CHAPTER 5

REDUCING COSTS AND IMPROVING THE QUALITY OF HEALTH CARE

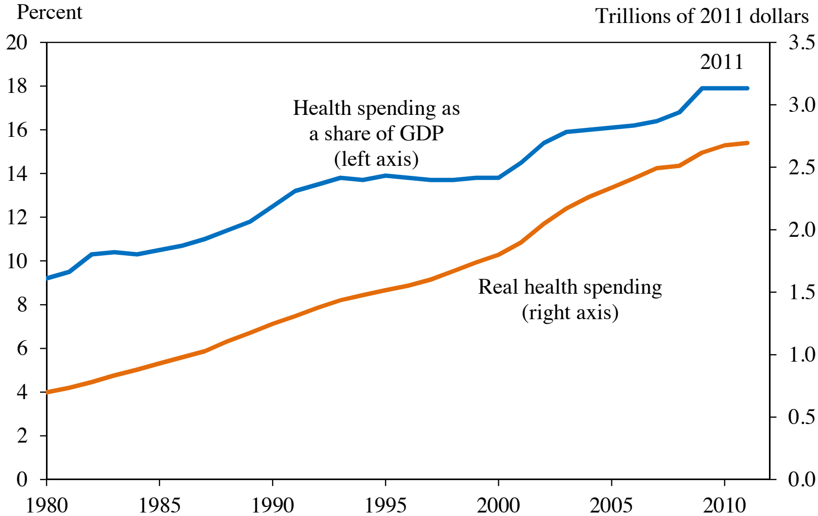
In March 2010, the President signed into law the Affordable Care Act. Provisions of the Act have already helped millions of young adults obtain health insurance coverage and have made preventive services more affordable for most Americans. When fully implemented, the law will expand coverage to an estimated 27 million previously uninsured Americans and ensure the availability of affordable comprehensive coverage through traditional employer-sponsored insurance and new health insurance marketplaces or exchanges. There are signs that the Affordable Care Act has started to slow the growth of costs and improve the quality of care through pay-for-performance programs, strengthened primary care and care coordination, and pioneering Medicare payment reforms. These provisions, as well as others in the Affordable Care Act, will help to bend the cost curve downward while laying the foundation for moving the health care system toward higher quality and more efficient care.

Health Care Spending

Health care spending has increased dramatically over the past half century, both in absolute terms and as a share of gross domestic product (GDP) (Figure 5-1). Spending in the U.S. health care sector totaled $2.7 trillion in 2011, up by a factor of 3.9 from the $698.3 billion (in 2011 dollars) spent in 1980. Health care spending in 2011 accounted for 17.9 percent of GDP—almost twice its share in 1980.

Some of the increase in health care spending is attributable to demographic changes. Of the real increase in spending on prescription drugs, office-based visits, hospitalizations, and all other personal care from 1996 to 2010, for example, 11.5 percent can be accounted for by the changing

Figure 5-1
GDP and Health Spending, 1980–2011

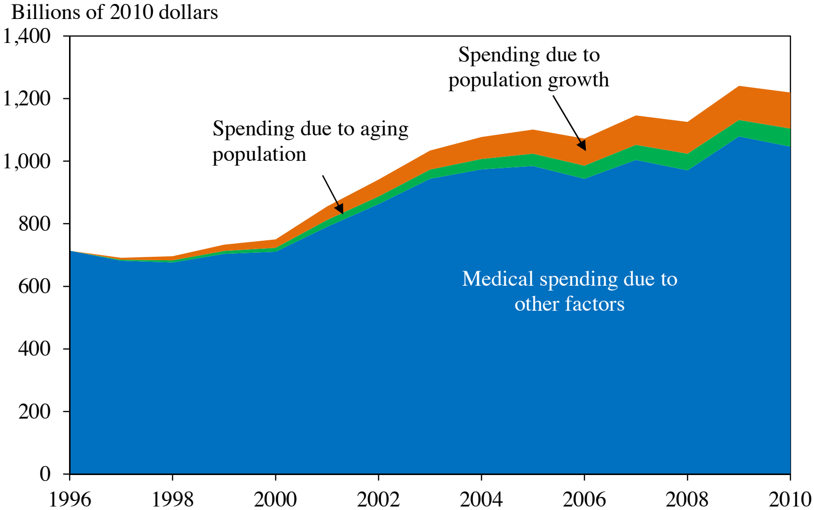


Source: Centers for Medicare and Medicaid Services, National Health Expenditure Accounts; Bureau of Economic Analysis, National Income and Product Accounts; CEA calculations.

age structure of the population and 22.8 percent can be accounted for by increases in the size of the population (Figure 5-2).[1] The effects of population aging will become a more important driver of higher spending in coming years; by 2030, one in five Americans will be over age 65, compared with only one in eight today, and per capita medical costs in a given year are approximately three times greater for those 65 and over than for younger individuals. The majority of the increase in health care spending, historically, has come from increases in the amount spent per person over and above any effects attributable purely to population aging and population growth, reflecting increases in the use of medical services driven at least in part by the development of new technologies and increases in unit costs that exceed the overall rate of inflation.

[1] Total annual spending on prescription drugs, office-based visits, hospitalizations and other personal care between 1996 and 2010 was estimated using the Medical Expenditure Panel Survey (MEPS). To estimate the effect of changes in the age distribution between 1996 and 2010 on spending, age-specific spending levels and total U.S. population were held constant at 1996 levels, but the proportion of the population within each age group was allowed to reflect the 2010 age distribution. To estimate the effect of population growth between 1996 and 2010 on spending, total spending increases were calculated holding age-specific spending levels constant at 1996 levels, but allowing both the age distribution and total population to reflect their 2010 values. Then, the estimated spending increases due to changes in the age distribution were subtracted from this figure.

Figure 5-2
Contribution of Population Growth and Aging
to Health Care Spending, 1996–2010



Source: Department of Health and Human Services, Agency for Healthcare Research and Quality, Medical Expenditure Panel Survey; CEA calculations.

Long-Term Spending Growth

Why has health care spending risen so much, even after taking into account changes in the size and age mix of the population? A likely piece of the story is that long-term growth in health care wages has not been accompanied by corresponding labor-saving technological progress. The theory of "cost disease" as developed by Baumol and Bowen (1966) notes that labor-saving technological progress has led to significant increases in labor productivity and hence wage growth in some important parts of the economy (such as the manufacturing sector). To compete for workers, labor-intensive sectors such as health care, education, and the performing arts also must raise their wages. According to the theory, productivity growth has been slower in these sectors. The result, the argument concludes, is an increase in the relative cost of output in these labor-intensive sectors, as higher costs are passed on to consumers in the form of higher prices.

Consistent with this theory, Nordhaus (2006) found that labor-intensive sectors generally experienced rising relative prices between 1948 and 2001. Nordhaus also found that shifts in labor from sectors that experienced labor-saving technological progress to sectors that remained relatively labor-intensive lowered overall productivity growth, as the share of labor-intensive sectors in overall output rose over the second half of the 20th century.

The cost-disease diagnosis assumes that, in labor-intensive sectors, it is difficult to reduce the amount of labor required to produce a given set of outputs. The health care sector, however, has experienced substantial technological progress, as new pharmaceutical therapies, diagnostic and medical devices, and surgical procedures have been introduced, allowing many conditions to be treated more effectively than in the past.

While some of these innovations have been labor-saving (some pharmaceuticals, for example), most others are complementary to expensive specialist labor (such as imaging and advances in surgical procedures). Consequently, technological change in medicine has caused the cost per treatment to rise, even as improvements in clinical effectiveness have led to increases in medical productivity. Technological change in medicine has contributed to long-term increases in spending. A recent study found that a quarter to a half of the rise in health care spending since 1960 can be explained by technological change in the health care system (Smith, Newhouse, and Freeland 2009). And rather than satisfying a relatively fixed demand for health care at lower cost, the development of many of these new technologies has contributed to an increase in the demand for health care services.

For some researchers, the importance of technological change for health care spending points to increases in demand as an additional explanation to the cost disease theory for why health care spending has increased disproportionately with income. If health care is a "super-normal good"—a good associated with an elasticity of consumption with respect to income that is greater than one—then as incomes rise by a certain percentage, consumption of health care rises by a greater percentage. Hall and Jones (2007) argue that this can happen if, after achieving a certain level of consumption, individuals prefer to spend additional income on life-extending health care (which allows for consumption in the extended years of life) rather than on extra consumption now. Consequently, as incomes rise, people choose to spend ever more on health care over other goods.

The disproportionate effect of income on the demand for health care may also operate through larger institutional mechanisms. Consistent with this idea, Smith, Newhouse, and Freeland (2009) find that income growth affects health care spending growth primarily through the actions of governments and employers on behalf of large insurance pools, suggesting a key role for payment reform in affecting medical spending growth.

These factors are not only a U.S. phenomenon. Indeed, while the United States has higher levels of health care spending than other members of the Organisation for Economic Co-operation and Development (OECD), the annual real rate of growth in health care spending per capita in the

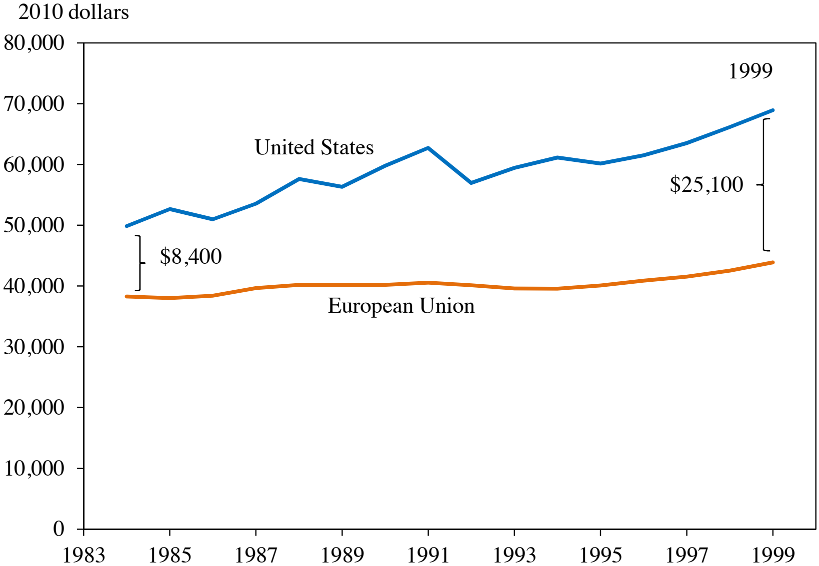
United States between 1960 and 2010 was not too different from elsewhere, averaging 4.13 percent compared with 3.62 percent in the other OECD countries, adjusted for purchasing power parity. In more recent years, health care spending has continued to grow at similar annual real rates—3.10 percent in the United States and 3.30 percent in the other OECD countries between 2000 and 2010, somewhat below the long-term rates of spending growth observed since 1960.

Medical Productivity

Productivity growth in health care largely has taken the form of improvements in the quality of care, with developments in new procedures and care practices contributing to increased survival, decreased morbidity, reduction in pain, and less onerous treatment administration in many cases.

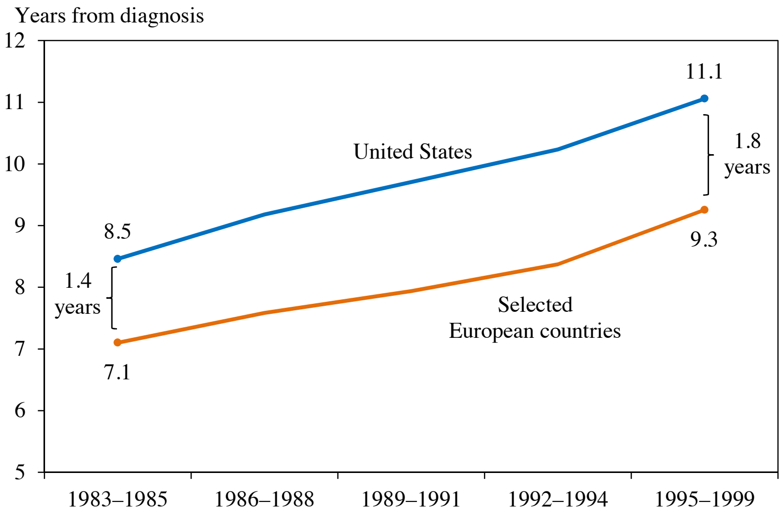
A full accounting of medical productivity growth should reflect changes not only in cost per service but also in health outcomes. However, medical productivity is often hard to measure because health outcomes are hard to measure. Recent studies comparing increases in life expectancy to increases in treatment costs over time suggest that productivity growth in the health care sector has been enormous. For example, Cutler and McClellan (2001) found that the value of increased survival rates and decreased morbidity rates as a result of improved treatment of heart attacks, low-birth-weight infants, and depression over the past few decades has far exceeded the increased spending on these conditions over the period. Using a similar methodology, Philipson et al. (2012) found that survival gains across all cancer patients in the United States between 1983 and 1999 cost on average only $8,670 per life-year gained. Estimates of the value of a statistical life-year, based on compensating wage differentials that measure the implied trade-off between wages and increased risk of fatality, are typically multiples higher (Viscusi and Aldy 2003). Therefore, even if some piece of the apparent gain in longevity results from earlier diagnosis, the introduction of these cancer therapies represents an enormous improvement in productivity. Faster growth in spending on cancer treatment in the United States than in Europe over this period is sometimes mistakenly taken to indicate the inefficiency of U.S. medical care, but it is also the case that the improvement in life expectancy for cancer patients was greater in the United States than in Europe. From 1983 to 1999, U.S. spending per cancer patient rose by $16,700 (in 2010 dollars) more than European spending per cancer patient (Figure 5-3), and U.S. cancer patient life expectancy rose by 0.4 years more than European cancer patient life expectancy (Figure 5-4), implying a cost per extra life year saved of approximately $42,000. Given the consensus

Figure 5-3
Cancer Spending per New Cancer Case, 1983–1999



Source: Philipson et al. (2012), updated data provided by the authors.

