five-year span—a contribution that equals 22 percent of the average annual increase in labor productivity of 1.62 percent.[30] (The contribution of education to economic growth depends partly on how the changes are measured. The text box and appendix 2B explain in more detail how the contribution of education to the effective labor force was measured.)

Improvements in educational attainment and the contribution of education to productivity varied during the twentieth century. As shown in table 2-1, in the two decades from 1980 through 2000 the mean educational attainment of the labor force rose by only 0.86 years; by comparison, mean educational attainment increased by 1.93 years from 1960 to 1980, by 1.52 years from 1940 to 1960, and by 1.38 years from 1915 to 1940. Increases in productivity attributable to education accelerated in the two decades from 1960 to 1980, then fell by nearly half from 1980 to 2000—to the lowest levels of the century. The slower growth in the educational attainment of the work force from 1980 to 2000 shaved productivity growth by 0.13 percent a year relative to the average for 1915 to 1980.

Measuring the Contribution of Education to Economic Growth

To measure the contribution of education to economic growth, we compute an education productivity index, E_t, of the U.S. work force for selected years t. The index is given by $E_t = \Sigma_i w_{i\tau} S_{it}$, where $w_{i\tau}$ is the (adjusted) wage of education group i (relative to a reference education group) in a base period τ, and S_{it} is the share of education group i in employment (or total hours) in year t. The wage of each education group is adjusted for differences across the groups in experience and demographic variables. If one assumes that differences in education reflect the impact of schooling on productivity, the growth in this index measures the contribution of educational upgrading to aggregate labor-input growth (through improvements in the average human capital or "quality" of the work force). Although an alternative view holds that education signals inherent differences in the productivity of workers that it *uncovers* but does not cause, the bulk of evidence supports the assumption that education actually contributes to increased economic productivity (see David Card, "The Causal Effect of Education on Earnings," in O. Ashenfelter and D. Card, eds., *Handbook of Labor Economics*, vol. 3A [Elsevier, 1999]). Appendix tables 2A-1 and 2A-2 provide detailed information on the changes in the educational attainment of the U.S. work force over the course of the twentieth century; these changes are summarized in figure 2-4. The relative wages used in the education productivity index can be computed either period by period, with changing weights in each period (a "chain-weighted" index), or with fixed weights. These two approaches produce similar results; the results shown in table 2-1 were obtained using the first approach.

Prospects for a return to rapid increases in educational attainment and high contributions of human capital to economic growth do not appear favorable. Recent projections indicate that during the next two decades, the proportion of the labor force that is college educated will increase by 1.5 to 5 percentage points.[31] By comparison, the college-educated portion of the labor force increased by 8.6 percentage points from 1980 to 2000. We project that the annual rate of productivity growth attributable to education, which was 0.35 percent from 1980 to 2000, will decline to between 0.06 and 0.17 percent from 2000 through 2020.[32]

Although the contribution is difficult to quantify precisely, increases in educational attainment also made a large indirect contribution to economic growth by fueling innovation and the diffusion of new technologies into the work place. Businesses with better-educated workers adopted new technologies sooner and showed greater productivity benefits from investments in information technology.[33] Furthermore, highly educated labor is the primary input into research and development (R&D), and some estimates suggest that the intensity of R&D has been a significant (and possibly the largest measurable) contributor to growth in U.S. labor productivity over the past fifty years.[34]

OTHER ASPECTS OF LABOR QUALITY. Wage rates vary not only with education but also with experience, sex, nativity, and race. If one makes the critical assumption that differences in wage rates reflect differences in worker productivity, it is possible to construct an "augmented" measure of the quality of the labor force that encompasses a broader set of worker characteristics associated with significant wage differentials. To the extent that discrimination on the basis of characteristics such as race, nativity, or sex distorts wages, the assumption that wage differentials measure genuine differences in economic productivity is not warranted.[35] However, the indirect effects of discrimination on wages—those that arise, for example, from being denied access to good schools or to in-service training—do affect productivity and are therefore included.

Labor force quality, measured in this fashion, increased by an average of 0.42 percent annually from 1915 to 2000 (table 2-2)—a contribution that is almost identical to that of increasing educational attainment. In other words, improvements in educational attainment can account for the entire secular increase in the measured quality of the labor force from 1915 through 2000. Factors other than education sometimes added to and sometimes subtracted from improvement in labor quality, but these effects canceled each other out over the period as a whole. The rising proportion of women in the work force slightly lowered measured labor quality. The effects of changes in the age composition of the work force differed by subperiod. As more and more children remained in school until their late teens, the proportion of youth in the labor force declined, which contributed to faster growth in the quality of labor from 1915 to 1940. From 1960 to 1980, the entry of the large baby boom cohorts, who were initially young and inexperienced, decreased the quality of the labor force. The resulting large increase in the proportion of younger, inexperienced workers almost completely offset the coincident rapid improvements in educational attainment. As a result, the period from 1960 to 1980 saw unusually small growth in overall labor quality, despite being a period of an

Table 2-2. *Augmented Labor Quality Index: Annual Percent Changes, Chain-Weighted Prices, 1915–2000*[a]

Period	*Employment*	*Hours*
1915–40	0.61	n.a.
1940–60	0.47	0.46
1960–80	0.12	0.14
1980–2000	0.43	0.43
1915–2000	0.42	n.a.

Sources: 1915 Iowa State Census sample; 1910, 1920, 1940, 1960, and 1980 IPUMS of the U.S. federal population censuses; 1980 and 2000 CPS MORG samples.

a. Details of the construction of the labor quality index are given in appendix 2B. The reported labor force quality changes are based on labor force quality indexes using chain-weighted prices. The indexes cover the civilian work force (aged sixteen or older) in each year. The chain-weighted index covering years t to t' uses a predicted wage, based on average wage differentials for t and t'. The employment-based indexes weight workers by their sampling weights; the hours-based indexes weight workers by the product of their sampling weight and their hours worked in the survey reference week.

unusually rapid work force educational advance. From 1980 to 2000, however, as baby boomers acquired experience, the corresponding increase in the quality of the labor force offset the unusually small increase in educational attainment. Thus the increase in the quality of the labor force during these two decades was equal to the average for the twentieth century.

Once again, prospects for the future are not good. During the next twenty years, as the baby boom cohorts move beyond their peak earning years, the gains in labor quality that have stemmed from changes in the age structure of the work force are projected to stop.[36] Because improvement in educational attainment is also projected to slow during the next two decades, improvement in the quality of the labor force is likely to contribute less to increased worker productivity than it did, on average, during the twentieth century.

Human-Capital Policy

Governments mandate and subsidize schooling in part because people, if left to their own devices, may invest less in education than is socially optimal. Many families are too poor to pay for much education directly. Neither children nor their parents can borrow against the future earnings that education will help pupils to earn. Some parents, even those who can afford to pay for education, may not act in the best long-term interests of their children. Nor are children always rational and compliant. Finally, many argue that, in addition to the direct benefits for students and their families, education benefits society at large through peer effects, knowledge spillovers, and reductions in crime.[37] Education can also facilitate the economic advance of those from disadvantaged backgrounds. The credit market imperfections facing many families in financing educational investments, along with the possible broader social benefits of education, help justify substantial government subsidies for investment in human capital.

Increased investments in human capital offer an unusual opportunity to both promote economic growth and reduce economic inequality. The key policy question is whether, given the current level of government support for education in the United States, many families still face large financial and information barriers that may seriously hinder them from making high-return educational investments, ranging from early-childhood education to postsecondary schooling and training. Much evidence suggests that such constraints remain significant for low-income and minority families. For that reason, targeted investments in education and training have the potential to generate social rates of return at least comparable to those of other private investments.[38]

A first area of concern involves the access to and affordability of college for low-income and minority youth. Since 1980, the earnings of college graduates have risen substantially in comparison to the earnings of those with less education. This evidence suggests the existence of large economic returns to expanding college attendance and completion. Although overall college attendance has increased since 1980 (the proportion of high school graduates continuing on to college rose from 49 percent in 1980 to 60 percent in 1990 and to 63 percent in 1999), the gap in college attendance rates by race, ethnicity, and parental income remains large—and appears to have widened over the last twenty-five years.[39] And among students with similar academic grades and scores on achievement tests, family income remains an important factor in explaining differences in college enrollment rates.[40]

Thus financial constraints appear to remain a barrier to college for low- and moderate-income youths.[41] Furthermore, reductions in college costs (lower tuition and increased financial aid) greatly increase college attendance rates for youths from moderate-income families.[42] Recent estimates—using "natural experiments" involving changes in access to college, changes in college costs, and compulsory schooling laws—indicate high rates of return accruing to the marginal (typically low-income) youths affected by such policy interventions.[43] From the early 1980s to the mid-1990s, college attendance costs—tuition and fees minus financial aid—

rose far more rapidly than did income for low- and moderate-income families.[44] These increases in net college costs are likely to have hindered low-income and moderate-income youth from attending college. Improvements in the targeting of private and public financial aid and the creation of a more transparent system for financial aid applications and financial aid information could increase college attendance among disadvantaged youth.

