CHAPTER 3

THE FOUNDATIONS OF GROWTH

As the United States economy shifts from crisis to recovery and growth, policy must also be rebalanced to emphasize the foundations of growth that promise Americans a stronger and more prosperous future. Policy must move beyond the short-run demands of the business cycle to support the broader economic environment that ensures rapid, broad-based, and sustained economic growth, bringing Americans greater income, higher-quality jobs, and longer and healthier lives.

At the core of the Nation's economic growth is our capacity to innovate, educate, and build. Innovation, drawing on a long tradition of American ingenuity, has made American workers and businesses world leaders in productivity. With private sector investments in the lead, U.S. marketplaces provide the test beds in which new ideas are proven and the means by which successful ideas spread. At the same time, the creation and diffusion of new ideas require essential public inputs in education, infrastructure, and the national innovation system, which all work together to sustain and accelerate U.S. economic growth. This chapter considers the foundations of that economic growth and the public policies that will ensure America's continuing economic success.

The Importance of Economic Growth

Rapid and sustained economic growth is a defining feature of U.S. history. Figure 3-1 shows the rise of real U.S. income per person from the Industrial Revolution in the early 19th century to the present. Adjusted for inflation, income per person in 2007 was double its level in 1971. Income per person in 1971 was double its level in 1940, and income per person in 1940—even after a decade of the Great Depression—was double its level in 1896. All told, average income per person in the United States today is 25 times what it was in 1820 (Maddison 2008). Income does not rise in every

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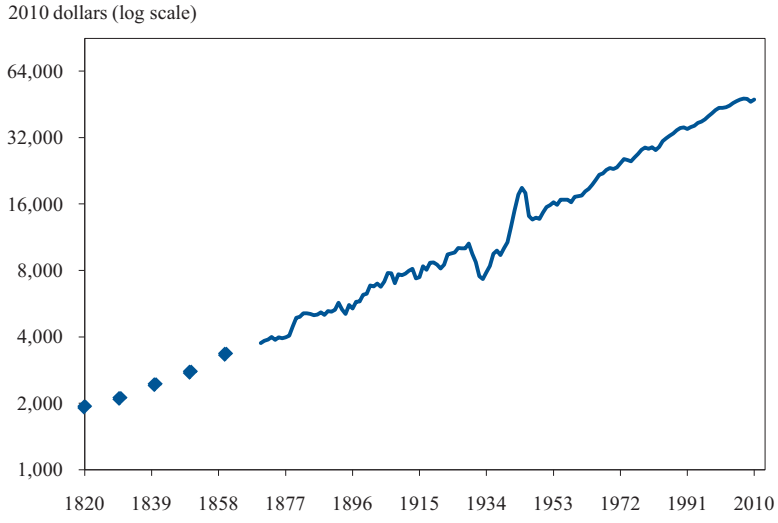
year, and it can fall sharply, but over the longer run the upward trend clearly dominates short-run cycles. The experience of the American economy in the past two years has been especially difficult, but Figure 3-1 also makes clear that, if America can capitalize on its long-run legacy of growth, then the Nation can expect to grow beyond its current challenges and reach new economic heights.

Figure 3-1
Progress in U.S. Real Income Per Person Since 1820



Sources: Maddison (2008); Bureau of Economic Analysis, National Income and Product Accounts.

Beyond the summary measure of income per person, the progress in American standards of living can be seen in how we live our lives—and how long those lives are. Life expectancy in the United States in the early to mid-1800s was approximately 40 years. Fifteen percent of children did not survive their first year of life, and over 30 percent did not reach their fifth birthday in many American cities (Haines 2001). Today, life expectancy is 78, and infant mortality has fallen by a factor of 20. In the early 1800s, primary school was the height of most Americans' educational attainment. Telegraphs and telephones had not been invented, let alone e-mail and wireless communications. There were no automobiles, no airplanes. There were no washing machines, dishwashers, air conditioners, or electric refrigerators. Indeed, there was no electrification—no light bulbs, radios, televisions, computers, or Internet—and none of the associated services that Americans now enjoy.

Overall, the economic growth imperative is clear. The improvements in income, health, and the variety and quality of products Americans consume all demonstrate the remarkable increase in prosperity the United States has enjoyed throughout its history. If the United States continues the same, sustained growth rate it has averaged since 1870, Americans can look forward to real incomes that are twice as high per person by 2046 and five and a half times higher in 2100, with new opportunities, higher-paying jobs, better educations, and healthier, longer lives.

Sources of Economic Growth

Any assessment of the appropriate role of growth policy starts with an analysis of how economic growth works, that is, how economies increase their output per person. Most directly, economists analyze the sources of growth by asking how the "inputs" workers use increase their output per unit of time. Economics offers three key ingredients for growth.

First, physical capital inputs, such as machines, tools, and infrastructure, make workers more productive. For example, investments in telecommunications equipment allow information to be exchanged rapidly, making wide arrays of workers, from emergency personnel to business managers, more productive. One source of growth, then, is this "physical capital deepening," investments that increase the amount of physical capital per worker.

Second, skill formation makes workers more productive. Investments in skill formation, or "human capital," include general education but also education specific to certain occupations, such as engineering, medicine, and law, as well as training to use certain types of machines and tools. For example, investment in training telecommunications engineers pays off in improved communication services. Thus, another source of growth is this deepening of human capital investments that raise the skills of workers.

Third, growth in advanced economies like the United States ultimately depends on technological progress, interpreted broadly to mean the creation and diffusion of new ideas. To continue the communications example, the advent of the telephone transformed people's ability to communicate, but once fixed-line telephones had spread across America, increasing the number of telephones per person had no such transformational power. Further progress awaited the invention of better communications technologies—the fax machine, the mobile telephone, the Internet—which have spurred additional investment in capital and further increased worker productivity. Technological progress drives capital deepening and creates new avenues to increased prosperity.

The foundational role of underlying technological progress can be inferred by considering the advance of major sectors of the U.S. economy. For example, advances in transportation were made possible by the invention and diffusion of numerous technologies, including engines, trains, automobiles, and airplanes. People and goods can now cross the country in six hours instead of months. This improvement was achieved through the invention of ever more advanced technologies. Box 3-1 considers an additional example—the advance of human health—at greater length.

Unfortunately, there are cracks in the foundations of America's growth that need to be addressed. The Nation's innovation system relies largely on the private sector but also depends on critical public inputs. For example, basic scientific breakthroughs in engineering, genetics, chemistry, and many other fields underpin commercial innovation but provide little or no direct profit themselves, so basic scientific research relies heavily on public support. Yet publicly funded research and development fell steadily from the early 1960s until recently.

