ECONOMICS of the PUBLIC SECTOR

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3 Market Efficiency

FOCUS QUESTIONS

1 What do economists mean when they say the economy is efficient?
2 What conditions have to be satisfied if markets are to be efficient?
3 Why is there a general presumption that competitive markets result in efficiency?

In most modern industrial economies, primary reliance for the production and distribution of goods lies in the private rather than the public sector. One of the most enduring tenets of economics holds that this form of economic organization leads to an efficient allocation of resources. But if private markets are efficient, why should there be an economic role for government? To answer this question a precise understanding of the meaning of economic efficiency is needed. That is the aim of this chapter. The next chapter will consider why private markets may fail to achieve efficient outcomes and how government may respond to these market failures.

THE INVISIBLE HAND OF COMPETITIVE MARKETS

In 1776 Adam Smith, in the first major work of modern economics, *The Wealth of Nations,* argued that competition would lead the individual in the

pursuit of his private interests (profits) to pursue the public interest, as if by an invisible hand:

> . . . he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it.[1]

The significance of Smith's insight is clarified by a look at the views about the role of government commonly held prior to Smith. There was widespread belief that achieving the best interests of the public (however that might be defined) required an active government. This view was particularly associated with the mercantilist school of the seventeenth and eighteenth centuries, which argued that government should promote industry and trade. Indeed, many European governments had actively promoted the establishment of colonies, and the mercantilists provided a rationale for this.

Some countries (or some citizens within them) had benefited greatly from the active role taken by their government, but other countries, whose governments had been much more passive, had also prospered. And some countries with strong, active governments had not prospered, as their resources were squandered on wars or on a variety of unsuccessful public ventures.

In the face of these seemingly contradictory experiences, Smith addressed himself to the question: Can society ensure that those entrusted with governing actually pursue the public interest? Experience had shown that while at times the policies governments pursued seemed consistent with the public good, at other times the policies pursued could not by any reasonable stretch of the imagination be reconciled with the public good. Rather, those in the position of governing often seemed to pursue their private interests at the expense of the public interest. Moreover, even well-intentioned leaders often led their countries astray. Smith argued that it was not necessary to rely on government or on any moral sentiments to do good. The public interest, he maintained, is served when each individual simply does what is in his own self-interest. Self-interest is a much more persistent characteristic of human nature than a concern to do good, and therefore provides a more reliable basis for the organization of society. Moreover, individuals are more likely to ascertain with some accuracy what is in their own self-interest than they are to determine what is in the public interest.

The intuition behind Smith's insight is simple: If there is some commodity or service that individuals value but that is not currently being produced, then they will be willing to pay something for it. Entrepreneurs, in their search for profits, are always looking for such opportunities. If the value of a certain commodity to a consumer exceeds the cost of production,

[1] Adam Smith, *The Wealth of Nations* (New York: Modern Library, 1937). Originally published in 1776.

there is a potential for profit, and an entrepreneur will produce the commodity. Similarly, if there is a cheaper way of producing a commodity than that which is presently employed, an entrepreneur who discovers this cheaper method will be able to undercut competing firms and make a profit. The search for profits on the part of enterprises is thus a search for more efficient ways of production and for new commodities that better serve the needs of consumers.

Notice that in this view, no government committee needs to decide whether a commodity should or should not be produced. It will be produced if it meets the market test—that is, if what individuals are willing to pay exceeds the costs of production. Nor does any government oversight committee need to check whether a particular firm is producing efficiently: competition will drive out inefficient producers.

There is widespread consensus among economists that competitive forces do lead to a high degree of efficiency, and that competition does provide an important spur to innovation. However, over the past two hundred years economists have come to recognize that in some important instances the market does not work as perfectly as the more ardent supporters of the free market suggest. Economies have gone through periods of massive unemployment and idle resources; the Great Depression of the 1930s left many who wanted work unemployed; pollution has choked many of our larger cities; and urban decay has set in on others.

WELFARE ECONOMICS AND PARETO EFFICIENCY

Welfare economics is the branch of economics that focuses on what were termed normative issues in Chapter 1. The most fundamental normative issue for welfare economics is the economy's organization—what should be produced, how it should be produced, for whom, and who should make these decisions. In Chapter 1, we noted that the United States and most other economies today are *mixed,* with some decisions made by the government but most left up to the myriad of firms and households. But there are many "mixes." How are we to evaluate the alternatives? Most economists embrace a criterion called **Pareto efficiency,** named after the great Italian economist and sociologist Vilfredo Pareto (1848–1923). Resource allocations that have the property that no one can be made better off without someone being made worse off are said to be **Pareto efficient,** or **Pareto optimal.** Pareto efficiency is what economists normally mean when they talk about efficiency.

Assume, for instance, that the government is contemplating building a bridge. Those who wish to use the bridge are willing to pay more than enough in tolls to cover the costs of construction and maintenance. The construction of this bridge is likely to be a **Pareto improvement,** that is, a change which makes some individuals better off without making anyone worse off. We use the term "likely" because there are always others who might be adversely affected by the construction of the bridge. For example,

if the bridge changes the traffic flow, some stores might find that their business is decreased, and they are worse off. Or an entire neighborhood may be affected by the noise of bridge traffic and the shadows cast by the bridge superstructure.

Frequently on summer days, or at rush hour, large backups develop at toll booths on toll roads and bridges. If tolls were raised at those times and the proceeds used to finance additional toll booths or more peak-time toll collectors, everyone might be better off. People would prefer to pay a slightly higher price in return for less waiting. But even this change might not be a Pareto improvement: among those waiting in line may be some unemployed individuals who are relatively little concerned about the waste of time but who are concerned about spending more money on tolls.

Economists are always on the lookout for Pareto improvements. The belief that any such improvements should be instituted is referred to as the **Pareto principle.**

"Packages" of changes together may constitute a Pareto improvement, when each change alone might not. Thus, while reducing the tariff on steel would not be a Pareto improvement (since steel producers would be worse off), it might be possible to reduce the tariff on steel, increase income taxes slightly, and use the proceeds to finance a subsidy to the steel industry; such

ON THE PROWL FOR PARETO IMPROVEMENTS

While finding Pareto improvements is difficult, economists are constantly on the lookout for such opportunities. Two recent proposals illustrate some of the problems that may be encountered.

