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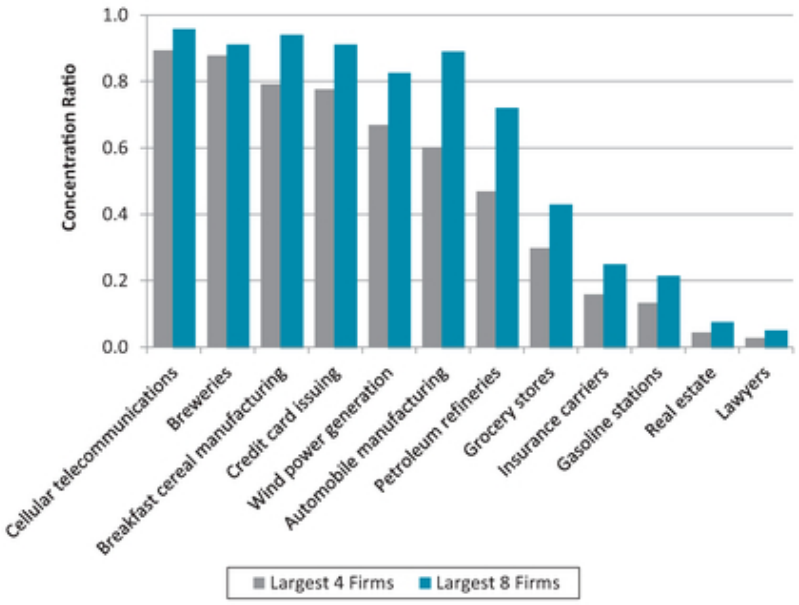
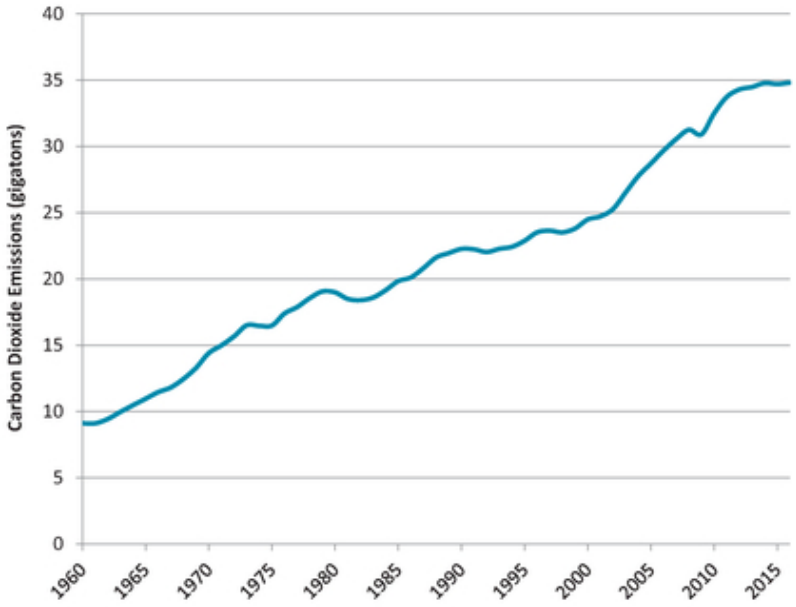


Source: U.S. Census Bureau, 2012 Economic Census. *Note:* Manufacturing concentration ratios based on value-added. All other concentration ratios based on revenues.

14. Global Carbon Dioxide Emissions

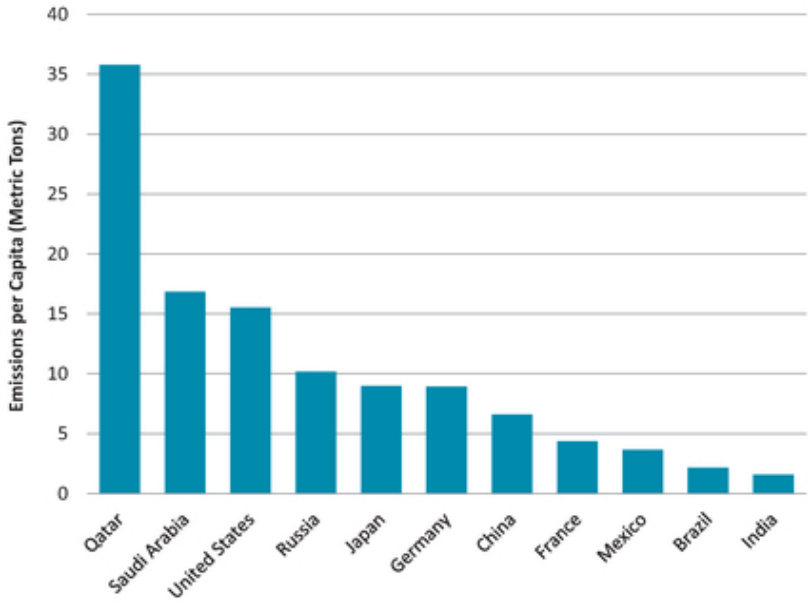
What it is:	The vast majority of scientists believe that human activities are impacting the global climate. Carbon dioxide emissions, which result when oil, coal, and natural gas are burned, have been identified as the primary cause of global climate change. The graph below shows global carbon dioxide emissions from 1960 to 2016, measured in gigatons (a gigaton is a billion metric tons).
The results:	We see that global carbon dioxide emissions increased from about 10 gigatons in 1960 to about 35 gigatons recently. While most projections indicate that global carbon dioxide emissions will continue to increase in the future, scientists note that emissions will need to decrease substantially in the next few decades to avoid significant negative consequences to the global ecosystem and to human societies. We will discuss global climate change in more detail in Chapter 13.



Source: Global Carbon Project. Global Carbon Atlas. http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas.

15. Per-Capita Carbon Dioxide Emissions–International Comparisons

What it is:	The graph below shows annual per-capita (average per person) carbon dioxide emissions for several countries, measured in tons. The data are from 2015.
The results:	Per-capita carbon dioxide emissions vary significantly across countries. In general, emissions per capita rise with higher incomes, but this is not always the case. The highest per-capita emissions are found in oil-producing countries. Emissions per capita are quite high in the United States, at around 16 tons. Per-capita emissions are about 9 tons in Germany, 7 tons in China, and 4 tons in Mexico. Per-capita carbon dioxide emissions are much lower in the worlds poorest countries. We will discuss carbon dioxide emissions, and global climate change, in Chapter 13.



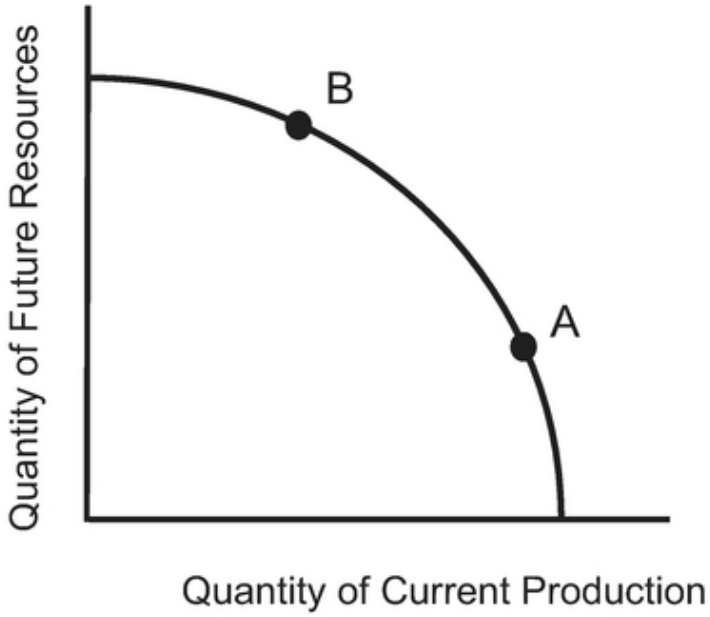
Source: Statista.com, CO_2 Emissions per Person in 2015. Original data from International Energy Agency. https://www.statista.com/statistics/270508/co$_2$-emissions-per-capita-by-country/.

■ ***Figure 1.2*** *An Expanded Production-Possibilities Frontier*

Some productive activities create an ongoing flow of outputs without drawing down the stock of resources, such as organic farming that maintains the nutrient levels in soil. Many other productive activities, however, lead to resource depletion or degradation. The intensive use of fossil fuels depletes petroleum reserves, degrades air quality, and contributes to global climate change. Production processes that destroy important watersheds and wildlife habitats are also resource depleting. Mind-numbing drudgery, work in dangerous circumstances, or excessively long hours of work can degrade human resources by leaving people exhausted or in poor mental or physical health. These kinds of productive activities are at odds with good resource management.

Taking a longer-term view, then, it is clear that getting the absolute most current production is generally not a wise social goal. Decisions such as our guns versus butter example need to be accompanied by another decision about *now* versus *later.*

The choice between current and future production can be presented in terms of a different PPF, as shown in Figure 1.3. In this case, the tradeoff is between current production and resource availability for the future. If society chooses point A, current production is high but resource availability for the future is low. However, choosing point B reduces current production but results in significantly greater resource availability in the future.



■ ***Figure 1.3*** *Society's Choice between Current Production and Future Resource Availability*

children and caring for the sick and the elderly. In some cases, these shifts are liberating, but in others they can cause psychic or financial impoverishment.

Another serious concern is environmental degradation. Like many types of businesses, markets do not do well, on their own, in protecting the environment because the costs of environmental damage are generally external to market transactions, as we discussed previously. Perhaps the greatest externality in human history is the challenge of climate change—a topic we will address in Chapter 13. There we will look at the situation described by ecologists who say that the scale of our entire economic system—the amount of materials taken from nature, processed, used, and thrown away—threatens the future functioning of all the systems on which we depend: natural, social, and economic.

4.2 Assessing Market Outcomes

Unfortunately, too often the debate about markets comes down to one side being "pro-market" while the other side is "anti-market." We seek to avoid such a polarizing distinction in this text. Such broad generalizations often reflect a lack of knowledge about the details of markets and economics. But it is only by knowing these details that we are truly able to understand when markets do, and do not, work effectively at enhancing well-being.

So rather than trying to decide whether you are "pro-market" or "anti-market," we will encourage you to think of three broad categories of market outcomes, assessed on a case-by-case basis:

1. situations in which market outcomes are reasonably efficient, fair, and sustainable, with only limited government involvement required
2. situations in which market outcomes are reasonably efficient, fair, and sustainable only with significant government involvement
3. situations in which market outcomes are not efficient, fair, and/or sustainable, necessitating provision through nonmarket institutions (such as government)

We can evaluate market outcomes in terms of three factors: efficiency, fairness, and sustainability. We will learn how economists define the efficiency of markets in more detail in Chapter 5. The issues of fairness and inequality we will address in Chapter 10. The topic of environmental sustainability is covered in Chapters 12 and 13. But for now we can begin to consider potential examples in each of these three categories.

Which category would the market for T-shirts in the United States fall into? A quick search on Amazon suggests that one can purchase a basic T-shirt for under $10, with hundreds if not thousands of choices. Significant competition among many producers means that prices are low. This suggests a relatively efficient market. The T-shirt market may also be considered fair, as virtually anyone in the United States who wants a T-shirt can afford one. Another, more difficult, equity issue is the working conditions of the workers making the T-shirts. The environmental impacts of a T-shirt may also be difficult to assess, as it depends on the materials used, how far it is transported, whether it is dyed, etc. We will consider this exact issue in Chapter 8. But overall, there is limited government involvement in the T-shirt market in the United States and we may reasonably suggest that this market could be classified in the first category, even though some may argue that more government regulation is needed to ensure fairness and sustainability.