Box 3-1: Technological Progress and the Advance of Health

Improvements in health have been possible through numerous medical advances. Polio, smallpox, diphtheria, and other debilitating or deadly viruses have been checked by vaccines. Bacterial infections, following the discovery of penicillin in 1928, are now treated by a wide range of antibiotics. Advances in controlling infection, bleeding, and pain made modern surgery possible, allowing surgeons to save and improve lives. Meanwhile, advances in the understanding of anatomy, molecular and cell biology, genetics, chemical synthesis, nuclear physics, and other areas have produced cascades of innovations for the diagnosis and treatment of disease. From laser eye surgery to X-ray, MRI, and ultrasound imaging technologies, to effective chemotherapies for particular cancers and pharmaceuticals that manage blood pressure, insulin levels, asthma, and many other chronic conditions, human health technologies have taken enormous leaps.

Health improvements raise workers' productivity, and increasing longevity can both extend working lives and encourage higher education. These mechanisms work to enhance economic growth. But much of the benefit of improved health—whether the decline in infant mortality or the direct enjoyment of longer lives—cannot be measured simply by tracking income per person. Thus, the benefits brought by these technological advances stand largely in addition to the 25-fold increase in U.S. per capita income since 1820.

Meanwhile, U.S. investments in infrastructure no longer lead the world, either in traditional physical infrastructure or in new information networks. American households rank only 14th among advanced countries in the adoption of high-speed Internet, for example, and average advertised download speeds in the United States rank 24th. Failure to provide American workers and businesses with efficient, modern infrastructure raises costs and disrupts the marketplace, making it increasingly difficult for the American economy to provide world-leading productivity and innovation.

In skill formation, the United States once led the world in the proportion of college graduates. It now ranks ninth in this measure among adults aged 25 to 34. Meanwhile, the quality of the Nation's primary and secondary education substantially lags other countries, especially in science and mathematics. These educational challenges are among the factors associated with stagnating wages among less-educated workers and with widening wage inequality, and they are further associated with unequal access to important goods and services, including health care. Furthermore, these challenges present obstacles to American workers and businesses seeking the high-productivity, high-wage jobs in the 21st-century global economy.

Making America more competitive and growing the economy is a preeminent goal of the Obama Administration. The rest of this chapter identifies the path forward, focusing on critical public policies and investments—in the Nation's innovation system and infrastructure and in the skills of individual Americans—that support rapid, broad-based, and sustained increases in America's prosperity.

Innovation and Economic Growth

Innovation, the introduction of new or improved goods, services, or practices into the economy, depends critically on private sector interest. Businesses, operating in a competitive market system, have numerous advantages in the creation and implementation of useful new ideas (Box 3-2). At the same time, the social rewards to innovation often exceed the private rewards to the original innovator, so the private sector may fall short in providing innovations and economic growth (Box 3-3). The Obama Administration is working to shore up the foundations of our national innovation system through critical public investments that will accelerate our future prosperity.

Box 3-2: The Power of Market-Based Innovation

Good ideas come from many quarters and from surprising directions, so their nature and source are fundamentally hard to foresee. The market system draws on American ingenuity from the ground up, relying on those individuals with close proximity to particular goods, services, or practices to develop the next-generation idea. Innovation can come from established firms, which developed the transistor, laser, and smartphone, for example, and from entrepreneurs, who led the creation of airplanes, personal computers, and Internet search engines.

Markets provide the crucible in which innovations are tested, then improved or discarded. Ultimately, it is buyers—consumers and other firms—who decide whether a new or improved good or service is worth paying for. The market system, with its price signals about costs and consumer demand, helps businesses direct their innovative efforts to high-value areas.

Once an idea is successfully demonstrated in the market, the market system invites other innovators to build on these ideas. For example, the laser turned out to have applications—in surgical devices and manufacturing tools, in computer printers, barcode scanners, and DVD players—far beyond those its early creators imagined. Early and uncertain visions of a large market for personal computers were realized only through a torrent of marketplace innovations across a vast array of established and entrepreneurial firms.

The market system also works to spread the best ideas, because competitive pressures favor the expansion of those firms with the most efficient methods and most desirable products. Flexible capital and labor markets pivot scarce resources toward the best ideas, constantly reinventing the American economy.

Basic Research

Basic scientific research typically has little direct commercial return, so its costs are not easily borne by firms. Yet downstream, commercial innovation is dependent on achievements in basic science. The biotechnology industry builds on Watson and Crick's discovery of the structure of DNA. The Web-based innovations and storefronts of the new economy build on government and university development of the Internet. Americans draw on achievements in basic science throughout their daily lives—in driving a car, using an electronic device, taking modern medications, talking on a telephone, or finding information online.

Box 3-3: The Social Gains from Innovation

The social gains from innovation typically extend well beyond the profits earned by the innovative enterprise. Telephones, light bulbs, subway trains, dishwashers, antibiotics, lasers, computers, Web browsers, and smartphones, for example, all offer large and ongoing social gains for Americans that far outstrip any commercial return to the original innovators. There are several reasons for this tendency. First, users will pay for an innovation only if its benefits exceed its price. These benefits in excess of the price—the "consumer surplus"—mean that much of the innovation's immediate value will accrue to the users rather than to the innovator. Second, the innovating business will face pressures to lower prices as other businesses imitate the successful innovation, especially once any intellectual property rights expire, transferring the innovation's value more fully to the user. Finally, a successful innovation often launches additional innovations, the benefits of which are not captured by the original innovator and additionally spill over to users.

Given that these users are workers or consumers, the social gains from innovation largely accrue through rising labor compensation, new workforce opportunities, and the higher quality and increasing variety of Americans' consumption. On average, the private firm may capture only a small percentage of the social gain from innovation. Thus, all Americans have an important stake in the innovation system. At the same time, because technological advances can be biased toward educated workers, investments in human capital become critical to ensure that the gains from workplace innovations remain widely shared, as discussed at the end of this chapter.

Given the importance of basic research, coupled with its low private return, the American innovation system relies on public support of university and government researchers who work to develop scientific breakthroughs and make these breakthroughs publicly available. This open science model for basic research expands collective knowledge and allows anyone with a good idea to tap these advances. Whether discovering fundamental properties of nature, developing understandings of disease that open new pathways for treatment, or creating the breakthroughs in nanotechnology that may revolutionize modern manufacturing, basic science will continue to create new foundations for future progress.

In 2009, the Obama Administration put in place the largest funding increase in basic science in U.S. history with an $18.3 billion contribution

from the American Recovery and Reinvestment Act. More broadly, the Administration is committed to doubling the long-term funding for three key basic science agencies, the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology laboratories. With these commitments and others, the Administration is working towards those frontiers that promise new industries and new growth. In clean energy and electric vehicles, nanotechnology, advanced manufacturing, biotechnology, wireless communications, and other promising fields, the Administration is deploying resources to create fundamental breakthroughs at the beginning of the innovation pipeline. These priority areas are discussed further below.