One proposal concerned offshore oil wells. The federal government leases the land to oil companies in return for a royalty, usually around 16 percent. The oil companies compete for these leases in competitive auctions; the lease goes to the firm offering the highest bid. As oil wells get old, the cost of extraction increases, often to the point where, with the royalty taken into account, it pays to shut down the well. If the price of oil is $20 a barrel, and there is a 16 percent royalty, it pays to shut down the well when the cost of extraction exceeds $16.80. ($16.80 plus the $3.20 royalty equals the $20 received.) This seems inefficient, since the value of the oil ($20) exceeds the cost of production. Hence, there have been proposals to eliminate royalties on old wells and to allow the oil companies to pay a fixed up-front fee. The government is no worse off (since if the well is shut down it receives no revenue), and, provided the fee is set low enough, the oil company is better off (since if the well is shut down it receives nothing). The oil companies have resisted the proposal: they prefer that the government simply eliminate royalties. Although the proposal is a Pareto improvement over the status quo, they would prefer to garner for themselves more of the potential gains from the increased economic efficiency.

A second proposal involved allowing private companies to construct improved turbines at hydroelectric sites, increasing the energy output. They would be allowed to sell the electricity at market prices. Hydroelectric energy is particularly attractive, since it generates no pollution. There would be no adverse environmental impacts, since the developments would occur only at sites already being used. This too appeared to be a Pareto improvement: economic efficiency would be increased as cheaper hydroelectric power replaced power relying on fossil fuels; the benefits of the improved efficiency would be shared between consumers, investors, and the government; future generations would be better off as a result of the more favorable environmental impacts. This proposal was opposed by utility companies who currently get electricity from these dams at below-market prices. Though the proposal did not alter the current level of preferential treatment, they were worried that once the principle that electricity from hydroelectric sites could be sold at market prices was established, their preferential treatment would be threatened. Though the proposal as framed was a Pareto improvement, they saw the long-run consequences of the proposal as a gain in efficiency at the expense of their future welfare.

a combination of changes might make everyone in the country better off (and make those abroad, the foreign exporters of steel, also better off).

PARETO EFFICIENCY AND INDIVIDUALISM

The criterion of Pareto efficiency has an important property which needs comment. It is *individualistic*, in two senses. First, it is concerned only with each individual's welfare, not with the relative well-being of different individuals. It is not concerned explicitly with inequality. Thus, a change that made the rich much better off but left the poor unaffected would still be a Pareto improvement. Some people, however, think that increasing the gap between the rich and the poor is undesirable. They believe that it gives rise, for instance, to undesirable social tensions. Less developed countries often go through periods of rapid growth during which all major segments of society become better off but the income of the rich grows more rapidly than that of the poor. To assess these changes, is it enough simply to say that everyone is better off? There is no agreement on the answer to this question.

Second, it is each individual's perception of his or her own welfare that counts. This is consistent with the general principle of **consumer sovereignty,** which holds that individuals are the best judge of their own needs and wants, of what is in their own best interests.

THE FUNDAMENTAL THEOREMS OF WELFARE ECONOMICS

Two of the most important results of welfare economics describe the relationship between competitive markets and Pareto efficiency. These results are called the **fundamental theorems of welfare economics.** The first theorem tells us that if the economy is competitive (and satisfies certain other conditions), it is Pareto efficient.

The second theorem asks the reverse question. There are many Pareto efficient distributions. By transferring wealth from one individual to another, we make the second individual better off, the first worse off. After we make the redistribution of wealth, if we let the forces of competition freely play themselves out, we will obtain a Pareto efficient allocation of resources. This new allocation will be different in many ways from the old. If we take wealth away from those who like chocolate ice cream and give it to those who like vanilla, in the new equilibrium, more vanilla ice cream will be produced and less chocolate. But no one can be made better off in the new equilibrium without making someone else worse off.

Let's say there is a *particular* distribution which we would like to obtain. Assume, for instance, that we care particularly about the aged. The second fundamental theorem of welfare economics says that the *only* thing the government needs to do is redistribute initial wealth. *Every Pareto efficient resource allocation can be obtained through a competitive market process with an initial redistribution of wealth.* Thus, if we don't like the income distribution generated by the competitive market, we need not abandon the use of the competitive market mechanism. All we need do is redistribute the initial wealth, and then leave the rest to the competitive market.

The second fundamental theorem of welfare economics has the remarkable implication that every Pareto efficient allocation can be attained by means of a **decentralized market mechanism.** In a decentralized system, decisions about production and consumption (what goods get produced, how they get produced, and who gets what goods) are carried out by the myriad firms and individuals that make up the economy. In contrast, in a **centralized allocation mechanism,** all such decisions are concentrated in the hands of a single agency, the central planning agency, or a single individual, who is referred to as the central planner. Of course, no economy has even come close to being fully centralized, though under communism in the former Soviet Union and some of the other Eastern bloc countries, economic decision making was much more concentrated than in the United States and other Western economies. Today, only Cuba and North Korea place heavy reliance on central planning.

FUNDAMENTAL THEOREMS OF WELFARE ECONOMICS

- Every competitive economy is Pareto efficient.
- Every Pareto efficient resource allocation can be attained through a competitive market mechanism, with the appropriate initial redistributions.

The second fundamental theorem of welfare economics says that to attain an efficient allocation of resources, with the desired distribution of income, it is not necessary to have a central planner, with all the wisdom an economic theorist or a utopian socialist might attribute to him: competitive enterprises, attempting to maximize their profits, can do as well as the best of all possible central planners. This theorem thus provides a major justification for reliance on the market mechanism. Put another way, if the conditions assumed in the second welfare theorem were valid, the study of public finance could be limited to an analysis of the appropriate governmental redistributions of resources.