Easier access to college may be too late for many low-income youth who do not have sufficient academic preparation. Mentoring programs that combine social and academic support with financial assistance for postsecondary training can substantially improve academic preparation and likelihood of going to college for low-income children.[45] Some "second-chance" job-training programs for disadvantaged youth who have dropped out of high school also appear promising. In particular, the residential-based Job Corps program, which serves mostly poor urban dropouts aged sixteen to twenty-four, has consistently produced high social returns by increasing earnings and reducing criminal activity.[46] Expanding the funding for successful mentoring programs and increasing the number of Job Corps slots are both warranted.

Policies intended to improve human capital should also target early childhood. Most research has found large returns from investment in high-quality early-childhood education programs targeted to low-income families.[47] Increased funding for Head Start, the largest federal preschool program, could strengthen its quality and increase access; with sufficient funding, it might also be possible to include children younger than three years old.

There is less agreement about the effectiveness of specific policies intended to improve the quality of primary and secondary schooling. The impact of increases in school resources within current public school systems remains a controversial issue.[48] For example, evidence from the large-scale random-assignment STAR experiment in Tennessee strongly suggests that, holding teacher quality constant, smaller class sizes in the early grades improve academic performance, particularly for poor and minority children.[49] Research also indicates that the quality of teachers, although difficult to measure, is especially important for pupils from disadvantaged backgrounds. But attempts to reduce class size for all public school students, as mandated under California's recent statewide policy, are likely to make it difficult to hold teacher quality constant: universal reductions in class size are quite likely to require increasing the share of teachers who are less experienced, less qualified, or both (at least for some intermediate-run period). Moreover, the more affluent schools and districts are likely to outbid their poorer counterparts in efforts to hire the most qualified teachers. Thus reducing class size for all may do little to help students from low-income backgrounds. For schools with low-income students, more targeted attempts to increase the quality of teachers and reduce class size appear to be more promising—and would certainly be less expensive than universal reductions in class size.

In the United States, where schools have traditionally been financed locally, parents have been able to express their educational preferences by choosing where to live. In effect, this exercise of parental choice created competition among schools—which, throughout much of the twentieth century, helped expand and improve schooling in the United States. But such a system may not work well for those from disadvantaged backgrounds when poverty constrains residential choice. Programs that allow low-income families to exercise choice and expand their children's educational options—including public school choice, charter schools, and vouchers—deserve further experimentation.

Since 1970, poverty has become increasingly concentrated in inner cities, and residential segregation by family income has risen sharply.[50] Both factors have lowered the level of investment in human capital for children from low-income families. Recent research on programs that enabled low-income families to move from high-poverty neighborhoods to middle-class communities indicates that concentrated neighborhood poverty greatly harms children and that living in lower-poverty neighborhoods improves children's educational performance, health, and behavior.[51] These studies suggest that policies to promote residential mobility—increasing the availability of housing vouchers, for example—would also improve human capital among children from low-income families.

Investment in Physical Capital

Could shifts in government policy produce large enough changes in rates of investment in physical capital to significantly boost economic growth? In the 1950s, Robert Solow and Moses Abramovitz published theoretical and empirical studies showing that physical capital was not the most important source of the increase in labor productivity and living standards in the twentieth century.[52] Physical capital deepening (increases in the quantity of capital used to produce each unit of output) has played second or even third fiddle. Nearly all research, at least since the pioneering work

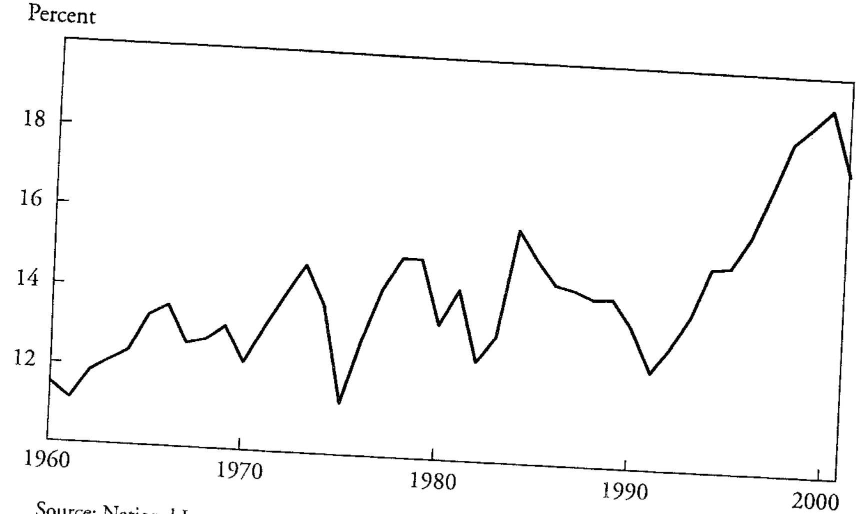
of Edward Denison, has found that total factor productivity—the "residual" increase in output that cannot be directly accounted for by increases in the quantity or quality of labor or capital—was the primary cause of rising U.S. incomes and productivity in the twentieth century.[53]

Moreover, the capacity for shifts in policy to generate faster growth through higher physical capital investment is lower than one would suppose from a standard growth-accounting analysis dividing growth between labor, capital, and the "residual." With a constant investment (or saving) rate as a share of national product, increases in incomes arising from growth in total factor productivity will induce increases in investment, so that the capital stock will grow roughly as fast as total output. In this case, a standard growth-accounting analysis will attribute perhaps a third of labor productivity growth to this increased physical capital stock. But this higher income–driven increase in the physical capital stock is, in some sense, mechanical. Policies—whether good or bad—that attempt to affect growth by affecting investment and saving must do so by *changing* the economy's capital-output ratio. Significant changes in the economywide capital-output ratio have been rare since the nineteenth century and are difficult to accomplish through economic policy.

Fluctuations in U.S. economic growth have stemmed primarily from changes in total factor productivity. Since World War II, growth in total factor productivity has oscillated from a relatively robust 2 percent a year from 1947 to 1973, to near zero from 1973 to 1995, and back to a healthy 1.5 percent a year since 1995. The ratio of capital to output, in contrast, was relatively steady from before World War I until the past decade. Neither economic policies nor changes in the behavior of the private sector materially changed the rate of investment in physical capital; thus the effect of capital investment on overall economic growth remained relatively constant.[54]

Starting in 1994, however, gross physical investment—much of it in information technology—began to rise sharply as a share of GDP (see figure 2-6). The extraordinary and ongoing revolution in information technology has substantially increased investment in physical capital since the mid-1990s and is likely to continue to increase such investment in the future. Almost all analysts agree that two factors account for much of the mid-1990s acceleration in the rate of American economic growth: the sharp rise in investment in information technology and the increases in total factor productivity in the manufacture of capital goods related to information technology. These two factors combined have boosted the

Figure 2-6. *Real Private Investment Divided by Real GDP*[a]



Source: National Income and Product Accounts, revised as of December 2001, as constructed by the Bureau of Economic Analysis.

a. Gross private domestic investment estimates.

growth rate of gross output by an estimated 1 percentage point a year (see table 2-3).

Government's Role in Physical Capital Investment

Higher rates of investment in physical capital eventually increase economic growth and the ratio of physical capital to output. In the short run, however, increased investment diverts output from current consumption, both public and private.