Figure 5-4
Life Expectancy after Cancer Diagnosis, 1983–1999



Note: European countries included are Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Sweden, Scotland, and Wales.
Source: Philipson et al. (2012), updated data provided by the authors; Surveillance, Epidemiology and End Results (SEER); European Cancer Registry (EUROCARE).

in the literature that the value of additional life-years is much higher, the additional U.S. spending has been a good value.

Murphy and Topel (2006) directly estimate the aggregate monetary value of increases in longevity, finding that, if valued in the national accounts, increases in life expectancy since 1970 would have added $3.2 trillion a year to national wealth. While a different set of assumptions about the statistical value of a life year, the elasticity of intertemporal substitution, and the value individuals place on non-working hours lowers the aggregate valuation of the observed longevity increase, the order of magnitude of the estimated valuation nonetheless suggests an enormous return to the increase in health care spending over this period.

In general, estimating how much the productivity of health care has grown is a difficult task. Changes in health outcomes, morbidity rates, and patient convenience are hard to measure, hard to attribute to the use of specific technologies, and hard to value. Furthermore, limitations in available data mean that spending often cannot be disaggregated to the treatment of specific diseases or patients. Given these difficulties, it is widely agreed that aggregate measures of the output of the health care sector do a poor job of capturing the effects of productivity growth. Developing better methods to measure real output and productivity growth in health care is an important area of ongoing research (Data Watch 5-1).

Sources of Inefficiency in Health Care Spending

Although growth in overall medical productivity has been large, not all increases in medical spending are productive. Cutler and McClellan (2001) showed that improved treatment of heart attacks produced significant increases in patient longevity between 1984 and 1998. By contrast, Skinner, Staiger, and Fisher (2006) found little improvement in survival rates among heart attack patients between 1996 and 2002 despite significant growth in treatment costs. The latter study also found that the regions with the largest increases in spending also experienced the smallest gains in survival. Geographic variation in practice patterns and health outcomes implies that more than 20 percent of Medicare spending on heart attack treatment produces little health value (Skinner, Fisher, and Wennberg 2005). The case of heart attack treatment points to more general inefficiencies in the allocation of spending within the health care system.

Among the many possible sources of spending inefficiencies, several stand out as key sources of waste. First, the fragmentation of the delivery system contributes to a failure to provide patients with necessary care. That in turn can lead to complications and readmissions, particularly for the chronically ill for whom care coordination is most essential for health.

Data Watch 5-1: Toward Disease-Based Health Care Accounting

Existing national data on health expenditures generally are organized by the type of medical care that individuals purchase (such as doctor visits or drugs). For addressing questions related to the productivity of health care, however, data on health care spending by disease would be far more useful.

Switching to disease-based accounting poses a challenge because patients often suffer from more than one disease at once, making it difficult to allocate spending to specific diseases. Three conceptual approaches to allocating spending across disease have been suggested: tracking each encounter with the health care system; tracking disease "episodes"; or identifying all conditions a person has and using regression analysis to allocate spending to diseases. All three approaches have advantages and limitations, and a consensus has not yet developed on which one is preferable. Whichever approach is adopted, the universe of conditions will need to be categorized into a set of disease groups, at an appropriate level of detail, to which medical costs then can be assigned for analysis.

The Medical Expenditure Panel Survey (MEPS) is a nationally representative survey that provides information on most health spending, although it fails to capture spending on behalf of institutionalized patients and active duty military. The MEPS sample is too small, however, to represent rare conditions. Although not comprehensive in their coverage, data on health care claims provide another valuable—and potentially much more detailed—source of information on health care spending. In addition to data on spending, data on health outcomes that can be linked to the disease-based spending data also are needed.

Important progress has been made toward developing disease-based health care data. The Bureau of Economic Analysis is working on a health care satellite account that will provide disease-based measures of household medical expenditures. These estimates will be based on private insurance claims data, Federal data on Medicare and Medicaid spending, and data from MEPS on the uninsured. Simultaneously, the Bureau of Labor Statistics is developing disease-based price indexes that account for shifts in treatment patterns. These indexes will be useful to the Bureau of Economic Analysis for decomposing spending into changes in prices versus changes in quantities.

The Affordable Care Act has significantly increased funding for research on patient-centered outcomes, and data will be available to qualified entities to evaluate the performance of providers and suppliers with respect to quality, efficiency, effectiveness, and resource use. Under the President's Open Data initiative, the Department of Health and Human Services has launched a Health Data Initiative to promote the availability of Medicare and Medicaid data, where appropriate, to researchers and entrepreneurs. Paralleling these initiatives, the Health Care Cost Institute, a nonprofit organization, has developed a claims database to be made available to researchers to foster a better understanding of what drives health care costs. These administrative data on claims hold the potential for further progress on understanding the drivers of health care spending increases and identifying high value medical care.

Second, lack of care coordination also contributes to duplicate care and overtreatment, a source of waste exacerbated by payment systems that compensate physicians based on the number of services provided (see Economic Applications Box 5-1). Overuse of expensive medical technologies is particularly costly, and some research suggests that a significant portion of coronary artery bypass graft surgery, angioplasty, hysterectomy, cataract surgery, and angiography is of questionable or low medical value (Goldman and McGlynn 2005).

Third, the failure of providers to adopt widely recognized best medical practices also contributes to waste. These failures include lack of adherence to established preventive care practices and patient safety systems, as well as widespread failure to adopt best treatment practices. In cases where the best medical practice is both clinically more effective and lower in cost—for example, the use of beta blockers in the treatment of acute myocardial infarction (Skinner and Staiger 2005, 2009)—failure to follow these practices results in worse clinical outcomes and higher readmissions and contributes to wasteful spending.

Finally, payment fraud also adds to system waste, not only through inappropriate payments but also through the administrative burden on honest providers who must adhere to the regulatory requirements of unavoidable but burdensome fraud detection systems.

Taken together, fragmentation of care, overtreatment, failures of care delivery, and payment fraud have been estimated to account for between 13 and 26 percent of national health expenditures in 2011 (Berwick and Hackbarth 2012). The magnitude of this waste offers an equally large opportunity for spending reductions and improvement in quality of care—an opportunity that underpins many of the provisions of the Affordable Care Act.

Economics Application Box 5-1: Matching in Health Care

Traditional economic analysis focuses on markets in which prices and quantities adjust so that in principle, supply equals demand. In some markets, however, prices do not exist and cannot be used to allocate resources. Gale and Shapley (1962) made early theoretical contributions to our understanding of how markets can be designed to allocate resources efficiently in the absence of prices. Taking the "marriage market" as an example, Gale and Shapley studied how, in the absence of prices, these markets can produce stable matches—matches where no alternative pairing would make both individuals in any match better off. These principles were extended by Roth, who applied them to the practical design of market institutions—for example, the market for medical students in residency programs (Roth 1984), and the assignment of students to public high schools in New York City and Boston (Abdulkadiroglu, Pathak, and Roth 2005). For these pioneering contributions, Shapley and Roth were awarded the 2012 Nobel Prize in Economic Sciences.

The market for live kidney transplants is yet another market where prices do not determine allocation. Paying for organs is a felony under the 1984 National Organ Transplant Act. Patients can receive a kidney from a compatible donor or are placed on a waiting list for a cadaveric kidney. Currently, nearly 95,000 patients in the United States are waiting for a kidney transplant. Dialysis for these patients costs approximately $60,000 a year, for a total of $30 billion a year, or 6.7 percent of total Medicare spending, the single most expensive component of Medicare. In 2011, there were about 11,000 transplants of deceased donor kidneys and only 5,770 transplants from living donors; in the same year, more than 4,700 patients died while waiting for a kidney transplant.

Many patients have willing potential donors. However, immunological incompatibility greatly limits the number of transplants using live kidneys, which are preferred to cadaverous kidneys for their tissue quality and greater longevity. Patients receiving a live kidney transplant are estimated to live 10-15 years longer than they would on dialysis.

Increasing exchanges between incompatible patient-donor pairs would greatly expand the opportunity for dialysis patients to receive a living donor kidney, and increase the quality of matches. In paired kidney exchanges, a donated kidney from one (immunologically incompatible) patient-donor pair is transplanted in the patient of a second patient-donor pair, and vice versa. The potential for improving the number of live kidney transplants is greater with "chains"—exchanges involving many donor-recipient pairs. The 2007 amendment to the National Organ Transplant Act clarified that kidney paired donations

(KPD) do not constitute "valuable consideration" (that is, financial compensation), thereby paving the way for the creation of KPD exchanges.

The economic principles of stable matches developed by Shapley and Roth can be applied to KPD exchanges. Whereas the concept of stability in the medical residency setting, for example, is based on the mutual preferences of medical students and residency programs, stability in a kidney exchange is primarily based on obtaining the best matches along immunological criteria. Using these principles, transplant centers have established KPD programs, as have nonprofit organizations such as the New England Program for Kidney Exchange, founded by Roth and colleagues. Congress also established a national KPD pilot program, operated under the Organ Procurement and Transplantation Network (OPTN) as a nonprofit under Federal contract.

In 2011, the separate pilot KPD programs, including OPTN, resulted in 430 transplants—a promising start to paired kidney exchanges, but nevertheless representing only a fraction of the potential number of possible transplants.

Computer models suggest that many more transplants could be achieved each year if there were a nationwide pool of all eligible donors and recipients. A larger pool of eligible donor-recipient pairs also could potentially increase the quality of matches. A living kidney transplant (and all subsequent care) saves money over dialysis after roughly two years. On average, Medicare would save $60,000 a year for every patient who receives a living kidney transplant rather than continuing to receive dialysis, all while increasing the life expectancy of a kidney recipient by 10–15 years, again relative to dialysis treatment.

Early Implementation of the Affordable Care Act

The Affordable Care Act includes a series of provisions that will transform the Nation's health care system. By expanding coverage, the health reform law stabilizes insurance markets and makes health insurance affordable. The Affordable Care Act also includes important provisions that are aimed at reducing inefficient spending, promoting competition, and improving the quality of medical care.

Economic Benefits of Insurance

Insurance provides important economic benefits to covered households. It covers unforeseen medical expenditures, allowing individuals to receive necessary medical treatment without suffering potentially crippling financial consequences.

The 2008 Medicaid expansion in Oregon provided a unique setting in which to study the effects of health insurance on health and financial security. Because access to the Oregon Medicaid coverage expansion was offered through a lottery, the benefits of insurance could be estimated without the usual statistical concerns that purchasers of insurance differ from non-purchasers in ways related to health and financial outcomes. Finkelstein et al. (2011) found that, after one year of Medicaid coverage, previously uninsured adults in Oregon were 10 percent less likely to report having depression and 25 percent more likely to report their health as good, very good, or excellent. They also experienced lower financial strain because of medical expenses, including lower out-of-pocket expenditures, lower debt on medical bills, and lower rates of refused medical treatment because of medical debt, than individuals who were not randomly assigned to Medicaid coverage.

The benefits of having insurance coverage are large. A recent study (CBO 2012a) estimated that the insurance value of Medicaid to enrollees in the lowest quintile of income earners is equivalent to 11 percent of their before-tax income, defined by the CBO as market income plus cash transfers. As a comparison, real average before-tax incomes in the lowest quintile rose 15 percent between 1995 and 2009, while real incomes in the highest quintile rose 24 percent. Hence, the value of Medicaid is roughly comparable to the additional income that would have kept average income in the lowest quintile growing at the same rate as average income in the highest quintile.

Expanding Affordable Health Insurance Coverage

The Affordable Care Act is projected to increase the number of insured individuals in the United States by 14 million in 2014 and by 27 million in 2022 (CBO 2012b). The requirement that health insurance plans offer dependent coverage to children up to age 26 went into effect in 2010. Sommers (2012) found that this provision resulted in more than 3 million uninsured young adults gaining health insurance between September of 2010 and December of 2011.