Why the competitive market, under ideal conditions, leads to a Pareto optimal allocation of resources is one of the primary subjects of study in standard courses in microeconomics. Since we will be concerned with understanding why under some circumstances competitive markets do not lead to efficiency, we first need to understand why competition under ideal conditions leads to efficiency. But before turning to this, it is important to emphasize that these results are *theorems;* that is, logical propositions in which the conclusion (the Pareto efficiency of the economy) follows from the assumptions. The assumptions reflect an ideal competitive model, in which, for instance, there are many small firms and millions of households, each so small that it has no effect on prices; in which all firms and households have perfect information, say, concerning the goods that are available in the market and the prices which are being charged; and in which there is no air or water pollution.[2] The accuracy of these assumptions in portrayal of our economy and the robustness of the results—the extent to which the conclusions change when the assumptions change—are two of the main subjects of debate among economists. In the next chapter we will look at some of the important ways in which markets fail to deliver efficient outcomes; that is, we will identify important circumstances in which the ideal conditions underlying the fundamental theorems of welfare economics are not satisfied.

EFFICIENCY FROM THE PERSPECTIVE OF A SINGLE MARKET[3]

We can see why competition results in economic efficiency using traditional demand and supply curves. The demand curve of an individual gives the amount of the good the individual is willing to demand at each price. The market demand curve simply adds up the demand curves of all individuals: it gives the total quantity of the good that individuals in the economy are willing to purchase, at each price. As Figure 3.1 illustrates, the demand curve is normally downward-sloping: as prices increase, individuals demand less of the good. In deciding how much to demand, individuals equate the

[2] There are also a number of technical assumptions.

[3] This is often called the partial equilibrium approach, in contrast to the general equilibrium approach, which looks at all markets simultaneously. We take the latter approach in the next section.

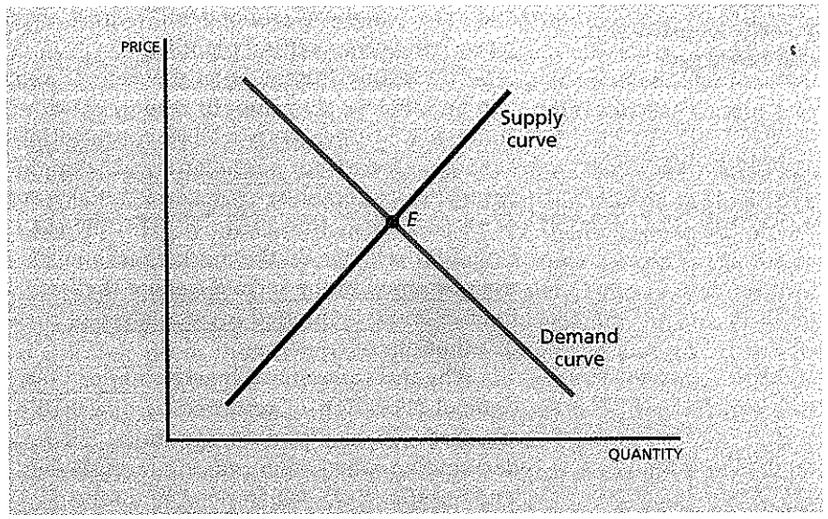

FIGURE 3.1 **Efficiency from the Perspective of a Single Market** In deciding how much to demand, individuals equate the marginal benefit they receive from consuming an extra unit with the marginal cost, the price they have to pay. In deciding how much to supply, firms equate the marginal benefit they receive, which is just the price, with the marginal cost. At the market equilibrium, where supply equals demand, the marginal benefit (to consumers) is equal to the marginal cost to firms—and each equals the price.

marginal (additional) benefit they receive from consuming an extra unit with the **marginal (additional) cost** of purchasing an extra unit. The marginal cost is just the price they have to pay.

The supply curve of a firm gives the amount of the good the firm is willing to supply at each price. The market supply curve simply adds up the supply curves of all firms: it gives the total quantity of the good that firms in the economy are willing to supply, at each price. As Figure 3.1 illustrates, the supply curve is normally upward-sloping: as prices increase, firms are willing to supply more of the good. In deciding how much of a good to produce, competitive firms equate the marginal (additional) benefit they receive from producing an extra unit—which is just the price they receive—with the marginal (additional) cost of producing an extra unit.

Efficiency requires that the marginal benefit associated with producing one more unit of any good equal its marginal cost. For if the marginal benefit exceeds the marginal cost, society would gain from producing more of the good; and if the marginal benefit was less than the marginal cost, society would gain from reducing production of the good.

Market equilibrium occurs at the point where market demand equals supply, point *E* in Figure 3.1. At this point, the marginal benefit and the

ANALYZING ECONOMIC EFFICIENCY

marginal cost each equal the price; thus the marginal benefit equals the marginal cost, which is precisely the condition required for economic efficiency.

ANALYZING ECONOMIC EFFICIENCY

To develop a deeper analysis that goes beyond the basic supply and demand framework just presented, economists consider three aspects of efficiency, all of which are required for Pareto efficiency. First, the economy must achieve **exchange efficiency,** that is, whatever goods are produced have to go to the individuals who value them most. If I like chocolate ice cream and you like vanilla ice cream, I should get the chocolate cone and you the vanilla. Second, there must be **production efficiency.** Given the society's resources, the production of one good cannot be increased without decreasing the production of another. Third, the economy must achieve **product mix efficiency** so that the goods produced correspond to those desired by individuals. If individuals value ice cream a lot relative to apples, and if the cost of producing ice cream is low relative to apples, then more ice cream should be produced. The following sections examine each of these types of efficiency in turn.

THE UTILITY POSSIBILITIES CURVE

In preparation for learning what is entailed by each of the three aspects of Pareto efficiency, the concept of the **utility possibilities curve** is useful. Economists sometimes refer to the benefits that an individual gets from consumption as the *utility* that she gets from the combination of goods she consumes.[4] If she gets more goods, her utility has increased. The utility possibilities curve traces out the maximum level of utility that may be achieved by two consumers. Figure 3.2 shows a utility possibilities frontier for Robinson Crusoe and Friday, showing Friday's maximum level of utility, given Crusoe's level of utility (and vice versa). Recall the definition of Pareto efficiency: An economy is Pareto efficient if no one can be made better off without making someone else worse off. That is, we cannot increase the utility of Friday without decreasing the utility of Crusoe. Thus, if an economy is Pareto efficient, it must be operating along the utility possibilities frontier. If the economy were operating at a point below the utility possibilities frontier, such as at point *A* in Figure 3.2, it would be possible to increase the utility of Friday or Crusoe without decreasing the utility of the other, or to increase the utility of both.