Although decisions about the allocation of output between investment and consumption are usually best left to the free market, there are some situations in which market allocation produces inferior results. For example, when investment in physical capital has powerful effects—known as spillovers, or externalities—on people and businesses that are not parties to the investment decision, markets may generate too little or too much investment. In the case of research, investment produces knowledge that is useful to people or businesses outside the company that sponsors the research—a positive externality. When, as in this case, the social value of investment exceeds the private gain, free markets produce less investment

Table 2-3. *Components of Acceleration in Productivity Growth, 1996–2000 versus 1991–95*

Component	*Percent*
Total acceleration in labor productivity 1996–2000 versus 1991–95	1.00
Capital deepening	0.57[a]
Information technology	0.54
Computer hardware	0.36
Computer software	0.13
Telecommunications equipment	0.07
Other capital	0.02
Multifactor productivity	0.62
Semiconductor production	0.30
Computer hardware manufacturing	0.06
All other sectors	0.26
Labor quality	−0.20

Source: Steven D. Oliner and Daniel E. Sichel, *Information Technology and Productivity: Where Are We Now and Where Are We Going?* (Washington: Federal Reserve Board, 2002).

a. Detail may not add to total due to rounding.

than is socially optimal. When investment produces negative externalities, however, as is the case with manufacturing processes that cause pollution, the investment will have a "negative" social value unless producers or consumers pay the true cost of cleanup. Similarly, when taxes reduce the private return to saving below total social returns, markets result in too little saving and investment. Saving and investment will also be too low when people are unable to look ahead—to see the future value of investments made today. In such cases, government policy can, in principle, improve economic welfare by encouraging saving or investment or by fostering a change in the composition of savings or investment. What is possible in principle may be difficult to implement in practice, however—a problem that will be discussed later in this chapter.

As noted earlier, governmental support of education—through mandates, financial assistance, or other policy initiatives—is justified by capital market imperfections that prevent individuals from borrowing in advance against the increased earnings that education will produce and by possible positive external benefits of educational investments. Preventing shortfalls in investment in both human and physical capital is important because each depends on the other: without substantial investment in physical capital, workers will not be able to use their skills effectively, and without the requisite education, workers will not be able to use capital equipment effectively.[55]

Cross-country studies of patterns of economic growth have identified a strong positive correlation between investment in physical capital—especially in machinery and equipment that embody modern technology—and rapid growth in labor productivity. This result is hardly surprising, but the estimated annual rate of social return—20 percent a year or more—exceeds the estimated after-tax private return to investment by 5 to 10 percentage points. Of course, correlation is not causation. Other factors could conceivably be causing both high investment and rapid increases in labor productivity. However, the cross-country correlation holds whether the source of high rates of investment is high national savings or low domestic prices on investment goods.[56]

Industry studies also point to important complementarities between investment in physical capital and the growth of total factor productivity. Successful workplace reorganizations to take advantage of new information technologies require substantial up-front investments in physical capital. But much larger investments are necessary to reorganize business operations to make full use of the new technologies.[57] Once one company has made such investments and figured out how to do business in a new way, other companies can apply these lessons at a lower cost. A historical example can illustrate such complementarities.[58] A century ago, when electric power first became available to U.S. industries, a few companies began to experiment with new ways to organize production. These experiments, which took advantage of the flexibility made possible by electric power, eventually led to the development of what became known as mass production. As other companies imitated these new techniques, they spread throughout the economy, producing vastly larger benefits than those that accrued to the companies that had originally developed them. The social learning and experimentation that produced these efficiencies were not possible, however, until the new technology had diffused sufficiently.

If other companies can save even a small proportion of the costs incurred by the innovating company, the social returns to investment in newly developed technologies are much larger than the private returns. It is because the social returns to investment in physical capital can exceed the private returns that government should concern itself with the level of physical investment. The steady decline of the U.S. private saving rate during the past generation strengthens the case for such involvement. During

the 1950s and 1960s household savings were more than 7 percent of household income; by 2001 they had fallen to 2 percent. One possible explanation is that there has been a radical drop in Americans' interest in the future relative to the present, but there is little other evidence that we no longer care about our future well-being or that of our children. Another possible explanation is that there is a sense that we are subject to fewer economic risks (and therefore have less need to build up wealth as a hedge). But risks have not vanished, as household saving very nearly did during the late 1990s. More likely, the drop in saving is not an example of purely rational household optimizing behavior, but stems instead from an somewhat irrational faith that the stock market gains of the 1990s would continue forever (a delusion that ended abruptly in 2001), or from aspects of American life that encourage consumption rather than saving.[59]

Precise estimates of the gap between private and social returns to investment in physical capital are hard to make. Nevertheless, most empirical research suggests that the social benefits of investment greatly exceed the private returns.[60] Thus, provided that effective policies can be designed, enacted, and implemented, government policies to boost saving and investment could produce social benefits that exceed their cost.

Strategies for Boosting Investment in Physical Capital

That it is desirable in principle to influence saving and investment does not mean that it is possible to do so effectively in practice. Nevertheless, there are a number of strategies worth exploring. Government can try to encourage private saving, it can try to make investment more attractive, and it can make a direct contribution to national saving by running budget surpluses.[61]

SAVING INCENTIVES. Traditional tax-based initiatives to provide incentives for household saving have been consistently difficult to design and implement. They also appear to have been relatively ineffective. During the 1980s and 1990s, for example, Congress enacted a welter of tax incentives to promote retirement saving, including two kinds of individual retirement accounts, two types of Keogh plans, simplified employee pensions, and 401k plans. These plans shared certain features: all permitted savers to make deposits in qualified accounts up to some legislatively defined limit; all allowed such deposits to be deducted or excluded from current taxable income; all excluded the investment earnings on such accounts from current tax; and all stipulated that when funds were withdrawn, they would be subject to ordinary income tax—and if withdrawn prematurely, to an additional penalty tax. Deposits in these plans grew rapidly and had reached $5 trillion by 1999.[62] Despite the large flow of funds into such accounts, however, household savings fell from over 7 percent of household income during the 1980s to an average of 2 percent in 2000–01. One of two conclusions is inescapable: that households would actually have been net borrowers but for these incentives or that the incentives substantially failed.

The problem with these saving incentives, and most others, is that they produce two roughly offsetting effects. On the one hand, tax concessions increase savers' real lifetime wealth by lowering their tax payments. Ordinarily, increases in wealth lead to increases in consumption, and increased consumption leads, in turn, to reduced saving—because saving is simply the difference between income and consumption. With tax and other saving incentives in place, however, current saving buys more future consumption—by, in effect, reducing the "price" of future consumption. And when the price of any good falls (holding real income constant), people want more of it. Research to determine whether the "wealth effect" (which decreases saving) or the "price effect" (which increases saving) is dominant has reached conflicting conclusions. The lack of clear findings suggests that whatever effect such saving incentives have, they are almost surely small.[63]

Unconventional saving incentives may prove to be more promising than tax incentives, however.[64] Some studies suggest that people divide their wealth into separate "mental accounts," some of which they regard as available for current consumption, while others are not. If household wealth can be channeled into accounts that are not regarded as available for current consumption, saving could increase. Evidence also suggests that people may be willing to commit a larger part of future wage increases to saving than of current income. Public policies designed to encourage households to make such commitments could gradually increase saving.[65] To the extent that household saving patterns are dominated by such quasi-rational behaviors, public policies that take advantage of such behaviors may prove to have large net effects on saving rates.[66] However, no consensus has emerged on the importance of such quasi-rational behaviors, or on how government economic policy can manipulate such behaviors to increase social welfare.

INVESTMENT INCENTIVES. Direct incentives to investment have considerable intuitive appeal. If the ultimate goal is to increase the positive externalities induced by investment, incentives that directly promote investment

are an appropriate strategy.[67] For most of the period from 1962 through 1986, Congress provided a tax credit for investment in equipment but not in structures. The Tax Reform Act of 1986 repealed this credit for several reasons. To begin with, because the government lacks the capacity to reliably distinguish between investments that were induced by the incentives and those that would have been made anyway,[68] most of the credits rewarded firms for having made investments that would have been undertaken in any case. In addition, the credit raised formidable administrative problems and distorted investment decisions. In order to minimize construction costs and maximize equipment costs, for example, office buildings were constructed with movable interior partitions and wiring (which were regarded as equipment and therefore favored under the tax law) rather than with fixed walls (which were regarded as structures and did not qualify for the credit). In addition, like all other tax incentives, the credit narrowed the tax base, which necessitated increased tax rates and brought about associated distortions in incentives on the items that remained taxable. In the end, Congress decided that a tax law that applied lower rates to a broader tax base would distort economic behavior less than would a tax law that applied higher rates to a narrow base.

