CHAPTER

10

Market Failures

In the previous chapters, we saw how markets utilize individual self-interest to efficiently allocate resources (means) among alternative ends via the pricing mechanism. However, markets only function efficiently with a narrow class of goods. We have already shown how monopolies undermine the ability of the market to efficiently allocate, but monopolies are a type of market failure generated by a structural problem—the absence of competition. Markets also fail because of inherent characteristics of certain types of resources, or because there are no institutions clearly defining property rights. The purpose of this chapter is to describe the characteristics that make a particular resource a market good, and to examine what happens when resources do not have these characteristics. As we will show, none of the goods and services provided by natural capital has all of the characteristics required for efficient allocation by the market.

For simplicity, in this chapter we will boil down the various conditions for arriving at Pareto optimal allocations, described in Chapter 8, to the generic equation "marginal cost equals marginal benefit," or MC = MB. In addition, we will often use the term *Pareto efficient* or just *efficient* as the equivalent of Pareto optimal.

Characteristics of Market Goods

Excludability

We first defined and discussed **excludability** in Chapter 4 and briefly review the concept here in recognition of its importance. An excludable good is one for which exclusive ownership is possible; that is, a person or community must be able to use the good or service in question and prevent others from using it, if so desired. Excludability is virtually synonymous with property rights. If a good or service is not owned exclusively by someone, it will not be efficiently allocated or produced by market forces. The reason for this is obvious. Market production and allocation are solely dedicated to profits. If a good is not excludable, someone can use it whether or not any producer of the good allows it. If people can use a good regardless of whether or not they pay for it, they are considerably less likely to pay for it. If people are unwilling to pay for a good, there will be no profit in its production, and in a market economy, no one will invest in producing it, or at least not to the extent that the marginal benefit to society of producing another unit is equal to the marginal cost of production.

Of course, many nonexcludable goods, such as fish in the ocean, are produced by nature, not by humans. In this case, "investment" is simply leaving smaller fish to grow larger, or maintaining a high-enough population stock to ensure future production. The "cost" of investment is opportunity cost—the profit that would have been earned by catching those fish today. If a fisherman throws back a small fish to let it grow larger, it is more than likely that a different fisherman will catch that larger fish, and in a market economy, people rarely invest when others will reap the returns.

Excludability is the result of institutions. In the absence of institutions that protect ownership, no good is truly excludable unless the possessor of that good has the physical ability to prevent others from using it. Some type of social contract, be it government or less formal social institutions, is required to make any good excludable for someone who lacks the resources to defend her property. Excludability, therefore, is not a property of the resource *per se*, but rather of the regime that controls access to the resource. It is fairly easy to create institutions that provide exclusive property rights to tangible goods such as food, clothing, cars, and homes. Slightly more complex institutions are required to create exclusive property rights to intangibles such as information. Patent laws protecting intellectual property rights are ubiquitous in modern society, but it remains difficult to enforce such property rights. For example, have you ever recorded copyrighted music or installed unpurchased, copyrighted software on your computer?

However, many goods and services, such as the majority of the fund-services produced by ecosystems, have physical characteristics that make it almost impossible to design institutions that would make them excludable. As we suggested in Chapter 6, it is pretty much impossible to conceive of a workable institution that could give someone exclusive ownership of the benefits of the ozone layer, climate regulation, water regulation, pollination (by wild pollinators), and many other ecosystem services. It is often possible to establish exclusive property rights to an ecosystem fund (e.g., a forest) while at the same time impossible to establish such rights to the services the fund provides (e.g., regional climate regulation). If, like a forest, the fund is simultaneously a stock that can supply a flow (e.g., of timber), market allocation will only account for the stock-flow benefits of the resource. When there are no excludable property rights to a good or service, that good or service is nonexcludable.

Rivalness

A second characteristic that a good or service must have if it is to be efficiently produced and distributed by markets is **rivalness**. We defined a rival good or service in Chapter 4 as one for which use of a unit by one person prohibits use of the same unit at the same time by another. Rivalness may be qualitative, quantitative, or spatial in nature. Again, food, clothing, cars, and homes are rival goods.

A nonrival good or service, therefore, is one whose use by one person has an insignificant impact on the quality and quantity of the good or service available for another person to use. Among nonrival goods produced by humans, streetlights, information, and uncrowded roads come to mind (though roads do wear out faster if more people use them). Climate stability, the ozone layer, beautiful views, and sunny days are a few of the nonrival goods produced by nature.

Note that all stock-flow resources are quantitatively rival. If I eat food (a stock), there is less for you to eat. In contrast, fund-service resources may be rival or nonrival. When a fund-service is rival, it is spatially rival at each point in time, and qualitatively rival over time. If I wear clothes, drive a car, use a machine that makes cars, or use a house (all fund-service), they are not available for you to use at the same time I do, and if you use them afterwards, they are just a bit more worn out. As we pointed out in Chapter 4, all nonrival resources are fund-service.

As discussed in Chapter 9, market efficiency requires that the marginal cost to society of producing or using an additional good or service be precisely equal to the marginal benefit. However, if a good is nonrival, an additional person using the good imposes no additional cost to society. If markets allocate the good, it will be sold for a price. If someone has to pay a price to use a good, he or she will only use the good until the marginal benefit is equal to the price. A price is by definition greater than zero, while the marginal cost of additional use of nonrival goods is zero.[1] Therefore, markets will not lead to efficient allocation of nonrival goods, or conversely, a good must be rival to be efficiently allocated by the market.

Nonrival But Congestible Resources

There are actually two types of nonrival goods and services. Some nonrival services, such as UV protection by the ozone layer, are not affected by

[1]This does not necessarily imply that providing a nonrival good free of charge is efficient either. We will return to this topic later.

the number of people using them. For other nonrival goods, use by too many people can seriously diminish the quality of the good or service. For example, if I drive my car down an empty road, it does not diminish your ability to drive down that same road. However, if thousands of people choose to drive down the same road at the same time, it results in traffic jams, and the ability of the road to move us from point A to point B is seriously diminished. Such goods are nonrival but congestible, and for shorthand will simply be referred to as congestible. Note that **congestibility** is an issue of scale—as scale increases, as the world becomes more full, congestion leads some nonrival goods to acquire attributes of rival goods.

The Interaction of Excludability, Rivalness, and Congestibility

What happens when goods and services are nonrival, nonexcludable, or both? The simple answer is that market forces will not provide them and/or will not efficiently allocate them. However, we need to be far more precise than this if we are to derive policies and institutions that will lead to the efficient allocation and production of nonrival and/or nonexcludable resources. Effective policies must be tailored to the specific combination of excludability, rivalness, and congestibility that characterizes a particular good or service. The possible combinations are laid out in Table 10.1, and described in some detail next.