As an example of a good that might be classified in the second category, consider the market for gasoline in Europe. While gasoline is provided by private companies in European markets, it is heavily taxed to account for its environmental impacts. Gasoline taxes in European countries are typically $3–$4 per gallon.[27] As we will see in Chapter 12, unregulated gasoline market outcomes are both inefficient and unsustainable.

Finally, what goods and services would fall into the third category? Some are rather obvious, such as national defense and major highways—which are nearly always provided by governments rather than private markets.

- American drivers have become more dependent on their vehicles over time. In particular, an increase in suburban development has increased the travel distances between where people live and where they work and shop. Thus alternatives such as walking and biking are less viable now than in the past.
- As incomes have increased over time, gasoline purchases comprise a smaller share of overall expenses. Thus consumers may be less responsive to increases in gas prices.
- Vehicles have become more fuel efficient over time. Consumers with relatively fuelefficient vehicles may be less responsive to gas price increases.

The authors conclude that attempts to achieve major reductions in gas consumption and greenhouse gas emissions by increasing gas taxes are likely to be ineffective. Instead, they suggest that higher fuel economy standards for new vehicles are likely to be both more effective and more politically acceptable.

A 2013 article also found that the demand for gasoline is very price inelastic, but that the elasticity increased slightly during the 2008–2012 period.[8] This makes sense, as during an economic downturn, such as the relatively high-unemployment years from 2008–2012, people are likely to be more sensitive to price changes than when the economy is booming.

Not all economists agree with the conclusion that the demand for gasoline has become highly price inelastic in recent years. A 2016 paper that relied upon detailed daily data on gasoline purchases (as opposed to weekly or monthly data in previous studies) concluded that the elasticity of demand is around -0.30, and that previous estimates were biased in favor of underestimating the elasticity.[9] Thus they suggest that gasoline taxes may be an effective means to reduce greenhouse gas emissions.

Going back to our MBTA example, what did the agency estimate for the elasticity of demand for public transportation? The MBTA obtained elasticity estimates based on analysis of the impacts of previous fare increases. It estimated separate elasticity values for different types of public transportation, such as buses, subways, and commuter trains. Moreover, it differentiated between riders who purchase monthly passes and those who pay for each ride.

As one example, the MBTA estimated that the elasticity of demand for commuter rail passengers with monthly passes was about -0.10 but for "single-fare" riders of the commuter trains it was -0.20. In either case, demand is inelastic, meaning that MBTA revenues would increase with a fare increase. But why would demand be relatively more inelastic for those with monthly passes? A likely explanation is that those with monthly passes use the commuter trains for daily transportation to their workplace. Although car travel is a potential alternative, the cost of parking and the hassle of traffic jams may make the commuter rail a better choice, even with a modest fare increase. Alternatively, single-fare riders may only take the commuter train occasionally, for work or pleasure, and might have viable transportation alternatives or decide just to stay home.

The MBTA also estimated that subway and bus demand would be less elastic for students than nonstudents. Again, this seems a reasonable result, given that students are less likely to have their own vehicles as a transportation alternative. Similarly, subway and bus demand was less elastic for seniors than for other adults.

Overall, the MBTA implemented a 9 percent increase in its fares, and estimated that ridership would decline by about 2 percent. How accurate was the MBTA's prediction? It turned out that in the immediate months after the fare increase, overall ridership actually increased slightly![10] Does this result refute the basic inverse relationship between price and quantity demanded? Not necessarily. Remember, elasticity only estimates movement along a demand curve. The increase in ridership after the fare increase may have been the result of an increase in demand (i.e., a shift in the demand curve), which more than offset a decrease in the quantity demanded as a result of the fare increase. The increase in demand may have been due to improving economic conditions, an increase in gas prices, the weather, or some other factor. It may also suggest that the actual

For many nonessential goods for which substitutes exist, the issue of vulnerability may seem relatively unimportant. But vulnerability is a more serious issue at the national or international level when the goods in question are resources such as oil, minerals, food, or water, the lack of which would seriously weaken an economy or country. In the United States, for example, some of the same people who argue for "free trade" in most goods also argue for increased development of domestic energy resources, on grounds that excessive reliance on petroleum imports decreases economic self-sufficiency and military preparedness.

Vulnerability is also a serious issue for countries that rely heavily on sales of a single, or a few, export goods for much of their national income. In Ethiopia, for example, producing coffee currently accounts for about one-quarter of the country's exports, employing 16 percent of the country's population. The Ethiopian economy has been impacted when coffee prices have declined significantly, as in 2011 and 2015. Even more threatening is the impact of climate change. A 2017 analysis finds that climate change could reduce Ethiopia's coffee growing area 40–60 percent by the end of the century.[10]

A similar problem with specialization is that it may lock a country into a production pattern that eventually becomes inefficient, making change difficult. Consider Ethiopia again. Currently Ethiopia may have a strong comparative advantage in coffee production, so it makes sense for Ethiopia to specialize in it now. But there is a danger that Ethiopia may become "locked in" to a focus on coffee production even when better opportunities arise in the future. A country should not over-specialize in what it does well today if doing so prevents it from developing its future potential in other, more rewarding, pursuits. For example, at some point Ethiopia may be better off switching to specialization in textile production or electronics instead of coffee.

Although the "gains from trade" argument appears logically correct, the benefits of specialization and trade must therefore be weighed against the costs. Diversification, rather than specialization, can increase national security, economic stability, and ecological diversity. Thus a decision to not rely on trade for certain important goods and services may be better than pure specialization.

3.2 Power Differentials

Our simple story of England and Portugal also ignored the real-world political context of international trade. While trade is voluntary, that does not mean that all trading partners have equal power. In our trade example, England obtained 100 cases of wine from Portugal in exchange for 100 bolts of cloth. But what if England was more powerful and could demand different terms, more in its own favor? England might have such a power advantage if it were the only seller of cloth or the only buyer of wine, or through its military might, or through controlling important financial institutions or access to technology.

Whatever the source of its power, suppose England were to demand that Portugal give it 100 cases of wine in exchange for only 60 bolts of cloth instead of 100. With this trade, Portugal would end up consuming 100 cases of wine (after trading 100 cases to England) and 60 bolts of cloth. Referring to Figure 6.1, Portugal would still end up consuming outside its domestic PPF, but only slightly. Meanwhile, England would end up with nearly all the gains from trade. (Note that if England offered only 50 bolts of cloth or less, Portugal would not want to trade, because it could do at least as well on its own.)

3.3 Trade and the Environment

Our simple model of trade between England and Portugal did not consider how trade impacts the environment. Suppose that there are environmental damages, such as soil erosion and industrial pollution, that result from the production of wine and cloth—negative externalities, as we discussed in Chapter 1. The overall effect of trade

between England and Portugal was expanded production of both goods, which would imply an increase in environmental externalities as well. Our model unambiguously demonstrated that both England and Portugal end up better off as a result of trade. This model can be extended to include the impacts of environmental externalities. While we don't present that model here, it shows that when we include externalities the net benefits of trade become ambiguous.[11] In other words, when we also consider the costs associated with environmental damages, it isn't always clear that both countries end up better off as a result of trade. For example, expanded grape production in Portugal when it trades with England may result in severe soil erosion, wildlife habitat loss, and toxic chemical runoff. These damages may be so large that they fully offset the economic gains of trade to Portugal.

Another environmental concern is that countries seeking to compete with other nations for export markets or to attract foreign investors may lower environmental standards to gain a cost advantage. This is often referred to as the "**race to the bottom**" hypothesis, where a country lowers environmental, labor, or social standards. For example, a country may not set or enforce laws regarding pollution control or child labor in order to gain a competitive advantage.

race to the bottom: a situation in which countries or regions compete in providing low-cost business environments, resulting in deterioration in labor, environmental, or safety standards

With regard to environmental impacts, the evidence for the race to the bottom hypothesis is mixed. Using data from over 100 countries a 2006 paper looked at whether private firms adopted voluntary environmental standards stricter than the national standards.[12] According to the race to the bottom hypothesis, firms should be less likely to adopt stricter standards if they were more dependent on export markets. However, the study found the opposite effect—that firms heavily reliant on exports were actually more likely to adopt strict voluntary environmental standards. But other research has supported the hypothesis, such as a 2015 paper that concluded that an increasing amount of toxic waste is being directed toward developing nations as a result of globalization.[13]

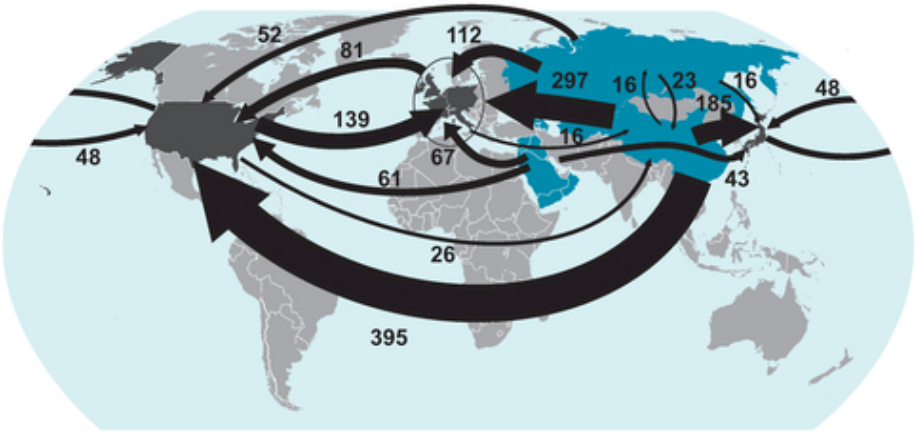
A third way global trade is related to the environment is that the transportation of goods around the world by land, air, and sea results in higher pollution than local production and consumption, ceteris paribus. According to the OECD, the most significant environmental impact of expanded global trade is higher emissions of carbon dioxide (CO_2), the main greenhouse gas.[14] Consider that 2–4 percent of global fossil fuel use is for ocean shipping. Air shipping results in the highest CO_2 emissions per ton of freight,[15] and about 40 percent of world trade is now shipped by air. The OECD notes that a 1 percent increase in trade leads to a 0.6 percent increase in CO_2 emissions for the average country.

A final linkage between trade and the environment is that global trade shifts the burden of pollution, in general from developed to developing countries. This is often referred to as "**exporting pollution**," whereby a country reduces its domestic manufacturing and associated pollution, becoming more dependent on imports manufactured elsewhere (normally in poorer countries), resulting in pollution in those countries instead. If we only look at pollution data from the country that exports its pollution, we may conclude that its emissions are declining. But when we also consider the pollution associated with the country's demand for imports, the story may be quite different.

exporting pollution: a situation in which a country reduces its domestic pollution, but increases its imports of products that cause similar pollution in other countries

In considering the impacts of carbon dioxide, it doesn't matter where it is emitted, as CO_2 is a global pollutant that contributes the same amount to climate change regardless of its country of origin. But the distinction is important when we want to track each country's responsibility for CO_2 emissions. In other words, who is responsible for CO_2 emissions—the country that directly emits it or the country that ultimately consumes the products associated with the emissions?