Looking ahead to 2022, the Congressional Budget Office (CBO 2012b) projects that the Affordable Care Act will lead to an additional 12 million people being insured through Medicaid and the Children's Health Insurance Program (CHIP), with the remainder of the estimated 27 million newly insured individuals covered through employer-based insurance, the Affordable Insurance exchanges, or the Small Business Health Options Program (SHOP) exchanges (Economics Application Box 5-2). The law likely will cause some firms that currently do not offer health benefits to begin doing so, and some workers who are currently uninsured will take up employer coverage that is already offered. At the same time, the new

Economics Applications Box 5-2: Economics of Adverse Selection and the Benefits of Broad Enrollment

In health insurance markets, adverse selection occurs when relatively unhealthy individuals are more likely than healthy individuals to purchase health insurance coverage at a given price. Insurers understand this tendency and attempt to set premiums to reflect average expected expenditures in a plan. The selection of relatively unhealthy enrollees into coverage raises average expected expenditures, resulting in higher premiums and more adverse selection into coverage.

Adverse selection explains why offered premiums in the individual and small group health insurance markets often are too high for most healthy people compared with the health costs they actuarially can be expected to incur, meaning that they either pay too much for coverage or choose to go uninsured rather than pay the high premiums. In some cases, insurance markets subject to extreme adverse selection may disappear completely (Cutler and Reber 1998).

Encouraging broad participation in health insurance coverage helps tremendously to solve the market failure associated with adverse selection. For example, adverse selection is virtually nonexistent in the large group employer sponsored insurance (ESI) market. Take-up rates in this market are very high, thanks both to the tax advantages associated with ESI and to the fact that employers typically pay a portion of premiums, which makes ESI a good deal for the vast majority of employees. While employer contributions are offset by lower wages in equilibrium (Gruber 1994; Baicker and Chandra 2005), employees who decline coverage rarely recoup the employer contribution on the margin. The large enrollment in many ESI plans means that a small number of high expenditure enrollees does not dramatically affect premiums for a large risk pool. This prevents adverse selection from taking root and reinforces broad enrollment through premium stabilization and affordability.

Similarly, the Affordable Care Act encourages broad enrollment through the widespread accessibility of health insurance exchanges, the individual responsibility requirement related to the purchase of health insurance, and the financial assistance offered to lower-income earners to purchase private plans on an insurance exchange. Other provisions of the Affordable Care Act raise consumer awareness and foster consumer choice through information campaigns, standardization, and consumer search tools, similar to those implemented in the successful rollouts of the Medicare Advantage and Medicare Part D prescription drug programs. As in ESI, broad enrollment in the exchanges is expected to foster premium stability and affordability and to reduce the incidence of cost-shifting from uncompensated care to the insured.

options created by the Affordable Care Act may make employer-sponsored insurance (ESI) coverage less attractive for some employers. The net effects on the prevalence of employer-sponsored coverage, however, are likely to be small.

Based on microsimulations of firms' optimizing behavior, analysts have estimated effects of the Affordable Care Act on the number of individuals with ESI coverage ranging from a 1.8 percent decline (CBO 2012b) to a 2.9 percent increase (Eibner et al. 2011). Other estimates fall with this narrow range (Buettgens, Garrett, and Holahan 2010; Lewin Group 2010; Foster 2010) and are consistent with the small positive effects of health reform on ESI coverage observed in Massachusetts, where similar statewide health insurance reforms were legislated in 2006 (Long, Stockley, and Yemane 2009).

Consumer Protection

The Affordable Care Act also establishes numerous consumer protections related to the purchase of private health insurance, some of which are already in effect. Starting in 2014, individual and group health plans will not be allowed to deny or limit coverage on the basis of an individual's health status. And within certain limits, premiums will be allowed to vary by age, geography, family size, and smoking status, but not by individual health status, gender, or other factors.

The Affordable Care Act also requires that double-digit increases in insurance premiums be reviewed by States or the Department of Health and Human Services, with insurance companies needing to provide justification for any such premium increases. Plans may be excluded from an insurance exchange based on premium increases that are not justified. Further, since the beginning of 2011, most insurers have been allowed to retain no more than 20 percent of consumers' premiums for profits, marketing, and other administrative costs. Overhead and administrative costs in excess of this limit are to be rebated to consumers (or in the case of employer-sponsored insurance, to employers, who must pass a share of these rebates to their employees as cash, improved benefits, or lower premiums, with the share depending on the proportion of the total health plan premium paid by the employees). As of August 2012, an estimated 12.8 million Americans had received rebates totaling $1.1 billion from insurers as a result of this 80/20 medical loss ratio rule.

Health Care Spending and Quality of Care

The Affordable Care Act includes a series of provisions designed to reduce spending while improving the quality of care in the health care system. Reducing excessive payments to Medicare Advantage plans, strengthening antifraud efforts, and initiating reforms to Medicare provider payment systems, among other policies, are expected to extend the life of the Medicare Trust Fund by an additional eight years. These reforms complement numerous other provisions that improve health care quality while lowering costs.

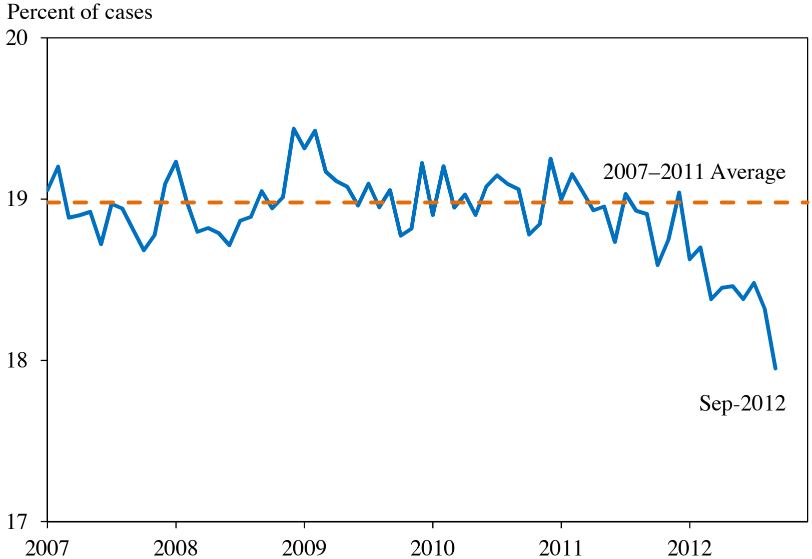
The Hospital Value-Based Purchasing Program went into effect in October 2012. The program rewards more than 3,500 hospitals for providing high-quality care and reduces payments for hospitals demonstrating poor performance. Similar pay-for-performance programs in Medicare Advantage and the end-stage renal disease prospective payment system encourage higher-quality care and more efficient care delivery. Additionally, pay-for-reporting initiatives in which providers are rewarded for reporting procedures and outcomes have been launched in virtually every Medicare payment category, and mark the first step toward value-based purchasing.

The Partnership for Patients program is a public-private partnership that aims to reduce hospital complications and improve care transitions in more than 3,700 hospitals and partnering community-based clinical organizations. By stopping millions of preventable injuries and complications in patient care, this nationwide initiative has set as its goal saving 60,000 lives and up to $35 billion in spending, including up to $10 billion in Medicare spending, over the three years following its launch. Data provided by the Centers for Medicare and Medicaid Services (CMS) show that since the Partnership for Patients program was introduced in 2011, the hospital readmission rate within Medicare has fallen to 17.8 percent, down from an average of about 19 percent that had prevailed from 2007 through 2010 (CMS 2013) (Figure 5-5). The data also show that the declines were larger in hospitals participating in Partnership for Patients.

The Affordable Care Act builds on the investments made in the Recovery Act to encourage the use of health information technology. By making it easier for physicians, hospitals, and other providers to assess patients' medical status and provide care, electronic medical records may help eliminate redundant and costly procedures. More than 186,000 health care professionals (about one-third of eligible providers) and 3,500 hospitals (about two-thirds of eligible hospitals) have already qualified for incentive payments for the meaningful use of electronic health records authorized by the Recovery Act.

The Affordable Care Act also launched extensive efforts to prevent and detect fraudulent payments under Medicare, Medicaid, and the Children's Health Insurance Program. An important goal of the Administration's efforts has been to prevent fraudulent payments before they are made rather

Figure 5-5
Acute Care Hospital Readmission Rates, 2007–2012



Source: Center for Medicare and Medicaid Services, Office of Enterprise Management.

than chasing them afterward, but there also are ongoing efforts to recover fraudulent payments if they occur. Antifraud efforts have recovered a record-high $14.9 billion over the last four years.

Medicare Payment Reform

Traditional fee-for-service Medicare reimburses physicians for each service provided, creating incentives for overutilization. Spending inefficiencies are exacerbated by fragmentation across providers, who historically have had few incentives to coordinate care. Likewise, the prospective payment system (PPS) for Part A hospital services, which is designed to control costs by paying hospitals a prospective amount per diagnostic-related group (DRG) episode, is not immune to waste. While the DRG-based PPS encourages more efficient care and reductions in length of stay compared with cost-based reimbursement (Sloan et al. 1988; Seshamani, et al. 2006), it also can encourage a reduction in necessary care, leading to negative short-term health effects and readmissions (Cutler 1995; Encinosa and Bernard 2005; Seshamani, et al. 2006). Further, the inpatient PPS also can be susceptible to "upcoding," whereby providers code patients as being sicker than they are to raise the risk-adjusted prospective payments (Cutler 1995; Carter et al. 2002; Dafny 2005).

To curb these inefficiencies, the Affordable Care Act has established initiatives that lay a foundation for reforming care delivery and physician payment. At their core, these initiatives are designed to foster greater coordination of care across providers, while simultaneously aligning financial incentives to encourage provider organizations to deliver higher-quality, more efficient medical care. Each initiative builds on a core of clinical and patient engagement quality measures to ensure that cost savings are derived from more efficient delivery of care and not reduced patient access or care quality.

One such initiative is the Medicare Shared Savings Program (MSSP). Under this program, providers deliver care through accountable care organizations (ACOs), contractual organizations of primary care physicians, nurses, and specialists responsible for providing care to at least 5,000 beneficiaries. The Federal Government shares any savings generated for those beneficiaries, relative to benchmarks, with ACOs that meet rigorous quality standards, giving the ACOs incentives to invest in delivery practices, infrastructure, and organizational changes that help deliver higher-quality care for lower costs. Currently, more than 4 million beneficiaries receive care from more than 250 ACOs participating in the MSSP and other CMS projects, with ACO participation and covered beneficiaries continuing to increase as the program expands.

The Affordable Care Act also created the Center for Medicare and Medicaid Innovation, which is charged with identifying, testing, and ultimately expanding new and effective systems of delivering and paying for care. The CMS Innovation Center is authorized to invest up to $10 billion in initiatives that have the potential to reduce program expenditures while preserving or enhancing quality of care furnished to individuals under Medicare, Medicaid, and the Children's Health Insurance Program. Initiatives within the CMS Innovation Center include shared savings models, as well as bundled payments to hospitals and post-acute-care providers.

The Innovation Center's Pioneer ACO program is a more aggressive version of the MSSP and is open to organizations that have had success with risk-based payment arrangements. Pioneer ACOs may keep a greater share of Medicare savings than ACOs in the MSSP but are also at greater risk for losses if spending benchmarks are not met. Successful Pioneer ACOs are also eligible to move to a population-based payment arrangement whereby they assume greater financial risks and rewards for a predetermined set of patients. This greater risk-reward profile further encourages investments in care coordination and best practice delivery reforms. Pioneer ACOs must also develop similar outcomes-based payment arrangements with other payers, extending payment innovations to the commercial market and maximizing the impact of the program's incentives.

Currently, roughly 860,000 beneficiaries are enrolled in 32 Pioneer ACOs. The Pioneer program is just entering its second year, so it is too early for any comprehensive assessment, but Pioneer ACOs do seem to be making substantial investments in infrastructure and care processes. Infrastructure investments include health information technology adoption and improved data analytic capabilities, which enable providers to identify opportunities for improvements in care processes and the quality of care. For example, the potential savings associated with early identification and treatment of patients with high propensity for developing a chronic disease have led some Pioneer ACOs to make organizational changes that place greater focus on primary care and disease management. CMS is supporting Pioneer ACOs by providing privacy-protected patient information to promote care coordination, hosting collaborative learning networks, and offering other technical assistance.

Care coordination is also central to the Comprehensive Primary Care (CPC) initiative. Primary care is critical to promoting overall health and reducing medical spending. Yet because any one insurer accounts for only a fraction of a provider's business, insurers underinvest in primary care systems that would improve care coordination. Through the CPC initiative, Medicare partners with State and commercial insurers to promote community-wide investments in the delivery of coordinated primary care. Simultaneously, through direct financial payments or shared Medicare savings, the CPC initiative rewards high-quality providers who reduce health care costs through investments in care coordination. At the end of 2012, about 500 primary care practices were participating in the CPC initiative, representing 2,343 providers serving approximately 314,000 Medicare beneficiaries.