Intellectual Property Rights

Effective protection of intellectual property rights, including patents and copyrights, is an essential role of government in encouraging innovation. Innovation typically requires substantial investments in the labor and materials necessary to create, develop, and test a new idea and then see it through to the marketplace. If others can steal the idea once it is proven, undermining the ability of the creator to recoup the costs of the innovative investment, then the incentive to innovate is reduced. Intellectual property rights address this problem by giving the innovator a limited-duration right to exclude others' use, thus helping to ensure that the private sector has the incentives to make innovative investments. In President Lincoln's words, the patent system adds "the fuel of interest to the fire of genius."

Intellectual property rights are particularly important to industries that make substantial investments in research and development (R&D), and R&D-intensive industries are leaders in driving U.S. growth and competitiveness. For example, among U.S. industries that produce internationally tradable goods and services, industries with above-average R&D levels generated more than twice the output and sales per employee, accounted for about 60 percent of exports, and accounted for five of the six U.S. industries that generated a trade surplus during the 2000–2007 period (Pham 2010).

Recognizing the importance of intellectual property, the Obama Administration is determined to improve the function of the patent system. The United States Patent and Trademark Office (USPTO) currently faces a backlog of 719,000 patent applications, and the average delay between patent application and patent grant has risen to 35 months. These delays are untenable for businesses, especially entrepreneurial businesses, which often rely on licensing their patents to generate revenue. The Obama Administration has begun to implement a five-year plan to improve the quality and timeliness of patent issuance. This strategic plan includes steps to redesign the agency's

information technology infrastructure, reform the reward system for patent examiners, and hire 1,000 additional examiners, while a new pilot program is also opening the USPTO's first branch office. The Administration is also seeking legislative authority to give the USPTO greater capacity to meet its ever-increasing workload and improve patent quality. Legislative priorities include letting the USPTO set and keep its patent fees, so that it can expand its operations to meet its workload, and allowing "post-grant review," which can help limit errors in patent issuance and thus reduce costly litigation and market uncertainty.

The Administration is also working aggressively to protect against copyright and patent infringement. The Nation's first Intellectual Property Enforcement Coordinator, working within the Executive Office of the President, has released a Joint Strategic Plan to coordinate U.S. government actions to combat unauthorized use of intellectual property, both domestically and internationally, and is facilitating voluntary cooperative efforts by the private sector to reduce infringement. The Department of Justice and the Department of Homeland Security have increased law enforcement activity, including shutting down Web sites trafficking in infringing content, prosecuting theft of innovative trade secrets, and coordinating global law enforcement sweeps against counterfeit drugs. In addition, the United States Trade Representative has negotiated the first international enforcement agreement, the Anti-Counterfeiting Trade Agreement, to limit global trade in counterfeited goods and pirated copyrighted works.

Antitrust and the Innovative Marketplace

The U.S. antitrust agencies evaluate the extent to which a merger between existing competitors can reduce the degree of competition in a market. In situations where firms actively innovate to improve their position vis-à-vis their competitors, the agencies must consider whether those innovations would still be pursued should the merger go forward. Given the importance of innovation to economic growth, sound merger enforcement policy aims to promote innovation by approving mergers that are likely to create efficiencies and potentially spur innovation, while preventing mergers that may inhibit innovation through a reduction in competition.

In August 2010, the Antitrust Division of the Department of Justice and the Federal Trade Commission issued new Horizontal Merger Guidelines, which describe the merger enforcement policies of the two agencies. The new guidelines include, for the first time, a section explaining how the agencies assess whether a merger is likely to inhibit innovation by, for example, reducing a firm's incentive to continue a product development effort or initiate new product development.

The Research and Experimentation Tax Credit

Even with well-functioning intellectual property rights and markets, and with public support for basic scientific research, commercial innovation incentives still tend to fall short of the social benefits. The Research and Experimentation (R&E) tax credit is therefore an important tool to enhance private sector innovation incentives and accelerate economic growth. In 2007, the R&E tax credit supported 12,548 corporations and 56,000 individual taxpayers with $8.8 billion in credits. Recent studies find that research tax credits translate dollar-for-dollar into increases in current research spending, especially over the longer run as businesses develop their research enterprises (Hall and Van Reenen 2000; Bloom, Griffith, and Van Reenen 2002). Unfortunately, because the R&E credit is temporary and must be renewed periodically, uncertainty about the credit's availability reduces its incentive effect, especially in planning projects that will not be initiated and completed before the credit's expiration.

The Obama Administration has proposed to expand, simplify, and permanently extend the R&E tax credit. The proposal will expand the credit by approximately 20 percent, making a commitment of $100 billion over the next 10 years, which represents the largest commitment in the tax credit's history. The Administration also proposes to make the credit easier to use, providing a simple 17 percent credit rate to businesses, and to make the credit permanent, ensuring that businesses can count on the credit as they plan research investments that span multiple years.

Entrepreneurship

The United States has long recognized the role of entrepreneurship in tapping American ingenuity to develop new products and solve problems. Small firms typically produce more patents per dollar of R&D than do large firms. New businesses are also engines of job growth, with small firm births creating 40 million U.S. jobs between 1992 and 2005. Yet entrepreneurs face special challenges. Raising funds is difficult for firms that are new and have little collateral or no established reputation, even if they have a great idea. Moreover, disclosing ideas in pursuit of funding can risk losing the idea to established firms. Should a startup be capable of financing the initial innovative investment, long administrative delays in patent issuance typically delay licensing opportunities and may cause the startup to fail.

Government support for entrepreneurship can help ensure that good ideas from all sources enter markets, thereby boosting economic growth. For example, the Small Business Innovation Research (SBIR) program, which is managed by the Small Business Administration and supported by 11 federal

agencies, assists small entrepreneurial businesses to compete for federal research and development awards. A recent report shows that during the 10-year period ending in 2006, businesses participating in the SBIR program frequently accounted for more than 20 of R&D Magazine's top 100 high-technology products of the year. The Administration's new Startup America initiative will facilitate entrepreneurship across the country, investing $2 billion in capital for entrepreneurs, improving the regulatory environment for young businesses, and increasing connections between entrepreneurs and high-quality business mentors. Meanwhile, on a different dimension, the Affordable Care Act will remove obstacles to entrepreneurship by enabling Americans to start and join new businesses without giving up access to health coverage, both by allowing workers with preexisting conditions to maintain their health insurance and by allowing Americans under age 26 to remain on their parents' insurance. Chapter 7 considers small business challenges and Administration policies in greater detail.

National Priority Areas

For national priorities where innovation is critical but market failures impede progress, government can help spur technological advances. Priority areas include developing clean energy sources, using information technology to improve health care and reduce costs, and nurturing the bio- and nanotechnology revolutions. The Administration is harnessing mechanisms, from basic research to government procurement, to help spark American ingenuity in these areas, driving economic growth and building the future industries that can provide American workers with quality jobs in the future global economy.