Scientists have estimated the trade flows of CO_2 emissions "embodied" in trade, shown in Figure 6.3. Countries colored in blue are responsible for less pollution than official statistics indicate when we account for exported emissions. The dark gray areas (the United States, Europe, and Japan) are responsible for more emissions than official statistics indicate when we account for exported pollution. We see that the largest flow is from China to the United States, meaning that about 400 million tons of CO_2 emitted in China each year is a result of demand in the United States for Chinese imports. The second-largest flow is from China to Europe. Flows from the Middle East mostly reflect the demand for oil imports.



■ ***Figure 6.3*** *Exported Carbon Dioxide Emissions*
Source: Davis and Caldeira, 2010.
Note: Values are in million metric tons of CO_2/year. Carbon flows to and from Western Europe are aggregated to include the United Kingdom, France, Germany, Switzerland, Italy, Spain, Luxembourg, the Netherlands, and Sweden.

For local pollutants, exporting pollution essentially shifts the negative impacts of these air and water pollutants to other countries. For example, a 2006 study found that 36 percent of the sulfur dioxide and 27 percent of the nitrogen oxides (both air pollutants harmful to human health) emitted in China were associated with the production of goods for export.[16] A 2017 study published in the journal *Nature* looked at how trade has shifted human mortality as a result of air pollution.[17] The study concluded that about 760,000 deaths each year, 22 percent of the global total deaths from air pollution, occur as a result of the production of goods and services that are consumed elsewhere. Consumption in Western Europe and the United States is linked to over 100,000 deaths each year in China alone. The study also found some evidence of a race to the bottom effect, and recommended international efforts to reduce air pollution in developing countries:

> [T]here is some evidence that . . . polluting industries have tended to migrate to regions with more permissive environmental regulations, suggesting that there may be tension between efforts to improve air quality in a given region and to attract direct foreign investment. Improving pollution control technologies in China, India and elsewhere in Asia would have a disproportionately large health benefit in those regions and worldwide, and international cooperation to support such pollution abatement efforts and to reduce 'leakage' of emission via international trade is in the global interest.[18]

the 2013 model year. While the previous labels provided information on expected fuel economy in miles per gallon, the revised labels also indicate how much money you'll save, or how much extra you'll spend, over five years in fuel costs compared to the average new vehicle. Clearly, this change makes buyers more aware of the monetary benefits of choosing an efficient vehicle. In the case of electric vehicles, one can save about $10,000 in fuel costs over five years compared to the average new vehicle. Without the sticker, potential buyers might well be unaware of these substantial savings.

The country that has made the most extensive use of behavioral economics in designing government policies is the United Kingdom. In 2010 the UK government set up the Behavioural Insights Team, commonly known as the "Nudge Unit," with the objectives of "improving outcomes by introducing a more realistic model of human behaviour to policy" and "enabling people to make 'better choices for themselves'."[27]

One of the issues studied by the Nudge Unit has been ways to reduce rates of tax evasion.[28] To encourage people to pay their taxes on time, they experimented with various versions of a reminder letter sent to people who had not yet paid their taxes. Making the letter as simple as possible did not significantly affect response rates. However, response rates nearly doubled when people were reminded of social norms such as "9 out of 10 people pay their taxes on time." This illustrates that people's behavior can be influenced when they are nudged to think of themselves in comparison to others.

In another study, the Nudge Unit studied ways to increase the proportion of young people from less advantaged backgrounds that apply to highly selective universities.[29] Some potential students were sent a letter from a current student enrolled at a prestigious university, also from a disadvantaged background, which emphasized the availability of government funding opportunities that can actually make more selective universities cheaper for students from low-income families than less selective universities. This letter significantly increased application rates to highly selective universities, compared to a group of students that received standard information about financial aid. Apparently, the letter encouraged students to have higher aspirations knowing that someone like them was able to enroll in a prestigious university, demonstrating the power of availability heuristics, discussed earlier in the chapter.

Insights from behavioral economics are also being increasingly applied to issues in developing countries. In 2015 the World Bank devoted its annual World Development Report to the topic of behavioral economics, stating that:

> In recent decades, research on decision making has cast doubt on the extent to which people make choices in [rational] ways. Novel policies based on a more accurate understanding of how people actually think and behave have shown great promise, especially for addressing some of the most difficult development challenges, such as increasing productivity, breaking the cycle of poverty from one generation to the next, and acting on climate change.[30]

Nudges appear to be even more important in developing countries because research shows that poverty imposes a "cognitive tax" on people, meaning that poverty induces stresses which hamper good decision making. For example, one study found that when farmers in India were under financial stress their cognitive scores, using IQ tests, significantly declined. And while people of all income levels tend to suffer from present bias, this problem is even more severe among poor people, who often must direct all their physical and mental resources toward present needs.

Numerous creative experiments have shown how behavioral economics can be used to design policies that address development challenges. In one study, researchers looked at ways to increase savings rates among construction workers in India who are paid weekly in cash handed to them in an envelope. Some workers were instead paid with the same total amount of cash but in two separate envelopes, with one marked as "savings." In principle, nothing prevented the workers from taking the money out of the two envelopes and disregarding the implication that a specific amount of their income should be set aside as savings. However, the results showed that the savings envelope increased savings by 39–216 percent! This illustrates the effect of anchoring—the

T-shirts, along with jeans, are perhaps the most ubiquitous articles of clothing on college campuses. What is the environmental impact of each of these T-shirts?[42]

Consider a T-shirt constructed of a cotton/polyester blend, weighing about four ounces. Polyester is made from petroleum—a few tablespoons are required to make a T-shirt. During the extraction and refining of the petroleum, one-fourth of the polyester's weight is released in air pollution, including nitrogen oxides, particulates, carbon monoxide, and heavy metals. About *10 times* the polyester's weight is released in carbon dioxide, contributing to global climate change.

Cotton grown with nonorganic methods relies heavily on chemical inputs. Cotton accounts for 10 percent of the world's use of pesticides. A typical cotton crop requires six applications of pesticides, commonly organophosphates that can damage the central nervous system. Cotton is also one of the most intensely irrigated crops in the world.

T-shirt fabric is bleached and dyed with chemicals including chlorine, chromium, and formaldehyde. Cotton resists coloring, so about one-third of the dye may be carried off in the waste stream. Most T-shirts are manufactured in Asia and then shipped by boat to their destination, with further transportation by train and truck. Each transportation step involves the release of additional air pollution and carbon dioxide.

Despite the impacts of T-shirt production and distribution, most of the environmental impact associated with T-shirts occurs *after purchase.* Washing and drying a T-shirt just 10 times requires about as much energy as was needed to manufacture the shirt. Laundering will also generate more solid waste than the production of the shirt, mainly from sewage sludge and detergent packaging.

How can one reduce the environmental impacts of T-shirts? One obvious step is to avoid buying too many shirts in the first place. Buy shirts made of organic cotton or recycled polyester or consider buying used clothing. Wash clothes only when they need washing, not necessarily every time you wear something. Make sure that you wash only full loads of laundry and wash using cold water whenever possible. Finally, avoid using a clothes dryer—clothes dry naturally for free by hanging on a clothesline or a drying rack.

4.1 The Link Between Consumption and the Environment

In quantifying the ecological impacts of consumerism, most people focus on the amount of "trash" generated by households and businesses. In 2014, the U.S. economy generated over 250 million tons of municipal solid waste, which consisted mostly of paper, food waste, and yard waste. Although the total amount of municipal solid waste generated has increased in recent decades (an increase of nearly 200 percent since 1960), the portion recycled has increased from around 6 percent in the 1960s to about 35 percent today.[43]

But most of the waste generation in a consumer society occurs during the extraction, processing, or manufacturing stages—these impacts are normally hidden from consumers. According to a 2012 analysis, the U.S. economy requires about 8 billion tons of material inputs annually, which is equivalent to more than *25 tons per person.*[44] The vast majority of this material is discarded as mining waste, crop residue, logging waste, chemical runoff, and other waste prior to the consumption stage.

Perhaps the most comprehensive attempt to quantify the overall ecological impact of consumption is the **ecological footprint** measure. This approach estimates how much land area a human society requires to provide all that it takes from nature and to absorb its waste and pollution. Although the details of the ecological footprint calculations are subject to debate, it does provide a useful way to compare the overall ecological impact of consumption in different countries.

Flexible Work Hours

One specific policy to reduce the pressure toward consumerism is to allow for more flexibility in working hours. Current employment norms, particularly in the United States, create a strong incentive for full-time employment, if available. Employees typically have the option of seeking either a full-time job, with decent pay and fringe benefits, or a part-time job with lower hourly pay and perhaps no benefits at all. Thus even those who would prefer to work less than full-time and make a somewhat lower salary, say in order to spend more time with their family, in school, or in other activities, may feel the imperative to seek full-time employment. With a full-time job, working longer hours with higher stress, one may be more likely to engage in "retail therapy" as compensation.

Europe is leading the way in instituting policies that allow flexible working arrangements. Legislation in Germany and the Netherlands gives workers the right to reduce their work hours, with a comparable reduction in pay.[64] An employer can only refuse such requests if it can demonstrate that the reduction will impose serious hardship on the firm. A Dutch law also prohibits discrimination between full-time and part-time employees regarding hourly pay, benefits, and advancement opportunities. Some government policies encourage part-time employment particularly for parents, such as a Swedish law that gives parents the right to work three-quarter time until their children are eight years old. Norwegian parents also have the right to work part-time or combine periods of work with periods of parental leave.

Such policies encourage "time affluence" instead of material affluence. Economist Juliet Schor argues that policies to allow for shorter work hours are also one of the most effective ways to address environmental problems such as climate change.[65] Those who voluntarily decide to work shorter hours will be likely to consume less and thus have a smaller ecological footprint.

Advertising Regulations

A second policy approach is to focus on the regulation of advertising. Government regulations in most countries already restrict the content and types of ads that are allowed, such as the prohibition of cigarette advertising on television in the United States. Additional regulations could expand truth-in-advertising laws, ensuring that all claims made in ads are valid. For example, laws in the United States already restrict what foods can be labeled "low fat" or "organic."

Children are particularly susceptible to advertising, as they generally cannot differentiate between entertainment and an ad intended to influence consumers. Again, European regulations are leading the way. Sweden and Norway have banned all advertising targeted at children under 12 years old. Regulations in Germany and Belgium prohibit commercials during children's TV shows. At least eight countries, including India, Mexico, France, and Japan have instituted policies to limit children's exposure to junk food ads.[66]

Another option is to change the tax regulations regarding advertising expenditures. In the United States, companies are generally able to fully deduct all advertising costs. Restricting the amount of this tax deduction (or eliminating the deduction entirely) would create an incentive for companies to reduce their advertising.

Consumption Taxation

Economics tell us that one of the ways to reduce the extent of any activity is to tax it. Taxes on foods considered unhealthy are increasingly common. One common target is sugary drinks—taxes on such drinks (including carbonated soft drinks, sports drinks, and energy drinks) have been implemented in several countries including

There is also a considerable imbalance in education, both nationally and internationally. Children in Australia can expect to receive, on average, about 20 years of schooling—the most years of any country. Meanwhile, the average for children in the sub-Saharan countries of Niger, Chad, and the Central African Republic is less than eight years of education.[4] Inequalities arise not only due to income differences, but also due to race and gender. In the United States, the difference in academic achievement between white and black students has decreased significantly in recent decades but still remains evident. However, the achievement gap between students from low- and high-income families in the United States has dramatically increased.[5] There are mixed results for gender-based educational inequality. By 2016, 24 countries had fully closed the educational gap by gender, while in 17 countries women still had less than 90 percent of the educational outcomes that men have.[6]

Related to both health and education is what Nobel laureate Amartya Sen has famously referred to as "capabilities." By his reckoning, money is only one dimension— albeit an important one—of an individual's "capability" to function in his or her economic environment. To Sen, what matters most is that people possess the necessary tools—including money, health, education, friends, and social connections—to provide them with realistic economic *choices*. As Sen has pointed out, there is considerable inequality of capabilities in the world, not just in the poor countries.