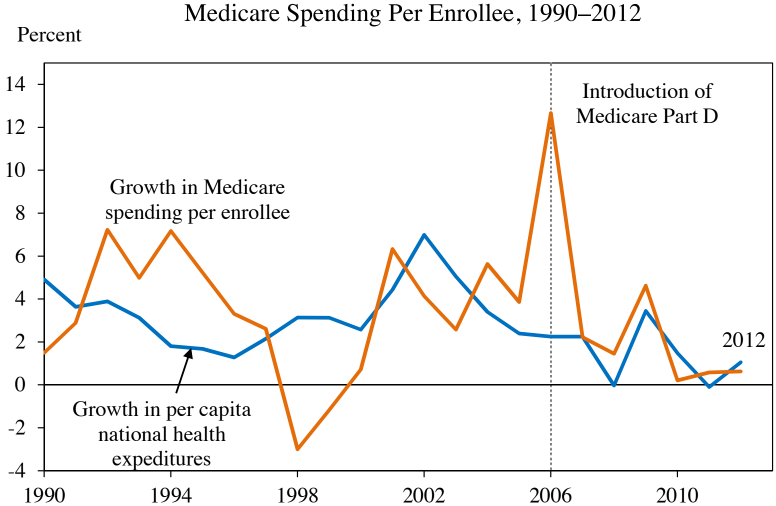
The CMS Innovation Center has introduced bundled payments as a model for hospital payment and delivery reform. A bundled payment is a fixed payment for a comprehensive set of hospital and/or post-acute services, including services associated with readmissions. Moving from individual payments for different services to a bundled payment for a set of services across providers and care settings encourages integration and coordination of care that will raise care quality and reduce readmissions. Variants on bundled payments are being demonstrated, differing in the scope of services included in the bundle, and whether payment is retrospective (based on shared Medicare savings) or prospective, which intensifies the financial risk and return to investing in changes to the efficiency and quality of care. Currently, 467 health care organizations across 46 states are engaged in the bundled payment initiative.

Is the Cost Curve Bending?

The real rate of health expenditure growth has declined or remained constant in every year between 2002 and 2011. For each of the three years 2009, 2010 and 2011, National Health Expenditure data show the real rate of annual growth in overall health spending was between 3.0 and 3.1 percent, the lowest rates since reporting began in 1960.

Additionally, the National Health Expenditure data show that growth in Medicare spending fell from an average of 8.6 percent a year between 2000 and 2005 to an average of 6.7 percent a year between 2006 and 2010. Notably, over a third—2.5 percentage points—of the 2006–2010 growth was attributable to increases in Medicare enrollment. With the exception of a spike in 2006, the year Medicare Part D was introduced, the growth rate of Medicare spending per enrollee—a measure of health care spending intensity—has been on a downward trend since 2001, with a particularly significant slowdown over the past three years (see Figure 5-6). Projections suggest the growth rate of Medicare spending per beneficiary will decline even further. While Medicare enrollment is expected to increase 3 percent a year over the next decade (CMS 2012), the rate of growth in spending per enrollee is

Figure 5-6
Real Annual Growth Rates of National Health Expenditures Per Capita and Medicare Spending Per Enrollee, 1990–2012



Note: Estimates for 2012 are projected.
Source: Center for Medicare and Medical Services, National Health Expenditure Accounts; CEA calculations.

projected to be approximately the same as the rate of growth in GDP per capita, according to the CBO and Office of the Actuary at CMS (Kronick and Po 2013). Similarly, the rate of growth in spending per Medicaid enrollee is projected to be near the rate of growth in GDP per capita. In the commercial health insurance market, per enrollee spending growth also has declined in recent years, the proximate cause being a slowdown in the growth rate of per-enrollee use of medical services (HCCI 2012).

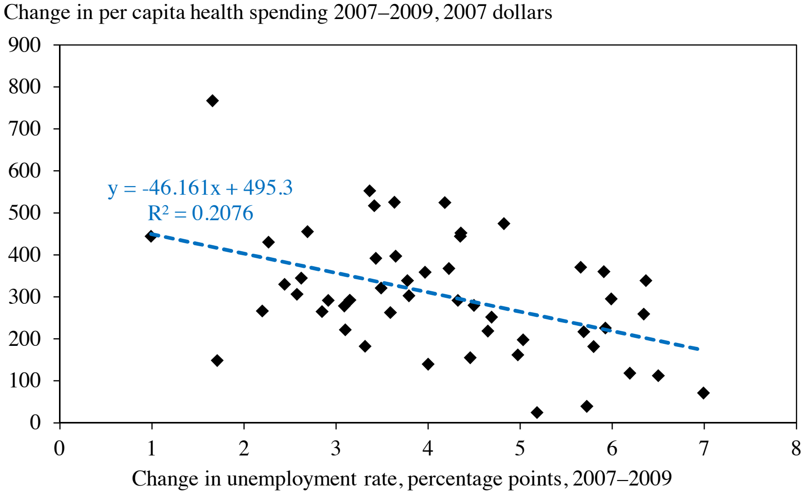
There are several potential causes of the recent declines in the growth rate of spending per enrollee. One factor is the recent recession, in which job losses have caused the loss of insurance coverage. However, the recession explains only a small fraction of the declines in spending growth rates since the start of the recession. The slowdown in the growth rate of per-capita health expenditures began before the recession took hold, and has continued through the economic recovery and into 2012.

As expected, changes in real per-capita total health care spending at the state level are negatively correlated with changes in unemployment in the state between 2007 and 2009 (Figure 5-7). If the relationship in Figure 5-7 holds at the national level, then the increase in the national unemployment rate between 2007 and 2011 of 4.3 percentage points was associated with a $199 decline in spending per-capita (in 2007 dollars), or 2.6 percent of per-capita health care spending in 2007. This accounts for only 18 percent of the slowdown in spending growth since the start of the recession in 2007 and an even smaller proportion of the slowdown in spending growth since 2002, when the growth rate in real per-capita total health care spending began to decline.[2]

Structural changes in the health care market offer another explanation for the decline in per-enrollee spending growth. One possibility is that hospitals and provider groups have increasingly sought to improve efficiency—through adopting more high value medical practices and performing fewer low value procedures—in response to evidence showing their potential for cost savings and quality improvements (Fisher and Skinner, 2010). At the same time, formulary changes that encourage substitution away from branded to generic drugs, and changes in insurance design that increase patient cost sharing for both services and pharmaceuticals, also may explain a portion of the declines in spending growth per enrollee over the past decade. For example, the sharp slowdown in the growth rate of medical

[2] Between 2001 and 2006, real per-capital spending grew by 21.5 percent. Between 2006 and 2011, real per-capital spending grew by 7.1 percent, where the 14.4 percentage point difference in spending growth captures the slowdown in spending growth. The 2.6 percent decline in total health care spending between 2007 and 2011 attributable to the recession accounts for approximately (2.6/14.4)*100 = 18 percent of the slowdown in spending growth since the start of the recession.

Figure 5-7
Relationship Between Change in State Unemployment Rate and Change in Real Per-Capita Personal Health Spending, 2007–2009



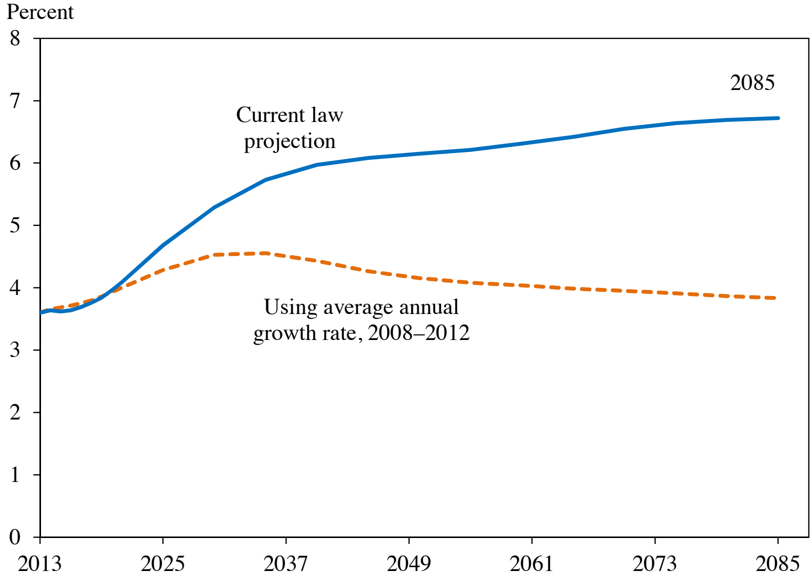
Source: Centers for Medicare and Medicaid Services, National Health Expenditure Accounts; Bureau of Labor Statistics, Current Population Survey; CEA calculations.

imaging since 2006 likely was due to a confluence of reforms including prior authorization, increased cost sharing and reduced reimbursements (Lee and Levy 2012). Notably, Lee and Levy found that a large fraction of the declines involved imaging identified as having unproven medical value. Similarly, payment reforms and regulations are thought to have contributed to long-run declines in Medicare spending growth rates (White 2008).

Early responses to the Affordable Care Act may have contributed to the decline in per enrollee spending since 2010 (Kronick and Po 2013). Relevant provisions of the law include provisions intended to foster coordinated care, improve primary care, reduce preventable health complications during hospitalizations, and promote the adoption of health information technology.

The decline in the hospital readmission rate, coinciding with the introduction of the Partnership for Patients program in 2011, also may point to early effects of the Affordable Care Act on spending. The Act's Medicare hospital readmissions reduction program, introduced in October 2012, should reinforce these effects. Likewise, infrastructure investments and care process changes, either funded directly by the Affordable Care Act or stimulated through the Affordable Care Act's payment reform, are other possible sources for the recent declines in spending growth.

Figure 5-8
Projected Medicare Spending as a Share of GDP, 2013–2085



Source: Medicare Trustees (2012); Social Security Trustees (2012); CEA calculations.

In addition, spending declines may reflect early changes in medical care delivery made in anticipation of impending Medicare payment reform. The Affordable Care Act moves providers towards savings-based payment models in Medicare that encourage improved coordination of care. Hospitals seeking new ways to reduce costs and increase bargaining power with suppliers and insurers may respond by consolidating their operations. Recent years have seen a continued consolidation and integration of physicians into provider networks.

The long-run growth rate of per-capita spending has significant implications for the budget. Medicare spending represented 3.7 percent of GDP in 2011 (Medicare Trustees 2012). Under current law, including cost control measures of the Affordable Care Act and the Sustainable Growth Rate-mandated physician payment cut, CMS projects that Medicare spending will rise to represent 6.7 percent of GDP in 75 years, with long-term nominal per-beneficiary spending growing at a rate on average equal to 4.3 percent per year (Medicare Trustees 2012). However, nominal growth rates of per-beneficiary Medicare spending have been declining since 2001, and over the past five years have averaged 3.6 percent. At least some of the recent decline in Medicare spending growth appears to be structural, implying that the low spending growth rates from the past few years may persist.[3] If the per-beneficiary growth rate of Medicare spending were to remain 3.6 percent per year, then after 75 years Medicare spending would account for only 3.8 percent of GDP, little changed from its share today, and substantially less than what the Medicare Trustees estimate. (Figure 5-8). This should not be interpreted as a forecast but rather an indication of how sensitive long-term projections are to the assumed rate of growth of Medicare spending per beneficiary. In this hypothetical scenario where per-beneficiary Medicare spending grows at a rate equal to the one observed over the past five years, Medicare spending as a share of GDP would be much lower than what current long-term projections suggest.

The causes for the recent and projected declines in the growth rate of medical spending and utilization, and their relationship to the major quality-improving and cost-saving provisions of the Affordable Care Act, remain an important area for future research. Enacted provisions of the health reform law appear to be having positive effects on care coordination, hospital outcomes and spending. And payment reforms that better align payment with cost and provide incentives for efficiency such as shared savings and bundled payment programs hold potential to improve to care quality and reduce medical spending.

[3] Regression analysis shows a flat and insignificant relationship between state-level 2007-09 changes in per-beneficiary Medicare spending and changes in unemployment, suggesting that little if any of the recent declines in per-beneficiary Medicare spending growth is related to regional cyclical factors.

CHAPTER 6

CLIMATE CHANGE AND THE PATH TOWARD SUSTAINABLE ENERGY SOURCES

The Administration is committed to a comprehensive energy strategy that supports economic and job growth, bolsters energy security, positions the United States to lead the world in clean energy, and addresses the global challenge of climate change. Finding a responsible path that balances the economic benefits of low-cost energy, the social and environmental costs associated with energy production, and our duty to future generations is a central challenge of energy and environmental policy.