In clean energy, the Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) has awarded nearly $400 million to more than 120 research projects that seek fundamental breakthroughs in energy technologies. The Administration's fiscal year 2012 Budget will more than double total funding to date for ARPA-E. It will also double, from three to six, the number of Energy Innovation Hubs, bringing innovative thinkers from different disciplines together to create research breakthroughs on tough problems. One new Energy Innovation Hub will focus on improving batteries and energy storage, with applications to advanced vehicles. Overall, the FY 2012 Budget will significantly expand R&D investments in critical electric vehicle components while transforming the existing $7,500 tax credit for electric vehicles into a rebate available to all consumers at the point of sale. Building on existing initiatives like the Advanced Technology Vehicles Manufacturing loan program, which has invested over $2.4 billion to support three electric car factories in California, Delaware, and Tennessee, these initiatives are working to meet the President's goal of putting 1 million

advanced vehicles on the road by 2015. Meanwhile, Department of Energy tax credits have leveraged gigawatts of private sector investments in wind, solar, and geothermal technologies, and the U.S. Navy is driving demand for new fuels by committing to convert half of the fuel used for powering its planes, ships, and vehicles to alternative fuels by 2020.

In health care, advances in information technology can help prevent medical errors; improve delivery of care for patients, doctors, and nurses; lower costs; and create data platforms to encourage further innovation. The Administration is making investments to accelerate the adoption of electronic health records, develop standards for secure exchange of health information over the Internet, and promote mobile and Web-based health technologies. The Strategic Health IT Advance Research Projects (SHARP) program is funding potentially game-changing advances to overcome obstacles to the adoption of health information technology.

The Administration has been making critical investments in biotechnology, nanotechnology, and advanced manufacturing. Through the Recovery Act, the Administration has invested in sequencing 1,800 complete human genomes, more than a 50-fold increase over the 34 genomes sequenced before Recovery Act funding, creating new capacity for understanding many diseases while also driving down DNA sequencing costs. The National Nanotechnology Initiative is developing a strategic plan to coordinate federal investments in nanotechnology fields, including investments to promote health, energy, materials, electronics and other applications. The FY 2012 Budget also increases investments at key science agencies to catalyze breakthroughs for advanced manufacturing applications and provides funding to initiate the Advanced Manufacturing Technology Consortia Program, a public-private partnership that will help spur innovation in manufacturing systems and shorten the time needed for innovations to reach the market.

Infrastructure and Economic Growth

Public investments in infrastructure reduce production and trade costs, enhance capital and labor mobility, and provide platforms to stimulate innovation. During the 1900s, America's infrastructure investments focused on the Nation's transportation systems and public utilities, including electrification, which provided a platform for the birth of major new industries and better opportunities for the American workforce. Today, as demand continues to grow and existing infrastructure decays, significant and renewed investment in our transportation and electricity systems is required.

The 21st century also calls for critical investments in the information and communication technology (ICT) infrastructure, including broadband Internet and wireless spectrum investments, that increasingly underpins the economy and provides abundant opportunities for further innovation and growth. Telecommunications investments have historically predicted substantial growth among advanced countries, and rapid adoption of ICT was associated with faster U.S. growth during the early Internet years. Of the world's 250 largest ICT companies today, 75 have their home in the United States; these 75 companies generated total revenues of more than $1 trillion in 2009. Additionally, ICT accounts for about 50 percent of U.S. venture capital spending, a key element in transforming innovative ideas into commercial applications (OECD 2010). Annual private investment in information processing equipment and software in the United States doubled between 1995 and 2009, growing 2.5 times faster than other U.S. private fixed investment.

Roads, Railways, and Runways

The United States has a rich history of government investment in transportation infrastructure leading to long-term economic benefits. The interstate highway system represents one example. Research has shown that well-designed infrastructure investments can raise economic growth, productivity, and land values, while also providing significant positive spillovers to economic development, energy efficiency, public health, and manufacturing.

In September 2010, President Obama announced a plan to renew and expand America's transportation infrastructure and increase government efficiency in making infrastructure investments. The plan includes a $50 billion investment to renew 150,000 miles of depreciating roads, construct and maintain 4,000 miles of passenger rail, and rehabilitate 150 miles of runways. Overall, the FY 2012 Budget seeks a six-year surface transportation reauthorization package totaling $556 billion, more than a 60 percent increase above the previous six-year package. The Administration is also seeking to modernize the transportation infrastructure to help people and goods move efficiently and keep American markets competitive. For example, the FY 2012 Budget provides $53 billion over the next six years for passenger rail, including the development of a high-speed rail system that will be accessible by 80 percent of Americans within 25 years, and $1.24 billion for the Next Generation Air Transportation System, a multiyear effort to improve efficiency, safety, and capacity of the Nation's aviation infrastructure.

The President's infrastructure plan also calls for the creation of a National Infrastructure Bank to leverage private capital and select projects of greatest national significance. The infrastructure bank, to be funded at $30 billion over six years, would depart from the Nation's traditional infrastructure decisionmaking process and instead weigh projects of national and regional significance against each other and fund those judged to have the greatest return to American taxpayers.

Electricity Infrastructure

Successful electrification across the United States in the early 1900s provided a general purpose technology upon which many further innovations would build, from lighting and household appliances to radio and television to computers and information technology. With rising carbon pollution and growing worldwide demand for scarce energy resources, the U.S. electricity infrastructure now faces new challenges. The Administration is currently taking numerous steps to modernize the Nation's electric grid and provide cleaner, more efficient, and more secure energy sources, largely through Smart Grid projects and transmission infrastructure financing.

The National Institute of Standards and Technology is coordinating Smart Grid standards, and the Recovery Act provided $4.1 billion for related Smart Grid investments. By providing a two-way flow of information, a Smart Grid promises to enable homes and businesses to manage electricity consumption based on need and price, thus reducing their utility bills. For example, energy usage and billing data can be provided nearly in real time to the consumer through smart meters or other technologies. Such data services can enable smart thermostats and smart home appliances to adjust their energy cycles based on price signals. Smart Grid technologies also include those that enable the broader electricity transmission infrastructure to operate more reliably and effectively, preventing brown-outs and other disruptions that can undermine the efficiency of the electric grid. Overall, Smart Grid technologies promise to lower consumer costs, increase the reliability of the electric grid, and facilitate the adoption of other innovative technologies, such as renewable energy resources and electric vehicles.