Table 10.1

THE MARKET RELEVANCE OF EXCLUDABILITY, RIVALNESS, AND CONGESTIBILITY

	Excludable	Nonexcludable
Rival	Market goods; food, clothes, cars, houses, waste absorption capacity when pollution is regulated	Open access regimes ("tragedy of the commons"), e.g., ocean fisheries, logging of unprotected forests, air pollution, waste absorption capacity when pollution is unregulated
Nonrival	Potential market good, but if so, people consume less than they should (i.e., marginal benefits remain greater than marginal costs); e.g., information, cable TV, technology	Pure public good, e.g., lighthouses, streetlights, national defense, most ecosystem services
Nonrival but congestible	Market goods, but greatest efficiency would occur if price fluctuates according to usage; e.g., toll roads, ski resorts	Nonmarket good, but charging prices during high-use periods could increase efficiency; e.g., non-toll roads, public beaches, national parks

Adapted from A. Randall, "The Problem of Market Failure." In R. Dorfman and N. Dorfman, eds. Economics of the Environment, *3rd ed. New York: Norton, 1993, pp. 144–161.*

Open Access Regimes

The first class of goods and services we will examine are open access resources—those that are nonexcludable but rival. The use of such goods commonly leads to what Garret Hardin has called "the tragedy of the commons."[2] The classic example Hardin used was the grazing commons once common in England. Say a village has a plot of land that anyone in the community can use for grazing cattle. There are 100 households in the community, and the plot of land is sufficient to support 100 head of cattle indefinitely without being overgrazed. In the terminology of Chapter 6, if we think of cattle as grass harvesters, then 100 cows will harvest the maximum sustainable yield of grass (see Figure 6.1). If one person adds one more cow to the commons (as might happen when there is no institution preventing her from doing so), not only does the grass need to be shared among more cows, but the grass yield declines, and each cow will be just a bit thinner. One person will gain the benefits of having two cows but will share the costs of all the cattle being thinner with everyone else in the community. If everyone thinks in the same manner, households will keep adding cattle to the commons until its productive capacity has declined, and it is no longer capable of generating the biomass it once did. Each person acting in what appears to be rational self-interest degrades the commons, and everyone is worse off than if he or she had stuck with one cow per person. Under these circumstances, rational self-interest does not create an invisible hand that brings about the greatest good for the greatest number, but rather creates an invisible foot that kicks the common good in the rear!

It is extremely important to note that the "tragedy of the commons" is a misnomer. Common property is property for which a community, not an individual, controls the property rights. Those who are not members of the community are not allowed access to the resource. In many cases, communities have developed institutions that prevent individuals within the community from overexploiting the resource, and there is no problem with the "tragedy of the commons." A better term, therefore, is the "tragedy of open access regimes" or simply "the open access problem."

There are many goods characterized by the open access problem. Hardin originally wrote his classic article to describe the problem of population growth. Especially in labor-driven agrarian economies, large families can be great assets. However, if everyone has a large family, the land must be divided up among all the children, and it eventually grows too scarce to sustain the population. People harvest soil nutrients faster than

[2] G. Hardin, The Tragedy of the Commons, *Science* 162: 1243–1248 (1968).

the system can restore them, and sustainable production declines. Another resource plagued by this tragedy is ocean fisheries, and the Atlantic cod is a classic example.

Box 10-1 THE ATLANTIC COD FISHERY: A TRAGEDY OF THE OPEN ACCESS REGIME

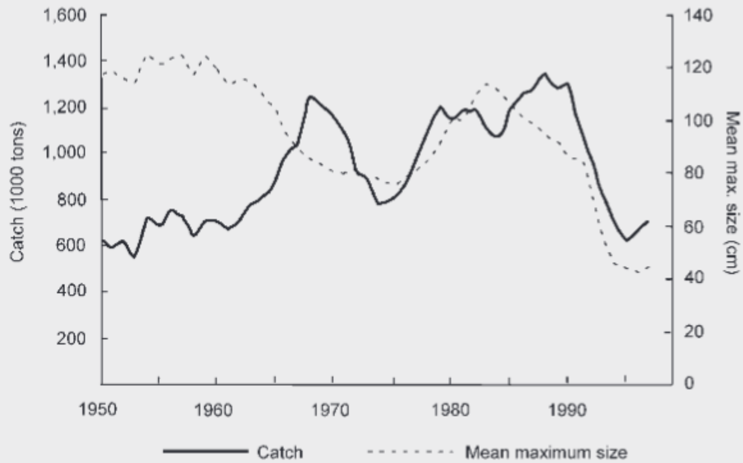

Figure 10.1 • Time series of total catch and average maximum size of species in catch for Canada, Northwest Atlantic. Note the trend to smaller species in the early 1990s. (Source: FAO Statistics. Online: http://www.fishbase.org/manual/fishbasefao_statistics00002679.htm.)

The Atlantic cod fishery was once capable of providing enormous sustained yields at a low harvest cost, but years of overharvesting have been blamed for dramatically reduced yield.[a] *Sustainable* yields may now be close to zero,[b] and scarcity has made those that remain more expensive to harvest. For cod and many other commercial species, selective fishing pressure has also drastically reduced the age and size at maturity. Smaller mature females produce far fewer and smaller eggs, threatening the ability of the species to re-establish.[c] All the fishermen as a group would clearly have been better off if they had limited their harvest to sustainable levels. However, in any given year, any given fisherman was better off continuing to harvest more fish as long as a profit was to be made. Lacking institutions to keep harvests sustainable, if one fisherman reduced his catch, those cod would simply be caught by another fisherman.

In the case of renewable resources, reducing harvests in one year is passive investment in future production. The costs of investment are the opportunity costs of not harvesting now. As we pointed out in our discussion of excludability, if a good or service is nonexcludable, the market provides no incentive to invest in it. In the case of Atlantic cod, each fisherman pursuing his own rational self-interest has virtually wiped out the stock, and other fishermen are rapidly following the same path for the majority of fish species worldwide.[d] Economists tell us that if we wipe out one species, we can always replace it with another. Fishermen have done this around the world, harvesting fish lower and lower on the trophic chain (i.e., lower-level predators), yet in spite of this substitution, harvests in many places are still plunging.

[a] *L. Burke, Y. Kura, K. Kassem, C. Revenga, M. Spalding, and D. Mcallister, Pilot Analysis of Global Ecosystems: Coastal Ecosystems. Washington, D.C.: WRI, 2000.*

[b] *It is actually quite possible that cod populations in the North Atlantic have fallen below the minimum viable population stock (point of critical depensation) and will gradually diminish, even in the absence of further harvests.*

[c] *F. Saborido-Rey and S. Junquera, Spawning Biomass Variation in Atlantic Cod (Gadus morhua) in Flemish Cap in Relation to Changes in Growth and Maturation,* Journal of Northwest Atlantic Fishery Science *25: 83–90 (1999).*

[d] *As mentioned earlier, the U.N. estimates that 11 of the world's 15 major fishing areas and 69% of major commercial fish species are in decline. The only reason that total harvests have not dropped accordingly is that favored species high on the food chain have been replaced by others lower down (Burke et al., op. cit.).*

Many economists have correctly pointed out that the open access problem results from a lack of enforceable property rights (i.e., excludability). If the English commons in the first example had been divided up into 100 equally productive excludable private lots, the rational individual would graze only one cow in each lot, and the tragedy would be avoided. Unfortunately, for many of the resources of concern to us, the ability to bestow individual property rights is more the exception than the rule, and in other cases we will describe later, property rights will not lead to efficient outcomes.[3]

For now, we will draw attention only to the difficulty of establishing property rights in the fairly simple case of open access resources. Analysis of oceanic fisheries provides a good starting point. Most of the oceans are international waters over which there is little or no institutional control. There are treaties limiting harvests, prohibiting certain harvest techniques or prohibiting harvests of certain species all together, but countries can choose whether or not to sign those treaties, and little in the way of enforcement is available even when they do sign. For example, most nations have agreed to cease or drastically reduce the harvest of many species of whale, but countries such as Norway, Japan, and

[3] Nonetheless, sloppy analysis and a lack of rigor on the part of too many economists have led to a widespread belief that establishing property rights is the answer to most, if not all, of our environmental problems.