The most significant long-term pollution challenge facing America and the world is the anthropogenic emissions of greenhouse gases. The scientific consensus, as reflected in the 2009 assessment by the U.S. Global Change Research Program (USGCRP) on behalf of the National Science and Technology Council, is that anthropogenic emissions of greenhouse gases are causing changes in the climate that include rising average national and global temperatures, warming oceans, rising average sea levels, more extreme heat waves and storms, and extinctions of species and loss of biodiversity. A multitude of other impacts have been observed in every region of the country and virtually all economic sectors.

As part of the United Nations Climate Change Conferences in Copenhagen and Cancún, the United States pledged to cut its carbon dioxide (CO_2) and other human-induced greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020, and to meet its long-term goal of reducing emissions by 83 percent by 2050. Approximately 87 percent of U.S. anthropogenic emissions of all greenhouse gases (primarily CO_2 and methane) are energy-related, and fossil-fuel combustion accounts for approximately 94 percent of U.S. CO_2 emissions (EPA 2010a).

Climate change is often described in terms of changes in background conditions that unfold over decades, but extreme events superimposed on, and possibly amplified by, those background changes can cause severe damage. For example, storm surges superimposed on higher sea levels will cause greater flooding, heat waves superimposed on already warmer temperatures will cause greater damage to crops, and a warmer atmosphere amplifies the potential for both droughts and floods.

From an economist's perspective, greenhouse gas emissions impose costs on others who are not involved in the transaction resulting in the emissions; that is, greenhouse gas emissions generate a negative externality. Appropriate policies to address this negative externality would internalize the externality, so that the price of emissions reflects their true cost, or would seek technological solutions that would similarly reduce the externality. Such policies encourage energy efficiency and clean energy production. In addition, prudence mandates that the Nation prepare now for the consequences of climate change.

Consequences and Costs of Climate Change

The clear scientific consensus is that anthropogenic greenhouse gas emissions are causing our climate to change. These changes include increasing temperatures, rising sea levels, changing weather patterns, and increasingly severe heat waves, with negative consequences for human health, property, and ecosystems.[1]

The Changing Climate

Projections using a wide variety of climate models paint a broadly similar picture of how global temperatures can be expected to rise in response to emissions—a picture that is also consistent with observed temperature changes (Rohling et al. 2012). Likely temperature paths, from a comparison of models by the USGCRP (2009), predict that the average global temperature under a low-emissions scenario will increase by approximately 4°F by the end of this century; under the medium and high emissions scenarios, end-of-century increases are 7°F and 8°F, respectively. Some regions are projected to experience greater temperature increases than others. The Arctic has warmed by almost twice the global average in recent decades, in part because warming melts snow and ice, leading to less reflected sunlight, which causes yet more warming (Arctic Monitoring and Assessment Programme 2011).

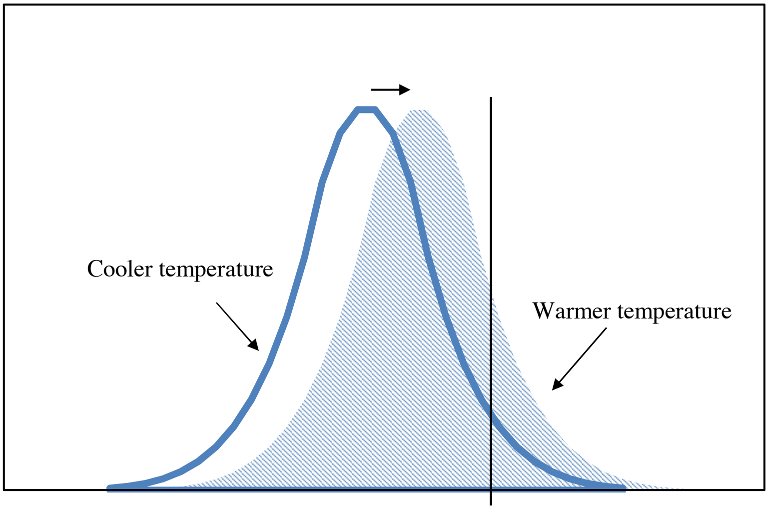
[1] The scientific consensus on the effects of greenhouse gas emissions on climate is summarized in reports by the USGCRP (2009) and the International Panel on Climate Change (IPCC 2012). The draft Third National Climate Assessment report, prepared by the National Climate Assessment Development Advisory Committee, was issued for public comment in January 2013.

Warming temperatures raise sea levels because of expanding ocean water, melting mountain glaciers and ice caps, and partial melting of the Greenland and continental Antarctic ice sheets. Since 1880, the global sea level has risen about 20 centimeters, more than half of which has occurred since 1950. Projections by the National Oceanographic and Atmospheric Administration show sea levels rising over the 21st century by 19 to 200 centimeters (NOAA 2012).

Increasingly common extreme events, such as heat waves, droughts, floods, and storms, pose some of the most significant risks of climate change. In its assessment of the current scientific literature, the IPCC (2012) concluded that increases in greenhouse gases will almost certainly increase the frequency and magnitude of hot daily temperature extremes during the 21st century, while episodes of cold extremes will decrease. In addition, the length, frequency, and intensity of heat waves are very likely to increase over most land areas, and droughts may intensify (Hansen, Sato, and Ruedy 2012; Rhines and Huybers 2013). In fact, an increase in the mean temperature implies more very hot days and fewer very cold days, even if the variability of daily temperatures around the mean remains unchanged. This phenomenon—a disproportionate increase in previously extreme temperatures as the mean temperature increases—is illustrated in Figure 6-1, which displays a shift in a hypothetical distribution of possible daily temperatures. The implications of Figure 6-1 accord with observed changes over the past decades and centuries as well as with climate model simulations. For example, according to the USGCRP estimates, under a high-emissions scenario, areas of the Southeast and Southwest that currently experience an average of 60 days a year with a high temperature above 90°F will experience 150 or more such days by the end of the century.

Patterns of precipitation and storms are also likely to change, although the nature of these changes currently is more uncertain than those for temperature. Northern areas of the United States are projected to become wetter, especially in the winter and spring; southern areas, especially the Southwest, are projected to become drier. Moreover, heavy precipitation events will likely be more frequent: downpours that currently occur about once every 20 years are projected to occur every 4 to 15 years by 2100, depending on location. The strongest cold-season storms are projected to become stronger, more frequent, and more costly. For more on the costs of storms, see Box 6-1.

Figure 6 - 1
Illustrative Average Temperature Distribution



Source: CEA illustration.

Estimating the Economic Cost of Climate Change: The Social Cost of Carbon

Because greenhouse gas emissions cause climate change, policies to reduce climate change must focus on reducing anthropogenic greenhouse gas emissions. An important step in informing a policy response is knowing precisely where carbon emissions are coming from, and that is the purpose of the Environmental Protection Agency (EPA) Greenhouse Gas Reporting Program discussed in Data Watch 6-1.

Another critical step in formulating policy responses to climate change is to estimate the economic costs induced by emitting an additional, or marginal, ton of CO_2. This cost—which covers health, property damage, agricultural impacts, the value of ecosystem services, and other welfare costs of climate change—is often referred to as the "social cost of carbon" (SCC). Having a range for the SCC provides a benchmark that policymakers and the public can use to assess the net benefits of emissions reductions stemming from a proposed policy. Although various studies, notably Stern (2006), have estimated the cost of climate change, until recently the Federal Government did not generate its own unique set of estimates of the SCC.

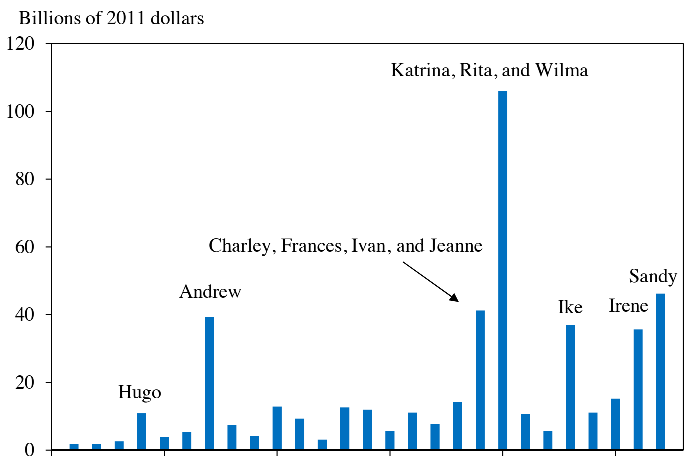
In 2010, a Federal interagency working group, led by the Council of Economic Advisers and the Office of Management and Budget, produced a white paper that outlined a methodology for estimating the SCC and

Box 6-1: The Cost of Hurricanes

Hurricanes draw energy from the temperature difference between the surface ocean and mid-level atmosphere. Although no one hurricane or storm can be attributed to global warming, there is some expectation that warming surface waters will increase the maximum intensity of hurricanes, and a trend toward increasing hurricane intensity has been observed in the North Atlantic over the past three decades (Kossin et al. 2007). As the figure shows, insured losses from storms have also been increasing over the past 20 years, a trend that is driven by losses from recent large hurricanes. Because many of the losses from hurricanes are uninsured, total costs can substantially exceed insured costs.

Development near vulnerable coasts, increasing intensity of storms, and rising sea levels point toward hurricane winds, precipitation, and storm surges that are increasingly destructive. In fact, several studies project substantial increases in hurricane-related costs because of climate change.[1] It is difficult to isolate the contribution of climate change to the historical increase in hurricane costs. Nonetheless, from the perspective of social cost, the relevant facts are that the total cost is increasing, and that storm costs will increase with coastal development and could well also increase in response to greater storm severity.

Total Insured Market Losses Caused by All Storm Types, 1985–2012



Note: Years with the 12 costliest hurricanes in U.S. history are labeled.
Source: Munich Reinsurance Company (2012).

[1] Mendelsohn et al. (2012); Nordhaus (2010); Pielke (2007); Narita et al. (2009).

Data Watch 6-1: Tracking Sources of Emissions: The Greenhouse Gas Reporting Program

In October 2009, the Environmental Protection Agency (EPA) launched its Greenhouse Gas Reporting Program, an ambitious effort to collect and make publicly available facility-level data on greenhouse gas emissions across the United States. Today, experts and non-experts alike can view, explore, and download comprehensive information on greenhouse gas emissions using the EPA's convenient online data tool. The program is a leap forward for greenhouse gas data collection and the first of its kind in its scale and "bottom-up" approach. It will be an important piece of administrative infrastructure for any future effort to regulate or price greenhouse gas emissions.

Since 1990, the EPA has reported estimates of greenhouse gas emissions in its annual Inventory of U.S. Greenhouse Gas Emissions and Sinks, in compliance with the U.S. commitment under the United Nations Framework Convention on Climate Change. These estimates, however, are mostly "top-down," in that the EPA estimates national emissions using aggregate data on fuel production, imports and exports, and inventories. In 2008, Congress instructed the agency to begin to collect facility-level data, and the EPA developed the Greenhouse Gas Reporting Program to augment the data collected through the National Greenhouse Gas Inventory. The first wave of data, which covers emissions in 2010, was made publicly available in January 2012. More than 6,000 facilities—refineries, power plants, chemical plants, landfills, and more—were required to report their emissions, which amounted to 3.2 billion tons of carbon dioxide equivalent (CO_2e) that year alone.[1] The EPA will release data on 2011 emissions in early 2013.

The EPA provides its database of facility-level greenhouse gas emissions online (http://ghgdata.epa.gov), and visitors can view data by sector or geography or both. The site's rich interface and powerful maps software permits easy spatial analysis of emissions, and built-in charts help users glean useful information from what might otherwise be an unwieldy dataset. Although the Greenhouse Gas Reporting Program is an important step forward for greenhouse gas data collection, there are a few limitations: only facilities that emit more than 25,000 tons of greenhouse gases (measured in CO_2e) a year are required to report (although some sectors are "all in," meaning even emitters below the 25,000-ton threshold report for the first three to five years), and the program does not cover emissions from agriculture or land use.

[1] http://www.epa.gov/ghgreporting/ghgdata/reported/index.html

provided numeric estimates (White House 2010). The SCC calculation estimates the cost of a small, or marginal, increase in global emissions. This process was the first Federal Government effort to consistently calculate the social benefits of reducing CO_2 emissions for use in policy assessment. To date, the 2010 interagency SCC values have been used to evaluate at least 17 rules at various stages in the rulemaking process by the EPA, the Department of Transportation (DOT), and the Department of Energy (DOE).

To estimate the SCC, the working group used three different peer-reviewed models from the academic literature of the economic costs of climate change and tackled some key issues in computing those costs. One issue is the choice of the discount rate used to compute the present value of future costs: because many of the costs occur in the distant future, the SCC is sensitive to the weight placed on the welfare of future generations. Another issue is how to handle some of the uncertainty surrounding climate projections. Box 6-2 explains how the working group dealt with uncertainty about the equilibrium climate sensitivity, which serves as a proxy for the climate system's response to greenhouse gas emissions.