The first fundamental theorem of welfare economics says that a competitive economy operates along the utility possibilities frontier; the second

[4] Note that the concept of utility is only a useful way of thinking about the benefits that an individual gets from consumption. There is no way of measuring utility (other than indirectly, by looking at what individuals are willing to pay), no machine which can ascertain the number of "utiles" (or whatever the unit of measurement of utility might be called) derived from eating a pizza or listening to a CD.

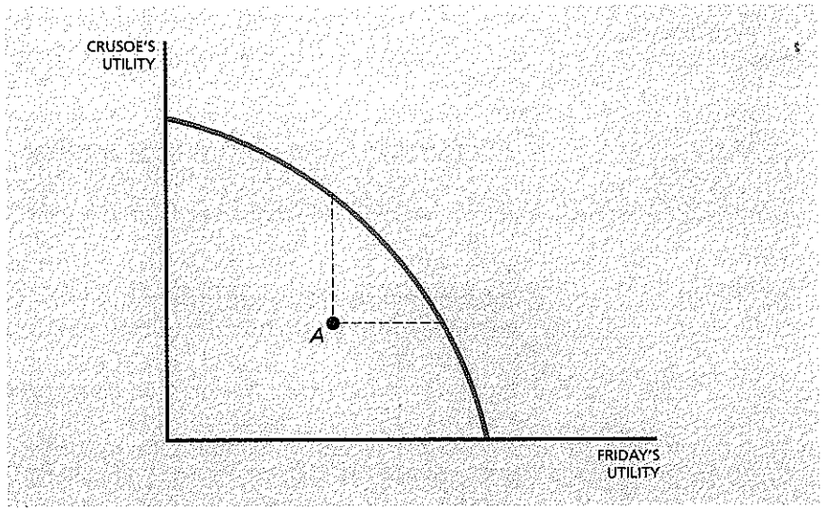

FIGURE 3.2 **The Utility Possibilities Curve** The utility possibilities curve gives the maximum level of utility that one individual (Friday) can achieve, given the level of utility of the other individual (Crusoe). Along the frontier, it is not possible for Crusoe to consume more unless Friday consumes less. Therefore, the utility possibilities curve is downward-sloping: the higher Crusoe's utility, the lower the maximum level of Friday's utility.

fundamental theorem of welfare economics says that we can attain any point along the utility possibilities frontier using competitive markets, provided we redistribute initial endowments appropriately.

EXCHANGE EFFICIENCY

Exchange efficiency concerns the distribution of goods. Given a particular set of available goods, exchange efficiency provides that those goods are distributed so no one can be made better off without someone else being made worse off. Exchange efficiency thus requires that there is no scope for **trades,** or exchanges that would make both parties better off.

Assume that Robinson is willing to give up one apple in exchange for one orange, or to get one apple in exchange for giving up one orange. Assume that Friday, on the other hand, is willing to give up three apples if he can get one more orange. At the margin, Friday values oranges more highly than does Robinson. Clearly, there is room for a deal: if Robinson gives Friday one of his oranges, and Friday gives Robinson two of his apples, both are better off. Robinson would have required only one apple to make him just as well off, but he gets two in exchange for his orange. Friday would have been willing to give up three apples; he only gave up two, so he is clearly better off.

The amount of one commodity which an individual is willing to give up in exchange for a unit of another commodity is called the **marginal rate of**

substitution. So long as Robinson and Friday's marginal rates of substitution differ, there will be room for a deal. Thus, exchange efficiency requires that all individuals have the same marginal rate of substitution.

We now will see why competitive economies satisfy this condition for exchange efficiency. To do so, we need to review how consumers make their decisions. We begin with the budget constraint—the amount of income a consumer can spend on various goods. Robinson has $100, which he can divide between apples and oranges. If an apple costs $1 and an orange $2, Robinson can buy 100 apples or 50 oranges, or combinations in between, as illustrated in Figure 3.3. If Robinson buys one more orange, he has to give up two apples. Thus, the slope of the budget constraint is equal to the ratio of the prices.

Robinson chooses the point along the budget constraint that he most prefers. To see what this entails, we introduce a new concept: **Indifference curves** give the combinations of goods among which an individual is indifferent or which yield the same level of utility. Figure 3.4 shows indifference curves for apples and oranges. For example, the indifference curve I_0 gives all those combinations of apples and oranges that the consumer finds just as attractive as 80 apples and 18 oranges (point A on the indifference curve). If points A and B are on the same indifference curve, the consumer is indifferent between the two combinations of apples and oranges represented by the two points. The indifference curve also shows how much of

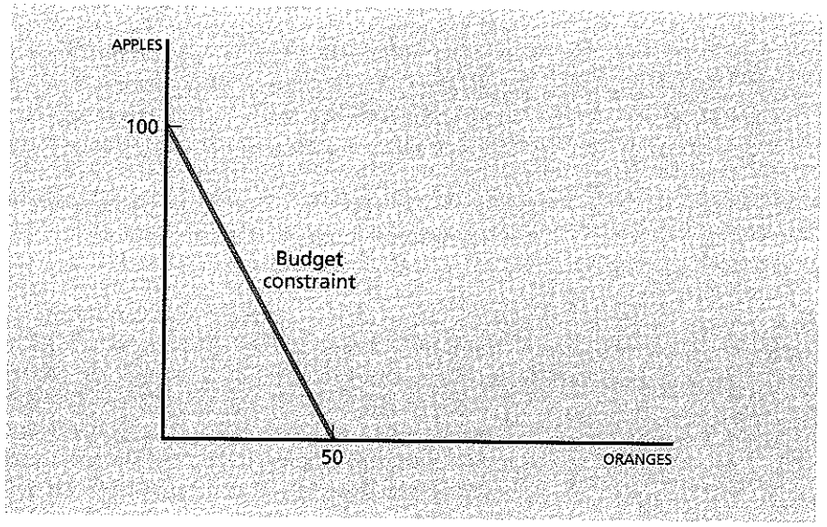

FIGURE 3.3 **Robinson's Budget Constraint** Given income of $100, the price of oranges of $2, and the price of apples of $1, an individual can purchase any combination of apples and oranges along or to the left of the budget constraint. Any combination to the right of the budget constraint is unaffordable. The slope of the budget constraint is based on the relative price of oranges and apples.