A tax credit that applied only to incremental investment would have narrowed the tax base less than did the full investment tax credit. But a narrow incremental credit creates even more vexing administrative complexities and unintended incentives: namely, businesses dissipate time, energy, and resources in making a normal investment project seem "incremental." The Internal Revenue Code is far from neutral in its treatment of different forms of investment—in part because, as a practical matter, it is impossible to tax everything in a complex modern economy (agriculture, mining, forestry, manufacturing, and finance, for example) in exactly the same way, and in part because some industry representatives are more successful than others in securing tax breaks from elected officials. But in nearly all cases, impartial analysts agree that taxing different forms of investment at different rates diverts capital from its most productive uses and reduces economic efficiency.

THE GOVERNMENT BUDGET. The most direct and effective means of boosting investment in physical capital through public policy is one that was proposed forty years ago. The 1962 *Economic Report of the President* recommended that over the business cycle as a whole, government should use a "tight," high-surplus fiscal policy to boost national saving, accompanied by a "loose," low–interest rate monetary policy to ensure that the savings are invested and that full employment is maintained. The logic is straightforward. National investment is constrained by national saving. National saving equals saving by the private sector plus the government's budget surplus (or minus the government's budget deficit). If public policy cannot, as a practical matter, increase private saving very much, the only way to boost national saving is for the government to run a budget surplus. Increasing national saving makes it possible to increase national investment.

The experience of the 1990s demonstrates clearly the effect of increased government saving. From 1990 through 1995, government budgets, on average, borrowed 3.9 percent of GDP. In 2000 government budgets were in surplus and added 2.6 percent of GDP to savings, a swing of 6.5 percentage points. Over this period, domestic investment rose by 3.5 percent of GDP, despite a drop in private savings of 4.5 percent of GDP. The events of 2001 and 2002 sharply reversed this situation. As a result of tax cuts, a recession, and increased defense spending, both the federal budget and state budgets swung from surplus to deficit. It now appears that for much of the upcoming decade, the government will once again drain private savings from potentially productive private investments to finance current consumption (for further detail on the prospects for the budget, see chapter 4).

Given the difficulty of accurately focusing incentives to encourage investments in physical capital and the ineffectuality of traditional saving incentives, a budget surplus remains possibly the best way for the federal government to boost physical capital investment.[69] Because of the tax cut of 2001, however, which was implemented in the face of increased federal spending, it now appears that federal policy will discourage, rather than encourage, investment and associated economic growth for much of the current decade.

Investment in Technology

Society invests not only in human capital and in physical capital but in ideas—in science, engineering, and business organization. Ideas have an important advantage over physical assets: they are "nonrival" goods, meaning that many people can use them at the same time without reducing the supply available for others.[70] Thomas Jefferson put it best: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me."[71]

Because each person can use ideas without diminishing the stock available to others, the most basic of economic principles suggests that technology should be available to everyone free of charge. Once an idea exists, the cost of letting another person use it is zero. But at this point, different economic principles cut in different directions. If the price of using an idea is zero, private companies have no incentive to create it. Profit-oriented businesses, which must cover their costs to keep operating, will not ordinarily invest in something that cannot be sold at a profit. Thus the price that will encourage companies to develop new ideas is higher than the price that will encourage the efficient use of existing ideas.

A government subsidy for the development of new ideas is one way to close this gap. But if the government is to subsidize investment in technology on a large scale, it needs to determine where the subsidies should flow. Unfortunately, government officials lack the incentive—and often the knowledge—to decide how best to allocate subsidies for applied R&D. As noted by the economist Friedrich von Hayek, market competition is a discovery mechanism and the best way to promote innovation. Von Hayek also recognized that there are powerful administrative defects in the top-down control that comes with centralized funding.

Another way to encourage R&D is by granting patents—or in the case of some intellectual property, copyrights—which enable the holders to charge what are essentially monopoly prices. Once again, however, the monopoly prices that encourage the development or discovery of new products discourage the efficient use of products covered by existing patents or copyrights. (This dilemma is particularly important for the burgeoning health technologies examined in chapter 5, and for the issues of international trade examined in chapter 10.) To complicate the matter still further, because both basic and applied research are cumulative enterprises, the benefits of basic research can be realized only if the research is widely disseminated. Isaac Newton said that the only reason he was able to see farther than others was that he stood on the shoulders of giants.[72]

The difficulties associated with creating incentives for research are particularly acute in the case of information technology. No one yet knows enough to design systems that will successfully nurture investment in ideas and technology. New institutions and new kinds of institutions may be required, and it may be necessary as well to revisit some that have been tried before. Some computer software developers, for example, found that they could do better when they removed program components that had prevented users from copying their software (in effect, enabling users to violate the developer's copyright) because increased use promoted sales. In the early nineteenth century, the French government purchased the first photographic patents and placed them in the public domain. Similar steps may again be necessary if the United States is to simultaneously ensure that goods can be sold at marginal production cost—the condition for production efficiency—and elicit entrepreneurial energy, support cumulative research, and promote R&D.[73]

So far, the difficulty of managing the rewards for innovation and the diffusion of knowledge has not prevented the American economy from undergoing a long-term, knowledge-driven productivity boom. Productivity growth normally collapses during recessions. But during the recession of 2001 and 2002 it remained robust, strongly suggesting that the productivity recovery that began in the mid-1990s will persist.

The inventions and innovations that fueled the information technology–driven boom promise a bright future for the growth of labor productivity in America. But the outlook could be brighter still. Estimates of the annual social rate of return to R&D investments often exceed 25 percent—at least twice as high as typical estimates of the private rate of return to R&D.[74] The large gap between social and private returns to investment in R&D suggests that the United States invests too little in R&D—and that even imperfect tax subsidies for private R&D may have substantial payoffs in term of economic growth, as long as decisions about what projects to undertake remain in private hands.

The importance of the system governing intellectual property cannot be exaggerated. Whether or not the United States can sustain rapid economic growth in the twenty-first century may well rest on our ability to devise rules for an economy in which nonrival goods are an increasingly important component. Such "idea products" are likely to be at the core of future economic growth, and it is in the realm of technology that the stakes involved in policies to boost economic growth may well be the largest. It is particularly frustrating, therefore, that little is currently known about how to design economic institutions that will encourage the development of these products and ensure their diffusion.

Conclusion

Rapid economic growth will facilitate solutions to virtually every problem examined in other chapters of this book. It not only directly increases household incomes and living standards but also softens many other policy

trade-offs that Americans face. Because so many factors affect economic growth, many different policies can contribute to or inhibit it, including those that are designed to boost the skills of the labor force; those that act as incentives to increase public saving, private saving, or private investment in physical capital or R&D; those that are intended to facilitate public R&D spending; and those that govern intellectual property.

Effective policy requires the solution of two problems: identifying what should be done and enacting and administering initiatives that actually accomplish the intended goals. Effective incentives for private saving and for private investment in physical capital and R&D are difficult to design; and we have much work to do in creating an intellectual property system that may be able accelerate technological progress. One line of policy, however, is both straightforward and effective in boosting capital accumulation and growth: the government should run a budget surplus. Unfortunately, recent policies are taking the United States in just the opposite direction.

In contrast to policies that appear to have less predictable outcomes, those that increase education and training among the young, especially those from minority and low-income families, promise both to spur economic growth and to reduce wage inequality. The enormous rise in educational wage differentials since 1980 has created greater incentives for increased education. Not all groups have invested equally, however. A lack of financial resources continues to deter low-income families from college enrollment, and differences in enrollment rates between blacks and whites and between Hispanic and non-Hispanic whites have actually widened since 1980. Earlier mentoring, improved targeting of financial aid, and a more transparent financial aid system promise large payoffs not only for disadvantaged families but for the United States as a whole. Ensuring wider access to effective second-chance training programs, such as the Job Corps, is also warranted.

Moreover, since "learning begets further learning," human-capital policies must target early childhood. As part of this effort, the United States should be willing to experiment further with policies—including school choice—that offer the potential to improve the quality of primary and secondary schooling. Policies, such as housing vouchers, that may help offset residential segregation by economic status could also prove beneficial.

During the twentieth century, America's investment in education was a principal source of its extraordinary economic performance. Projections indicate, however, that the increase in the educational attainment of the

American labor force is slowing. A renewed commitment to invest in education is probably the most important and fruitful step that federal, state, and local officials can take to sustain American economic growth.

Appendix 2A
Educational Attainment of the Work Force

Table 2A-1 presents summary measures of the educational attainment of the civilian work force (aged sixteen or older) that weight individual workers equally. Table 2A-2 presents summary measures that weight individual workers according to their hours worked. The "person weights" provide a sense of the educational attainment of a typical worker, whereas the "hours-worked weights" are more useful for evaluating the contribution of education to labor productivity (output per hour worked).