The working group report provided four values for the social cost of emitting a ton of CO_2 in 2011: \$5, \$22, \$36, and \$67, in 2007 dollars. The first three estimates, which average the cost of carbon across various models and scenarios, differ depending on the rate at which future costs and benefits are discounted (5, 3, and 2.5 percent, respectively). The fourth value, \$67, comes from focusing on the worst 5 percent of modeled outcomes, discounted at 3 percent. All four values rise over time because the marginal damages increase as atmospheric CO_2 concentrations rise.

The SCC study acknowledged that these estimates, while a substantial step forward, need refinement, for example by a more complete treatment of some damage categories. A detailed discussion of the methodology can be found in Greenstone, Kopits, and Wolverton (2013). The interagency working group has committed to update its estimates of the SCC as the literature evolves and as new scientific and economic evidence become available.

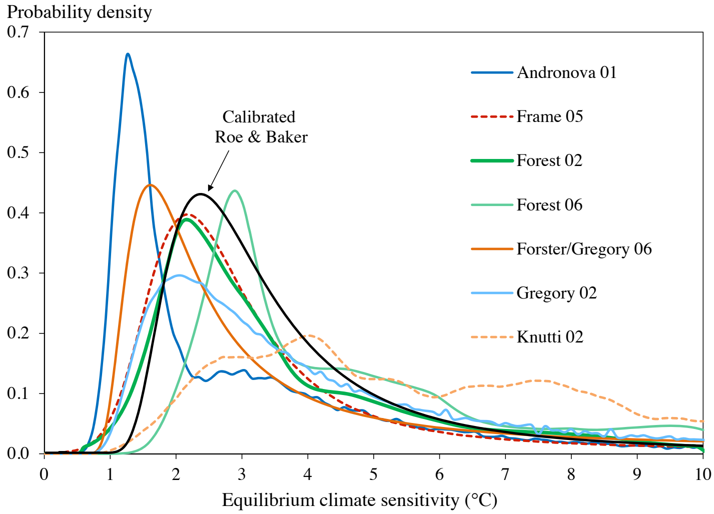
Policy Implications of Scientific and Economic Uncertainty

As a general matter, policy decisions must commonly be made in the presence of uncertainty. A standard approach for cost estimation or policy evaluation in the presence of uncertainty is to consider different scenarios and to compute a weighted average (expected value) over those scenarios. But in some cases it is difficult to quantify this uncertainty. In particular, some of the unknowns about climate change concern extreme scenarios that are far outside recorded human experience. Although such events are

Box 6-2: Handling Uncertainty About Equilibrium Climate Sensitivity

The 2010 Federal study on the social cost of carbon (SCC) used three integrated economic-geophysical models to estimate the cost of climate change: the DICE model, the PAGE5 model, and the FUND model.[1] The costs estimated by each model are sensitive to climatic, economic, and emissions parameters. A key input parameter for each model is the equilibrium climate sensitivity, defined as the increase in the long-term annual global-average surface temperature increase associated with a doubling of atmospheric carbon dioxide (CO_2) concentration relative to pre-industrial levels.

Estimates of Uncertainty About Equilibrium Climate Sensitivity



Source: IPCC (2007); Roe and Baker (2007).

The Intergovernmental Panel on Climate Change (IPCC 2012) suggests a range for the equilibrium climate sensitivity of 2–4.5°C (3.2–7.2°F), but the scientific uncertainty extends outside this range. The figure shows distributions of possible values of this parameter arising from different studies; each line in the figure corresponds to a given study, and the higher the line, the greater the chances (according to that study) of the corresponding value of the equilibrium climate sensitivity.

[1] The DICE model was developed by William Nordhaus, David Popp, Zili Yang, Joseph Boyer, and colleagues. The PAGE model was developed by Chris Hope with John Anderson, Paul Wenman, and Erica Plambeck. The FUND model was developed by David Anthoff and Richard Tol.

Although the distributions from different studies differ, each holds open the possibility that the value of this parameter might be very large.

This range of uncertainty over the equilibrium climate sensitivity matters for estimating the economic costs of carbon emissions: a higher value implies a more amplified response of temperature to carbon emissions, which would be associated with greater human consequences. To handle this uncertainty, the task force adopted a standard approach used by economists, which is to compute a weighted average—technically, an expected value—where the weighting reflects the uncertainty in the scientific literature. Specifically, simulations were run for many values of the equilibrium climate sensitivity drawn randomly from an assumed probability distribution and the results were averaged, producing the expected value for the SCC. The resulting SCC estimate incorporates the uncertainty in the equilibrium climate sensitivity.

therefore difficult to quantify, the possibility of very severe outcomes can and should inform policy.

One principle of policy design under uncertainty is that the policy should be able to adapt as more is learned and the uncertainty is resolved; another is that a policy should be robust to uncertainty.[2] A robust policy aims to give acceptable outcomes no matter what happens, within a given range of possible outcomes. As applied to climate change, this idea of robust policy in the face of uncertainty leads to policies that avoid worst-case outcomes. Such an approach has been advocated by Weitzman (2009, 2011), who argues that, when considering the expected damages of unmitigated global climate change, it is important to consider low probability but potentially catastrophic impacts that could occur. By focusing on avoiding the most costly climate outcomes, a climate change policy that is robust to scientific uncertainty would be more aggressive than a policy that simply focuses on quantifiable uncertainty or a consensus temperature path. If future scientific knowledge were to determine that the worst outcomes could be ruled out, then a robust policy could be adjusted. Thus, although uncertainty complicates the task of computing costs, it is not in itself a reason for inaction or delay.

[2] An important early paper on policymaking under uncertainty is Brainard (1967). Recent work in economics on robust policy in the face of model uncertainty includes Hansen and Sargent (2001, 2007), Giannoni (2002), Onatski and Stock (2002), and Funke and Paetz (2011).

Carbon Emissions: Progress and Projections

The past five years have seen a remarkable turnaround in U.S. emissions of carbon dioxide. As can be seen in Figure 6-2, from the early 1980s through the mid-2000s, energy-related CO_2 emissions increased from approximately 4,500 million metric tons (MMT) to a peak of just over 6,000 MMT in 2007. Since 2007, however, emissions have fallen sharply to approximately 5,500 MMT in 2011, the most recent year for which there is complete data. Indeed, as shown in the figure, this reduction in emissions makes significant progress toward achieving the Copenhagen Accord target of a 17 percent reduction in greenhouse gas emissions below 2005 levels by 2020.[3]

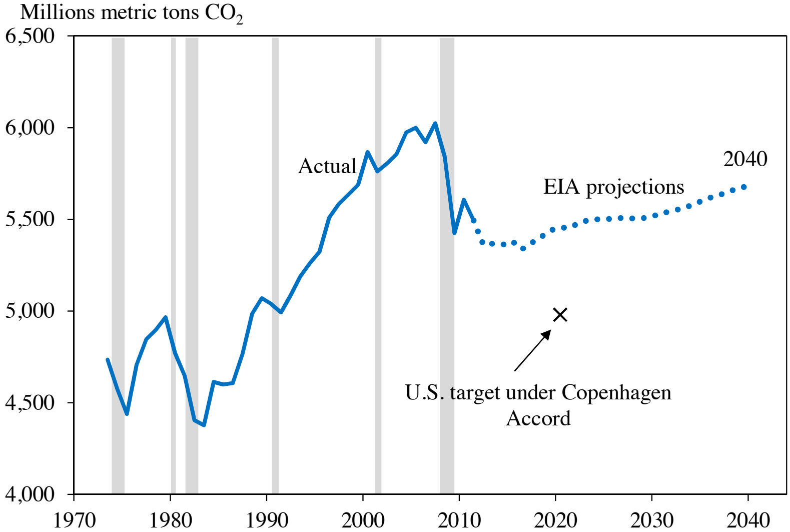
A natural question is what set of new events or initiatives led to the sharp reduction in emissions. There are a number of candidate explanations: reductions in the carbon content of energy, most notably the substitution of natural gas and renewables for coal; improvements in economy-wide energy efficiency; and unexpectedly low energy demand because of the recession. To estimate the contribution of these factors to the decline in emissions, one needs to posit a counterfactual path for these three variables, that is, for the carbon content of energy (CO_2 per British thermal unit, or Btu), energy use per dollar of gross domestic product (Btu/GDP), and GDP. Given a counterfactual, or baseline, path for these variables, one can decompose the decline in carbon emissions to a decline in the carbon content of energy, an accelerated improvement in energy efficiency, or a shortfall of GDP, relative to the baseline path.[4] Because the question focuses on the role of new developments, a natural approach is for the baseline to be a business-as-usual projection from a given starting point. For the purpose of this exercise, the starting point is taken to be the 2005 values of the carbon content of energy, energy efficiency, and GDP; the business-as-usual projections are made either by using historical published forecasts or by extrapolating historical trends.

The results of this decomposition estimate that actual 2012 carbon emissions are approximately 17 percent below the "business as usual" baseline. As shown in Figure 6-3, of this reduction, 52 percent was due to the recession (the shortfall of GDP, relative to trend growth), 40 percent came

[3] United Nations Framework Convention on Climate Change, Appendix I, http://unfccc.int/meetings/copenhagen_dec_2009/items/5264.php.

[4] Specifically, CO_2 emissions are the product of $(CO_2/Btu)\times(Btu/GDP)\times GDP$, where CO_2 represents U.S. CO_2 emissions in a given year, Btu represents energy consumption in that year, and GDP is that year's GDP. Taking logarithms of this expression, and then subtracting the baseline from the actual values, gives a decomposition of the CO_2 reduction into contributions from clean energy, energy efficiency, and the recession.

Figure 6-2
U.S. Energy-Related Carbon Dioxide Emissions, 1973–2040



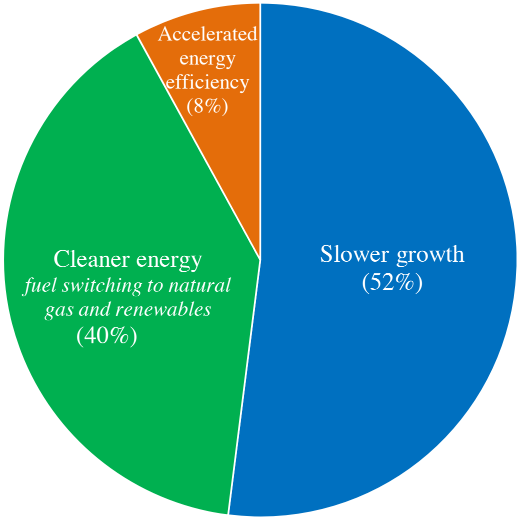
Note: Shading denotes recession.
Source: EIA (2012b).

from cleaner energy (fuel switching), and 8 percent came from accelerated improvements in energy efficiency, relative to trend. Of the cleaner energy improvements, most (approximately two-thirds) came from reductions in emissions from burning coal. Reductions in emissions from petroleum combustion also made important contributions (approximately one-third), as these high-carbon content fuels were replaced by lower carbon-content natural gas and clean renewable energy sources, notably wind and biofuels. The contribution from energy efficiency stems from efficiency improvements over the 2005–12 period that were faster than projected; in particular, the Energy Information Administration (EIA 2005) forecast a reduction in the energy content of GDP of 1.6 percent per year, but energy efficiency improved by more than this forecast.[5]

As the economy improves, GDP will rise, and the weakness of the economy in 2007–09 will no longer restrain energy consumption. Thus if the recent reductions in emissions are to be continued, a greater share will need to be borne by fuel switching into natural gas and into zero-emissions renewables, and by accelerating improvement in economy-wide energy efficiency.

[5] Houser and Mohan (forthcoming) undertake a similar decomposition. They use different assumptions for the baseline, including somewhat stronger post-2005 GDP growth in the "business as usual" case than is assumed here, and as a result attribute slightly more of the post-2005 reduction in CO_2 emissions to slower economic growth.

Figure 6-3
Decomposition of CO_2 Emission Reductions, 2005–2012



Source: Bureau of Economic Analysis, National Income and Product Accounts; EIA (2013); CEA calculations.

Policy Responses to the Challenge of Climate Change

As a general matter, government intervention may be warranted if an individual's action produces a negative externality; that is, if the action imposes costs on another person and those costs are not borne by the person taking the action. As with many environmental problems, the impacts of pollution are broadly shared by society, and individuals emitting pollution do not bear the full, direct costs of their individual action (or reap the full benefits individually of reducing pollution). In the case of anthropogenic emissions of greenhouse gases, the costs of climate change are borne by others, including future generations, and those costs are not reflected in the price of greenhouse gas emissions. This market failure is also present in reverse: an entrepreneur with a clever idea for reducing greenhouse gas emissions, such as a novel energy conservation technology, cannot recoup the full benefit of her innovation because there is no way she can charge those who will benefit from the abatement of those emissions.

This diagnosis of the market failure underlying climate change clarifies the need for government to protect future generations that will be affected by today's emissions. Responding to the challenge of climate change leads to a multipronged approach to policy. Four such responses are implementing market-based solutions; technology-based regulation of greenhouse gas emissions; supporting the transition of the U.S. energy sector to technologies, such as renewables and energy efficiency, that reduce our overall carbon footprint; and taking actions now to prepare for those impacts that are by now unavoidable.