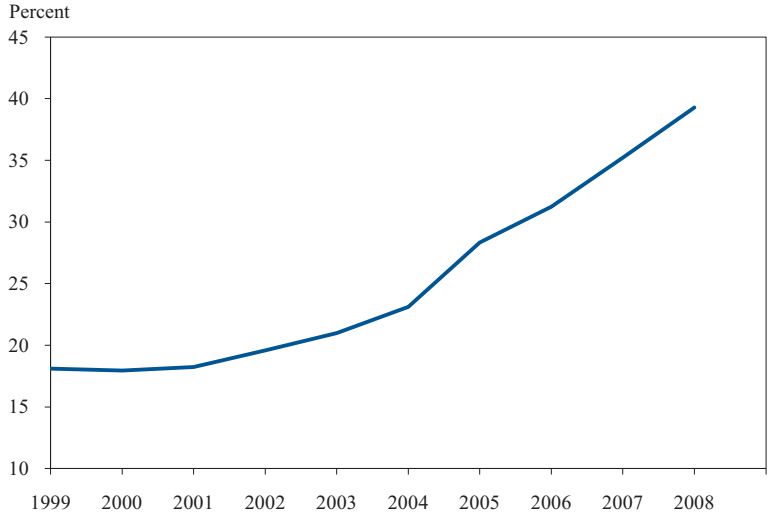
Smart Grid investments alone are not expected to alleviate fully the need for increased high-voltage transmission capacity. The Recovery Act also increased the borrowing authority of the power marketing agencies within the Department of Energy by $6.5 billion to finance new transmission investments that can accommodate increased generation to meet future energy demand, enhance grid reliability, and integrate location-constrained renewable energy resources. Taken together, investments in Smart Grid and electricity distribution and transmission will help modernize the Nation's

electric grid, making electricity delivery to U.S. citizens more efficient, secure, and reliable.

Information Networks

In less than a decade, broadband (or high-speed) Internet access has transformed the American economy. The explosion in business-to-business (Figure 3-2), business-to-consumer, and government-to-consumer "e-commerce" has dramatically reduced transactions costs by reducing geographic and time constraints. Households can comparison shop, register their cars, and pay their bills online, saving time and money. Many workers can save hours of commuting time through telecommuting. More generally, broadband has expanded the ability to communicate ideas and information, a key to faster problem solving and innovation. The great potential for high-speed, low-cost information networks to trigger continued economic growth lies in their role as a general purpose technology that businesses and households can use in creative ways—some not yet imagined—to further transform their productive capacities.

Figure 3-2
E-Commerce Share of Business-to-Business Manufacturing Shipments



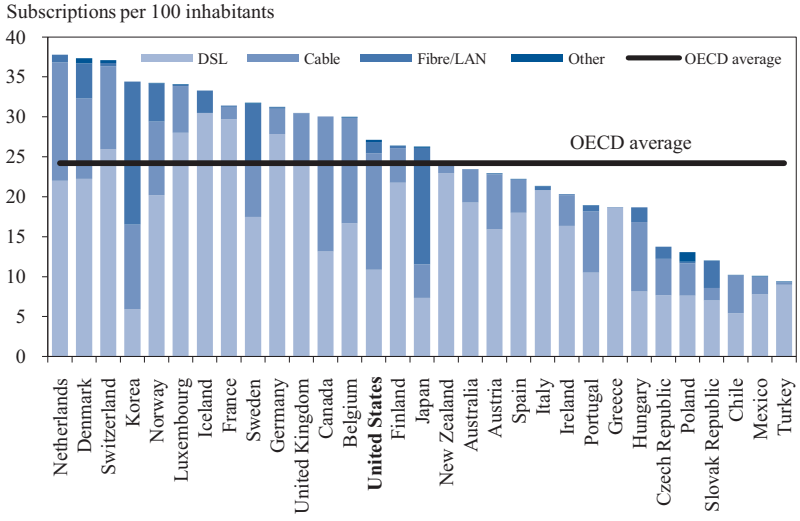
Sources: Census Bureau, Annual Survey of Manufacturers and the Economic Census.

In 2000, about 3 percent of Americans aged 18 and older had broadband at home. By 2010, the share had grown to about 66 percent.[1] Despite this tremendous progress, evidence suggests that the United States trails behind a substantial number of other advanced countries in broadband

[1] Smith 2010. Similar adoption rates are found in other studies; see Department of Commerce 2010.

adoption. One international comparison of broadband subscriptions per 100 inhabitants shows the United States ranking 14th (Figure 3-3) (OECD 2010).

Figure 3-3
Broadband Adoption across OECD Countries



Source: OECD Information Technology Outlook (2010).

Jobs increasingly require Internet skills, but while 97 percent of schools are connected to the Internet, more than 50 percent of teachers say slow or unreliable Internet access presents obstacles to their use of technology in the classroom (FCC 2010). Additionally, broadband adoption is relatively low among certain groups of Americans, including poor households, African American and Hispanic households, and rural households (Department of Commerce 2010). As broadband becomes essential to learning, working, and improving productivity, these gaps in broadband adoption create a "digital divide" in the opportunities available to different groups of Americans.

To expand broadband Internet availability and strengthen this critical platform for the Nation's economic growth, the Administration has awarded $6.9 billion through the Recovery Act. These funds in part support the National Telecommunications and Information Administration's Broadband Technology Opportunities Program, which is deploying "middle-mile" infrastructure in areas with nearly 40 million households and 4 million businesses, bringing broadband to approximately 24,000 institutions, including schools, libraries, health care facilities, and public safety entities. These funds also support the Rural Utilities Service's Broadband Initiatives Program,

which is bringing broadband access to approximately 2.8 million households, 364,000 businesses, and 32,000 community anchor institutions like hospitals and schools in rural America.

Spectrum policy is another critical component in managing the Nation's information infrastructure. More and more Americans are connecting wirelessly to broadband Internet services using computers, smartphones, and e-book readers, and increasing numbers of smart machines, such as smart parking meters and remote patient health monitoring systems, rely on wireless infrastructure. Smartphone penetration among Americans increased almost threefold between 2006 and 2009 by one measure, a trend that has multiplied wireless data traffic. The rapid expansion of wireless technologies may contribute substantially to future American productivity and economic growth, but additional gains will require allocating more electromagnetic spectrum for commercial and government use.

On behalf of the American people, the Federal Government manages the rights to electromagnetic spectrum, a scarce national resource. Today, the United States has provided just over 500 megahertz of spectrum for mobile communication. Experts believe that the United States will require hundreds of megahertz more of spectrum in coming years, yet only 50 megahertz are in the pipeline for commercial use. The Administration has committed to developing 500 megahertz of additional wireless spectrum and ensuring that spectrum is allocated to its highest-value uses.

Freeing additional spectrum to avoid "spectrum crunch" is essential to nurturing the next generation of high-speed wireless services and further innovations that businesses and entrepreneurs are beginning to deploy. However, more spectrum alone will not guarantee secure and interoperable systems that can support critical applications, such as public safety, or the extension of these essential wireless platforms to Americans living in remote rural areas. The Administration has budgeted over $18 billion to catalyze deployment of a nationwide, interoperable public safety wireless network, to invest in research solutions to overcome wireless technology obstacles, and to help businesses extend the next generation of wireless services to 98 percent of all Americans, including those in remote rural areas.