Inequality is also manifest in certain environmental outcomes. Proponents of "environmental justice," point out that polluting industries and toxic waste disposal sites in the United States tend to be located disproportionately near poor and minority communities. This effect is even more pronounced in some developing countries. Oil and gas development in Nigeria by international corporations has resulted in thousands of oil spills that have impoverished local residents due to reduced agricultural production, lower fish harvests, and polluted drinking water.[7] In many developed countries, there are stronger regulations on industrial pollution, but major impacts from oil and chemical spills and other emissions still occur, often affecting lower-income communities.

One also sees considerable inequality when confronting the issue of climate change. Numerous studies find that climate change will hit poor countries the hardest, exacerbating global inequality. Warmer temperatures and changing precipitation patterns in Africa and other developing regions could reduce the growing season and lower yields, leading to a 20 percent global increase in the number of people at risk of hunger by 2050.[8] According to a 2015 analysis in the journal *Nature*, by the end of the twenty-first century climate change will have a significantly higher proportionate impact on incomes in the world's poorest countries.[9] In addition to these specific effects, a critical fact about climate change, as well as other environmental damage, is that the rich can generally protect themselves much better than the poor can.

1.2 Measuring Inequality

While recognizing these various types of inequality, for the purposes of economic analysis we will focus primarily on inequality of income and wealth. The two most common metrics used to measure income inequality are:

1. Measure the income share (percent of all income) held by various groups ordered by income from poorest to richest, such as the bottom 20 percent, the middle 20 percent, the top 1 percent, etc.
2. Measure the overall distribution of income in a society, using mathematical and graphical techniques.

Income Distribution Data

summarize five tax types here:

- *National sales tax:* This tax functions similar to a state sales tax—as an addition to the retail price of certain products. Business-to-business sales are excluded to avoid taxes compounding. Few countries currently rely on national sales taxes, as those countries that have used them in the past converted to value-added taxes (discussed below) instead.[23] The main problem with a national sales tax is evasion—it creates a strong incentive for the emergence of black market exchanges to evade the tax. Another problem with a national sales tax is that it can be highly regressive. A national sales tax could be made less regressive, or even progressive, by providing rebates for low-income households. Eligible households could complete a form at the end of the year to determine their rebate amount.
- *National consumption tax:* This is slightly different from a national sales tax. A household would pay taxes at the end of the year, or through estimated monthly payments, based on the value of its annual consumption of goods and services. Rather than having a household keep track of everything purchased, consumption is calculated as total income less money not spent on goods and services (i.e., invested or saved). A consumption tax would promote savings by exempting it from taxation. A consumption tax could also be designed to be progressive by taxing different levels of consumption at different marginal rates. No country currently has a national consumption tax, and only India and Sri Lanka have implemented one in the past.[24]
- *Value-added tax:* Most developed countries levy some form of value-added tax (VAT). VAT is levied at each stage in the production process of a product, collected from manufacturers according to the value added at each stage. Thus the tax is not added to the retail price but incorporated into the price of the product, similar to the way excise taxes become embedded in the price of products. The advantage of VAT over a national sales or consumption tax is that evasion is more difficult as taxes are collected at each stage in the production process. Every OECD country relies on VAT except the United States. On average, OECD countries collect about one-third of all taxes through VAT.[25] Numerous proposals have been made for some form of sales or value-added tax in the United States, but so far none have come close to implementation.[26]
- *Wealth taxes:* Although the U.S. tax system includes local property taxes and estate taxes, it does not have a tax on holdings of other assets such as corporate stocks, bonds, and personal property. Several European countries, including Italy, Spain, and Switzerland, have instituted an annual wealth tax. A wealth tax can be highly progressive by applying only to very high wealth levels.
- *Environmental taxes:* Such a tax is levied on goods and services in proportion to their environmental impact. One example is a carbon tax, which taxes products based on the carbon emissions attributable to their production or consumption. The rationale of environmental taxation is that it encourages the use and development of goods and services with reduced environmental impacts. Like other taxes on goods and services, environmental taxes can be regressive—suggesting that environmental taxes need to be combined with other progressive taxes or rebates for low-income households. Among developed countries, the United States collects the smallest share of tax revenues from environmental taxes, both as a share of GDP and as a share of total tax revenues. The countries that collect the most in environmental taxes, as a share of all taxes, include India (13 percent of all taxes), Costa Rica (10 percent), South Korea (9 percent), and the Netherlands (9 percent).[27]

Chapter 12
The Economics of the Environment

A 2017 opinion poll asked Americans which should be given the higher priority: economic growth or protecting the environment.[1] By 56 percent to 35 percent, more people thought that environmental protection should be given the higher priority. But the way that this survey question was formulated assumes that a tradeoff necessarily exists between economic and environmental goals. For example, we often hear from politicians and media pundits that environmental regulations lead to job losses and hamper economic growth. But is this characterization of a tradeoff accurate?

Environmental issues are certainly not separate from economics. Poor environmental quality affects important aspects of well-being. Deteriorating environmental conditions can create serious health problems, as well as reduce the quantity and quality of natural resources that contribute to productivity. Climate change is an example of environmental damage that is imposing economic costs on people in many countries, such as the damages from hurricanes. Although no individual weather event can be linked conclusively to global climate change, more "extreme weather events" are likely to result from a global buildup of carbon dioxide (CO_2) and other greenhouse gases that contribute to planetary warming.

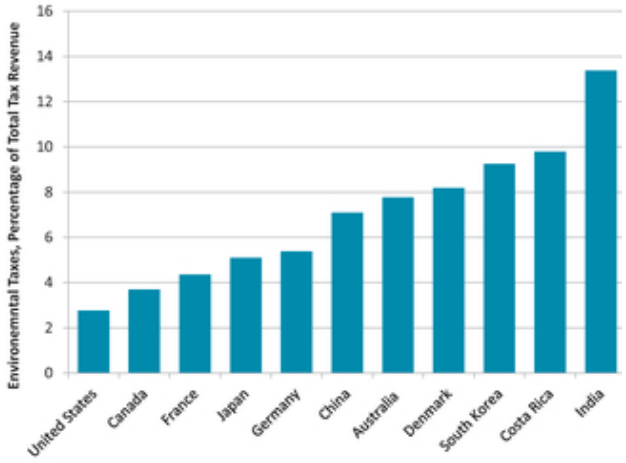
Because improvements in environmental quality enhance most people's wellbeing, economists often favor environmental protections (despite common views that economists don't care about the environment). Further, economics has subdisciplines focused on environmental issues, including environmental economics, natural resource economics, and ecological economics. The Nobel Prize-winning economist Paul Krugman has written that:

> my unscientific impression is that economists are on average more proenvironment than other people of similar incomes and backgrounds. Why? Because standard economic theory automatically predisposes those who believe in it to favor strong environmental protection.[2]

In this chapter and Chapter 13, we summarize how to use insights from economics to better manage our shared environment. Among other things, we find that environmental concerns often present a valid justification for government intervention in markets. Recall from our study of welfare analysis in Chapter 5 that under certain assumptions government intervention decreases economic efficiency. But in this chapter, we will see important examples where this is not the case. Instead, when economic production and consumption cause negative environmental impacts, government intervention can actually increase economic efficiency.

We also discuss the environmental policy tools that economists have developed to address environmental problems, and the ways in which economists express the value of the environment in monetary terms. Economics, indeed, can be the most effective tool for environmental protection. As one commentator put it:

> If you want to fight for the environment, don't hug a tree, hug an economist. Hug the economist who tells you that fossil fuels are not only the third most heavily subsidized economic sector after road transportation and agriculture but that they also promote vast inefficiencies. Hug the economist who tells you that the most efficient investment of a dollar is not in fossil fuels but in renewable energy sources that not only provide new jobs but cost less over time. Hug the economist who tells you that the price system matters; it's potentially the most potent tool of all for creating social change.[3]



■ ***Figure 12.4*** *Environmental Taxes as a Percentage of Total Tax Revenue, Select Countries, 2014*
Source: OECD, Environmental Taxation, http://www.oecd.org/env/tools-evaluation/environmentaltaxation.htm.

revenue-neutral (taxes): offsetting any tax increases with decreases in other taxes such that overall tax collections remain constant

In addition to higher economic efficiency, a broad shift away from taxes on income and toward taxes on negative externalities also provides people with more options to reduce their tax burden. If environmental taxes constituted a large portion of someone's total tax burden, he or she could reduce this burden by using more efficient vehicles and appliances, relying more on public transportation, reducing energy use, and numerous other options. Of course, that is not always easy to do; one example is someone whose job requires a long commute in a location in which public transportation is not available. In such a case, it becomes necessary for government involvement to go beyond taxes and subsidies, to take into account the social infrastructure and institutions that will allow people—especially those whose financial resources limit their options—to respond without undue pain to the signals given by a market that has been shifted toward greater environmental responsibility.

Despite the economic logic supporting taxes on negative externalities, many environmentally damaging activities, including fossil fuel production, mining minerals, and harvesting timber, are actually subsidized instead of taxed (see Box 12.1). Obviously, this results in production and pollution levels that are not optimal. From an economic point of view, these subsidies are perverse—that is, they encourage exactly those activities that we should be seeking to discourage.

Box 12.1 Fossil Fuel Subsidies

Fossil fuels are subsidized by governments around the world in numerous explicit and implicit ways. Beyond reducing suppliers' production costs through direct subsidies, implicit subsidies include the failure to institute appropriate Pigovian taxes on fossil fuels for air pollution and climate change damages. According to a comprehensive 2017 journal article, global fossil fuel subsidies were $5.3 trillion in 2015, equal to 6.5 percent of global GDP.[4]

About half of total subsidies were attributed to a failure to internalize the externalities associated with local air pollution. Another 22 percent of subsidies were related to global climate change externalities. The analysis found that coal subsidies were larger than oil and natural gas subsidies combined. Among countries, China's annual subsidy was the largest at nearly $2 trillion, while the United States had the second-largest subsidy, around $0.6 trillion.

The authors conclude that the economic and environmental benefits of eliminating perverse fossil fuel subsidies are significant:

> The gains for subsidy reform are substantial and diverse: getting energy prices right (i.e., replacing current energy prices with prices fully reflecting supply and environmental costs) would have reduced global carbon emissions in 2013 by 21 percent and fuel-related air pollution deaths by 55 percent, while raising extra revenue of 4 percent of global GDP and raising social welfare by 2.2 percent of global GDP.[5]

2. Valuing the Environment

In order to set a Pigovian tax at the correct level, we need to estimate negative externality damages in monetary terms. Environmental damages include such diverse effects as reduced air and water quality, biodiversity loss, human health impacts, and lost recreation opportunities. Economists have developed various techniques to estimate environmental values. We summarize some of these methods below, but first we address the conceptual approach used to measure the value of the environment.