Market-Based Solutions

In his 2013 State of the Union Address, President Obama urged Congress to pursue a bipartisan, market-based solution to climate change. Market-based solutions to greenhouse gas emissions provide economic incentives so that the cost of polluting reflects the economic harm caused to others by that pollution. In this sense, market-based solutions are said to "internalize" the externality caused by the pollution. Under the standard assumptions of economic theory, market-based solutions to pollution are economically efficient because those who create the externality can choose the least costly and disruptive way to reduce their emissions. Under market-based solutions, the effective price of the activity producing the negative externality is adjusted so that it reflects the cost of that externality. There are various ways that market-based solutions can be implemented, one of which is a cap-and-trade system like the one Senators McCain and Lieberman worked on.[6]

Another example of a market-based solution is a Clean Energy Standard that would require electric utilities to obtain an increasing share of delivered electricity from clean sources but would allow them to meet the standard by trading clean-energy credits. By allowing trading in credits, electric utilities that produce renewable energy at relatively low cost can sell credits to those for which renewable production would be high-cost. Thus the total cost across all utilities of meeting the standard is reduced, relative to the cost were each utility required to meet the standard without tradable credits. In this way, a market for clean energy credits harnesses private-sector incentives to minimize the cost of generating electricity from clean energy sources.[7]

Direct Regulation of Carbon Emissions and the Vehicle Greenhouse Gas / Corporate Average Fuel Economy (CAFE) Standards

Another way to address the externality of carbon emissions is by direct regulation. In 2007, the Supreme Court ruled in *Massachusetts v. EPA* that it is incumbent upon the EPA to determine whether greenhouse gases

[6] For a more detailed discussion of cap-and-trade, see the *2010 Economic Report of the President,* chapter 9.

[7] For further discussion of a Clean Energy Standard, see the *2012 Economic Report of the President,* chapter 6.

pose a risk to public health or welfare and, if so, to regulate greenhouse gas emissions under the Clean Air Act. In 2012, the U.S. Court of Appeals for the District of Columbia Circuit upheld the EPA's authority to regulate greenhouse gas emissions.

The Administration's corporate average fuel economy (CAFE) and greenhouse gas regulations, released in 2012 jointly by the EPA and the DOT, require automakers to increase the fuel economy of passenger cars and light trucks so that they are estimated to achieve 54.5 miles per gallon by 2025, approximately doubling the previous mileage standards.[8] The new fuel economy standards are expected to save more than 2 million barrels of oil a day by 2025—more than we import from any country other than Canada—and to reduce consumer expenditures on gasoline. The standards are projected to reduce annual CO_2 emissions by over 6 billion metric tons over the life of the program, roughly equivalent to the emissions from the United States in 2010 (White House 2011a).

The new fuel economy standards help to correct the externality that the cost of carbon emissions is not accounted for in the price of gasoline. The standards also provide a clear signal to the thousands of firms in the auto supply chain that investments in fuel-saving innovation will pay off. These innovations range from large (batteries for electric cars) to small (lighter-weight bolts), and often require suppliers to coordinate with each other. For example, use of innovative high-strength steels can reduce the overall weight of a vehicle, but only if firms making automotive parts and those making tooling for the parts each invest in new production processes (Helper, Krueger, and Wial 2012). The new standards ensure demand for fuel-saving innovations and thus provide an incentive for such investments.

Energy Efficiency

An important way to reduce greenhouse gas emissions is to use energy more efficiently, that is, to use less energy to provide a given service outcome. For example, weatherizing a home improves efficiency by requiring less energy to maintain a given inside temperature. Using less energy, in turn, reduces greenhouse gas emissions.

The Administration has made energy efficiency initiatives an important component of its energy plan.[9] These initiatives include major research

[8] Because the standards regulate greenhouse gas emissions, they can be met in part in ways that do not improve fuel economy. In particular, if improvements are made by reducing leakage of greenhouse gases in auto air conditioners, or by replacing refrigerants with non-greenhouse gases, then the goal of reducing greenhouse gas emissions is achieved without improving fleet fuel economy.

[9] http://www.whitehouse.gov/sites/default/files/email-files/the_blueprint_for_a_secure_energy_future_oneyear_progress_report.pdf

investments to improve the efficiency of building designs and components such as lighting, heating, and air conditioning, along with smart building controls. Other important initiatives include the weatherization of more than 1 million homes across the country, the President's Better Buildings Challenge with $2 billion in private-sector commitments to energy efficiency retrofits, new standards for residential and commercial appliances, and the Rural Energy for America Program. The Administration has also introduced a variety of programs to help consumers learn about developments in energy efficiency; one such example is the Home Energy Score, a new voluntary program from the DOE to help homeowners make cost-effective decisions about energy improvements. Additionally, as part of a broader manufacturing strategy, the Administration has partnered with manufacturing companies representing more than 1,400 plants that plan to make investments that will improve energy efficiency by 25 percent over 10 years.

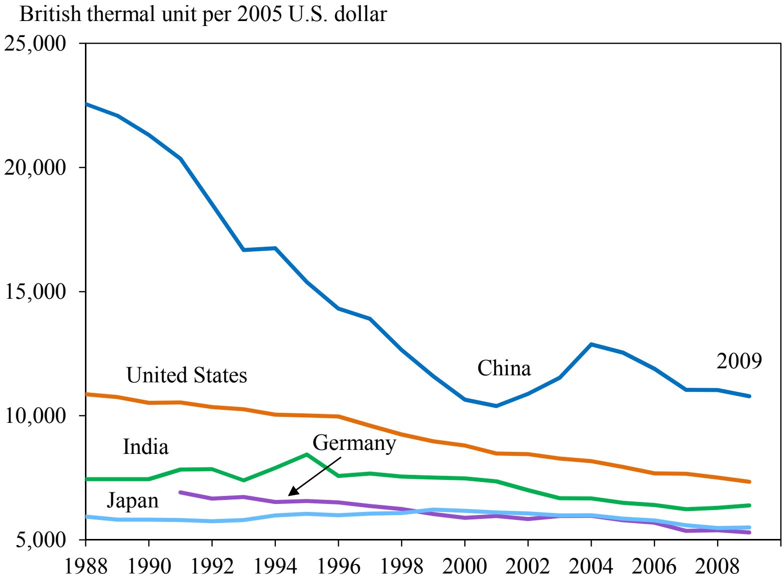
An overall measure of economy-wide energy use is the amount of energy needed to generate a dollar's worth of goods and services ("energy intensity"). As is shown in Figure 6-4, the energy intensity of the U.S. economy has fallen steadily over the past quarter century, with an annual average rate of decline of 1.7 percent from 1990 through 2011. However, U.S. energy intensity is still one-third higher than that of Germany and Japan, in part because Germany and Japan have automobiles and building codes that are more energy efficient, as well as smaller homes set more densely.[10]

One reason for the decline in the energy intensity of the U.S. economy is the increasing importance of services as a share of U.S. GDP. Manufacturing is more energy-intensive than is the production of services, and for decades the share of U.S. GDP derived from services has been growing while the share derived from manufacturing has been declining. This shift from manufacturing to services therefore has reduced the energy intensity of the U.S. economy.

To control for changes in the energy-GDP ratio driven by changes in the sectoral composition of output, the DOE developed an "Economy-wide Energy Intensity Index." This index estimates the amount of energy needed to produce a basket of goods in one year, relative to the previous year. As indicated in Figure 6-5, between 1985 and 2010, the DOE Energy Intensity Index fell by 14 percent. In contrast, the energy-GDP ratio fell by 33 percent. Thus, while much of the decline in energy usage per dollar of GDP has come from improvements in energy efficiency, much of it has also come from

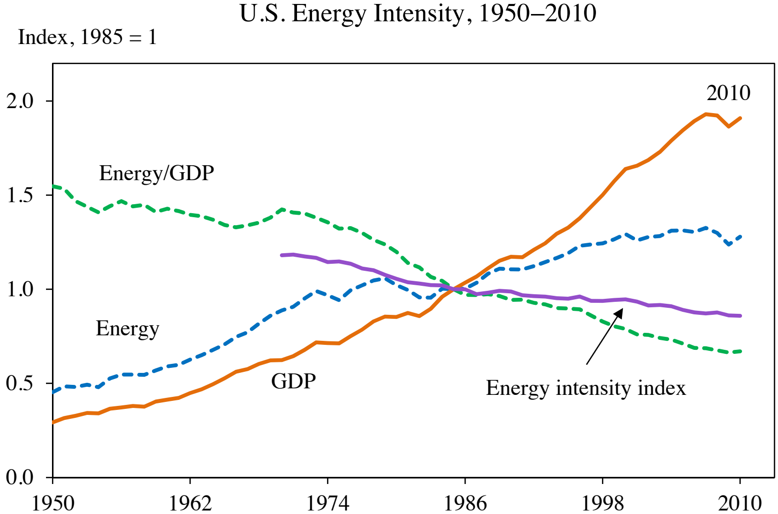
[10] In neither Germany nor Japan is the lower energy intensity due to having less manufacturing than the United States. In fact, manufacturing (an energy-intensive sector) is almost twice as high as a share of GDP in Germany as it is in the United States.

Figure 6-4
Energy Use per Dollar of GDP, Selected Countries, 1988−2009



Source: Energy Information Administration, International Energy Statistics.

Figure 6-5
U.S. Energy Intensity, 1950–2010



Note: "Energy" is the amount of energy consumed (measured in Btu) compared to 1985 levels. "Energy/GDP" is energy consumed divided by GDP, compared to 1985 levels. The energy intensity index is available starting in 1970.
Source: Department of Energy, Office of Energy Efficiency and Renewable Energy, Energy Intensity Indicators: Trend Data.

factors other than improved efficiency such as shifts in the composition of output.

The energy intensity index measures the energy footprint of U.S. production, not of U.S. consumption. This distinction arises because energy intensity includes energy used to produce exported goods and services (which are not consumed domestically) and excludes energy used to produce imports. To estimate the CO_2 intensity of consumption, as opposed to the CO_2 intensity of production, one needs to adjust U.S. CO_2 emissions for the difference of foreign emissions in the production of imports less domestic emissions in the production of exports.

Technical developments that use less energy to provide a service, such as maintaining a room at a comfortable temperature, can both reduce energy consumption and improve consumer welfare. Because technical improvements in energy efficiency reduce the energy cost of the service, consumers are better off, and because the price of the service declines, they might use more of it. For example, weatherizing a home might tempt the homeowner to bump up the thermostat a couple of degrees. This consumer response of using more of the newly efficient service is known as the rebound effect. The magnitude of the rebound effect depends on the particular service, more specifically on the elasticity of demand for the service. Viewed solely through the lens of CO_2 reduction—a lens that is appropriate because CO_2 emissions are underpriced—the rebound effect suggests that government efforts on energy efficiency should emphasize services with inelastic demand, so that price changes do not substantially alter service consumption and actual energy savings approach the technically feasible energy savings.

One such example is the services derived from automobiles. In the context of the vehicle greenhouse gas–CAFE standard discussed earlier, the EPA assumes a rebound effect of about 10 percent[11], that is, consumers will drive about 10 percent more than if the efficiency of their vehicles had not increased (EPA 2010b). In their reviews of the rebound effect, Greening, Greene, and Difiglio (2000) and Gillingham et al. (2013) suggest more generally that the rebound effect tends to range between 10 percent and 30 percent. Although much has been written on the rebound effect, the base of original research is limited, and more research is needed concerning the rebound effect (and the associated price elasticities) empirically, both in the short and long run.

[11] The EPA rebound estimate draws on the literature, for example, Small and Van Dender (2007).

Energy Production in Transition

The United States is in a period of swift and profound change in the way that energy is produced and consumed. Thanks to recent advances in technology, more of the country's domestic oil and gas resources are now accessible. As a result, U.S. oil production has climbed to the highest level in 15 years and natural gas production reached an all-time high. This increase in domestic oil production enhances energy security, and increased natural gas production has substituted for coal, which reduces CO_2 emissions per unit of energy produced. At the same time, the Obama Administration has taken historic steps to promote greater energy efficiency and the deployment of renewable energy across the U.S. economy. In the past five years, the United States has more than doubled non-hydroelectric renewable electricity generation. The Administration is working to continue these trends through a comprehensive "all of the above" approach to energy policy that takes advantage of all domestic energy resources, while also igniting the innovation needed to lead the world in clean energy.