Skills and Economic Growth

Ensuring that future economic growth is rapid, sustained, and broadly based requires investments in Americans' skills. Education is the pathway to higher-income jobs and the growing industries of the 21st century. Education is also needed to train the next generation of researchers and innovators, who will drive future technological progress. For both reasons,

Americans' skills are critical to future economic prosperity. The Obama Administration is working to ensure that our educational system is internationally competitive, comprehensive, and innovative in preparing our workforce for an increasingly knowledge-intensive economy.

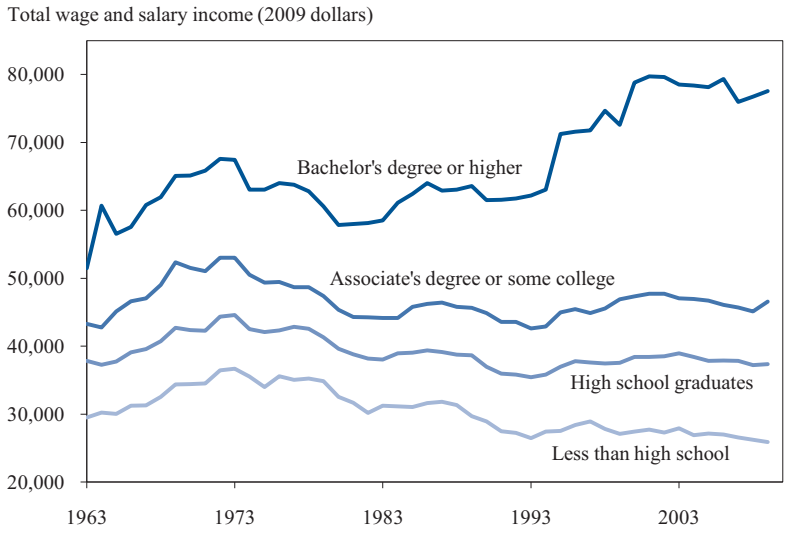
The rapid technological changes of the 20th century not only enhanced productivity and created new industries but also increased demand for skilled labor (Goldin and Katz 2007). Higher education is the key to many modern occupations, and over the years Americans have correspondingly raised their educational attainment, with average years of schooling at age 30 rising 6.2 years between 1900 and 2000. But American gains in educational attainment are slowing. Average schooling duration in the final quarter of the 20th century increased at only about one-third of its previous pace. Compared with other countries, American educational attainment also appears to be falling behind.

While growth in educational attainment has slowed, the demand for skilled workers continues to increase. According to the Bureau of Labor Statistics, 14 of the 30 fastest-growing occupations in the United States require at least a bachelor's degree, with 7 others requiring either an associate's degree or a postsecondary vocational certificate or award. Moreover, over the past 30 years, the return to a college education has also risen, further suggesting that increasing demand for high-skilled workers is outstripping their supply. Figure 3-4 shows wage and salary income by degree attainment from 1963 to 2009. In 2009, workers with a bachelor's degree or more earned more than twice as much as those with only a high school diploma, while those with some college or an associate's degree earned 25 percent more. These wage premiums have risen 72 percentage points and 10 percentage points, respectively, since 1963. Although not shown in the figure, the returns to postgraduate education have risen even more steeply. In the mid-1960s, those with postgraduate degrees earned about 50 percent more than high school graduates; by 2009, this wage premium had more than tripled to 159 percent.

While earnings of workers who have attended college have risen, the annual income of those with only a high school degree or less has fallen since the 1970s, even before the declines during the recent recession. High school dropouts have fared the worst among all workers, with earnings falling 12 percent, in real terms, since 1963. These workers currently earn 30 percent less than high school graduates. This trend mirrors a broader pattern of rising wage and income inequality in the United States, with gains from economic growth concentrated in some segments of the population. In the past 20 years, real income for the top 20 percent of all households has grown by 20 percent, while incomes for households in the bottom half of the distribution have been essentially flat. By contrast, in other periods of economic

growth, such as that from World War II to the mid-1970s, advances in labor income were spread roughly evenly throughout the wage distribution (Goldin and Katz 2007). A leading hypothesis about the causes of rising income inequality over the past 30 years points to technological advances that have increased the demand for high-skilled workers, while the supply of these workers has not accelerated to meet the demand (Katz and Murphy 1992). Institutional factors, such as declines in unionization and the real minimum wage, may also have played a role in increased wage inequality (DiNardo, Fortin, and Lemieux 1996).

Figure 3-4
Average Wage and Salary Income by Educational Group



Notes: Calculations are for full-time workers aged 25–65 who worked 50–52 weeks in the calendar year. Before 1991, education groups are defined based on the highest grade of school or year of college completed. Beginning in 1991, groups are defined based on the highest degree or diploma earned. Incomes are deflated using the CPI-U.
Source: Bureau of Labor Statistics, March Current Population Survey, 1964–2010.

Further, the overall data on educational attainment mask large disparities by race and socioeconomic status. Whereas 49 percent of non-Hispanic whites aged 25 to 34 hold a postsecondary degree, only 29 percent of African Americans and 19 percent of Hispanics do. In addition, children from high-income households are almost four times as likely to obtain a postsecondary degree by age 24 as those from low-income families.

Finally, achievement lags in science, technology, engineering, and mathematics (STEM) fields, all areas that show high wage returns to training and underpin future innovation. Recent test results in primary and secondary education suggest that American schoolchildren are lagging

behind in math and science. The 2009 Programme for International Student Assessment survey, for example, showed that American students placed 17th of 34 developed countries in science and 25th in math.[2]

President Obama recognizes that education is not only a driver of growth but also the surest way for individuals to share in the gains from growth. The challenge in developing a world-leading workforce involves both increasing educational attainment and enhancing the quality of education in this country. That is why the President has established a goal for the United States to resume world leadership in college degree attainment by 2020. To reach this goal, the Nation must raise its college completion rate from 40 percent to 60 percent. That requires 8 million additional young people to graduate from America's colleges and universities over the next 10 years.

The Administration has put forward a two-pronged strategy that, first, seeks to ensure that higher education is accessible and affordable to all individuals and, second, promotes innovative reform to ensure educational quality. The Administration's strategy gives states incentives to innovate toward comprehensive education reform as well as to adopt college- and career-ready standards of achievement. Effective education requires support from cradle to career. Reforms are needed at every level to produce a strong and competitive workforce.

Early Childhood Education

The years before kindergarten are among the most significant in shaping a child's foundation for learning and school success. Research shows that high-quality early learning programs help children arrive at kindergarten ready to succeed in school and in life, reducing achievement gaps that first appear at early ages. Disadvantaged students who have access to such programs realize positive gains in their cognitive, social, emotional, and language skills (Cunha et al. 2006). Investments in early childhood education can improve academic attainment, reduce the need for special education, and increase future graduation rates. Early childhood education also has been shown to reduce future crime and teenage pregnancy for disadvantaged children. Furthermore, investments in high-quality early childhood learning programs have been shown to be extremely cost-effective, with lasting returns to society as high as 17 percent per year (Belfield et al. 2006).