Iceland do not always follow these regulations, and little can be done to force them to do so.[4]

Nations now enjoy 200-mile zones of exclusion in coastal waters, where they can prohibit boats from other nations from harvesting marine species and physically enforce this exclusion if necessary. Exclusion zones at least allows the potential for the regulation of fisheries within these waters, and we will discuss effective mechanisms in Chapter 20. Unfortunately, fish are generally pretty disrespectful of such boundaries, and once outside of those bounds, they are fair game to all. In addition, many species of fish migrate from the coastal exclusion zone of one nation to the exclusion zone of its neighbor. This is the case with many salmon populations off the coasts of Canada and the U.S. These two nations, which enjoy some of the best relations of any two nations in the world, are in the midst of a bitter dispute over who is entitled to what share of the catch. In the meantime, salmon populations continue their rapid decline.

If we are unable to establish defensible property rights to a resource such as fish, how are we going to address the far more difficult "tragedy of the commons" problem of overpopulation?[5]

Excludable and Nonrival Goods

A second class of goods of great interest is those that are excludable but nonrival and noncongestible. The prime example of this type of good is information. In the not-too-distant past, most information was relatively nonexcludable as well as being nonrival. In Adam Smith's time, firms would jealously guard their trade secrets, but if such secrets got out, there was nothing to prevent others from using them. As Smith[6] pointed out, trade secrets were equivalent to monopolies, and "the monopolists by keeping the market constantly understocked, by never fully supplying the effectual demand, sell their commodities much above the natural price. . . . The price of monopoly is upon every occasion the highest which can be got" (p. 164). "Monopoly, besides, is a great enemy to good manage-

---

[4]The regulations actually put a moratorium on harvesting certain species of whales for commercial purposes, but still allow harvesting for scientific research. Japan now harvests endangered whale species for "scientific research," selling the carcasses commercially afterwards. CNN.com, Japan Whaling Fleet Returns Home Amid U.S. Dispute, *Nature* (2000). Online: http://www.cnn.com/2000/NATURE/09/21/whaling.japan.reut/ posted September 21, 2000.

[5]Kenneth Boulding actually proposed a solution to the overpopulation problem based on awarding all women the "property right" to 2.1 children (replacement fertility level) in the form of tradable permits. Needless to say, many people object to such a system. Can you suggest a better solution? See K. Boulding, *The Meaning of the Twentieth Century*, New York: Harper & Row, 1964.

[6]A. Smith, *The Wealth of Nations: Books I–III* (with an introduction by Andrew Skinner), Harmondsworth, Middlesex, England: Penguin Books, 1970.

ment . . ." (p. 251). (We will say more about patents, which are monopolies on information, in our discussion of globalization in Chapter 18.) In more recent times, of course, trade secrets have been protected by patents,[7] an institution that makes them legally excludable, and hence marketable. The justification for this is the assumption that without excludable property rights, people would not profit from inventing new things. Inventors would have no incentives, and the rate of advance of technology would slow, to the detriment of society. Once a patent expires, the knowledge embodied in it becomes a pure public good.

The problem is that one person's use of information not only has no negative impact on someone else's use, it can actually lead to improvements in quality—in the words of one computer programmer, "the grass grows taller when it's grazed on."[8] Intellectual progress is invariably a collective process. In academia, people have freely shared and built upon each other's ideas for centuries. The Internet and much of its associated software were primarily the result of freely shared knowledge. In many ways, the free flow of information and ideas creates an "efficiency of the commons," not a tragedy.

Patents, on the other hand, may slow the rate at which we develop new knowledge and use it. Existing knowledge is the most important input in the production function of new knowledge. Keeping existing knowledge artificially expensive during the life of the patent also makes the production of new knowledge more expensive. In addition, corporations often patent scientific methodologies and even mathematical algorithms, thereby making it much more expensive to conduct research using those methodologies. Many researchers are engaged in research for the sake of advancing knowledge and not for making profits, and any additional costs are likely to reduce their ability to advance knowledge. For example, a new virus-resistant strain of rice cannot be distributed because there are as many as 34 separate patent holders with competing claims on the knowledge that went into its invention.[9]

The costs of intellectual property rights have become a serious issue. For example, the U.S. Constitution authorizes Congress to issue copyrights and patents "for limited times" to "promote the progress of science

[7]Trade secrets do still exist in the traditional form. Patents only provide exclusive ownership to information for a fixed time period. To avoid making information public knowledge at the end of this time span, some companies prefer not to patent certain processes or recipes, instead keeping them hidden from potential competitors. See J. E. Stiglitz, "Knowledge as a Global Public Good." In I. Kaul, I. Grunberg, and M. A. Stern, eds. *Global Public Goods: International Cooperation in the 21st Century*, New York: Oxford University Press, 1999.

[8]Cited in D. Bollier, *Silent Theft: The Private Plunder of our Common Wealth*, London: Routledge, 2002.

[9]Ibid.

BOX 10-2

THE LINUX OPERATING SYSTEM AND OPEN SOURCE: THE EFFICIENCY OF THE INFORMATION COMMONS

Dr. Ferdinando Villa, pioneer in eco-informatics, writing open-source code on a Linux operating system.

Much information is covered by patents designed to make it excludable. Open-source software, in contrast, is protected by licenses designed to keep it nonexcludable. While many open-source licenses allow people to sell open-source software, they insist that it also be legal to redistribute the software for free. Even more important, the licenses must allow distribution of the source code, that is, the computer program written in a language intelligible to humans, compared to the compiled binary code intelligible only to computers. This practice enables other programmers to find and remove bugs in the software, to modify the software, and to incorporate the software into their own work on the condition that that work remain open-source as well. The philosophy behind this approach is that when many programmers are free to improve the source code for a piece of software, it evolves and improves at an astonishing rate. The grass grows taller the more it's grazed on.

While some economists would tell us that invention requires the incentive of the profit motive, empirical evidence suggests otherwise. Take the example of the Linux operating system. Linux is an open-source operating system for computers invented by Linus Torvald. Computer experts around the world have worked on this operating system free of charge, and as a result it has become stable, powerful, and adaptable.[a] IBM has contributed to the Linux code, and both IBM and HP use the

Linux operating system on their high-end mainframe servers. The use of Linux continues to increase rapidly. Apple has turned to open-source for its Mac OS-X operating system. Open-source Apache runs more than half of the world's Web servers, and hundreds of thousands of other open-source packages exist.[b] Certainly this proves that neither profits nor patents are always required to spur innovation.