We used the federal population censuses for 1940 to 1990 and the Current Population Survey for 2000 to estimate the distribution of the highest grade attained for the U.S. work force. (The 1940 census was the first to ask about educational attainment.) For 1915, the tables include comparable data from the Iowa State Census, the earliest large-scale representative sample with information on educational attainment and earnings.[75] Iowa was a leading state in education early in the century and had a more educated population than did the rest of the United States in 1940. By the end of the twentieth century, however, Iowa was no longer a leading state and was far more like the U.S. average.

Appendix 2B
Constructing the Educational Productivity and Labor Quality Indexes

To construct educational productivity and labor quality indexes for the U.S. work force for selected years from 1915 to 2000, we followed the approaches of Goldin and Katz and Aaronson and Sullivan.[76] We began by assuming that the impact of worker characteristics on productivity equals the impact of worker characteristics on wages. We then used standard regressions of (log) wages on education, experience, sex, and other control variables to identify the impact of worker characteristics on wages (and productivity). These regression coefficients were combined with microdata on the characteristics of the work force to arrive at an average predicted

Table 2A-1. *Educational Attainment of the Work Force, 1915–2000*[a]

	United States					*Iowa*					
	U.S. census			*CPS*		*State census,*	*U.S. census*			*CPS*	
	1940	*1960*	*1980*	*1980*	*2000*	*1915*	*1940*	*1960*	*1980*	*1980*	*2000*
Mean years of education	9.01	10.53	12.46	12.54	13.40	8.45	9.83	10.87	12.49	12.51	13.40
Fraction, by years of education											
0–8	0.522	0.303	0.087	0.079	0.034	0.726	0.476	0.289	0.077	0.062	0.021
9–11	0.174	0.218	0.154	0.142	0.080	0.129	0.165	0.184	0.126	0.132	0.074
12	0.185	0.262	0.346	0.368	0.322	0.083	0.229	0.316	0.424	0.461	0.340
13–15	0.061	0.121	0.228	0.219	0.288	0.037	0.076	0.128	0.210	0.188	0.326
16+	0.058	0.096	0.185	0.192	0.275	0.026	0.055	0.083	0.164	0.157	0.240

Sources: 1915 Iowa State Census; 1940, 1960, and 1980 Integrated Public Use Microsamples (IPUMS) of the U.S. federal population censuses; 1980 and 2000 Current Population Survey (CPS) Merged Outgoing Rotation Group (MORG) samples.

a. Samples were restricted to those aged sixteen or older and excluded those who were in the military or institutionalized. The work force in each year from 1940 to 2000 consists of those who were employed during the survey reference week. The work force for Iowa in 1915 consists of those reporting occupational earnings for 1914; each individual is weighted according to the number of months worked in 1915. Years of schooling for 1940 to 2000 were measured using the same approach as that used for figure 2-1. Measures of years of schooling and months worked for Iowa in 1915 were constructed using the methods of Goldin and Katz, "Education and Income in the Early Twentieth Century." For 1960 to 1980, all those who had attained thirteen years of schooling (whether or not they completed the final year) were included in the 13–15 years of schooling category, following the methods of Autor, Katz, and Krueger, "Computing Inequality." Sampling weights were used for all samples.

Table 2A-2. *Educational Attainment of the U.S. Work Force, Weighted by Hours, 1940–2000*[a]

	United States					Iowa				
	U.S. census			CPS		U.S. census			CPS	
	1940	*1960*	*1980*	*1980*	*2000*	*1940*	*1960*	*1980*	*1980*	*2000*
Mean years education	9.10	10.61	12.58	12.65	13.51	9.81	10.88	12.58	12.62	13.50
Fraction, by years education										
0–8	0.514	0.299	0.084	0.076	0.033	0.484	0.296	0.078	0.059	0.021
9–11	0.173	0.210	0.138	0.126	0.066	0.161	0.168	0.103	0.104	0.052
12	0.191	0.269	0.354	0.375	0.323	0.229	0.332	0.443	0.480	0.352
13–15	0.063	0.119	0.224	0.219	0.285	0.073	0.117	0.201	0.188	0.328
16+	0.060	0.102	0.199	0.204	0.292	0.053	0.086	0.175	0.169	0.247

Sources: 1940, 1960, and 1980 federal population census IPUMS; 1980 and 2000 CPS MORG samples.

a. Methodology is the same as for table 2A-1, except that the summary statistics weight all individuals by the product of hours worked during the reference week and sampling weight.

wage (only the education variables were used for the education productivity index; a wider range of variables was used for the augmented labor quality index). Using the same base-period regression coefficients to predict wages for two different years (t and t'), we measure the change in labor quality from t to t' as the change in the average predicted wage.

We used data from the 1915 Iowa State Census; the 1940, 1960, and 1980 Integrated Public Use Microsamples (IPUMS) of the U.S. federal population censuses; and the 1980 and 2000 Current Population Survey (CPS) Merged Outgoing Rotation Group (MORG) samples. Our first step was to estimate a wage regression in each year of the following form:

$$\log w_{it} = E_{it}\alpha + X_{it}\beta + R_{it}\delta + \varepsilon_{it},$$

where w_{it} is the wage of worker i in year t; E_{it} is a vector of dummy variables for educational attainment levels (0–4, 5–6, 7–8, 9–11, 12, 13–15, and 16 or more years of schooling); X_{it} contains other variables that are potentially related to productivity, including a quartic in potential experience, a female dummy and its interaction with the experience variables, a nonwhite dummy, and a U.S.-born dummy; R_{it} are census-region dummies; and ε_{it} is the error term. The wage regressions were estimated for national samples of civilian, nonagricultural wage and salary workers aged eighteen to sixty-five. The estimates for 1915 cover Iowa only and include the self-employed. Following the approach of Goldin and Katz, we adjusted the 1915 estimates of wage differentials for Iowa to be representative for the entire United States.[77] The educational attainment categories for 1940 to 1980 are based on the highest grade completed, except that all those who completed thirteen years of schooling were placed in the 13–15 group. To compute years of schooling and potential experience for the 2000 CPS, we followed the approach of Autor, Katz, and Krueger.[78] In the wage regressions for the hours-weighted indexes, we used log hourly wages as the dependent variable. Data on hours worked were not available for the 1915 Iowa state sample, so we used a monthly wage measure for 1915. The wage regressions for the employment-weighted indexes were restricted to samples of workers who had worked fifty or more weeks within a year, and log annual earnings were used as the dependent variable (except for the 1980–2000 changes, where hourly wages for full-time workers were used).

The next step was to estimate average predicted wages in each year for the entire civilian work force aged sixteen or older. A chain-weighted index for t to t' used the average of the wage regression coefficients for t and t'. The fixed-weight indexes used the average regression coefficients prevailing for the entire 1915–2000 period. The predicted wage for the education productivity index for i in year t using base-period b regression coefficients is given by

$$W_{it}^{e} = \exp(E_{it}\alpha^{b}).$$

The analogous predicted wage for the labor quality index is given by

$$W_{it}^{q} = \exp(E_{it}\alpha^{b} + X_{it}\beta^{b}).$$

The educational productivity index for t (E_t) is the weighted mean of W_{it}^{e} for all members of the civilian noninstitutional work force aged sixteen or older; person-sampling weights were used for the employment-based indexes, and the product of the sampling weight and hours worked last week were used for the hours-based indexes. Thus

$$E_t = \Sigma_i\, \omega_{it} W_{it}^{e} = \Sigma_j W_{jt}^{e} S_{jt},$$

where ω_{it} is the appropriate sampling weight, j indexes education groups, and S_{jt} equals the share of the work force in education group j in year t. The augmented labor quality index for t is given by the analogous weighted mean of W_{it}^{q}.

The civilian noninstitutional work force in each year from 1940 to 2000 includes those sixteen or older who were employed during the survey reference week and excludes those who were in the military or institutionalized.