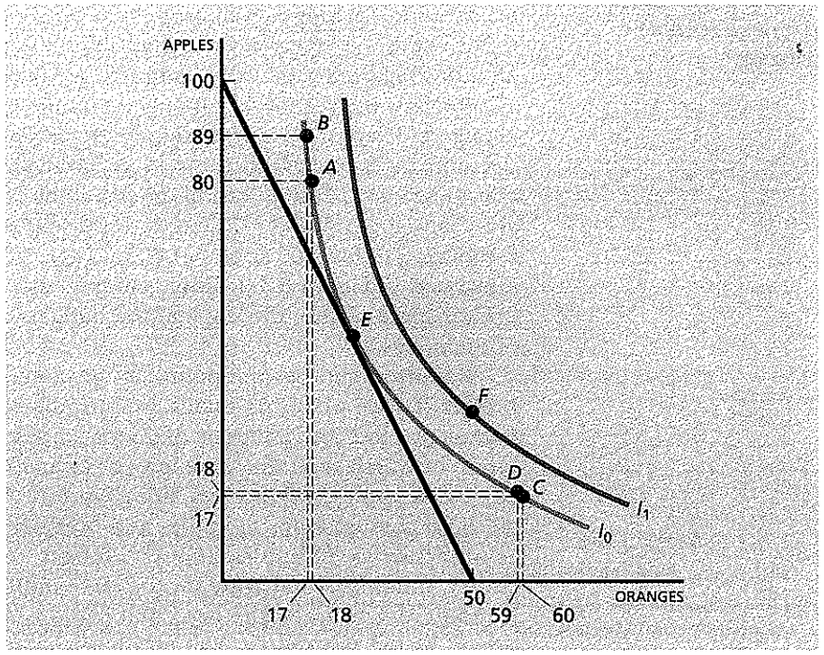

FIGURE 3.4 **The Consumer's Choice Problem** The budget constraint gives the combinations of apples and oranges that Robinson can buy, given his income and given the price of apples and oranges. The indifference curve gives those combinations of apples and oranges among which Robinson is indifferent. *A* and *B* are on the same indifference curve; Robinson is indifferent between them. Individuals prefer combinations of apples and oranges which are on a higher indifference curve. Thus, point *F* is preferred to either *A* or *B*. Robinson chooses the point along the budget constraint which he most prefers, that is, the point where the indifference curve I_0 is tangent to the budget constraint (point *E*).

one good (apples) the consumer is willing to give up in return for one more unit of another good (oranges). The amount of one good the individual is willing to give up in return for one more unit of another good is just the marginal rate of substitution, which we defined earlier. Thus, *the slope of the indifference curve equals the marginal rate of substitution.* In Figure 3.4, in moving from point *A* to point *B*, Robinson gives up one orange, but he is just as well off if he is compensated with nine extra apples. Note that the number of apples that he needs to compensate him for having one less orange is much higher when he moves from *A* to *B* than when he moves from *C* to *D*. When he has 60 oranges, he is much more willing to give up one of

his oranges: he only needs one more apple to compensate him. Thus the marginal rate of substitution diminishes as the number of oranges which Robinson consumes increases. This explains why the indifference curves have the shape depicted.

Clearly, individuals are better off if they have more apples and oranges; that is why combinations of goods along a higher indifference curve give a higher level of utility. Thus, any of the points on I_1 are more attractive than the points on I_0. By definition, a consumer does not care which point along an indifference curve he is at; but he wants to be along the highest indifference curve possible. Robinson would like to get to any point along the indifference curve I_1, but he cannot: all of these points lie above the budget constraint, and so are not feasible. The best that Robinson can do is to choose point *E*, where the indifference curve is tangent to the budget constraint.

At the point of tangency, the slope of the indifference curve is identical to the slope of the budget constraint. But the slope of the indifference curve is the marginal rate of substitution, and the slope of the budget constraint is the price ratio. Thus, individuals choose a combination of apples and oranges where the marginal rate of substitution is equal to the price ratio.

Because all consumers face the same prices in a competitive economy, and each sets his or her marginal rate of substitution equal to the price ratio, they all have the same marginal rate of substitution. Earlier, we showed that the condition for exchange efficiency was that all individuals have the same marginal rate of substitution. Thus **competitive markets have exchange efficiency.**

Another way to represent exchange efficiency is illustrated in Figure 3.5. For simplicity, we continue the example of Robinson Crusoe and Friday. Whatever Crusoe does not get, Friday gets. Thus we can represent all possible allocations in a box (called an Edgeworth-Bowley Box, after two early-twentieth-century English mathematical economists), where the horizontal axis represents the total supply of oranges and the vertical axis represents the total supply of apples. In Figure 3.5, what Crusoe gets to consume is measured from the bottom left corner (O), and what Friday gets is measured from the top right corner (O'). At the allocation denoted by the point *E*, Crusoe gets *OA* oranges and *OB* apples, while Friday gets the remainder ($O'A'$ oranges and $O'B'$ apples). We then draw Crusoe's indifference curves, such as U^c. We have also drawn Friday's indifference curves. His indifference curves look perfectly normal if you turn the book upside down.

Let us now fix Crusoe's utility. Pareto efficiency requires us to maximize Friday's utility, given the level of utility attained by Crusoe. Thus we ask, given that Crusoe is on the indifference curve U^c, what is the highest indifference curve that Friday can get to? Remember that Friday's utility increases as we move down and to the left (Friday is getting more goods, Crusoe fewer goods). Friday attains his highest utility where his indifference curve is *tangent* to Crusoe's, at *E*. At this point, the slopes of the indifference curves are the same, that is, their marginal rates of substitution of apples for oranges are the same.