[a]*The Great Giveaway.* New Scientist *(2002). Online: http://dsl.org/copyleft/dsl.txt; D. Bollier,* Silent Theft: The Private Plunder of Our Common Wealth, *London: Routledge, 2002.*

[b]*Open Source Initiative Website (http://www.opensource.org/).*

and the useful arts." The initial Copyright Act awarded copyrights for 14 years, with the possibility of a single 14-year extension if the author was still alive. Under pressure from corporate lobbies, Congress has gradually increased copyright longevity, and corporate copyrights are now good for 95 years, while individual copyrights are good for the life of the individual plus 70 years. The latest extension was brought before the Supreme Court, with the argument that it actually deters the progress of science.[10]

Patents can also generate serious inefficiencies for other reasons. Consider the case of AIDS medicine. A currently available drug cocktail can dramatically reduce the level of HIV in the human bloodstream, potentially decreasing the risk of transmission. The benefits of controlling contagious and deadly diseases are nonexcludable. Currently drug companies hold patents on these medicines, making them prohibitively expensive for Third World countries,[11] decreasing their ability to control the disease, and increasing the risk of everyone contracting it. Of course, from the perspective of corporations that profit from these medications, total elimination of the disease would be a very unprofitable outcome. The argument in favor of patents is that without profits, corporations would not have the incentives to invent new drugs. The irony is that patent rights are protected in the name of the free market, yet patents simply create a type of monopoly—the antithesis of a free market.

So we see that while there may be a solid rationale for allowing patents, there also exist compelling arguments against them. If information is free, it will presumably be used until the marginal benefits of use are just equal to the marginal costs of additional use, which is zero. This is a prerequisite for efficient allocation. On the other hand, if a good is nonexcludable,

[10]L. Greenhouse, Justices to Review Copyright Extension, *New York Times*, February 20, 2002.

[11]In spring 2001, a number of drug companies agreed to drop their suit against the South African government and its policy of producing and selling the drug without paying full royalties. Numerous other drug patents exist that still illustrate the basic principles explained here.

the market provides no incentive to invest in it. Patent laws recognize this problem by imposing artificial excludability on information, at least for the time period of the patent. Nonetheless, Linux (see Box 10.2) and many other examples show that patents are not necessary to spur invention, so the belief that patents will result in a faster rate of technological advance is little more than an assertion. Widespread recognition of this problem has led to the “copyleft” movement, “a copyright notice that permits unrestricted redistribution and modification, provided that all copies and derivatives retain the same permissions.”[12]

Still, goods such as information and knowledge present difficult issues. We will return to these issues later in this chapter, and again in our discussion of trade and development in Chapter 17, with the issue of so-called trade-related intellectual property rights.

What about excludable, congestible goods? As discussed earlier, congestible goods are nonrival at low levels of use and rival at high levels of use. We used roads and traffic jams as an example, and recreational resources such as beaches, swimming pools, parks, and wilderness hiking trails are similar (though for the gregarious, crowding may actually add value). When goods or resources have these properties, positive prices may produce efficient outcomes for high levels of use, while at low levels of use, pricing will lead to inefficient outcomes. This suggests that under certain circumstances, it may be reasonable to treat congestible goods as market goods during peak usage and nonmarket goods at other times.

Multi-tier pricing structures are one possible solution. **Multi-tier pricing** involves charging different prices at different times or for different users. In this case, prices could be charged when congestion occurs (e.g., rush hour tolls on a bridge), but the good or service would remain free while uncongested. Such pricing structures can be expensive to implement, and whether the strategy is reasonable generally depends on the specific case. Whether the strategy is possible depends on excludability.

Pure Public Goods

As most economists readily admit, the market is not capable of optimally producing or efficiently allocating pure public goods, which are both nonrival and nonexcludable. Pure public goods are both nonrival and nonexcludable. We add the adjective “pure” only because many people are careless in their use of the term “public goods.” As we explained in Chapter 8, in a market setting, each person can purchase a good or service until the marginal benefit from purchasing one more unit of that good or service is just equal to the marginal cost. As long as anyone is willing to pay

[12] M. Stiltz, Copyleft and the Information Renaissance (2002). Online: http://dsl.org/copyleft/.

more for a good than it costs to produce that good, the supplier will supply an additional unit. If a public good exists, however, anyone can use it regardless of who pays for it. An additional unit of a market good is worth producing only as long as at least one individual alone is willing to pay at least the cost of producing that unit. In contrast, a public good is worth producing as long as all individuals together are willing to pay the cost of producing another unit.[13] Look again at Figure 9.4 for supply and demand. When we moved from the individual demand curve to the market or social demand curve, we added up the quantities each individual would be willing to pay at a given price because we were talking about market goods. This is because the goods were rival, and what one person consumed another could not. However, public goods are nonrival, so one person consuming the good does not leave any less for others. In this case, we obtain the social demand curve by adding up the prices each individual is willing to pay for a given quantity to find out how much society as a whole is willing to pay for that quantity.

For market goods, each person consumes exactly as much as they purchase, so people's consumption preferences (weighted by their income, of course) are revealed by how they spend their money in the market. For public goods, in contrast, each person consumes as much as all of society purchases. This leads to problems.

For example, assume a nice forested park in the middle of a big city would cost $100 million for land purchase, landscaping, and infrastructure. Imagine that if we added together everyone's demand curve for the park, we would find that for a park of the proposed size, society is cumulatively willing to pay $150 million. Therefore, if everyone in the city contributed two-thirds as much money to building the park as he or she thought it would be worth, the park would be built. The problem is, how do we get everyone to contribute toward the park the amount that the park would be worth to him or her? Would market forces (i.e., the private sector) build it? Assume a corporation builds the park, fences it off, then charges admission. Knowing that the average person should be willing to pay $150 for a lifetime pass to the park, the corporation decides to sell such passes to recoup its investment. But problems arise. Not everyone values the park equally. Some people would be willing to pay much more than $150 for the pass, while others would be willing to pay very little. Those who are only willing to pay less than $150 will in effect no longer value the park at all if there is a $150 fee, and the corporation fails to recoup its investment. The corporation runs into similar problems if it charges an entrance fee for each use, say $1. In this circumstance, even

[13] P. Samuelson, The Pure Theory of Public Expenditure, *Review of Economics and Statistics* 36: 387–389 (1954).

those who value the park the most will use the park less than they would have if it were free. Since they will use it less, they will value it less. Again, the corporation will be unable to recoup its investment, and the park will not be built. If the park were free, more people would use it, increasing the total welfare of society while imposing no additional costs on society, but then, of course, the corporation would not build the park. Therefore, the market will not provide the park even as a private good, and if it did, it would not be efficiently utilized.

Box 10-3 The Free-Rider Effect

What would happen if some institution solicited voluntary donations to build a public park in my neighborhood? I am trying to decide how much to donate. If I meet standard neoclassical economic assumptions, I want to maximize my own utility. I live close to the proposed park site and would value it more than most people. I decide that I am indifferent between a park of the proposed size and $1000, and prefer the park over any cost less than $1000. However, I rationalize that if I contribute nothing to the park and others contribute what it's worth to them, that will only reduce the size of the park by one one-hundred-thousandth. I would vastly prefer a park 99.999% of the size of the proposed park at zero cost to myself than the proposed full-size park for $1000. Alternatively, if I contribute what the park is worth to me and others contribute less, the resulting park will be smaller because of insufficient funds, and therefore no longer worth $1000 to me.