2.1 Total Economic Value

In a broad sense, everyone "values" the environment. All life depends on various natural systems, including those that process waste and provide energy. But to an economist, the term "value" has a specific meaning. The **willingness-to-pay (WTP) principle** states that something has economic value only according to the maximum amount that people are willing to pay for it. Note that this principle represents an extension of the market concept of marginal benefits. As discussed in Chapter 5, a demand curve is made up of points that indicate the maximum willingness to pay of consumers for a good or service. Although most environmental attributes are not traded in markets, people may still place significant value on them (i.e., be willing to pay to protect or enhance them).

willingness-to-pay (WTP) principle: the economic value of something, such as an environmental benefit, is equal to the maximum amount people are willing to pay for it

The aggregate social value of something is the sum of each individual's WTP. Although each individual's preferences count in this framework, it is also important to recognize that ability to pay varies across individuals. Thus instead of a "one person, one vote" approach, the WTP principle translates to "one dollar, one vote."

Another implication of the WTP principle is that if no one is willing to pay to preserve something, then it does not have economic value. So the economic value of an endangered insect species in a remote forest, which has no obvious human uses, may well be zero. However, some economists believe that nature has certain inherent rights apart from any human economic values. In particular, even if the WTP to preserve a species is zero, the species could still be said to have **intrinsic value**, or value in a broader ecological or ethical sense, and thus have a right to exist.[6] Intrinsic value is especially difficult to express in monetary terms.

intrinsic value: the value of something in an ecological or ethical sense, apart from any economic value based on willingness to pay

People's willingness to pay for environmental attributes may derive from a variety of motivations. Potential reasons for valuing the environment include:

1. *Profit-making enterprises:* activities such as harvesting timber, fishing, grazing, and agriculture depend on natural systems.
2. *Recreation:* natural sites provide places for outdoor recreation, including camping, hiking, fishing, hunting, and viewing wildlife.
3. **Ecosystem services**: tangible benefits obtained freely from nature, as a result of natural processes. Ecosystem services include nutrient recycling, flood protection from wetlands and vegetation, waste assimilation, carbon storage in trees and other plants, water purification, and pollination by bees.
4. **Nonuse benefits**: nontangible welfare benefits that we obtain from nature. Nonuse benefits include the psychological benefits that people gain just from knowing that natural places exist, even if they will never visit them. The value that people gain from knowing that ecosystems will be available to future generations is another type of nonuse benefit.

ecosystem services: tangible benefits that humans obtain from natural processes, such as nutrient recycling, flood control, and pollination

nonuse benefits: nontangible welfare benefits that people derive from ecosystems without physical interaction (i.e., psychological benefits)

The **total economic value** of a natural system is the sum of all the benefits for which people are willing to pay. Thus the total economic value of, for example, a national forest is the sum of any profits obtained from harvesting timber, the WTP of all those who engage in recreation in the forest, the value of the ecosystem services such as soil erosion prevention and carbon storage, and the nonuse benefits that people obtain from knowing that the forest exists and is protected. It is important to realize that in calculating total economic value, priority is not given to any particular use of the forest. When uses are incompatible, such as deciding whether a particular tract of forest should be clear cut or preserved for recreation and wildlife habitat, economic analysis can determine which use provides the highest overall economic value to society.

Although markets do not exist for many environmental goods and services, we can sometimes infer the values that people place on them through their behavior in other markets. **Revealed preference methods** are techniques that obtain nonmarket values based on people's decisions in related markets. Economists generally prefer deriving nonmarket values based on actual market behavior. Thus revealed preference methods are generally considered the most reliable approach to nonmarket valuation from an economic point of view. However, the environmental benefits for which revealed preference methods can be used to provide nonmarket values are limited.

revealed preference methods: valuation techniques that infer the value of nonmarket goods and services based on people's decisions in related markets

One common revealed preference method is **travel cost models**. These models are used to estimate the economic benefits that people obtain by engaging in recreation at natural sites such as national parks or lakes. Even if the recreation site does not charge an entry fee, all visitors must pay a "price" equal to their costs to travel to the site, such as gas, plane tickets, accommodations, and even the time required to travel to the site. As visitors to a recreation site from different regions effectively pay a different travel price, economists can use this information to derive a demand curve for the site using statistical models, and thus estimate consumer surplus. Travel cost models are most applicable for recreation sites that attract visitors from distant places, in order to provide enough variation in travel costs to estimate a demand curve.

travel cost models: a revealed preference method used to obtain estimates of the recreation benefits of natural sites based on variations in the travel costs paid by visitors from different regions

Numerous travel cost models have estimated the recreational benefits of natural sites. For example, a study of recreational visitors to the Murray River in Australia found that the average visitor received a consumer surplus of US$155 per day.[8] Another study found that the consumer surplus from visiting a National Park in Greece ranged from US$170 to US$350 per visit.[9] Other travel cost models have been used to explore how changes in fish catch rates affect the consumer surplus of anglers visiting sites in Wisconsin,[10] how a drought affects the benefits of visitors to reservoirs in California,[11] and how climate change will impact recreational benefits in Europe.[12]

Another type of revealed preference method is the **defensive expenditures approach**. This approach is applicable in situations where people are able to take actions to reduce their exposure to environmental harm. For example, people with concerns about their drinking water quality may choose to purchase bottled water or install a water filtration system. These expenditures may reflect their WTP for water quality. For example, a 2006 study in Brazil found that households were paying US$16–$19 per month on defensive expenditures to improve drinking water quality.[13]

defensive expenditures approach: a nonmarket valuation technique that obtains benefit estimates based on the cost of actions that people take to avoid environmental harm

tradable pollution permits: a system of pollution regulation in which a government allocates permits that are required in order to produce pollution. After they are allocated, these permits may be traded among firms or other interested parties

Firms with higher MCR curves (higher marginal costs for pollution reduction) will generally seek to purchase permits so that they do not have to pay high pollution reduction costs. Firms that can reduce pollution at lower marginal costs may be willing to sell permits, as long as they can receive more money for the permits than it would cost them to reduce pollution. Under this system, private groups interested in reducing pollution could purchase permits and simply not use them to emit pollution, thus reducing total emissions below the original target level. Pollution permits are normally valid only for a specific period. After this period expires, the government can issue fewer permits, resulting in lower overall pollution levels in the future.

A detailed analysis of tradable permits, which we do not present here, demonstrates that a given level of pollution reduction is achieved at the same total cost as levying a tax. Thus whether one prefers pollution taxes or tradable permits depends on factors other than pollution reduction costs. One issue is administrative costs, since these may differ for the two approaches. Taxes are generally easier to understand and implement. But taxes are politically unpopular, and firms may prefer to use a permit system if they believe that they can successfully lobby in order to obtain permits for free.

The main difference between the two approaches is where the uncertainty lies. Using pollution taxes, firms have certainty about the cost of emissions, which makes it easier for them to make decisions about long-term investments. But the resulting level of total pollution with a tax is unknown in advance. If pollution levels turn out to be higher than expected, then the government might have to take the unpopular step of raising taxes further.

Under a permit system, the level of pollution is known because the government sets the number of available permits. But the price of permits is unknown, and permit prices can vary significantly over time. This has been the case with the European permit system for carbon emissions. The price of permits initially rose to around €30/ton in 2006, shortly after the system was instituted. But then prices plummeted to €0.10/ton in 2007, when it became evident that too many permits had been allocated. After some changes to the system, prices rose to exceed €20/ton in 2008 but then fell again to less than €3/ton in 2013 before slightly increasing over the last few years. Such price volatility makes it difficult for firms to decide whether they should make investments in technologies to reduce emissions.

3.2 Design and Performance of Environmental Policies

Summary of Major Environmental Policies

Early pollution regulations enacted in the 1960s and 1970s in the United States relied primarily on standards and technology-based approaches. For example, the Clean Air Act, enacted by Congress in 1970, set maximum allowable levels of emissions for several key pollutants. The Clean Air Act specifies that pollution standards are to be set based on the best scientific evidence to protect human health with an "adequate margin of safety" and adjusted over time as new evidence becomes available. The Act specifically rules out CBA as a factor in setting standards.

The Clean Air Act has been very successful at reducing pollution levels in the United States. The aggregate concentration of the six major air pollutants has declined 73 percent between 1970 and 2016.[24] The decline in lead pollution has been particularly dramatic—lead concentrations have declined 99 percent over this same

are less prevalent than in European countries. But the overall negative relationship suggests that higher gasoline taxes can be effective at reducing gasoline consumption, and thus emissions of various air pollutants.

The first major attempt to use a tradable pollution system to control pollution was the U.S. program to regulate sulfur dioxide, enacted with the 1990 Amendments to the Clean Air Act. The goal of the program was to reduce sulfur dioxide emissions to 50 percent of 1980 levels by 2010. The program is widely considered a success, with a decline in emissions of 83 percent by 2010 and costs significantly lower than expected. (For more on this program, see Box 12.3.)

The other major attempt at emissions trading has been the European Union's carbon trading system, enacted in 2005. The initial phase covered major facilities such as electricity plants, cement plants, and paper mills. In 2012 the program was extended to cover airline transportation. As mentioned earlier, the main problem with the program has been price volatility, generally attributed to an over-allocation of permits during the initial phases. In the current phase (2013–2020) the European Union is moving toward setting an overall EU emission limit rather than individual national limits.

Box 12.3 Sulfur Dioxide Emissions Trading in the United States

The 1990 Clean Air Act Amendments in the United States created a national program to allow trading and banking of sulfur dioxide (SO_2) emissions, the primary cause of acid rain. The program applies to more than 2,000 large electricity plants, which must hold permits in order to emit SO_2. Most permits are freely allocated to plants based on their capacity to generate electricity. About 3 percent of the permits are auctioned off every year. Permits may then be traded, normally with brokers facilitating trades. Although most trades occur between two electricity-generating plants, some permits are purchased by environmental groups or individuals (and even economics classes!) and then "retired" to reduce the overall quantity of SO_2 emissions.

Economic theory suggests that a system of tradable permits can reduce pollution at a lower overall cost than a uniform standard. Dallas Burtraw, an economist with Resources for the Future, notes that the "SO_2 allowance market presents the first real test of economists' advice, and therefore merits careful evaluation."[28] After more than 20 years in operation, how has the program performed?

To evaluate the policy, the effects of emissions trading must be isolated from other factors. Even without a trading system, declining prices for low-sulfur coal in the 1990s, along with technological advances, would have reduced the cost of lowering emissions. Economic simulation models comparing the SO_2 program to an emissions standard suggest that the cost savings from trading were about 50 percent.[29] The savings are even greater than in a technology-based approach.

The emissions targets of the SO_2 program have been met at a lower cost than originally anticipated. Acidification problems in the Northeastern states, widespread in the past, have declined. However, aquatic systems in the Southeastern states are expected to continue to decline without further emissions reductions. And although the program has been effective, analysis of the marginal benefits and marginal costs of emissions suggests that further emissions reductions would produce even larger net benefits.