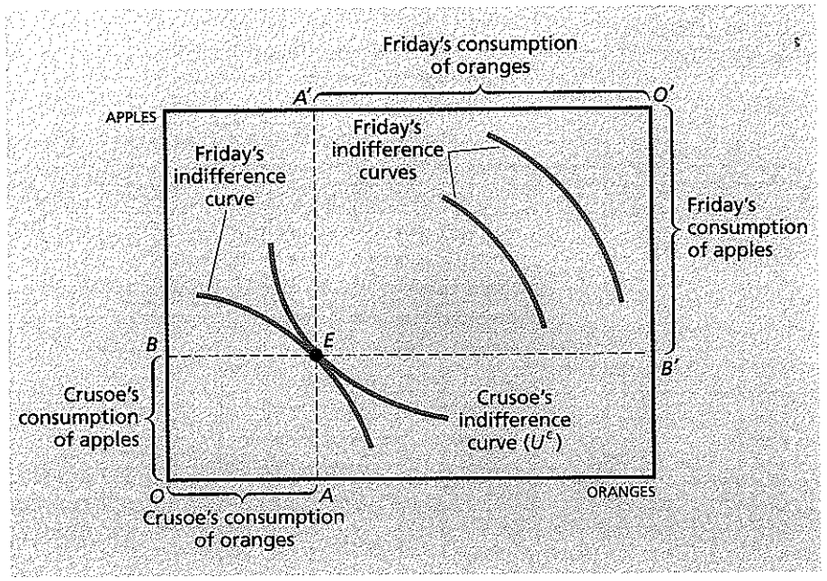

FIGURE 3.5 **Exchange Efficiency** The sides of this Edgeworth-Bowley Box give the available supplies of apples and oranges. *OA* and *OB* give Crusoe's consumption of the two commodities. Friday gets what Crusoe does not consume, that is, *O'A'* and *O'B'*. Pareto efficiency requires the tangency of the two indifference curves (one such point is at *E*), where the marginal rates of substitution of apples for oranges are equal.

PRODUCTION EFFICIENCY

If an economy is not productively efficient, it can produce more of one good without reducing production of other goods. Along the production possibilities frontier in Figure 3.6, the economy cannot produce more of one good without giving up some of another good, given a fixed set of resources.[5]

The analysis used to determine whether an economy is productively efficient is similar to the one we used above for exchange efficiency. Consider Figure 3.7. In place of the budget constraint we have an **isocost line,** giving the different combinations of inputs that cost the firm the same amount. The slope of the isocost line is the relative price of the two factors. The figure also shows two **isoquants.** These trace out the different combinations of inputs—in this case, land and labor—that produce the same quantities of outputs. Thus, isoquants are to the analysis of production what indifference curves are to the analysis of consumption. Economists call the slope of an isoquant the **marginal rate of technical substitution.** In Figure 3.7, the marginal rate of technical substitution is the amount of land required to compensate for a decrease in the input of labor by one unit. When relatively little labor is being used, it is hard to economize further in its use, so if one less worker is used, there must be a large increase in land if output is to remain unchanged. That is why the isoquants have the shape they do. There is a diminishing marginal rate of technical substitution.

Just as exchange efficiency required that the marginal rate of substitution between any pair of commodities be the same for all individuals, production efficiency requires that the marginal rate of technical substitution be the same for all firms. Assume the marginal rate of substitution between land and labor is 2 in producing apples and 1 in producing oranges. That means if we reduce labor by one in oranges, we need one more unit of land. If we reduce labor by one in apples, we need two more units of land. Conversely, if we increase labor by one in apples, we need two fewer units of land. Thus, if we take one worker from producing oranges and put him to

[5] The production possibilities schedule has the shape it does because of the law of diminishing returns. As we try to produce more and more oranges, it becomes harder and harder to produce an additional orange. Thus, as we give up apples, we get more oranges, but for each additional apple we give up, we get fewer and fewer extra oranges.

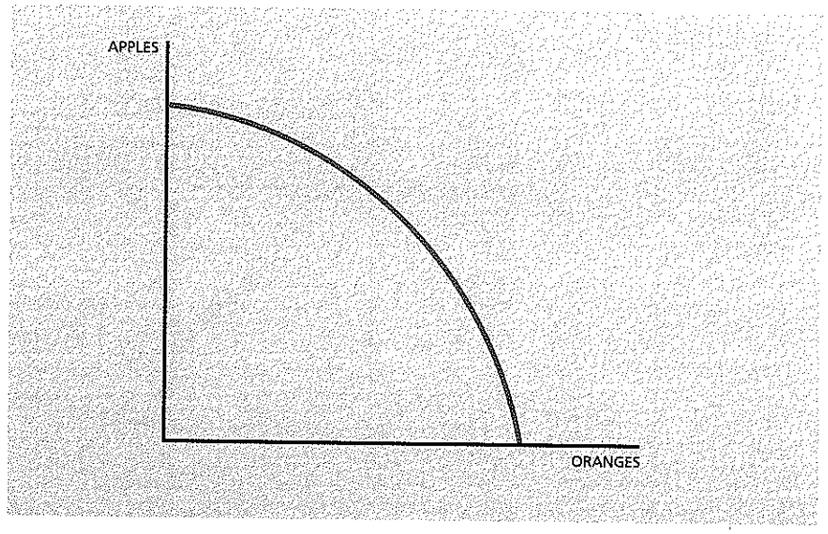

FIGURE 3.6 **Production Efficiency and the Production Possibilities Frontier** Points inside the frontier are attainable but inefficient. Points along the frontier are feasible and efficient. Points outside the frontier are unattainable, given the resources of the economy.