Recognizing the benefits of early childhood learning, the Administration's FY 2012 Budget proposes to establish a new, competitive Early Learning Challenge Fund (ELCF). States would compete for grant

[2] Results of the most recent National Assessment for Educational Progress show that, although American students have improved in math over the past 30 years, only 26 percent of 12th graders are "proficient" or better in math.

aid from this fund by establishing systems of early learning that set high standards and ensure that more children enter kindergarten with the skills necessary for success. The fund would promote evidence-based evaluation of programs, strategies for families and parents to assess the quality of early learning programs, and the creation of age-appropriate curricula and assessment systems.

Elementary and Secondary Education

Just as early childhood education is important to prepare children for primary education, the K–12 system is crucial to prepare students for college and the workplace. Too many students leave high school with inadequate academic preparation. In the 2007–08 school year, one in five first-year college students took remedial courses, a costly situation for both the student and society. The need for remedial work is also a warning sign that the student is more likely to drop out without completing his or her degree (Adelman 1998). The task of improving college and labor market preparedness thus begins well before a student reaches college or the labor market.

The Administration is committed to fostering innovation that will improve educational outcomes. The Recovery Act created Race to the Top, the largest-ever federal competitive investment in school reform. Race to the Top is designed to spur state and local reforms in K–12 education by allowing states to innovate and formulate their own solutions. The program provides competitive grants to encourage and reward states that have taken action to improve teacher quality, adopt college- and career-ready standards, incorporate better data into decisionmaking, and improve student achievement in low-performing schools.

Encouraged by the Race to the Top initiative, 48 states worked together to create a voluntary set of college- and career-ready standards, which establish a shared set of clear educational guidelines for language arts and mathematics education. As of December 2010, 40 states and the District of Columbia had adopted these standards. Many states also pledged to undertake a variety of innovative measures, including allowing more charter schools and promoting the use of better student achievement data to inform teacher evaluations. In August 2010, nine states and the District of Columbia were named Phase 2 winners of Race to the Top, joining Phase 1 winners Delaware and Tennessee. The program will benefit all of America's students, whether or not they live in a state that was awarded a grant. By providing incentives for all states to institute reforms, the program has spurred reform across the country. Thirty-four states have changed state education laws or policies to make them more conducive to reform that

will provide higher-quality instruction and give students in low-performing schools access to the education that they deserve.

Another focus of the Administration's reform efforts is improving low-performing schools. As established in the Recovery Act, School Improvement Grants provide a total of $3.5 billion to transform the lowest-performing schools so that disadvantaged students receive the instruction and resources they need to succeed in the college or career of their choice. Already more than 700 schools are participating in this program.

The theme of giving states incentives to undertake reforms, adopt national standards of achievement, and improve the lowest-performing schools is embodied in the Administration's Blueprint for Reform in K–12, released in March 2010. Building on the success of Race to the Top, the Blueprint seeks to bring innovative strategies and meaningful standards to all 50 states. This plan will fix No Child Left Behind's accountability system with a new federal framework built around five key priorities: implementing college- and career-ready standards, placing effective teachers and leaders in every school, providing equity and opportunity for all students, rewarding states and school districts that excel, and promoting innovation and continuous improvement. Recognizing the importance of finding and supporting local solutions, the Blueprint proposes federal funding to support state and local school district efforts in tackling these goals. The FY 2012 Budget proposes consolidating dozens of redundant programs from No Child Left Behind, providing resources to help schools focus on results. The Blueprint's framework is centered on rewarding success and providing greater flexibility to local actors in developing school improvement plans.

In today's global economy, it is essential that all students be prepared academically for whatever career path they choose. The Administration has specifically targeted improving education in STEM subjects to maintain a skilled, innovative workforce in these growing fields (Box 3-4). In addition, the Obama Administration dramatically increased funding for the Teacher Incentive Fund, which supports efforts to develop and implement performance-based teacher and principal compensation systems in high-need schools. In September 2010, grants were awarded to school districts and state education departments that had developed "rigorous, transparent, and fair" teacher and principal evaluation systems, as measured by both higher achievement for students and classroom observations.

Box 3-4: STEM Education and Educate to Innovate

Training in science, technology, engineering, and mathematics (STEM) fields is an important pathway to high-quality jobs, and STEM education is also critical to producing future innovators who will develop new products and ideas. Recognizing the importance of teachers in K–12 education and especially in STEM fields, the President has set a goal of training an additional 100,000 effective STEM teachers over the next 10 years. The Administration's proposed FY 2012 Budget includes $100 million devoted to this task.

The Administration's Educate to Innovate campaign focuses specifically on improving children's education in STEM fundamentals in the classroom and beyond. Key elements of the campaign are harnessing public-private partnerships that build support around science and math teachers, connecting kids to the wonder of invention and discovery, and raising the profile of science through initiatives like the White House Science Fair. The Educate to Innovate campaign hopes to increase STEM literacy; move American students to the top of the international pack in STEM performance; and expand awareness, especially among under-represented groups, of STEM career opportunities.

As part of this campaign, the President announced the launch of Change the Equation in September 2010. This nonprofit organization was formed by the business community in response to the President's spring 2009 "call to action" at the National Academy of Sciences for all Americans to join in elevating STEM education as a national priority. In its first year of operation, Change the Equation will work with member companies to spread effective STEM education programs to sites across the country. It will also create a scorecard to assess the condition of STEM education in all 50 states, building a baseline from which to measure progress in coming years. Furthermore, Change the Equation will identify and share principles for effective business involvement in STEM education, helping its member companies judge and improve the effectiveness of their own programs through robust self-evaluation tools.

The immediate goal of Change the Equation is to replicate, within one year, successful privately funded programs in 100 high-need schools and communities. These programs include robotics competitions and improved professional development for math and science teachers. With leadership from the President and the private sector, a membership of more than 100 CEOs, and funding of $5 million for its first year of operations, Change the Equation is well positioned to promote its three key goals: great teaching, inspired learners, and a committed Nation.

Advancements in education technology have the potential to improve K–12 education by personalizing the learning experience and reducing the time needed for students to gain new knowledge. The Administration supports several programs, as well as the launch of an Advanced Research Projects Agency for Education, which will promote education technology innovations. With broadband, cloud computing, digital devices, and software, these technologies can spread widely and allow both the identification and adoption of best practices.

Higher Education

American universities remain a renowned strength of the Nation's educational system (Box 3-5). To reach the President's goal of leading the world in college completion by 2020 and to provide the skilled workforce needed for the economy to thrive, the Administration has prioritized making the college and university system accessible and affordable to all.