Burtraw, along with colleague Sarah Jo Szambelan, concludes that the SO_2 market has

> been liquid and active, and according to most observers [has] worked well in achieving the emissions caps at less cost than would have been achieved with traditional approaches to regulation. There is evidence that both process and patentable types of innovation are attributable to the [SO_2 program]. At the same time, there is evidence that some cost savings have not been realized. Moreover, despite substantial emissions reductions, ultimate environmental goals have not been achieved.[30]

The Economic Impact of Environmental Regulation

Finally, we briefly consider the economic impact of environmental regulations. Environmental laws are often accused of slowing economic growth and causing job losses. However, most of the evidence suggests that the notion of a tradeoff between environmental quality and economic vitality is a myth. For example, a 2008 analysis of the U.S. economy found that "contrary to conventional wisdom, [environmental protection (EP)], economic growth, and jobs creation are complementary and compatible: Investments in EP create jobs and displace jobs, but the net effect on employment is positive."[31]

A 2009 review of the literature on the relationship between environmental policies and employment reached the conclusion that strong environmental policies will change the distribution of jobs in society but have little effect on the overall level of employment.[32] Focused on Europe, the study found that well-designed environmental policies can result in net job gains. For example, the additional revenue from higher environmental taxes could be used to reduce the taxes on labor, thus reducing the cost of hiring workers and lead to higher overall employment.

A similar conclusion was reached by a 2016 analysis which estimated the employment impacts of various potential policies to reduce carbon emissions in the United States.[33] For each policy analyzed, the authors' model predicted that job losses in "dirty" sectors such as coal mining were essentially offset by job gains in cleaner sectors such as renewable energy. They concluded that the "overall effects on unemployment should not be a substantial factor in the evaluation of environmental policy" because the net effects are likely to be quite small.

Under various executive orders in the United States, starting with Ronald Reagan and more recently Barack Obama, all major federal regulations, including environmental laws, must be reviewed using CBA. This process is designed to screen out inefficient policy proposals. A 2016 study by the U.S. Office of Management and Budget found that the aggregate cost of all federal environmental regulations enacted by the U.S. Environmental Protection Agency from 2005 to 2015 was $43 billion–$51 billion, but benefits were estimated to be $135 billion–$523 billion.[34] In other words, benefits exceeded costs by a factor of 3–10 times. During this period, environmental laws were responsible for the majority of the net benefits of all federal regulations.

Analysis by the United Nations concludes that a significant increase in global investment in renewable energy and energy efficiency—an amount equal to 2 percent of global GDP—would result in higher rates of long-term economic growth than a "business-as-usual" scenario.[35] The report finds that "green" investments benefit the world's poorest in particular. The poor disproportionately depend on natural resources for their livelihood. So investment in natural capital, including water resources, sustainable agriculture, and forests, reduces global poverty while also improving the natural environment. Investment in natural capital also fosters ecotourism, which offers another way to increase incomes in developing countries.

We have seen in this chapter that a strong *economic* case can be made for protecting the natural environment. Given existing market failures, especially those arising from externalities, government intervention is not only justified; it is necessary to achieve an efficient outcome. Nature has significant economic value, and techniques have been devised to measure these values. Despite common perceptions, environmental regulations are generally effective and do not harm economic vitality. Economic research suggests that we need more, not less, environmental regulation.

In Chapter 13, we turn to additional theoretical insights from economics on environmental management. We also focus on the issue of global climate change, one of the major challenges of the twenty-first century.

Review Questions

for socially beneficial purposes or for lowering taxes. Do you think that some public lands should be sold to private interests?

2. Consider the provision levels of the following public goods in society: national defense, public education, environmental quality, and highways. Do you think that the current "supply" of each of these goods is too high, too low, or about right? What factors do you think determine the amount of resources that are allocated toward each of these goods? Do policies need to be changed to adjust the allocation?

5. Climate Change

The issue of global warming, more accurately described as **climate change**,[8] has been called "the greatest market failure the world has ever seen."[9] Developing an adequate policy response to climate change brings together much of our discussion over the last two chapters regarding externalities, environmental issues, and common property resources and public goods. Even further, climate change raises important questions about fairness between rich and poor countries, about the present versus the future, and about how to devise policies in the presence of uncertainty.

> **climate change**: long-term changes in global climate, including warmer temperatures, changing precipitation patterns, more extreme weather events, and rising sea levels

The scientific consensus on climate change is well-established—approximately 97 percent of scientists studying the issue conclude that human emissions of various greenhouse gases, primarily carbon dioxide (CO_2), are significantly impacting the global climate system.[10] According to the National Aeronautics and Space Administration (NASA), 2014, 2015, and 2016 each set a new record for the warmest year on record, and 16 of the 17 warmest years have occurred since 2001.[11]

Climate change has significant economic costs. According to the OECD, the economic damages from climate change are estimated to be between 1.0 percent and 3.3 percent of world economic output by 2060, rising to between 2 percent and 10 percent of global output by 2100.[12] Other research suggests the damages will be even larger—around 10 percent of global output by as soon as 2050 according to the United Nations.[13] But the negative consequences of climate change are already occurring. According to a 2017 report, the damages from climate change are already currently averaging $240 billion per year in the United States, effectively offsetting about 40 percent of the economic growth in the United States.[14] Another study estimated that 400,000 deaths in 2010 were attributable to climate change, primarily as a result of malnutrition and disease, with over 80 percent of those deaths in developing countries.[15]

Policy responses to limit the future damages from climate change need not sacrifice economic vitality. In 2013 the managing director of the International Monetary Fund, Christine Lagarde, called climate change "the greatest economic challenge of the twenty-first century." She went on to say:

> Make no mistake: without concerted action, the very future of our planet is in peril. So we need growth, but we also need green growth that respects environmental sustainability. Good ecology is good economics.[16]

In our analysis of climate change we first explore the data and projections on the topic, then we discuss economic analyses of climate change, and finally we summarize current policy approaches to respond to climate

change and limit its negative impacts.

5.1 Climate Change Data and Projections

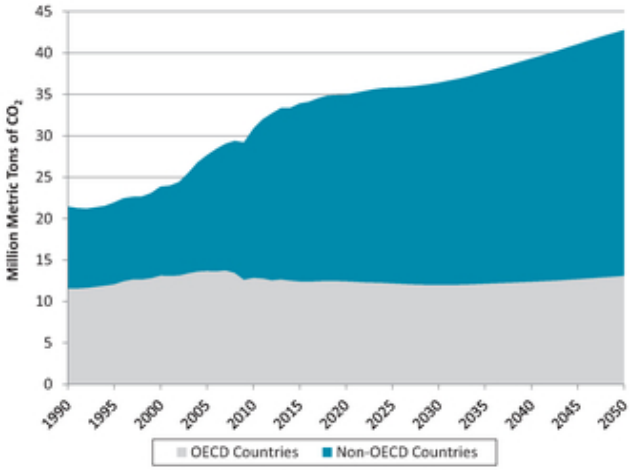
Humans can influence the global climate by the emissions of various **greenhouse gases**. These gases act much like the glass in a greenhouse—allowing solar radiation to penetrate but then trapping it and increasing temperatures. Although various greenhouse gases exist naturally in the earth's atmosphere and make life possible on earth, human activities have increased the concentration of many of these gases and introduced greenhouse gases into the atmosphere that do not occur naturally. The most relevant greenhouse gas emitted by humans is carbon dioxide (CO_2), which is formed when fossil fuels (coal, oil, and natural gas) are burned. Other important greenhouse gases include methane, nitrous oxide, and chlorofluorocarbons (CFCs).[17]

greenhouse gases: gases such as carbon dioxide and methane whose atmospheric concentrations influence global climate by trapping solar radiation

As shown in Figure 13.4, global emissions of CO_2 have increased significantly over the past few decades and are projected to increase a further 23 percent between 2018 and 2050. We see that virtually all the increase in emissions in the coming decades will be a result of higher emissions in developing countries (i.e., those that are not members of the OECD). Most of the carbon emitted from human activities to date, however, has come from developed countries.

Further, CO_2 emissions *per capita* are much higher in developed countries and will continue to be so for the foreseeable future. For example, annual emissions per capita are currently about 16 tons in the United States, 9 tons in Germany, 7 tons in China, 1.4 tons in India, and 0.3 tons in Kenya.[18] This disparity in emissions per capita roughly reflects the global disparity in income. Thus simply requiring all countries, say, to reduce emissions by 50 percent would reinforce current global income inequalities by limiting the development options available to developing countries.

CO_2 and other greenhouse gas emissions remain in the atmosphere for a long time, decades or even centuries. This means that even if we reduce annual emissions by 50 percent or more, total concentrations will continue to rise. The atmosphere can be viewed as a bathtub with a very, very slow leak. As long as we keep adding more water (i.e., greenhouse gases) beyond a slight trickle to the bathtub, its level will continue to rise.



■ ***Figure 13.4*** *Past and Projected Global Emissions of Carbon Dioxide, 1990–2050*
Source: United States Energy Information Administration online database.
Note: Projections are for the EIA Reference Scenario.

As atmospheric concentrations of greenhouse gases increase, the world is expected to become warmer, on average. Not all regions will warm equally, and some regions may actually become cooler. Warmer average temperatures increase evaporation, which in turn leads to more frequent precipitation, but again all regions will not be affected equally. In general, areas that are already wet will become wetter and dry areas will become drier. Climate change is also expected to result in more frequent and more intense tropical storms. The melting of polar ice caps and glaciers will contribute to rising sea levels. Sea levels are also rising because the volume of ocean water expands when it is heated.

Global average temperatures have already increased by about 1 degree Celsius (1.8 degrees Fahrenheit) over the past several decades. At the 2015 international climate meeting in Paris, nearly 200 nations agreed that it was necessary to limit the eventual warming to "well below" 2 degrees Celsius, and to "pursue efforts" to limit the warming to 1.5 degrees Celsius, based on the scientific consensus that warming above these levels is likely to cause dangerous economic and ecological impacts.[19]

Climate scientists have developed complex models to predict how much average temperatures will increase as CO_2 concentrations increase. Because predicting long-term climate trends involves considerable uncertainty, these models have produced a range of potential outcomes. Adding to the uncertainty in models is the extent to which warming will be influenced by the policy decisions made in the next couple of decades.

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to assess the science of climate change. A 2014 IPCC report concludes that human emissions of greenhouse gases "are extremely likely to have been the dominant cause of the observed warming since the mid-20th century" and that "continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system."[20] The report estimates that the global temperature increase by 2100, relative to the pre-industrial average temperature, will be from 1.0 degree Celsius (1.8 degrees Fahrenheit) to as high as 5.4 degrees Celsius (9.7 degrees Fahrenheit), reflecting uncertainty in both physical modeling and policy actions. The negative impacts of climate change will fall disproportionately on developing countries. Warming above 4 degrees Celsius is considered particularly dangerous to poorer nations, with the IPCC estimating that this would result in a high risk of reduction in fresh water availability and food supplies, along with a spread in diseases and an increase in heat-related mortality.

5.2 Economic Analysis of Climate Change

Strong policy action to reduce emissions of greenhouse gases could avoid the most damaging effects of climate change. Scientists at the IPCC estimate that, rather than increasing as projected in Figure 13.4, global CO_2 emissions must be reduced 40–70 percent by mid-century, relative to 2010, in order to have a likely chance to limit the temperature increase to no more than 2 degrees Celsius.[21] Of course, most countries are still highly dependent on fossil fuels as an energy source, with coal, oil, and natural gas providing 81 percent of the world's energy supplies.[22] Transitioning to a low-carbon economy will require investment in energy efficiency and renewable energy technologies.

Various economic studies have analyzed climate change using the techniques of cost-benefit analysis, which was discussed in Chapter 12. Cost-benefit analysis of climate change is particularly difficult for two main reasons: the high degree of uncertainty about future impacts and the long period of the analysis. Most of the

costs of responding to climate change are borne in the short term, while most of the benefits (in terms of avoided damages) occur in the long term. Thus the choice of a discount rate is critical.