From this narrow perspective of self-interest, my best strategy, regardless of what others choose, is to contribute nothing and instead rely on the contributions of others. Unfortunately, if everyone else also makes a similarly rational calculation in his or her own self-interest, the city ends up with no park whatsoever, and everyone is worse off than they would have been if the park had been built. This is known as the **free-rider effect,** and it is a serious obstacle to the provision of public goods. In this case, rational self-interest has created an invisible foot that kicks the common good in the rear!

Let's examine another example of the clash between markets and public goods. A small sharecropper in southern Brazil is kicked off his land share so that the landowner can grow soybeans under a heavily mechanized system requiring little labor. The soybeans are exported to Europe as cattle feed for higher profits than the landowner could make using sharecroppers to produce rice and beans for the local market. The sharecropper heads to the Amazon and colonizes a piece of land. Researchers have "guess-timated" the value of the ecosystem services sustainably produced by this land at roughly $1660/hectare/year.[14] These ecosystem services are primarily public goods. If the colonist deforests the land, he may make a one-time profit of $100/hectare for the timber (the timber is, of course, worth much more on the market, but the market is far away, and middlemen and transportation costs eat up the profits) and an estimated $33 annualized net profits per year from slash and burn farming.[15]

In terms of society, there is no doubt that the annual flow of $1660/year far outweighs the private returns to the farmer. However, the ecosystem services are public goods that the farmer must share with the entire world, and there is no realistic way of giving the farmer or anyone else meaningful private property rights to the ecosystem services his forests supply.[16] In contrast, the returns to timber and agriculture are market goods that the farmer keeps entirely for himself, and existing institutions give him the right to do as he pleases with his private property. Clearly, both the farmer and society could be better off if the beneficiaries of the public goods paid the farmer to preserve them. As long as the farmer receives more than $150/year he is better off, and as long as global society pays less than $1660/ha/year, it is better off.

Unfortunately, a number of serious obstacles prevent this exchange from happening, and we'll mention three. First, most people are ignorant about the value of ecosystem services (more on this later). Second, the free-rider effect means that many beneficiaries of public goods will pay little or nothing for their provision. Third, we currently lack institutions suitable for transferring resources from the beneficiaries of ecosystem services to the farmer who suffers the opportunity cost of not deforesting. Thus, from the farmer's point of view, in a market economy, deforestation is clearly the rational choice, and society suffers as a result.

Public Goods and Scarcity

Anyone who accepts the basic premise that global ecosystems create life-sustaining ecosystem services must believe that public goods are critically important. Yet market economic theory offers little advice concerning the production and allocation of public goods.

---

[14]R. Costanza, R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R. V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt, The Value of the World's Ecosystem Services and Natural Capital, *Nature* 387: 253–260 (1997). The land also produces a number of goods, such as timber and marketable nontimber forest products, which are valued in the cited paper, but those values are not included in this estimate.

[15]A. Almeida and C. Uhl, Developing a Quantitative Framework for Sustainable Resource-Use Planning the Brazilian Amazon, *World Development* 10 (1995).

[16]This does not mean we cannot develop mechanisms for compensating the farmer for providing ecosystem services; it simply means that if the farmer provides them, they are provided for one and all.

As we have repeatedly stressed, it is impossible to make something from nothing, and nothing from something. The production of market goods requires raw materials and generates waste. Raw materials are stock-flow resources taken from ecosystem structure, which therefore deplete ecosystem fund-services. Waste returned to ecosystems further depletes these services. Thus, if our economic system provides incentives solely for producing and allocating market goods, it will systematically undermine the production of absolutely invaluable public goods—and life-sustaining functions of our planet. One of the underlying assumptions of ecological economics is that many of the scarcest and most essential resources are public goods (services provided by natural resource funds), yet the existing economic system only addresses market goods.

Let's return now to the question of knowledge and information, presented above. If information is a private good, it will not be efficiently allocated; if it's a public good, it will not be produced in sufficient quantity by market forces. If we set theory aside momentarily and simply look at the rate of technological progress, we might believe we have little to complain about. Technological progress is extremely rapid. While it is true that patents create legal monopolies, they only do so for a limited time, after which knowledge becomes a public good. It is not difficult to believe that it is the lure of temporary monopoly profits that brings new inventions onto the market faster than would otherwise be the case. Why worry about a system that works?

One reason is that the creation of this knowledge imposes an opportunity cost on society. There is a limited pool of resources (e.g., money, scientists, laboratories) for conducting research, and if it is being used in one task, it is simply not available for another. If new inventions are driven primarily by the pursuit of profits, then we have a serious bias against the invention of public goods or technologies that preserve or restore public goods. For example, the pharmaceutical industry employs legions of scientists and spends billions on research and development for noncommunicable diseases afflicting the wealthy.

On the other hand, the control of communicable diseases is a public good, and from a societal perspective, we should channel resources toward it. An excellent example is found with the case of tuberculosis treatments. Tuberculosis is a highly contagious disease that is difficult to treat. Effective treatments were developed in the 1950s, but they require close monitoring of patients for 6 months to a year. Many people who suffer from tuberculosis are not sufficiently responsible to treat themselves and governments throughout the world have spent enormous amounts of public money to track down people and force them to take their medicine. In response to declining infection rates, federal funding in the United States targeted for tuberculosis treatment was slashed in the 1970s, and public health expenditures suffered further cuts in the 1980s. As a result, many tuberculosis sufferers did not receive treatment, or began to take their medicine only erratically. This contributed to a resurgence of tuberculosis in the 1980s, including multiple-drug-resistant varieties. In New York City alone, it cost over $1 billion in government spending to bring this epidemic back under control.

Tuberculosis primarily affects the poor, which reduces the profitability of any cures and explains the lack of investment in new treatments by drug companies.[17] (It is no coincidence that only 13 of the 1240 new drugs licensed between 1975 and 1996 dealt with lethal communicable diseases that primarily afflict people from developing countries.[18]) However, even if drug companies did develop new treatments, they would need to patent the medicine and sell it for a profit to recoup their investments. Patents increase the prices of medicines to cure contagious diseases, while from the perspective of society their cost to patients should actually be *negative*. In other words, it would be efficient for the government to pay people to use such medicines because their use provides positive benefits to the rest of society.

Most research scientists working today are employed by the private sector, which retains rights to whatever they produce. The private sector is increasingly responsible for funding research in universities as well. It will logically concentrate on research with market potential. Corporate scientists would presumably work for a public organization for the same salaries. In this case, the resulting knowledge could be free for all to use, a prerequisite for efficient use (as defined by neoclassical economics) of nonrival goods. We are not suggesting here that all research be government funded.[19] But unless some nonmarket institutions fund research into public goods, technological advance will tend to ignore nonmarket goods.