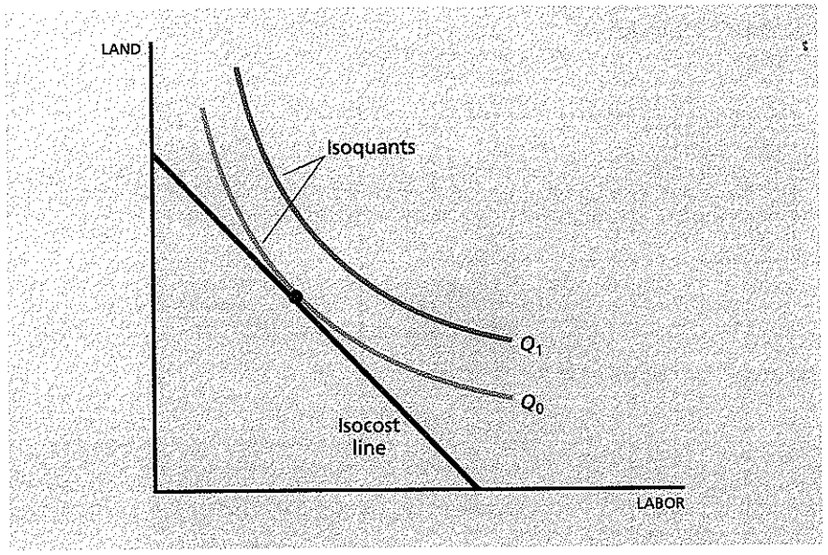

FIGURE 3.7 **Isoquants and Isocost Lines** An isoquant gives combinations of inputs (land and labor) which yield the same output. The isoquant labeled Q_1 represents a higher level of output than the isoquant labeled Q_0. The slope of the isoquant is the marginal rate of technical substitution. The isocost line gives those combinations of inputs which cost the same amount. The slope of the isocost line is given by the relative prices of the two inputs. The firm maximizes its output, given a particular level of expenditures on inputs, at the point where the isoquant is tangent to the isocost line. At that point, the marginal rate of technical substitution equals the relative price.

work in apples, and we take one unit of land, and switch it from producing apples to producing oranges, production of oranges is unchanged but production of apples is increased. Whenever the marginal rates of substitution differ, we can switch resources around in a similar way, to increase production.

A firm maximizes the amount of output that it produces, at a given level of expenditures on inputs, by finding the point where the isoquant is tangent to the isocost line. At the point of tangency, the slopes of the two curves are the same—the marginal rate of technical substitution is equal to the ratio of the prices of the two inputs. In a competitive economy all firms face the same prices, so all firms using labor and land will set their marginal rate of technical substitution equal to the *same* price ratio. Hence all will have the same marginal rate of technical substitution—the condition that is required for production efficiency.

In Figure 3.8 we see the same principle diagrammatically using another Edgeworth-Bowley Box. We wish to know how to allocate a fixed supply of inputs to ensure productive efficiency. We represent the fixed supply of the

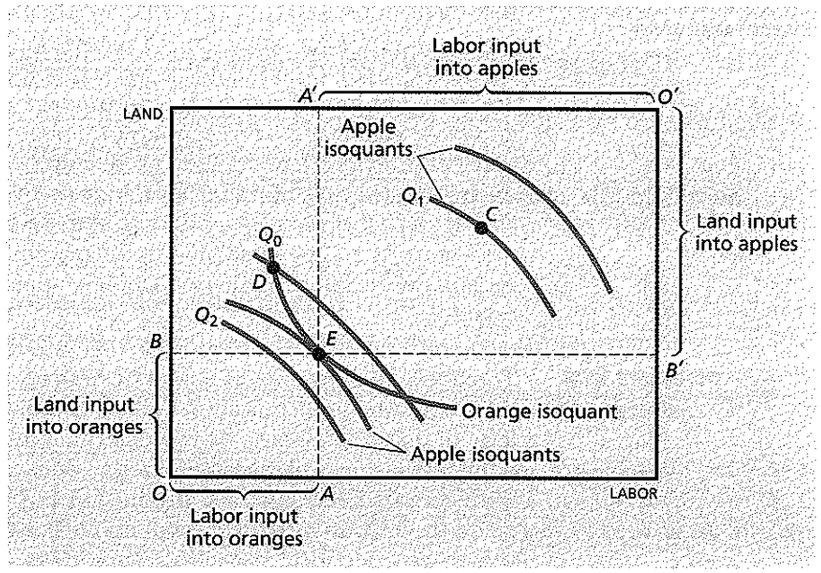

FIGURE 3.8 **Production Efficiency** The sides of this Edgeworth-Bowley Box give the available supply of resources—land and labor. Resources used in the production of oranges are given by *OA* and *OB*; resources not used in the production of oranges are used in the production of apples, O_9A_9 and O_9B_9. Production efficiency requires the tangency of the isoquants. At tangency points, such as *E*, the marginal rate of substitution of land for labor is the same in the production of apples and oranges.

two inputs by a box, with the total available supply of land measured along the vertical axis and the total supply of labor along the horizontal axis. We measure inputs into orange production from the bottom left-hand corner. Thus, point *E* means that the amount *OB* of land is used in orange production, and *OA* of labor. That in turn means that the *remaining* inputs are used in the production of apples. Thus, we measure inputs into apples from the upper right-hand corner. At *E*, the amounts O_9B_9 of land and O_9A_9 of labor go into apple production.

The isoquants also appear in the figure. Q_0 gives a typical orange isoquant. Remember that the quantities of inputs going into apple production are measured from O_9. That is why the isoquants for apples have the shape they do; they look perfectly normal if you turn the book upside down. Clearly, production efficiency requires that for any level of production of oranges the output of apples is maximized. As we move down and to the left in the box, more resources are being allocated to apple production; hence, isoquants through those points represent higher levels of apple output. If we fix the output of oranges at the level corresponding to isoquant Q_0, it is clear that the output of apples is maximized by finding the apple isoquant

that is tangent to isoquant Q_0. Given that we produce Q_0 of oranges, producing Q_1 of apples (at, say, point C) means that some resources are unused. Producing along Q_0, but not at E (at, say, point D), means that all resources are used, but not efficiently; we can produce the same number of oranges and more apples at E. The economy cannot produce more than Q_1 of apples and still produce Q_0 of oranges; producing Q_2 of apples would require producing less than Q_0 of oranges. Only at point E are all resources used efficiently and Q_0 of oranges produced. At the point of tangency, the slopes of the isoquants are the same, that is, the marginal rate of substitution of land for labor is the same in the production of apples as it is in the production of oranges.