Virtually all economists agree that carbon emissions represent a negative externality and that a market-based policy such as a Pigovian tax or a tradable permit system should internalize this externality. However, there is a lively debate among economists about how aggressive such policies should be. Until recently, most economic studies of climate change suggested a relatively modest carbon tax, perhaps around $20–$40 per ton of carbon emitted (a $30 per ton tax on carbon would increase the price of gasoline by about 8 cents per gallon).

The economic debate over climate change changed significantly in 2006 when Nicholas Stern, a former chief economist at the World Bank, released a 700-page report, sponsored by the British government, titled "The Stern Review on the Economics of Climate Change." Publication of the Stern Review generated significant media attention and has intensified the debate over climate change in policy and academic circles. Unlike previous studies, the Stern Review strongly recommends immediate and substantial policy action:

> The scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response. This Review has assessed a wide range of evidence on the impacts of climate change and on the economic costs, and has used a number of different techniques to assess costs and risks. From all these perspectives, the evidence gathered by the Review leads to a simple conclusion: the benefits of strong and early action far outweigh the economic costs of not acting.

The Stern Review estimated that if humanity continues "business as usual," the costs of climate change in the twenty-first century would reach at least 5 percent of global GDP and could be as high as 20 percent. It also suggested the need for a much higher carbon tax—over $300 per ton of carbon.

What accounts for the difference between the Stern Review and most earlier analyses? The primary difference was that Stern applied a lower discount rate, 1.4 percent, compared to 3–5 percent in most other studies. Stern argued that his discount rate reflected the view that each generation should have approximately the same inherent value. Stern's analysis also incorporated the precautionary principle (discussed in Chapter 12), in that he placed greater weight on the possibility of catastrophic damages.

5.3 Climate Change Policy

Because climate change can be considered a very large environmental externality associated with carbon emissions, economic theory suggests a carbon tax as an economic policy response. Alternatively, a tradable permit system (also known as cap-and-trade) could be applied to carbon emissions.

As discussed in Chapter 12, a tax offers price certainty, while a tradable permit system offers emissions certainty. If you take the perspective that price certainty is important because it allows for better long-term planning, then a carbon tax is preferable. If you believe that the relevant policy goal is to reduce carbon emissions by a specified amount with certainty, then a cap-and-trade approach is preferable, although it may lead to some price volatility.

Both approaches have been used. Carbon taxes have been instituted in several countries, including a nationwide tax on coal in India (about $1/ton, enacted in 2010), a tax on new vehicles based on their carbon emissions in South Africa (initiated in 2015), a carbon tax on fuels in Costa Rica (enacted in 1997), and local carbon taxes in the Canadian provinces of Quebec, British Columbia, and Alberta that apply to large carbon emitters and motor fuels.[23]

The European Union instituted a cap-and-trade system for carbon emissions in 2005. The system covers more than 11,000 facilities that collectively are responsible for nearly half the EU's carbon emissions. In 2012 the system was expanded to cover the aviation sector, including incoming flights from outside the EU. The goal of

the EU program is to reduce greenhouse gas emissions by at least 40 percent, relative to 1990 levels, by 2040.[24] The state of California instituted a cap-and-trade system in 2013 for electrical utilities and large industrial facilities, with a goal of reducing greenhouse gas emissions in 2050 by 80 percent, relative to 1990 levels.[25]

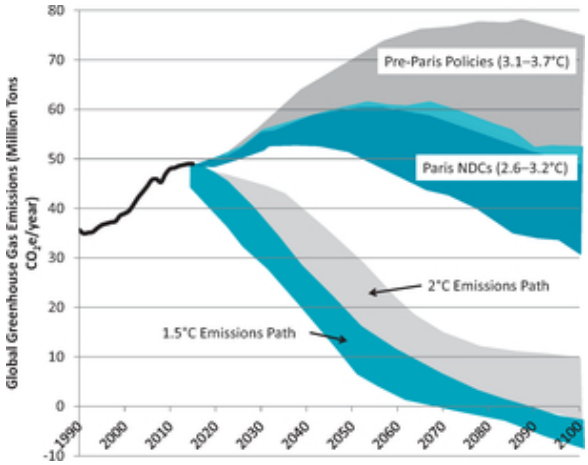
According to most scientists, however, an adequate policy response to climate change will require actions at the international level. Each individual country has very little incentive for reducing its emissions if other countries do not agree to similar reductions. Action to reduce climate change can be regarded as a public good that also generates a positive externality. As we have noted, in the case of public goods, the problem of free riders means that they will not be provided effectively without collective action.

The 2015 Paris climate agreement provides the framework for an international response to climate change. As mentioned above, the goal of the agreement is to limit eventual warming to below 2 degrees Celsius, or even better to below 1.5 degrees Celsius. Rather than imposing universal climate policy mechanisms, such as a global carbon tax, or legally binding emissions targets, the Paris agreement is built upon voluntary "nationally determined contributions" (NDCs). Each participating country is free to set its own emissions targets, with some targets being relatively ambitious while others are comparatively modest. For example, Costa Rica has set strong interim targets along a path to become fully carbon neutral (no net carbon emissions) by 2085.[26] Other countries' NDCs have been rated "critically insufficient" by the nonprofit organization Climate Action Tracker, including Russia, Chile, and Saudi Arabia.

As of late 2018, a total of 174 countries have submitted their NDCs to the United Nations.[27] While the United States signed the Paris agreement in 2015, in June 2017 President Donald Trump announced that the country was withdrawing from the treaty, although under the terms of the agreement it cannot officially withdraw until 2020. Despite the lack of current policy action on climate change at the federal level in the United States, numerous states and municipalities continue to pursue aggressive policies. A group of at least 20 states and 50 major cities have pledged to continue efforts to meet the country's Paris climate targets.[28]

Each country is free to set its own national policies to meet its NDC, and there are no penalties for countries that fail to meet their targets. Still, the Paris agreement represents the most comprehensive international climate framework so far; the 1997 Kyoto Protocol only included developed nations. The agreement calls for developed nations to contribute $100 billion per year to help developing countries transition away from fossil fuels and adapt to the impacts of climate change. Every five years participating countries will meet to reevaluate their NDCs, with the intention of setting more ambitious targets to reflect each country's "highest possible ambition."

More ambitious NDCs will be needed in order to meet the objective of limiting eventual warming to 2 degrees Celsius or less, as shown in Figure 13.5. Prior to the Paris agreement, under existing national policies global greenhouse gas emissions were projected to continue to increase until at least 2050 and potentially until 2090 (the top gray-shaded range of emissions), with an expected global temperature increase between 3.1 and 3.7 degrees Celsius. If all countries meet their Paris NDCs, then global emissions will peak sooner, and will be between 39 percent lower and 6 percent higher than current emissions in 2100 (the higher blue-shaded range of emissions). But the global average temperature will still increase between 2.6 and 3.2 degrees Celsius if all countries meet their NDCs. We see that in order to meet the 2 degrees Celsius target, global emissions will need to begin to decline essentially immediately, and be between 80 percent and 106 percent lower than current emissions in 2100. (Negative net emissions are possible if large amounts of carbon are removed from the atmosphere through expansion of forests or other methods.) Even more dramatic emissions reductions are necessary to achieve the 1.5 degree Celsius target, as shown by the bottom blue-shaded emissions range.



■ ***Figure 13.5*** *Global Greenhouse Gas Emissions Under Alternative Scenarios*
Source: Climate Action Tracker, http://climateactiontracker.org/global.html.
Note: Emissions data include carbon dioxide and other greenhouse gases converted to carbon dioxide equivalents.

5.4 Economics of Renewable Energy

Significant reductions in global greenhouse gas emissions will necessitate a major shift away from fossil fuels toward renewable energy sources such as solar and wind. As mentioned above, carbon taxes and tradable permits are two effective economic policies that can help to motivate this transition. But while such policies have generally not been implemented to the extent necessary to meet global climate targets, recent market forces have begun driving an energy revolution in favor of renewables.

The dominance of fossil fuels has primarily been attributed to their cost advantage, with coal, and more recently natural gas, being the cheapest sources to generate electricity. That is no longer true in much of the world, as the cost of solar and wind energy has declined steeply. Between 2009 and 2017 the average cost of generating

Box 13.4 The Cost Competitiveness of Renewable Energy

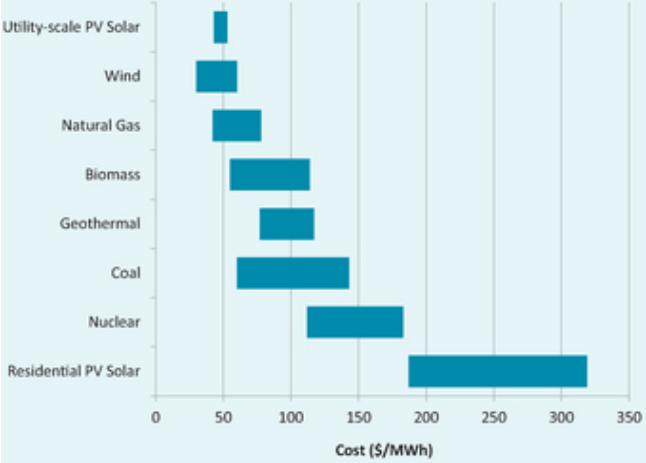
The world's cheapest energy is increasingly coming from renewable sources. Many energy experts feel we have now reached an irreversible "tipping point" where renewable energy will increasingly gain an advantage over fossil fuels based solely on price. A 2016 analysis by the business-oriented World Economic Forum notes:

> The cost of generating electricity from renewable sources is now on par or below that of coal and natural gas . . . Just 10 years ago, solar costs would be around $600/MWh [megawatt-hour], much above the widely-used coal and natural gas sources at $100/MWh. However, solar costs were halved five years later, and compressed again to around $100/MWh today. Wind costs are around $50/MWh.[31]

In more than 30 countries, solar and wind energy is already the same price or cheaper than traditional fossil fuel energy.[32] Even more compelling are the new record-low prices that have been announced in recent years. In 2014 the cheapest solar energy being produced anywhere in the world cost around $60/MWh.[33] But in mid-2016 a record-low price for solar energy of $29/MWh was set in Chile, only to be broken by a "jaw-dropping" $24/MWh in Abu Dhabi a few months later.[34] Then a "stunning new low"

price for solar energy was reached in October 2017 in Saudi Arabia of $18/MWh,[35] only to be slightly beaten in Mexico the following month.[36] Record-low prices for wind energy are also being continually set, reaching $22/MWh in Mexico in late 2017.[37]

A well-respected 2017 analysis of the cost of different energy sources reached the "stunning conclusion" that in many parts of the world it is now cheaper to stop operating existing coal and nuclear plants and instead build and operate new renewable energy facilities.[38] The study's cost comparison is presented in Figure 13.6, based on unsubsidized costs. While residential rooftop solar energy is still relatively expensive, utility-scale solar and wind energy have become the world's cheapest energy sources. And while future fossil fuel prices are difficult to predict, the cost of renewables is only likely to decline further with technological progress.