As the great Swiss economist Sismondi argued long ago, not all new knowledge is a benefit to humanity. We need a social and ethical filter to select out the beneficial knowledge. Motivating the search for knowledge by the purpose of benefiting humanity, rather than by securing monopoly profit, provides a better filter—a filter more likely to give us a cure for

---

[17]L. Geiter, "Ending Neglect: The Elimination of Tuberculosis in the United States," Committee on the Elimination of Tuberculosis in the United States, Division of Health Promotion and Disease Prevention, 2000. Online: http://www.nap.edu/books/0309070287/html/.

[18]Garret, Laurie (2000). *Betrayal of Trust: the Collapse of Public Health*, New York: Hyperion.

[19]It is worth noting that the government currently does fund enormous amounts of primary research with taxpayer dollars, yet subsequently allows private corporations to establish patents to products derived from that research. This allows corporations to earn monopoly profits from taxpayers on research paid for by those very taxpayers.

AIDS or tuberculosis or malaria, than a new liposuction or heart transplant technique.

If the market is extremely effective at producing market goods but very poor at producing or preserving public goods, then over time, public goods inevitably become more scarce relative to private goods, giving rise to a problem of what we call **macro-allocation**, which is the allocation of resources between market and nonmarket goods and services.

Public Goods and Substitution

In previous chapters, we discussed the issue of substitution, pointing out that ecological economists believe we cannot substitute efficient cause for material cause, except at a very small margin, while neoclassical economists (NCEs) argue that manmade capital is essentially a perfect substitute for natural capital. After all, haven't people been arguing that resource exhaustion is imminent since the time of Malthus, and haven't they consistently been proven wrong? NCEs (and many other people) argue that as a resource grows scarce, the price increases, encouraging the invention and innovation of substitutes. It is true that some civilizations in the past appear to have disappeared from exhaustion of their natural capital, but NCEs assert that the market has averted such collapses since the advent of capitalism. This, of course, is tantamount to claiming that the profit motive is more powerful than the survival motive.

One can certainly find numerous examples where the profit motive has apparently produced substitutes for scarce resources, but that's no guarantee that there will be adequate substitutes for every vital resource. Moreover, even if the profit motive does provide a marvelous spur to our creative processes, what happens when the resources becoming increasingly scarce are public goods? Such goods have no price, and there will therefore be no price signal telling our entrepreneurs that we need substitutes, nor is there any profit to be made by creating such substitutes.[20] What happens then? Conventional market economics does not address this question.

The Distribution of Public Goods Through Space

Another complication arises with some public goods, particularly those produced by ecosystem function, which is highly relevant to policy choices. We pointed out earlier that ecosystems can provide different public goods and services for different populations. For example, water regulation and storm surge protection provided by intact mangrove forests are

[20]Not to mention, as we pointed out in Chapter 6, that it is probably much easier to create substitutes for ecosystem structure (stock-flow resources, raw material) than for ecosystem services provided by the wickedly complex interaction of structural elements in an ecosystem.

local public goods, the role of mangroves as a fishery nursery is a regional public good, and global climate stability promoted by forest carbon storage is a global public good. Individuals are ultimately responsible for how ecosystem stock-funds are treated, they will prefer market flows over public good services, and the two are often mutually exclusive. Unlike individuals, society in some circumstances should prefer public goods over the production of private goods that deplete them. However, local communities may show little concern for providing national public goods. Sovereign nations may show little concern for providing global public goods. Thus, decision makers at different levels (individual, local, national, international, intergenerational) will have different incentives for preserving or destroying ecosystem function, and these incentives must be understood in order to develop effective policies that meet differing needs at all levels. Unfortunately, political systems are largely based on the nation-state or smaller political units, and hence are inadequate for addressing global issues.

The inadequacy of existing political and economic systems for managing public goods is particularly problematic in light of the fact that many ecosystem services are public goods that provide vital services. On the global level, such functions include protection from excessive solar radiation, global climate regulation, and the role of biodiversity in sustaining the web of life. On the local level, ecosystems provide microclimate regulation (often critical for successful agricultural production), buffering from storms, and maintenance of water quality and quantity, all of which may be essential for community sustenance.

Externalities

Another important type of market failure is known as an externality. An **externality** occurs when an activity or transaction by some parties causes an unintended loss or gain in welfare to another party, and no compensation for the change in welfare occurs. If the externality results in a loss of welfare, it is a negative externality, and if it results in a gain, it is positive. The **marginal external cost** is the cost to society of the negative externality that results from one more "unit" of activity by the agent.

The classic example of a negative externality is a coal-fired utility plant that moves in next door to a laundry service that air-dries its wash. The soot from the coal plant dirties the laundry, and the laundry service receives no compensation from the coal utility. Both air and water are great conveyors of externalities. If a farmer allows his cattle to defecate in a stream flowing through his property, all those downstream from him suffer the negative externality of polluted water. Alternatively, a farmer might reforest his riparian zone, reducing access by cattle. The canopy shades the stream, killing in-stream vegetation. Water can now run faster, allowing it to scour sediments out of buried springs in the stream, thereby increasing water flow.[21] Shaded water is cooler, reducing the ability of some harmful bacteria to thrive, thereby increasing water quality. Downstream landowners benefit from these positive externalities. Similarly, if I plant a beautiful flower garden that all my neighbors enjoy yet I receive no compensation from them, I have created a positive externality. A final example is the pollution we spew every time we drive a car, which decreases air quality and contributes to global warming.

Because the agent conducting the activity in question is not compensated for positive externalities and pays no compensation for negative ones, she does not take into account these costs or benefits in her decision to pursue the activity. In the case of negative externalities, the agent carries the activity too far. With positive externalities, the agent engages in too little of the activity. If the agent conducting the activity were to be appropriately compensated or charged, there would be no more externality; the activity would be carried out until marginal benefits equaled marginal costs, not only for the agent conducting the activity but also for society.

As in the case of public goods, economists have suggested that assigning property rights will eliminate the externality problem. If the laundry has the right to clean air, then the coal utility will be forced to pay the laundry service for dirtying its laundry.[22] Once compensation is paid, the externality is gone. Alternatively, it would be possible to assign the right to pollute to the coal utility. In this case, the laundry would have to pay the coal utility not to pollute.[23] As Ronald Coase showed in perhaps the most widely cited article ever written on externalities, under certain circumstances, it doesn't matter whether the utility is assigned the right to pollute or the laundry is assigned the right to clean air.[24] In either case, the negotiated outcome will lead to an identical amount of pollution, precisely at the level marginal costs of pollution to the laundry are just equal to the marginal benefits to the utility. The implication is that the external-

[21]Note that the outcomes of reforestation are highly dependent on both the system in question and the techniques and species used for reforestation. In some cases, reforestation may reduce water quantity.

[22]In reality, this will not necessarily lead to an efficient solution in a dynamic setting. For example, if the payment makes the laundry service profitable, another laundry may locate nearby, which would also be profitable with a subsidy from the utility. For fairly obvious reasons, it is inefficient if the promise of a subsidy from the utility attracts businesses that are otherwise harmed by the utility's presence.

[23]In this case, we would have to look at installation of pollution reduction equipment as generating a positive externality for which the laundry service must compensate the public utility.

[24]R. Coase, The Problem of Social Cost, *Journal of Law and Economics* 3: 1–44 (October 1960).