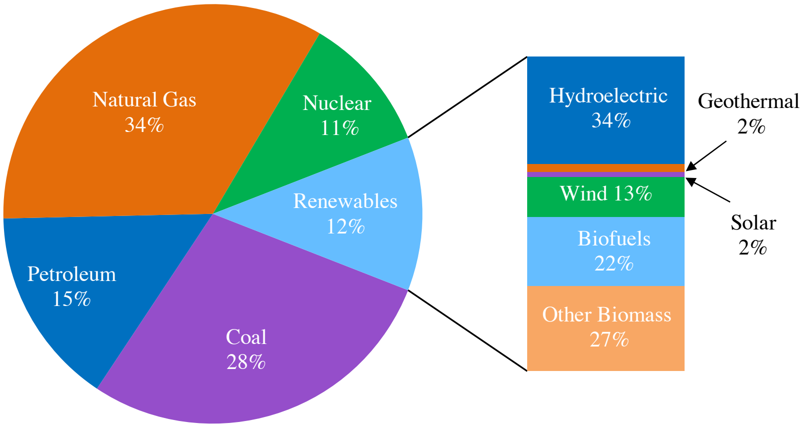
The transformation of the U.S. energy sector to one with a smaller carbon footprint is central to climate change policy. As Figure 6-6 shows, approximately 77 percent of U.S. energy production in 2011 came from burning fossil fuels, and the remaining 23 percent was approximately evenly split between nuclear and renewables. In broad terms, the share of natural gas (the fossil fuel with the lowest carbon content) and the share of renewables have been expanding, displacing the share of coal (the fossil fuel with the highest carbon content).

Oil and Natural Gas

New developments in exploration and production techniques and technology have made the extraction of new sources of oil and natural gas economically viable, resulting in a U.S. production boom. Figure 6-7 shows the changing consumption and production trends of natural gas in the United States, along with the U.S. share of global production since 2000. As a result of the developments in shale gas production, total U.S. natural gas production rose 27 percent, from 18.1 trillion cubic feet in 2005 to 23.0 trillion cubic feet in 2011, and wellhead prices fell 46 percent, from $7.33 per thousand cubic feet to $3.95 per thousand cubic feet. In 2011, for the first time in 30 years, energy production from dry natural gas exceeded energy production from coal.

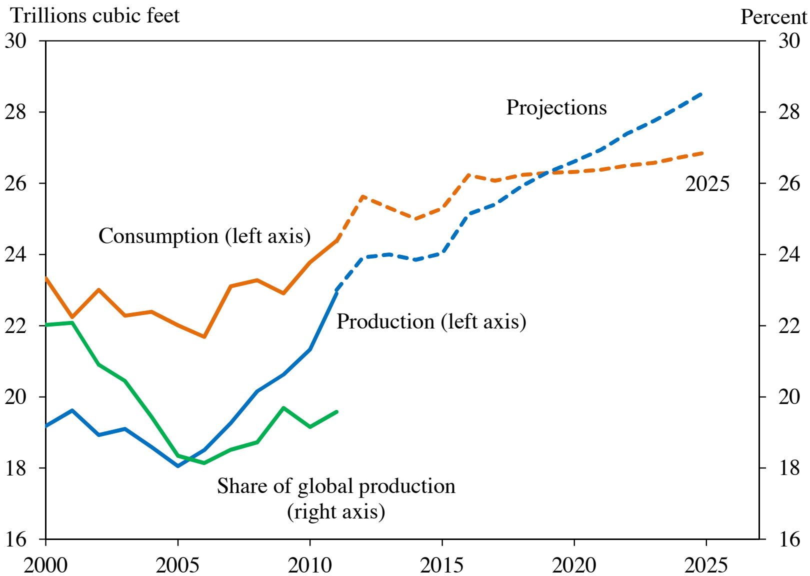
The benefits of increased production of natural gas are observed throughout the U.S. economy. In recent years, low energy costs have become a competitive advantage to the U.S. industrial sector. Additionally, low

Figure 6-6
Total U.S. Primary Energy Production, 2011



Note: Natural gas includes natural gas plant liquids.
Source: EIA (2012a).

Figure 6-7
U.S. Natural Gas Consumption and Production, 2000–2025



Source: EIA (2012b).

prices for byproducts of natural gas such as methane, ethane, and propane spur growth in agriculture, petrochemical manufacturing, and other industries that use these byproducts.

In the power sector, burning natural gas produces nitrogen oxides, carbon dioxide, and other pollutants, but in lower quantities than burning coal or oil. The life-cycle emissions of greenhouse gases from a combined-cycle natural gas plant is roughly half that of a typical coal-fired power plant per kilowatt hour (Logan et al. 2012). On the other hand, methane, a primary component of natural gas and a greenhouse gas, can be emitted from natural gas systems into the atmosphere through production processes, component leaks, losses in transportation, or incomplete combustion. Measuring fugitive methane emissions from the U.S. natural gas supply chain and, more generally, understanding the potential impacts of natural gas development on water quality, air quality, ecosystems, and induced seismicity, are critical to understanding the impact on the environment of the increasing use of natural gas.

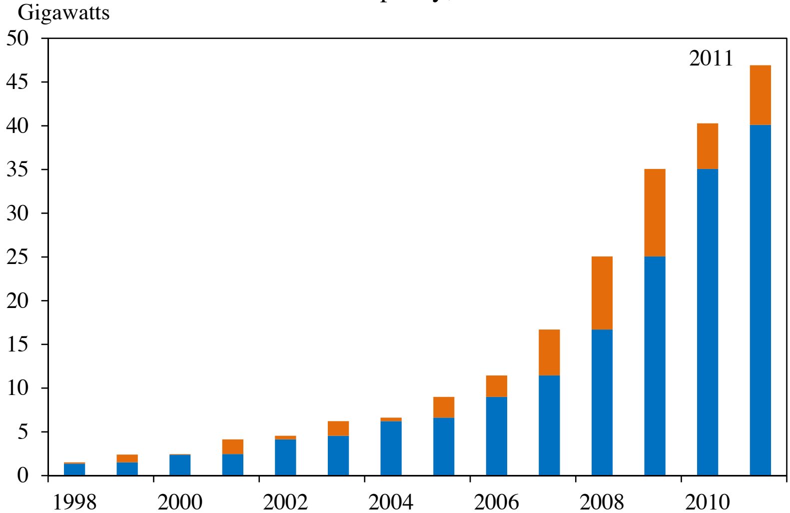
Renewable Energy

In the long run, large reductions in carbon emissions require large increases in energy production from zero-emissions sources, especially renewable energy. In the beginning of his Administration, President Obama set a goal of doubling U.S. renewable energy generation capacity from wind, solar, and geothermal sources by 2012. This ambitious goal has been achieved, thanks both to the Administration's historic investments in clean energy technologies and to decades of government-funded research and development (R&D) aimed at driving costs down to the point where renewable energy is competitive with traditional fossil-fuel energy.

Since 2008, the most significant increase in renewable energy production has been in wind energy. The dramatic increase in wind generating capacity is shown in Figure 6-8. In 2011, wind power constituted more than 30 percent of new additions to U.S. electric generating capacity: close to 6.8 gigawatts of new wind generating capacity was installed in the United States, representing an investment of $14 billion. Wind energy supplies 20 percent of electricity consumption in some states, including Iowa and South Dakota. As a nation, the United States accounts for 20 percent of total global wind power generation and 16 percent of global installed capacity. In 2012, wind power provided more than 3 percent of the nation's electricity generation (EIA 2013b).

The Administration also continues a strong commitment to the development and promotion of solar energy. An important aim is bringing the cost of solar photovoltaics down closer to grid parity with traditional,

Figure 6-8
Annual and Cumulative Growth in U.S.Wind Power Capacity, 1998–2011



Note: Orange bars are annual additions to capacity and blue bars are total installed capacity at the outset of the year.
Source: DOE (2012b).

fossil sources of energy, including natural gas. The Administration's support for solar energy has included more than $13 billion since September 2009 through DOE programs for solar-related projects, including applied R&D, demonstrations, and the DOE clean energy loan guarantee program. In 2011, the DOE launched an ambitious new effort, the Sunshot Initiative, aimed at reducing the installed costs of solar energy systems of all sizes (residential, commercial, and utility) by an additional 75 percent by the end of the decade.

Solar photovoltaic capacity is growing rapidly, with current installed capacity estimated to be approximately 4 gigawatts.[12] The Interstate Renewable Energy Council estimates that grid-connected photovoltaic capacity increased more than tenfold between 2007 and 2011.

President Obama has set a goal of once again doubling generation from wind, solar, and geothermal sources by 2020, and has called on Congress to make the renewable energy Production Tax Credit permanent and refundable, as part of comprehensive corporate tax reform, providing incentives and certainty for investments in clean energy.[13]

---

[12] The Interstate Renewable Energy Council (IREC), the Solar Energy Industries Association (SEIA), and the National Renewable Energy Lab (NREL).
[13] http://www.whitehouse.gov/sites/default/files/uploads/sotu_2013_blueprint_embargo.pdf.

Advanced Technologies and R&D

The Federal Government also has an important role to play in R&D involving frontier fossil-fuel technologies. Notably, the Administration has invested nearly $6 billion in clean coal technology R&D—the largest such investment in U.S. history—and this strategy has attracted more than $10 billion in additional private sector capital investment. Clean coal technology involves removing CO_2 from flue gases released from burning coal, then preventing its escape into the atmosphere by injecting it underground, a process known as carbon capture and sequestration. The recovered CO_2 can potentially be used to recover hard-to-reach oil reserves, partially offsetting the carbon capture costs. Another clean coal technology in the R&D stage is hydrogen production from coal, in which the highly concentrated CO_2 stream is captured and sequestered. Advanced technologies also have the potential to make natural gas burn even cleaner by capturing and storing CO_2 emissions, and the government has a role to play in encouraging research into these technologies.

Federal research efforts on zero- and reduced-emissions energy sources extend into other domains as well, including research toward shifting cars and trucks to nonpetroleum fuels.

Preparing for Climate Change

The policies discussed so far aim to reduce emissions of greenhouse gases and thereby to stem future costs of climate change. But the climate has not yet fully adjusted to current levels of greenhouse gases, and ongoing anthropogenic emissions will continue to increase greenhouse gas concentrations because CO_2 remains in the atmosphere for centuries. Thus, while it is important for all countries to sharply reduce CO_2 emissions to limit the extent of further climate change, even with the most concerted international efforts additional climate change is inevitable. We therefore face a world with an unavoidably changing climate for which we need to prepare.

Policies to prepare for climate change occur at many scales. At the local level, preparing for climate change can entail changing building codes to make structures more storm- and flood-resistant and investing in stronger community planning and response. More substantially, destructive effects of coastal storms can be partially dissipated by restoring natural storm barriers such as tidal wetlands, sand dunes, and coastal barrier landforms.

National policies to prepare for climate change range from providing information about likely changes in local climates and weather patterns, to supporting further research on and monitoring of climate change and its consequences, to providing proper incentives for individuals to prepare for climate change. For example, federal insurance programs, such as the Agriculture Department's crop insurance program and the Federal Emergency Management Agency's flood insurance program, provide insurance either with a subsidy or where there is no private market (that is, the price a private insurer would charge would exceed what a purchaser would be willing to pay). Revisiting federal insurance subsidies could encourage practices that could be increasingly important in the face of accelerating climate changes, such as farmers planting drought-resistant varietals or homeowners building or renovating away from flood plains.

Preparing for climate change will also entail larger-scale infrastructure investments. Some of these investments involve maintaining existing infrastructure. For example, a 2007 investigation by the American Society of Civil Engineers reported that chronic underfunding of the New Orleans hurricane protection system was one of the principal causes of the levee failures after Hurricane Katrina, a storm that inflicted over $110 billion of damages.

Other investments involve enhancing or extending existing infrastructure. For example, the electric power grid can be made more resilient to increasingly severe storms and rising sea levels by using smart grid technology, which pinpoints outage locations and helps to isolate outages, reducing the risk of widespread power shutdowns. The Recovery Act provided the single largest smart grid investment in U.S. history ($4.5 billion matched by an additional $5.5 billion from the private sector), funding both the Smart Grid Investment Grant and Smart Grid Demonstration programs, among others, to spur the Nation's transition to a smarter, stronger, more efficient, and more reliable electricity system (White House 2011b).

Conclusion

The scientific consensus is that the anthropogenic emission of greenhouse gases is causing climate change. The results can be seen already in higher temperatures and extreme weather, and these are but precursors of what lies ahead. Although greenhouse gas emissions and climate change are global problems, the United States is in a unique position to tackle these challenges and to provide global leadership.

The Nation has made substantial progress toward the Administration's ambitious short-term Copenhagen targets for reducing emissions of carbon dioxide, but much difficult work lies ahead. Undertaking this work, which reflects the Administration's commitment to future generations, entails many policy steps that are economically justified by the negative externalities imposed by greenhouse gas emissions. Policies to reduce emissions of greenhouse gases include market-based policies; encouraging energy efficiency; direct regulation; encouraging fuel switching to reduced-emissions fuels; and supporting the development and widespread adoption of zero-emissions energy sources such as wind and solar. And, as the country reduces emissions along this path, it also needs to prepare for the climate change that is occurring and will continue to occur. Together these policies pave the way toward a sustainable energy future.