■ ***Figure 13.6*** *Cost Comparison of Electricity Generation from Different Energy Sources, 2017*
Source: Lazard, 2017.

electricity from wind power declined by 67 percent, and the cost of utility-scale solar power fell by 86 percent.[29] (For more on the cost competitiveness of renewable energy, see Box 13.4.) As a result of declining costs, renewable energy (excluding large-scale hydropower) accounted for more than half (55 percent) of all new energy investments in 2016.[30] Further, about half of the investment in renewables is occurring in developing countries, meaning that economic development is no longer dependent upon expanded use of fossil fuels.

Further declines in the cost of renewables are expected, which will hasten the phaseout of fossil fuels. A 2017 analysis predicted that the cost of solar power will decline an additional 66 percent by 2040, along with a further 47 percent drop in onshore wind energy costs.[39] By 2030 generating power using renewable sources will be cheaper than the majority of existing fossil fuel power stations. The lead author of the study concludes:

> This . . . report suggests that the greening of the world's electricity system is unstoppable, thanks to rapidly falling costs for solar and wind power, and a growing role for batteries, including those in electric vehicles, in balancing supply and demand.[40]

Renewable energy currently only provides about 11 percent of the world's power generation,[41] and fossil fuel power stations last for decades, so it will still take considerable time until we obtain the majority of our energy from renewables. But as detailed in a 2017 paper, a complete global transition to renewable energy by 2050 is economically feasible using existing technologies.[42] The authors conclude that such a transition will avoid about 4.6 million premature air pollution deaths per year, create a net gain of 24 million full-time jobs, save an average

of about $85 per person annually in energy costs, and possibly allow the aggressive 1.5 degrees Celsius target to be met.

Despite the significant potential for renewable energy, economic policies will make a very large difference in the scale and timing of an energy transition. As noted above, some states and countries have set ambitious targets, such as California's goal of an 80 percent greenhouse gas reduction by 2050. But such ambitions will have to be extended worldwide, greatly strengthening the existing Paris commitments, to achieve effective mitigation of the impacts of climate change. The economics of common property and public goods management will be essential in guiding this process.

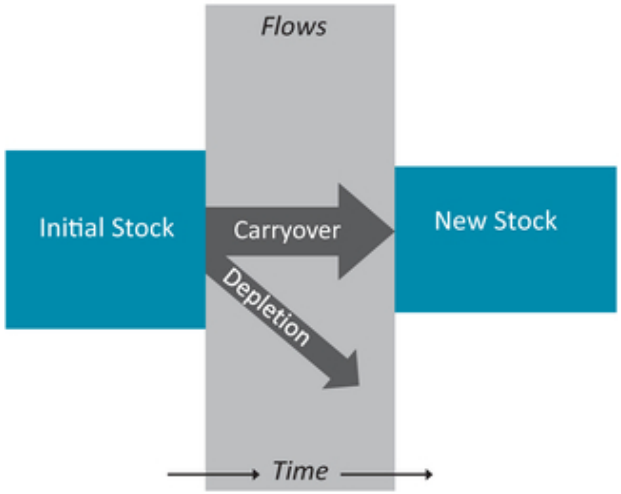
Discussion Questions

1. How serious a problem do you think climate change is? Compare your judgment of this based on news reports and the economic studies that have tried to evaluate the costs and benefits of climate change. How effective do you think economic analysis has been in approaching the problem?
2. Which policies do you think are most likely to be effective in responding to climate change? Given the political resistance to taxes, what do you think would be the best strategy for achieving reduction of greenhouse gas emissions?

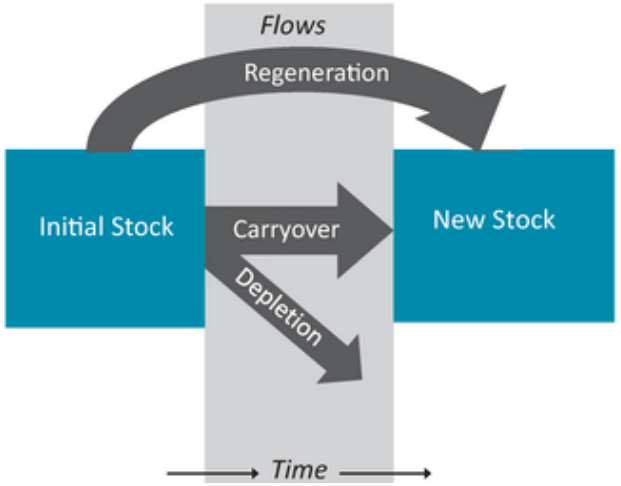
Review Questions

1. What are the two characteristics of private goods? Provide some examples.
2. What are the two characteristics of public goods? Provide some examples.
3. What are the two characteristics of common property goods? Provide some examples.
4. What are the two characteristics of artificially scarce goods? Provide some examples.
5. How do economists define congestion?
6. What is the supply curve for an artificially scarce good?
7. Why does the private provision of an artificially scarce good result in economic inefficiency?
8. What is price discrimination?
9. How can we model the market for a common property resource?
10. How can we determine the utilization or harvest for a common property resource without any regulation?
11. How do we determine the efficient outcome for a common property resource?
12. What policies can be implemented in the case of a common property resource?
13. What is the tragedy of the commons?
14. What is the likely equilibrium outcome for a public good in a private market?
15. Can voluntary donations result in the efficient provision of public goods?
16. What are free riders?
17. How can we model the demand for a public good in a simple society with two individuals?
18. Why do someone's marginal benefits differ from his of her willingness to pay in the case of a public good?
19. What policies are needed to provide for the efficient provision of public goods?
20. What is climate change?
21. What are the projections for future greenhouse gas emissions, considering both developed and developing countries?

illustrated in Figure 14.4. But natural inputs that are renewable—such as lumber from forests and fish from the seas—can be exhausted if so much of them is destroyed or extracted that they can no longer renew themselves.



■ ***Figure 14.3*** *Depletion of Nonrenewable Natural Capital Over Time*



■ ***Figure 14.4*** *Stock Changes for a Renewable Natural Resource*

In addition, nature's ability to absorb pollution and break down waste is limited, and there are tipping points beyond which degraded natural capital may be dramatically altered in some essential respect. As we saw with climate change, dramatic ecological change may occur over the next several decades, including the extinction of numerous species. It is very difficult to predict whether ecosystems will be sustainable in the face of such dramatic changes. Rising sea levels could cause the flooding of many low-lying areas; New Orleans and southern Florida, in the United States, and Bangladesh are well-known examples, but many other cities worldwide are also in low-lying areas close to oceans. Some island countries are already losing significant land mass. Thoughtful resource management for natural capital means tracking the size, quality, and changes in natural resources and making wise decisions about their management.

2.2 Natural Capital and Sustainability

knowledge can be embodied in manufactured capital, indicating technological progress. For example, a worker at an automobile company may start with an existing engine design, and develop a new technique to make that engine more fuel efficient.

Discussion Questions

1. In what ways is it useful to think of human bodies and brains as if they were like productive machinery? What might be some drawbacks of this way of thinking?

2. One obvious way that you are increasing your human capital by going to school is that you can be more productive in a career. In what other ways do you believe that you are increasing your human capital through your education?

5. Social Capital

The English poet John Donne penned the famous line that "no man is an island." Although the development of individual human capital is important for increasing productivity, nearly all economic activity involves the coordination of actions among numerous actors. Social capital consists of shared knowledge, ideas, and values, along with social organization and workplace relationships. These relationships and common understandings provide the social context for economic activity.

Production possibilities depend on the ability to coordinate production among different people. Even with no change in machinery or technology, productivity can increase if coordination among workers improves or if workers become more motivated because of good management techniques. **Social organization** refers to the ways in which human productive activities are structured and coordinated.

social organization: the ways in which human productive activities are structured and coordinated

Social capital also includes the cultural beliefs and goals that determine which knowledge is applied, which scientific questions are researched, and which technological possibilities are explored. A growing public awareness and acceptance of the hazards posed by global climate change, for example, could be considered a form of social capital, because it increases the ability of society to respond to a significant threat to its future well-being.

In contemporary industrialized economies, the term "social capital" is most often used to refer to characteristics of a society that encourage cooperation among groups of people (e.g., workers and managers) whose joint efforts are needed to achieve a common goal. This kind of capital is built up to the extent that a society is characterized by strong norms of reciprocity, which lead people to trust and help one another, and dense networks of civic participation, which encourage people to engage in mutually beneficial efforts rather than seeking only to gain individual advantage. Business accountants have led the way in recognizing one kind of social capital—goodwill— which they view as a significant business asset that makes a firm more valuable than one might think from looking at its physical assets alone. Goodwill includes a number of intangible factors, such as a firm's good reputation among its customers and creditors, good management, and good labor

The problem of covering costs arises again in the case of research for the development of new technologies. Patents, copyrights, and other protections of intellectual property are not granted simply to enrich inventors. The rationale for these forms of government-granted monopoly power is to *encourage* research and innovation. Development of new computer technologies, medical technologies, and drugs can be very expensive. Firms argue that they need a period of exclusive, high profits to recover the cost of research and development. Without the ability to patent an innovation, it is argued, firms might find research unprofitable and so do less of it, to the detriment of all.

Of course, patents also have a social cost in that they restrict the production of some important and valuable goods while raising their price. The cost can be extremely high: In many cases, exorbitant prices for certain indispensable medications result in unnecessary human suffering and premature death—see Box 17.2. Also, as societies become more concerned about climate change, there is concern that allowing new low-emission energy technologies to be patented could slow their rates of adoption, as the owner of the patent would produce such technologies based on maximum profit, not social need. Other forms of government action have been suggested as ways of encouraging invention that would not carry the patent system's harmful effect of restricting production and use. These include direct funding of research, offering research prizes, and buying patents from companies for a one-time fee.

Box 17.2 Monopoly Power and Drug Price Increases

In August 2015 Turing Pharmaceuticals purchased the rights to the drug Daraprim from another company, CorePharma. Daraprim, which has been available for more than 60 years, is a drug used by AIDS patients and others to treat a life-threatening parasitic infection. The drug is on the World Health Organization's list of essential medicines.[6] At the time of the sale, CorePharma was charging $13.50 per pill for Daraprim. Overnight, Turing Pharmaceuticals raised the price to $750 per pill in the United States, or $75,000 for a full course of treatment.[7] In other countries, Daraprim can be purchased for $1 per pill or less.

Turing Pharmeceutical's former CEO, Martin Shkreli, was convicted of securities fraud in August 2017, but the price of Daraprim has remained high. Dr. Judith Aberg, a leading HIV/AIDS researcher, says "It's not illegal what they've done [at Turing], but it's unethical and immoral. This is affecting patient care. . . . What's more frustrating is that other companies are following Turing's lead. At some point, our economy can't support this."[8]

Another prominent recent example of a drug company dramatically raising its prices is the company Mylan, which raised the price of its EpiPen, used to treat severe allergic reactions, from $100 in 2009 to over $600 in 2016. Mylan controls about 90 percent of the market for drugs to treat severe allergic reactions. In September 2016 Mylan CEO Heather Bresch was called to testify to the U.S. Congress, where she defended the price increases.[9] Lawmakers expressed their frustration with the company, with one Congressman saying, "Yet another drug company, Mylan, has jacked up the price of a lifesaving product for no discernable reason." However, in the absence of new legislation, such as setting price ceilings for drugs or giving Medicare the power to negotiate drug prices, Congress is currently unable to force companies to lower their drug prices.

Pressure to Appear Competitive

Without regulation, a monopolist is free to maximize profits with no concern for the social consequences. But even if a monopolist faces neither a serious rival nor any meaningful government restriction, it may fear