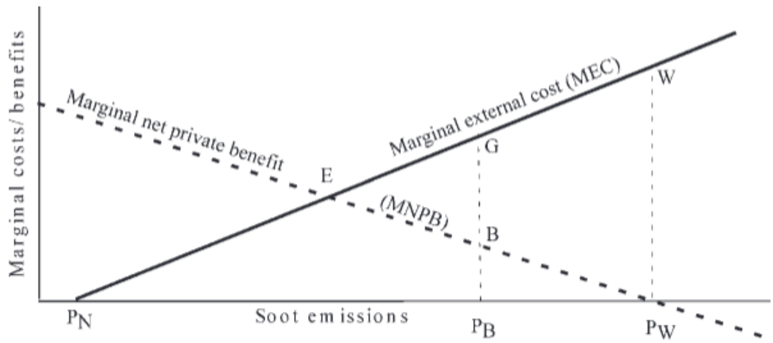

Figure 10.2 • "Optimal" pollution levels. "Optimal" pollution levels are theoretically determined by the intersection of the marginal external cost (MEC) curve and the marginal net private benefit (MNPB) curve.

ity issue requires no government intervention—market forces are perfectly capable of sorting it out. This is known as the **Coase theorem**.

The *Coase theorem* states that the initial allocation of legal entitlements does not matter from an efficiency perspective so long as they can be exchanged in a perfectly competitive market.[25]

A graphic analysis may help make this a bit clearer. Figure 10.2 shows pollution on the X-axis and marginal costs and benefits on the Y-axis. The coal-fired utility benefits from polluting, while this pollution imposes costs on the laundry service. There are several technologies available for reducing pollution. If the problem is simply to reduce local pollution, the utility can install higher smokestacks at a reasonably low cost. The higher the smokestack, the more it reduces local pollution, but the more expensive it is to install. To reduce pollution even further, it is necessary to install scrubbers, which are more expensive than higher smokestacks. To really reduce pollution, the coal-fired utility would have to convert to natural gas at a very high cost, and to eliminate pollution, the plant would have to close down,[26] imposing yet higher costs. It is clear, then, that the marginal cost of reducing pollution is increasing, which is the same as saying that the marginal net private benefits (MNPB) of pollution are decreasing. This is depicted by the MNPB curve, the dashed line sloping down to the right.

For the laundry service, the cost of a small amount of pollution is negligible. As the amount of pollution increases, however, drying the laundry outside makes it noticeably dirtier. Initially, this might result in fewer

[25]R. Cooter, "Coase Theorem." In *The New Palgrave: A Dictionary of Economics*, New York: Macmillan, 1987, pp. 457–459.

[26]Reducing pollution has real energy costs attached to it. For example, studies by Cutler Cleveland have shown that unregulated coal-fired utility plants generate 9 units of energy for every unit of energy required to build and maintain the plant, feed the workers, mine and transport the ore, etc. Scrubbers and other antipollution devices consume considerable energy in manufacturing, installation, and maintenance, and reduce the energy efficiency of plants from 9:1 to 2.5:1. Cited by C. Flavin in *Worldwatch*, January/February 2001, response to letter, p. 6.

customers and reduced profits. If the pollution gets worse, the laundry service will have to move its laundry lines indoors or install electric dryers. Very severe pollution might even reduce air quality inside the laundry service, imposing the need for an air filtration system. Each of these options is more expensive than the last. The basic point is that the marginal cost of pollution to the laundry is increasing. We depict this with line MEC, the marginal external cost curve, sloping up and to the right. In reality, it is unlikely that either the MNPB or the MEC curves would be smooth. Technologies are "chunky"—one cannot purchase smokestacks one row at a time, or scrubbers in small units. External costs often exhibit thresholds beyond which costs increase dramatically. The assumption of smooth curves, however, does not affect the discussion.

Economic efficiency demands that MNPB = MEC (a variant of our basic MB = MC rule of efficiency). Let's assume initially that there are no laws preventing the coal-fired utility from polluting. The utility will produce until the MNPB of additional pollution is zero, which occurs at point P_W. However, at pollution level P_W, the laundry service suffers very high costs from the soot—the area EWP_w measures the net loss to society. The laundry service could increase its profits by paying the coal utility anything less than P_WW to reduce pollution by one unit from point W. The coal utility will increase its profits as long as the laundry service pays it anything at all to reduce pollution. If the laundry pays the coal utility to reduce pollution to P_B, there is still room for mutually beneficial exchanges. At this point, if the laundry pays any sum less than P_BG it will benefit, and if the utility receives any amount greater than P_BB it will benefit. The possibility for mutually beneficial exchanges (payments from the laundry service to the coal utility to reduce pollution) continues until we reach point E, where MNPB = MEC and we have achieved a socially efficient outcome in the absence of government intervention. The same result applies if the laundry has the right to clean air, and we start at pollution level P_N. In this case, the coal utility will keep paying the laundry service for the right to pollute until reaching point E.

A serious problem with this analysis is that it assumes that both the laundry and the utility are able to pay (i.e., that there are no wealth effects) and that there are no real transaction costs. If the laundry earns insufficient profits to pay the utility to decrease pollution and must go out of business if the utility is assigned the right to pollute, that is an example of the *wealth effect*. A **transaction cost** is simply the cost of thrashing out an agreement, which can include legal fees, the cost of gathering information, locating the interested parties, the time cost of bargaining and so on. Transaction costs may not be that high in the case of one laundry service and one utility. However, pollution from a coal-fired utility affects many people in many locations. For example, a coal-fired utility in Ohio causes local pollution in the surrounding community and also contributes to smog and acid rain at least as far away as New York and Canada; it contributes to global warming, which affects everyone on the planet.

Similarly, a farmer who pollutes his water supply may be one of many upstream farmers affecting thousands of downstream neighbors. Bringing all the relevant agents together to the negotiating table would range from difficult to impossible, and even if it could be achieved, free-riding would become a problem. For example, if I live on the stream polluted by upstream farmers and my neighbors agree to pay the farmers some sum to reduce pollution, I may prefer that level of reduction for free to even more reduction at a positive cost to myself.

Coase explicitly recognized that high transaction costs could justify government intervention, though this caveat seems to have been lost on many of his devoted followers. In the definition of the Coase theorem supplied earlier, we must take "perfect market" to mean no transaction costs and perfect information. Even then, however, the presence of wealth effects undermine the theorem. Remember that efficiency of allocation is defined only for a given distribution. Since vesting property rights in the polluter implies a different distribution (wealth effect) than does vesting them with the pollutee, the two cases are not strictly comparable in terms of efficiency—we simply cannot say that the two situations envisaged by Coase are "equally efficient," because they are based on two different distributions of wealth. "Efficiency" in the Coase theorem is from the viewpoint of society, and different legal entitlements also have significant direct impacts on the well-being of the parties involved.

In reality, transaction costs are likely to be very important any time an externality impacts more than a very few agents, which is the general rule rather than the exception. Many externalities, in fact, affect the provision of public goods and confront the same obstacles as the provision of private goods. Yet again we must stress that all economic production requires raw material inputs and generates waste outputs, thus depleting ecosystem services. All economic production inevitably generates "externalities." Indeed, "externalities" is a misnomer, since there is an unbreakable link (throughput) between resource depletion, production, and waste emissions, so these "externalities" are actually 100% *internal* to the economic process. If converting a forest to farmland imposes negative externalities at the local, national, and global levels, transaction costs for an efficient solution would be prohibitively expensive. When externalities affect future generations, we must accept that transaction costs between generations are infinite, and the market will not solve the "externality" problem unaided.