PRODUCT MIX EFFICIENCY

To choose the best mix of apples or oranges to produce, we need to consider both what is technically feasible *and* individuals' preferences. For each level of output of apples, we can determine from the technology the maximum feasible level of output of oranges. This generates the production possibilities schedule. Given the production possibilities schedule, we wish to get to the highest possible level of utility. For simplicity, we assume all individuals have identical tastes. In Figure 3.9 we have depicted both the production possibilities schedule and the indifference curves between apples and oranges. Utility is maximized at the point of tangency of the indifference curve to the production possibilities schedule. The slope of the production possibilities schedule is called the **marginal rate of transformation;** this tells us how many extra apples we can have if we reduce production of

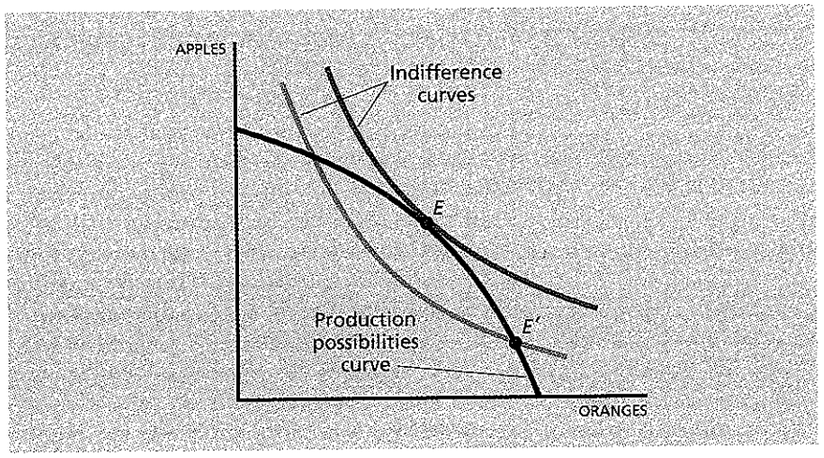

FIGURE 3.9 **Product Mix Efficiency Requires that the Marginal Rate of Transformation Equal Consumers' Marginal Rate of Substitution** In order to reach the highest level of consumers' utility, the indifference curve and the production possibilities schedule must be tangent (point E). At any other point, such as E', consumer utility is lower than at E.

BASIC CONDITIONS FOR PARETO EFFICIENCY

1 Exchange efficiency: Marginal rate of substitution between any two goods must be the same for all individuals.

2 Production efficiency: Marginal rate of technical substitution between any two inputs must be the same for all firms.

3 Product mix efficiency: Marginal rate of transformation must equal marginal rate of substitution.

Competitive economies satisfy all three conditions.

oranges by one. At the point of tangency, E, the slopes of the indifference curve and the production possibilities schedule are the same, that is, the marginal rate of substitution of apples for oranges is equal to the marginal rate of transformation.

Under competition, the marginal rate of transformation will be equal to the relative price of apples to oranges. If, by reducing production of apples by one, firms can increase the production of oranges by, say, one, and sell the oranges for more than the price of apples, profit-maximizing firms will clearly expand production of oranges. We have shown why under competition consumers' marginal rates of substitution will equal the price ratio. Since both the marginal rates of substitution and the marginal rate of transformation will equal the price ratio, the marginal rate of transformation must equal consumers' marginal rates of substitution. Hence, under ideal competitive markets, all three conditions required for Pareto efficiency are satisfied.

REVIEW AND PRACTICE

SUMMARY

1 Resource allocations that have the property that no one can be made better off without someone else being made worse off are called Pareto efficient allocations.

2 The Pareto principle is based on individualistic values. Whenever a change can make some individuals better off without making others worse off, it should be adopted. Most public policy choices, however, involve trade-offs, where some individuals are better off and others are worse off.

3 The principle of consumer sovereignty holds that individuals are the best judges of their own needs and pleasures.

4 Pareto efficiency requires exchange efficiency, production efficiency, and product mix efficiency.

5 The fundamental theorems of welfare economics provide conditions under which a competitive economy is Pareto efficient, and under which

every Pareto efficient allocation can be obtained through markets, provided that there is the appropriate redistribution of initial endowments (incomes).

6 Exchange efficiency means that, given the set of goods available in the economy, no one can be made better off without someone else being made worse off; it requires that all individuals have the same marginal rate of substitution between any pair of commodities. Competitive markets in which individuals face the same prices always have exchange efficiency.

7 Production efficiency requires that, given the set of resources, the economy not be able to produce more of one commodity without reducing the output of some other commodity; the economy must be operating along its production possibilities curve. Production efficiency requires that all firms have the same marginal rate of technical substitution between any pair of inputs; competitive markets in which firms face the same prices always have production efficiency.

8 Product mix efficiency requires that the marginal rate of transformation—the slope of the production possibilities curve—equal individuals' marginal rate of substitution. Competitive markets have product mix efficiency.

KEY CONCEPTS

Invisible hand
Pareto efficiency
Pareto principle
Consumer sovereignty
Fundamental theorems of welfare economics
Centralized allocation mechanism
Marginal benefit
Marginal cost
Exchange efficiency
Production efficiency
Product mix efficiency
Utility possibilities curve
Marginal rate of substitution
Marginal rate of technical substitution
Marginal rate of transformation

QUESTIONS AND PROBLEMS

1 Explain why an economy in which airlines charge different passengers different prices for the same flight will not have exchange efficiency.

2 Doctors often charge patients different amounts depending on their judgment concerning their ability to pay. What implications does this have for exchange efficiency?

3 Can you think of other common practices and policies that might interfere with exchange efficiency?

4 Explain why a tax which is only levied on the use of capital by corporations will interfere with the production efficiency of the economy. (Compare the marginal rates of technical substitution between corporations and unincorporated enterprises.)

5 Advocates of small businesses often argue that they should receive special tax treatment. Assume that small businesses had to pay only half the social security tax that is imposed on large corporations. What effect would that have on production efficiency?

6 Consider an economy which produces two goods, cars and shirts. Explain why if a tax is imposed on the consumption of cars but not on shirts, the economy will not exhibit product mix efficiency.

7 An individual is indifferent among the combinations of public and private goods shown in the following table.

COMBINATION	PUBLIC GOODS	PRIVATE GOODS
A	1	16
B	2	11
C	3	7
D	4	4
E	5	3
F	6	2

Draw the individual's indifference curve. Assuming that the economy can produce one unit of public goods and ten units of private goods, but that it can produce one more unit of public goods by reducing its production of private goods by two units, draw the production possibilities schedule. What is the maximum production of private goods? The maximum production of public goods? Can it produce five units of public goods and one unit of private goods? Which of the feasible combinations maximizes utility?