The Health Care and Education Reconciliation Act (HCERA), signed in March 2010, helps build a more reliable and effective financial aid system by making all federal loans—Stafford loans, PLUS loans, and consolidation loans—available directly to students, ending subsidies once paid to third-party administrators. By saving $68 billion in subsidies over the next 11 years, the direct loan program allows for deficit reduction and for greater investments in college affordability.

To make college more affordable to low-income students, the Administration also has greatly expanded the Pell Grant program. In addition to Recovery Act support for the Pell Grant program, HCERA invests more than $40 billion in Pell Grants, raising the maximum Pell award from $4,730 in 2008 to $5,550 in 2010 and to an estimated $5,975 in 2017. Pell Grants can be applied toward traditional college expenses as well as to vocational and adult education programs.

The impact of these efforts is already evident, with nearly 8 million Pell Grant recipients in the 2009–10 academic year. That is more than double the figure from 10 years earlier and is 26 percent above the 2008–09 level. Furthermore, the average award of $3,646 is 25 percent larger than the average award in 2008–09.

In addition, the American Opportunity Tax Credit (AOTC), established in the Recovery Act, provides up to $2,500 a year for college tuition and related expenses for American families. The AOTC is refundable, thereby also reaching lower-income families. The tax credit increased tax incentives for higher education by more than 90 percent and benefited 8.3 million students and their families in 2009. In December 2010, the President signed an extension of the AOTC through the end of 2012, and he has proposed making it permanent.

Box 3-5: America's Universities: Leading the World

Despite the relative decline in educational attainment in the United States, America's universities remain the strongest in the world. According to the *Times Higher Education* rankings for 2010–11, the United States boasts 15 of the top 20 universities in the world. In addition, American institutions remain the most popular destination for foreign graduate and undergraduate students. Of students traveling out of their country of residence for tertiary education, 19 percent go to the United States, more than the combined share of those who go to the next two most popular countries, the United Kingdom and Germany. The remarkable diversity of America's graduate programs has been shown to increase innovation and research productivity (Stuen, Maskus, and Mobarak 2010), making these programs even more attractive to both domestic and international students.

Universities play the dual role of creating new ideas and training high-skill workers, and American universities lead the world on this front. Since 1960, 63 percent of Nobel Prize winning research has been performed in the United States, mostly at universities. The diversity of the Nation's colleges and universities is a great strength: 31 percent of the U.S. Nobel Prize winners since 1960 were foreign born, and 44 percent of these immigrants received their graduate degrees in the United States.

Furthermore, American universities give students world-class training for the high-skill jobs of the future. University students in the United States have the opportunity to learn from the world's leading scientists and scholars, ensuring that the best new ideas enter the American workforce. Preparing the American workforce for the 21st century depends on taking innovative ideas from the laboratory to the workforce, and universities provide that bridge.

Federal efforts to increase financial aid, particularly the Pell Grant program, are the primary reason that net tuition (tuition minus grant aid) has fallen at all types of colleges and universities over the past five years, even as published tuition has risen substantially. To make higher education more accessible to all students, the HCERA provides $2.6 billion over the next decade to strengthen Minority-Serving Institutions (including Historically Black Colleges and Universities) nationwide. These schools play a key role in educating low- and middle-income students, enrolling nearly 60 percent of the Nation's 4.7 million minority undergraduate students and accounting for nearly one-third of all degree-granting institutions in higher education. These steps will ensure that minority students are given every chance to earn

degrees and to enter (or return to) the workforce with the skills they need to succeed.

Job Training

In addition to traditional education pathways, job training programs provide vital opportunities for workers to gain new skills well suited to today's economy. Skill upgrading can be especially important for displaced workers whose skills might otherwise erode while they search for new job opportunities. Training is provided by a diverse set of institutions, including proprietary (for-profit) schools, four-year colleges, community-based organizations, labor unions, and public vocational and technical schools. Studies have documented that well-designed training and adult education programs can improve participants' labor market outcomes, increasing earnings and the probability of employment (CEA 2009). These improvements appear to be especially strong in training programs with a targeted focus on specific sectors, such as technical or high-growth sectors, and in programs that operate with a high level of employer involvement (Maguire et al. 2010). The Skills for America's Future initiative encourages and promotes these types of partnerships (Box 3-6).

The Administration has acted to promote career training for displaced workers, giving them the new skills they need to meet the demands of a competitive economy. HCERA provides $2 billion to fund the Trade Adjustment Assistance Community College and Career Training Grant Program, which provides grants to institutions of higher education to improve and expand programs suited to help workers affected by trade. Under the program, competitive funds will be made available to community colleges over the next four years to help increase completion of degrees, certificates, and other industry-recognized credentials. In addition, the Affordable Care Act, passed in March 2010, makes investments in workforce training in the high-growth field of health care, providing funding to train additional doctors, dentists, physicians' assistants, and much-needed nurses.

Finally, the Administration has called on Congress to reauthorize and modernize the Workforce Investment Act (WIA). The aim is to fuel the development and replication of effective practices in job training, adult education, and vocational rehabilitation. The Recovery Act provided nearly $4 billion for WIA programs, including $500 million for adult employment and training activities, nearly $1.5 billion to train displaced workers, and $750 million for a program of competitive grants for worker training and placement in the high-growth sectors of health care and clean energy. About 35 percent of workers receiving job training through WIA programs attend community colleges, putting those institutions on the front lines of training America's workforce for the jobs of tomorrow.

Box 3-6: Skills for America's Future

In October 2010, President Obama announced the creation of the Skills for America's Future (SAF) initiative to foster collaborative efforts between the private sector, community colleges, labor unions, and other institutions, with a commitment to scaling up meaningful and measurable solutions. The goal is to build a nationwide network of stakeholders who will work to maximize workforce development strategies, job training programs, and job placement.

SAF will identify and highlight characteristics of successful training programs that can be replicated and scaled up to reach more workers and institutions. The initiative already has the commitment of private sector leaders, along with innovative institutions, to advance these efforts. Actively engaging private employers, with expertise and knowledge of required credentials as well as local labor market conditions, is critical to the success of training programs. Building and encouraging collaborative efforts between private employers and public community colleges and other institutions is one of the cornerstones of the Skills for America's Future initiative.

In conjunction with SAF, the President also established the Skills for America's Future Task Force, cochaired by top-level Administration policymakers, to coordinate federal efforts to ensure that the private sector is well poised to work with and leverage federal training and education efforts.

Conclusion

Throughout its history, the United States has demonstrated a remarkable capacity to innovate and generate substantial increases in American standards of living. With the private sector in the lead and appropriate public investments where markets fall short, Americans will continue to see rapid, broad-based, and sustained economic growth. The Obama Administration is making investments in our national innovation system, infrastructure, and skills to provide the right foundations for prosperity. These foundations will ensure that, year after year, America's greatest resource—its people—can build a brighter future.