We must also recognize that perfect information concerning human impacts on ecosystems is unobtainable. Uncertainty and ignorance are such ubiquitous obstacles to market efficiency that they can be considered market failures in their own right. It is hard to equate MC and MB when we do not know the probabilities of possible outcomes, and it is virtually impossible to do so when we are ignorant even of the possible outcomes.

MISSING MARKETS

For a market to function optimally, everyone who would want to produce or consume the goods being marketed must be able to participate. For example, if the *Mona Lisa* were to be auctioned off and only people from Waco, Texas, were allowed to participate, it might not fetch as high a price as it would on the international market. Yet the fact is that future generations cannot possibly participate in today's markets, and hence today's market prices will not reflect their preferences. The market can therefore only "efficiently" allocate resources if we assume that future generations have no rights whatsoever to the resources being allocated.

How could we provide future generations with property rights to resources? One way to bring this about would be to impose sustainability criteria. For example, we might decide that the rights of future generations to certain resources, such as the ecosystems responsible for generating life-support functions, are inalienable[27]—much like human and political rights, where entitlements are not decided by efficiency criteria. As we deplete nonrenewable resources, we could invest a sufficient percentage of the profits in renewable substitutes to replace the depleted resource (we'll describe this option in greater detail later). For renewable resources, we could make sure that they were never depleted beyond their capacity to regenerate. If renewables were depleted below their maximum sustainable yield (MSY), we would need to bequeath some substitute that would compensate for the reduction in future harvests. Or we could lower offtake (passive investment in natural capital) enough to replenish the renewable resource to at least the MSY level.

How we handle intergenerational gambles with unknown reward structures is an ethical issue, but it would certainly seem that most ethical systems would demand at the very least that we do not risk catastrophic outcomes for the future in exchange for nonessential benefits today. Given our ignorance of ecosystem function, this means we would have to stay well back from any irreversible ecological thresholds. Such sustainability criteria would essentially distribute resources between generations, and the market could then function to allocate them within a generation.

---

[27] D. Bromley, *Environment and Economy: Property Rights and Public Policy*, Oxford, England: Blackwell, 1991.

Alternatively, we could just continue to act on the ethical assumptions of neoclassical economics. If we are indeed rational maximizers of self-interest, and Pareto efficiency is an objective criterion for allocation, then the rights of future generations can be completely ignored. After all, as Kenneth Boulding once asked: What have future generations ever done for us? We certainly cannot increase our own well-being by redistributing resources to the future.

In reality, conventional economists do not disregard future generations entirely, but in their analyses they do systematically discount any costs and benefits that affect future generations. In Chapters 11 and 12, we'll look at how the convention of discounting can affect decisions concerning natural resource use.

Intertemporal Discounting

Do conventional economists really ignore future generations? In a standard economic analysis where they have to compare costs and benefits in the future with costs and benefits in the present, conventional economists will systematically discount any costs and benefits that affect future generations. There are some very plausible reasons for giving less weight to resources in the future than resources in the present, and we will explore the topic in some detail in Chapter 15. Here we offer only a brief introduction to help you understand, in the following chapters, how the convention of **intertemporal discounting** can affect decisions concerning natural resource use. When evaluating present and future values, intertemporal discounting is the process of systematically weighting future costs and benefits as less valuable than present ones.

Why should resources in the future be worth less than resources today? If I have \$100 today, I can invest it in some profit-making venture, and I will have more than \$100 next year. In perhaps the simplest example, if I can safely invest money in the bank at 5% real interest (i.e., at an interest rate 5% greater than inflation), then I will always prefer \$100 today to anything less than \$105 a year from now for the simple reason that if I have the money today I have the option to spend it now or allow it to become \$105 next year. Next year, of course, I would again have the option to spend the money, or leave it again to grow at 5% to become \$110.25, then \$115.76, then \$121.55, and so on indefinitely. Conversely, \$100 in the future is worth less than \$100 today because of the *opportunity cost* involved (the lost opportunity to invest), and the farther in the future we look, the less the money is worth. Most conventional economists assume that money is an adequate substitute for anything, and therefore anything in the future is worth less than the same thing today. In general, the present value (PV) of a sum of money t years in the future, X_t, when the interest rate is r, will be given by

$$PV = X_t/(1 + r)^t$$

If we have a stream of money at different dates in the future, we can calculate the PV for each yearly amount, and sum them. This is basically what is done in the more complicated formula below.

A standard cost-benefit analysis (CBA) will tell us the **net present value (NPV)**—the value to us today—of a given stream of costs and benefits through time. The farther off in time that a cost or benefit occurs, the more we discount its present value. The basic equation is:

$$NPV = \sum_{t=0}^{T} (Benefits_t - costs_t)\left(\frac{1}{1+r}\right)^t$$

The discount rate is r, and the discount factor is 1/(1 + r). If we let r = 5%, as in the earlier example, then the discount factor is 1/1.05, which is less than one. The letter t represents time, and $benefits_t$-$costs_t$ is simply net benefits in period t. As t increases, the discount factor is raised to a larger and larger power, and, because it is less than one, raising it to a higher power makes it ever smaller, reducing the net present value by ever more the farther in the future the benefit or cost is. The symbol Σ tells us to sum together the net benefit stream from time 0 to time T.

THINK ABOUT IT!
Do you think the convention of estimating net present value ignores the rights of future generations? Why or why not?

SUMMARY POINTS

What are the most important points you should take home from this chapter? Markets only balance supply and demand, possibility with desirability, under a very restrictive range of assumptions. Among others, goods and resources must be both excludable and rival (where excludable implies well-defined and enforced property rights), market actors must be able to make transactions with zero cost (which would automatically eliminate most transactions), and people must have perfect information concerning all the costs and benefits of every good. Even if all of these conditions are met, markets will not account for future generations. In reality, these conditions are never met, though many excludable and rival goods meet these criteria well enough that the market is a very useful allocation mechanism. When resources are nonrival and/or nonexcludable, the specific combination of these characteristics has much to tell us about how the resources should be allocated. You should clearly understand the implications of these various combinations. Remember also that social institutions are required to make resources excludable, but some resources are nonexcludable by their very nature, and rivalness is a physical property.

In particular, we must recognize that the "optimal" production of pure public goods cannot be based on the criterion of Pareto efficiency. The public good problem appears to be beyond the scope of market allocation. You might think about policies and institutions that could be effective mechanisms for allocating public goods and the ecological fund-services that provide many of them. One possibility worth considering is a participatory democratic forum that captures a broader spectrum of human values than self-interest, and does not weight participant values solely by the purchasing power at their disposal.

BIG IDEAS to remember

- Excludable
- Rival
- Congestible
- Public goods
- Open access regimes
- Nonrival, excludable resources
- Externalities
- Coase theorem
- Transaction costs
- Wealth effects
- Missing markets
- Intertemporal discounting and net present value
- Inalienable rights