Changes in the educational productivity index from 1915 to 1940, shown in table 2A-1, are based on data on the distribution of education in the Iowa work force for 1915 (from the Iowa State Census) and 1940 (from the U.S. Census). The 1915 Iowa work force includes those aged sixteen or older who reported positive occupational earnings for 1914 and excludes those who were in the military or institutionalized. We assumed that the growth of educational productivity from 1915 to 1940 was the same for Iowa and the United States. The U.S. labor quality index in table 2A-2 uses information on the age, sex, race, and nativity distribution of the U.S. work force from 1915 to 1940 and uses information only from Iowa for changes in the education component. The characteristics of the U.S. work force for 1915 are the average of characteristics for 1910 and 1920, based on the 1910 and 1920 U.S. Census IPUMS data. The work force for 1910 and 1920 excludes students and includes those aged sixteen to sixty-five who were gainfully employed. The 1940 federal census sample used for the 1915–1940 change in augmented labor quality also excludes students and includes labor force participants aged sixteen to

sixty-five. In both tables, changes from 1940 to 1960 and from 1960 to 1980 use the U.S. Census IPUMS data, and changes from 1980 to 2000 use the CPS MORG data.

Notes

1. Also see chapter 3, on inequality.

2. Paul Krugman, *The Age of Diminished Expectations: U.S. Economic Policy in the 1990s* (MIT Press, 1994).

3. George H. W. Bush, *Inaugural Address of President George H. W. Bush* (Government Printing Office, 1989).

4. Martin Baily, "The New Economy: Post Mortem or Second Wind?" *Journal of Economic Perspectives,* vol. 16, no. 2 (2002), pp. 3–22, summarizes the growth-accounting literature on the productivity slowdown as "large but inconclusive." No single factor provides a convincing and coherent explanation, and the theory that a large number of growth-retarding factors suddenly happened to hit at once is but the least unlikely of the proposed explanations. Dale Jorgenson, "Productivity and Postwar U.S. Economic Growth," *Journal of Economic Perspectives,* vol. 2, no. 4 (1988), pp. 23–41, convincingly demonstrates that the oil-price shocks can account for slow growth in potential output during the 1970s, but why did potential output growth remain slow after 1986, when real oil prices fell? Zvi Griliches, "Productivity Puzzles and R&D: Another Nonexplanation," *Journal of Economic Perspectives,* vol. 2, no. 4 (1988), pp. 9–21, finds that a slowdown in innovation is an unattractive explanation; Robert Gordon, "Technology and Economic Performance in the American Economy," Working Paper 8771 (Cambridge, Mass.: National Bureau of Economic Research, February 2002), finds the opposite.

5. See, for example, Gordon, "Technology and Economic Performance in the American Economy"; Steven D. Oliner and Daniel E. Sichel, "The Resurgence of Productivity Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives,* vol. 14, no. 4 (2000), pp. 3–22; Dale Jorgenson, Mun S. Ho, and Kevin J. Stiroh, "Projecting Productivity Growth: Lessons from the U.S. Growth Resurgence," Harvard University, Department of Economics, 2001; and J. Bradford DeLong, "Productivity Growth in the 2000s," in M. Gertler and K. Rogoff, eds., *NBER Macroeconomics Annual,* vol. 17 (National Bureau of Economic Research, 2002).

6. Richard R. Nelson and Edmund S. Phelps, "Investment in Humans, Technological Diffusion, and Economic Growth," *American Economic Review,* vol. 56, no. 2 (1966), pp. 69–75.

7. Claudia Goldin, "The Human Capital Century and American Economic Leadership: Virtues of the Past," *Journal of Economic History,* vol. 61, no. 2 (2001), pp. 263–92. These characteristics persist, although some are now being questioned. The movement to stricter standards, for example, which promises benefits in some directions, threatens to prevent poor performers from recovering later. The proliferation of small, independent school districts led to fiscal inequalities, and the resulting variations in spending for each pupil are now the subject of judicial scrutiny; nevertheless, the very system that created inequalities also fostered educational expansion and allowed parents to express their different educational preferences.

8. Ibid.

9. The text refers to industrial nations. Some oil-rich countries have higher per capita incomes.

10. Claudia Goldin and Lawrence F. Katz, "The Origins of Technology-Skill Complementarity," *Quarterly Journal of Economics*, vol. 113, no. 3 (1998), pp. 693–732; Claudia Goldin and Lawrence F. Katz, "Decreasing (and Then Increasing) Inequality in America: A Tale of Two Half-Centuries," in F. Welch, ed., *The Causes and Consequences of Increasing Income Inequality* (University of Chicago Press, 2001), pp. 37–82.

11. Claudia Goldin and Lawrence F. Katz, "Education and Income in the Early Twentieth Century: Evidence from the Prairies," *Journal of Economic History*, vol. 60, no. 3 (2000), pp. 782–818; Goldin and Katz, "Decreasing (and Then Increasing) Inequality in America."

12. Claudia Goldin and Lawrence F. Katz, "The Shaping of Higher Education: The Formative Years in the United States, 1890–1940," *Journal of Economic Perspectives*, vol. 13, no. 1 (1999), pp. 37–62.

13. Organization for Economic Cooperation and Development, *Education at a Glance 2001* (Paris, 2001).

14. Even these measures, however, inadequately represent formal education because they do not adjust for the quality of "a year of education." The length of the school year increased during the twentieth century, particularly for the elementary grades and in rural schools. Nonetheless, our figures for educational attainment are not adjusted for changes in education days. (Nor are adjustments made for aspects of educational quality, such as teacher certification, school facilities, and curriculum.) Although an adjustment for the length of the school year would be imprecise, it would probably modestly increase estimates of the growth in educational attainment for the first half of the twentieth century.

15. We use the decennial U.S. Censuses of Population for 1940 to 1990 and the Current Population Surveys for 1999 and 2000 to estimate the mean years of schooling and the share of college graduates by birth cohort for native-born Americans, standardized to age 35. Where the data allowed, we used the actual educational attainment of each cohort at age 35. In other cases, we predicted what the cohort's attainment was (or will be) at age 35 using the observed within-cohort historical patterns of changes in (reported) educational attainment over the life cycle, from ages 25 to 64 for birth cohorts born from 1876 to 1975. We know from comparisons with administrative records that census respondents, especially in 1940, occasionally overstated their educational attainment (Claudia Goldin, "America's Graduation from High School: The Evolution and Spread of Secondary Schooling in the Twentieth Century," *Journal of Economic History*, vol. 58, no. 2 [1998], pp. 345–74). We did not adjust the data for the overstatement, which imparts a downward bias to the increase in educational attainment across the twentieth century, just as the quality issue probably does.

16. These calculations are based on the 2000 Current Population Survey.

17. David T. Ellwood, "The Sputtering Labor Force of the Twenty-First Century: Can Social Policy Help?" Working Paper 8321 (Cambridge, Mass.: National Bureau of Economic Research, June 2001).

18. John Bound and Sarah Turner, "Going to War and Going to College: Did World War II and the G.I. Bill Increase Educational Attainment for Returning Veterans?" *Journal of Labor Economics*, vol. 20, no. 4 (2002), pp. 784–815; Marcus Stanley, "College Education and the Mid-Century GI Bills," *Quarterly Journal of Economics*, vol. 118, no. 2 (2003, forthcoming).

19. Pedro Carneiro, James J. Heckman, and Dayanand Manoli, "Human Capital Policy," in James Heckman and Alan Krueger, eds., *Inequality in America: What Role for Human Capital Policies?* (MIT Press, 2003, forthcoming); David T. Ellwood and Thomas Kane, "Who Is Getting a College Education? Family Background and the Growing Gaps in Enrollment," in S. Danziger and J. Waldfogel, eds., *Securing the Future: Investing in Children from Birth to College* (New York: Russell Sage Foundation, 2000), pp. 283–324.

20. The evolution of the educational attainment of the work force as a whole, shown in figure 2-4, differs from that shown in figures 2-1 through 2-3 because of the inclusion of immigrants, differences in cohort size over the past century, and variation in labor force participation rates by age and sex.

21. Data from Iowa (see appendix 2A) indicate that progress was also rapid from 1915 to 1940.

22. Lawrence F. Katz and David H. Autor, "Changes in the Wage Structure and Earnings Inequality," in Orly Ashenfelter and David Card, eds., *Handbook of Labor Economics*, vol. 3A (Amsterdam: Elsevier, 1999), pp. 1463–555.

23. David H. Autor, Lawrence F. Katz, and Alan B. Krueger, "Computing Inequality: Have Computers Changed the Labor Market?" *Quarterly Journal of Economics*, vol. 113, no. 4 (1998), pp. 1169–213; Claudia Goldin and Lawrence F. Katz, "The Decline of Non-Competing Groups: Changes in the Premium to Education, 1890 to 1940," Working Paper 5202 (Cambridge, Mass.: National Bureau of Economic Research, August 1995); Goldin and Katz, "The Origins of Technology-Skill Complementarity."

24. David Card and Thomas Lemieux, "Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis," *Quarterly Journal of Economics*, vol. 116, no. 2 (2001), pp. 705–46; Richard B. Freeman and Lawrence F. Katz, *Differences and Changes in Wage Structures* (University of Chicago Press, 1995).

25. Robert M. Solow, "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, vol. 70, no. 1 (1956), pp. 65–94, and Robert E. Lucas, "On the Mechanics of Economic Development," *Journal of Monetary Economics*, vol. 22, no. 1 (1988), pp. 3–42, posit that the rate of growth of the human-capital stock (typically measured by the rate of growth in the educational attainment of the work force) affects the rate of economic growth by changing the effective quantity of labor. Paul Romer, "Endogenous Technological Change," *Journal of Political Economy*, vol. 89, no. 5 (1990), pp. S71–102, posits that the level of the educational attainment of the work force affects economic growth by influencing technological progress and the creation of new ideas.

26. Alan B. Krueger and Mikael Lindahl, "Education for Growth: Why and for Whom?" *Journal of Economic Literature*, vol. 39, no. 4 (2001), pp. 1101–36. Issues related to measurement error and to the likely omission of important variables correlated with national schooling levels (and changes in those levels) raise questions concerning the causal interpretation of the estimates from such cross-country growth regressions.

27. Edward F. Denison, *The Sources of Economic Growth in the United States and the Alternatives before Us* (New York: Committee for Economic Development, 1962).

28. Charles I. Jones, "Sources of U.S. Growth in a World of Ideas," *American Economic Review*, vol. 92, no. 1 (2002), pp. 220–39, argues that the standard growth-accounting framework *understates* the contribution of human capital because it does not include the

indirect effect on capital investment of the higher incomes generated by increases in human capital. Jones's alternative framework implies that a 1 percent increase in human capital per worker would boost output by a full 1 percent. Mark Bils and Peter Klenow, "Does Schooling Cause Growth?" *American Economic Review,* vol. 90, no. 5 (2000), pp. 1160–83, argue, in contrast, that to the extent that increased schooling endogenously responds to other sources of improvement in productivity, standard growth accounting *overstates* the causal contribution of human capital to growth.

29. Dale Jorgenson and Mun S. Ho, "The Quality of the U.S. Workforce, 1948–95," Harvard University, Department of Economics, 1999, using a slightly different methodology, provide estimates of the growth in the educational quality of the U.S. work force since 1948, and Daniel Aaronson and Daniel Sullivan, "Growth in Worker Quality," *Economic Perspectives* (4th quarter, 2001), pp. 53–74, using a methodology close to ours, provide estimates for the post-1960 period. Our estimates are quite similar to the findings of these two studies.

30. This estimate from Robert J. Gordon, "Interpreting the 'One Big Wave' in U.S. Long-Term Productivity Growth," Working Paper 7752 (Cambridge, Mass.: National Bureau of Economic Research, June 2000), is for the increase in nonfarm, nonhousing, business GDP per worker. Using the alternative growth-accounting framework of Jones, "Sources of U.S. Growth in a World of Ideas," our estimates imply that the full contribution of education to the growth in labor productivity over the twentieth century was 0.5 percent a year, or 31 percent of the overall increase.

31. Ellwood, "The Sputtering Labor Force of the Twenty-First Century."

32. These projections are based on our estimates from the 2000 Current Population Survey of educational wage differentials and on Ellwood's estimates of the change in the educational attainment of the U.S. labor force (aged twenty-five and over) from 2000 to 2020 (ibid.).

33. See, for example, Mark Doms, Timothy Dunne, and Kenneth R. Troske, "Workers, Wages, and Technology," *Quarterly Journal of Economics,* vol. 112, no. 1 (1997), pp. 253–90; and Timothy F. Bresnahan, Erik Brynjolfsson, and Lorin M. Hitt, "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence," *Quarterly Journal of Economics,* vol. 117, no. 1 (2002), pp. 339–76.

34. Jones, "Sources of U.S. Growth in a World of Ideas," estimates that the increasing intensity of R&D can account for 49 percent of the growth in U.S. output per worker from 1950 to 1993.

35. In practice, the inclusion or exclusion of race and nativity as productivity-related variables makes little difference to the estimates of the labor quality index. But changes in the sex composition of the work force are significant for certain subperiods.

36. Aaronson and Sullivan, "Growth in Worker Quality"; Ellwood, "The Sputtering Labor Force of the Twenty-First Century."

37. Daron Acemoglu and Joshua Angrist, "How Large Are Human Capital Externalities? Evidence from Compulsory Schooling Laws, " in B. Bernanke and K. Rogoff, eds., *NBER Macroeconomics Annual,* vol. 15 (National Bureau of Economic Research, 2000), pp. 9–59.

38. Carneiro, Heckman, and Manoli, "Human Capital Policy," and Alan B. Krueger, "Inequality, Too Much of a Good Thing," Princeton University, Department of Economics, 2002, offer comprehensive evaluations of evidence on the effectiveness of a wide range of targeted education and training policies, including early-childhood interventions,

changes in resources for primary and secondary schools, second-chance programs for youth, and financial aid for college.

39. U.S. Department of Education, National Center for Education Statistics, *The Condition of Education 2001* (Government Printing Office, 2001).

40. Ellwood and Kane, "Who Is Getting a College Education?"

41. Pedro Carneiro and James J. Heckman, "The Evidence on Credit Constraints in Post-Secondary Schooling," Working Paper 9055 (Cambridge, Mass.: National Bureau of Economic Research, 2002), provide a more skeptical interpretation of the evidence on the effect of credit constraints on low-income youths' investments in postsecondary education.

42. Susan Dynarski, "The Behavioral and Distributional Implications of Aid for College," *American Economic Review,* vol. 92, no. 2 (2002), pp. 279–85; Thomas Kane, *The Price of Admission: Rethinking How Americans Pay for College* (Brookings, 1999).

43. David Card, "The Causal Effect of Education on Earnings," in O. Ashenfelter and D. Card, eds., *Handbook of Labor Economics,* vol. 3A (Amsterdam: Elsevier, 1999), pp. 1801–63.

44. Kane, *The Price of Admission,* table 3-1, p. 60, estimates that mean real net tuition for public two-year and four-year colleges increased by 107 percent and 106 percent, respectively, from 1980–81 to 1994–95. Reductions in the share of expenditure on public college from state government subsidies contributed substantially to these rising costs. In contrast, real family incomes were essentially stagnant for the bottom 40 percent of families from 1980 to 1995.

45. James J. Heckman and Lance Lochner, "Rethinking Myths about Education and Training Policy: Understanding the Sources of Skill Formation in a Modern Economy," in S. Danziger and J. Waldfogel, eds., *Securing the Future: Investing in Children from Birth to College* (New York: Russell Sage Foundation, 2000), pp. 47–83.

46. Krueger, "Inequality."

47. Ibid.; Janet Currie, "Early Childhood Intervention Programs: What Do We Know?" *Journal of Economic Perspectives,* vol. 15, no. 2 (2001), pp. 212–38.

48. Larence Mishel and Richard Rothstein, *The Class Size Debate* (Washington: Economic Policy Institute, 2002).

49. Alan B. Krueger, "Experimental Estimates of Educational Production Functions," *Quarterly Journal of Economics,* vol. 114, no. 2 (1999), pp. 497–532; Krueger, "Inequality."

50. Tara Watson, "Inequality and the Rising Income Segregation of American Neighborhoods," Harvard University, Department of Economics, 2002.

51. Lawrence F. Katz, Jeffrey R. Kling, and Jeffrey B. Liebman, "Moving to Opportunity in Boston: Early Results of a Randomized Mobility Experiment," *Quarterly Journal of Economics,* vol. 116, no. 2 (2001), pp. 607–54; James E. Rosenbaum, "Changing the Geography of Opportunity by Expanding Residential Choice: Lessons from the Gautreaux Program," *Housing Policy Debate,* vol. 6, no. 1 (1995), pp. 231–69.

52. Robert M. Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics,* vol. 39, no. 3 (1957), pp. 312–30; Solow, "A Contribution to the Theory of Economic Growth"; Moses Abramovitz, "Resource and Output Trends in the United States since 1870," *American Economic Review,* vol. 46, no. 2 (1956), pp. 5–23.

53. Denison, *The Sources of Economic Growth in the United States and the Alternatives before Us.*

54. Moses Abramovitz and Paul David, "Reinterpreting Economic Growth: Parables

and Realities," *American Economic Review*, vol. 63, no. 2 (1973), pp. 428–39; Jones, "Sources of U.S. Growth in a World of Ideas."

55. Daron Acemoglu, "A Microfoundation for Social Increasing Returns in Human Capital Accumulation," *Quarterly Journal of Economics*, vol. 111, no. 3 (1996), pp. 779–804; Goldin and Katz, "The Origins of Technology-Skill Complementarity."

56. J. Bradford DeLong and Lawrence H. Summers, "Equipment Investment and Economic Growth," *Quarterly Journal of Economics*, vol. 116, no. 2 (1991), pp. 445–502. Xavier Sala-i-Martin, "I Just Ran Four Million Regressions," Working Paper 6252 (Cambridge, Mass.: National Bureau of Economic Research, November 1997), and others have noted that the association between investment in physical capital and growth is remarkably robust to changes in regression specifications.

57. Erik Brynjolfsson and Lorin Hitt, "Beyond Computation: Information Technology, Organizational Transformation, and Business Performance," *Journal of Economic Perspectives*, vol. 14, no. 4 (2000), pp. 23–48.

58. Paul David, "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," in Organization for Economic Cooperation and Development, *Technology and Productivity: The Challenge for Economic Policy* (Paris, 1991); Warren Devine, "From Shafts to Wires: Historical Perspectives on Electrification," *Explorations in Economic History*, vol. 63, no. 2 (1983), pp. 347–72.

59. Clear evidence that private decisions led to the wrong balance of resources and well-being across generational cohorts would be an additional reason for government action to influence investment. Unfortunately—or perhaps fortunately—economists have reached no consensus on whether the past (and the likely future) cross-generational cohort pattern of consumption is unfairly weighted toward early generations, unfairly weighted toward later generations, or about right. The likelihood that future cohorts will be richer than their forebears, coupled with a simplistic utilitarianism, suggests that current consumption is too low, current saving is too high, and the current rate of American economic growth too fast. On the other hand, the likelihood that an America rich and powerful enough, in relative terms, to be a global superpower confers massive positive external benefits on the rest of the world—the defeat of Germany in World War II, for example—suggests that the current rate of American economic growth is too slow. The behavioral economic literature on "impatience" and "myopia" suggests that Americans devote less attention to the distant future than they "really want to," which implies that the current rate of saving is too low (David Laibson, "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics*, vol. 112, no. 2 [1997], pp. 443–77). These self-control problems may be the most important of all.

60. Lawrence H. Summers, "What Is the Social Return to Capital Investment?" in Peter Diamond, ed., *Growth, Productivity, Unemployment: Essays to Celebrate Bob Solow's Birthday* (MIT Press, 1990).

61. The fourth option—direct government investment—will not be considered because, apart from investment in public capital goods, such as roads, canals, airports, and other items lumped under the heading of infrastructure, the record of direct government investment, except during national emergencies, has been poor around the world.

62. Investment Company Institute, "Mutual Funds and the U.S. Retirement Market in 2001," *Fundamentals: Investment Company Institute Research in Brief*, vol. 11, no. 2 (2002).

63. See, for example, Eric Engen, William G. Gale, and John Karl Scholz, "The Illusory Effects of Saving Incentives on Saving," *Journal of Economic Perspectives*, vol. 10, no. 4

(1996), pp. 113–38. But recent work in behavioral economics suggests that changes in financial education and in the plan rules (and default options) for private defined-contribution pensions have potentially powerful effects on retirement saving; see James J. Choi and others, "Defined Contribution Pensions: Plan Rules, Participant Choices, and the Path of Least Resistance," *Tax Policy and the Economy*, vol. 16 (2002), pp. 67–113.

64. See David Laibson, "Psychological Perspectives on 401Ks," in David Wise, ed., *Frontiers in the Economics of Aging* (University of Chicago Press, 1998), pp. 106–20; Choi and others, "Defined Contribution Pensions."

65. Shlomo Benartzi and Richard Thaler, "Save More Tomorrow: Using Behavioral Economics to Increase Employee Savings," Anderson School of Business, University of California, Los Angeles, 2001.

66. As Annamaria Lusardi, Jonathan Skinner, and Steven Venti, "Saving Puzzles and Saving Policies in the United States," Working Paper 8237 (Cambridge, Mass.: National Bureau of Economic Research, 2001), have pointed out, such "impatience," or "myopia," can be generated by the interaction between even fully rational and farsighted households and a means-tested social insurance system. For example, if the chances are high that health problems late in life will eat up all accumulated private wealth before Medicaid kicks in, households will regard this eventuality as a powerful disincentive to private saving. A countervailing government focus on saving incentives might well be appropriate to offset the effects of such a distortion.

67. The belief that such incentives can be counterproductive because they encourage foreign investment in the United States—which would mean that a significant part of the returns from the increased capital stock would flow abroad—is simply wrong: the point of the exercise is to capture the positive externalities that arise from increasing capital stock. It is true that when foreigners invest in America, the normal—that is, private—profits flow abroad, but it is also true that foreign investment does not have to be financed through reductions in current American consumption. These two effects balance each other, leaving the positive external benefit from investment as an improvement in social welfare.

68. Alan Auerbach and James Hines, "Investment Tax Incentives and Frequent Tax Reforms," *American Economic Review*, vol. 78, no. 2 (1988), pp. 211–16.

69. That Robert Barro's ("Are Government Bonds Net Wealth?" *Journal of Political Economy*, vol. 82, no. 6 [1974], pp. 1095–117) doctrine of Ricardian equivalence (and of the neutrality of government budget deficits) is likely to be of limited applicability in the contemporary United States appears to be demonstrated by the failure of private saving rates to offset either the rise in the federal deficit in the 1980s or the fall in the federal deficit in the 1990s. B. Douglas Bernheim and Kyle Bagwell, "Is Everything Neutral?" *Journal of Political Economy*, vol. 96, no. 2 (1988), pp. 308–38, argue that the assumptions about altruism and intergenerational linkages needed for such Ricardian equivalence to be effective with respect to government finance carry other powerful unobserved and unrealistic consequences for economic behavior.

70. Romer, "Endogenous Technological Change."

71. Quoted in Summers, "What Is the Social Return to Capital Investment?"

72. Nancy Gallini, "The Economics of Patents: Lessons from Recent U.S. Patent Reform," *Journal of Economic Perspectives*, vol. 16, no. 2 (2002), pp. 131–54.

73. Michael Kremer, "Patent Buyouts: A Mechanism for Encouraging Innovation," *Quarterly Journal of Economics*, vol. 113, no. 4 (1998), pp. 1137–67.

74. Charles I. Jones and John C. Williams, "Measuring the Social Return to R&D," *Quarterly Journal of Economics,* vol. 113, no. 4 (1998), pp. 1119–35.

75. The data from the Iowa 1915 State Census are described and documented in Goldin and Katz, "Education and Income in the Early Twentieth Century: Evidence from the Prairies."

76. Claudia Goldin and Lawrence F. Katz, "The Legacy of U.S. Educational Leadership: Notes on Distribution and Economic Growth in the Twentieth Century," *American Economic Review,* vol. 91, no. 2 (2001), pp. 18–23; Aaronson and Sullivan, "Growth in Worker Quality."

77. Goldin and Katz, "Decreasing (and Then Increasing) Inequality in America: A Tale of Two Half-Centuries," in F. Welch, ed., *The Causes and Consequences of Increasing Income Inequality.*

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3

American Inequality and Its Consequences

INCOME INEQUALITY HAS risen sharply in the United States over the past generation, reaching levels not seen since before World War II. But while almost two-thirds of Americans agree with the statement "income differences in the United States are too large," policies aimed at reducing income differences command relatively little popular support.[1] In most rich countries sizable majorities "agree strongly" that the government ought to guarantee each citizen a minimum standard of living. Only one American in four agrees strongly with this proposition.[2] The same pattern holds in Congress, where legislators show little interest in policies aimed at taxing the rich, raising the wages of the poor, taxing inherited wealth, or guaranteeing shelter and health care to all Americans.

One possible explanation for this apparent paradox is that, while most Americans think income inequality is too high, most also distrust the government and attribute America's economic success to the fact that its economy is lightly regulated. A second possible explanation is that while

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