CHAPTER 4

# Valuing Benefits and Costs in Primary Markets

A cost-benefit analysis of a project or a change in government policy sums all the benefits resulting from the project or policy and subtracts all the associated costs. Doing this requires that the values of all these benefits and costs are measured in monetary terms. Although this is often difficult to accomplish in practice, in principle it would be relatively straightforward if the changes in consumer surplus and producer surplus resulting from a change in government policy, as well as the policy's effects on government revenues, could be determined. Under most circumstances, as indicated in Chapter 3, it is changes in these values that provide conceptually correct measures of the monetary value of a government policy's benefits and costs.

This chapter and the next illustrate how changes in consumer surplus, producer surplus, and net government revenues could be readily estimated if all the pertinent market demand and supply curves were known. This chapter focuses on demand and supply curves in *primary markets,* while Chapter 5 examines demand and supply curves in *secondary markets*. Primary markets refer to markets that are directly affected by a policy or project; for example, if a city builds a new subway system, the primary markets are the market for public transportation and the market for materials used to build the subway. Secondary markets are markets that are indirectly affected—for example, the market for gasoline if some commuters switch from driving to riding the new subway.

The chapter begins with a brief discussion of why real CBA studies often fail to use conceptually correct measures of benefits and costs and what the implications are of this. We then examine how the effects of government policies in primary markets can be valued. In doing so, we emphasize the concept of willingness to pay (WTP) and, thus, demand curves and consumer surplus. We next describe the valuation of resources purchased in primary markets as inputs for government projects, stressing the concept of opportunity costs and, hence, the use of supply curves and producer surplus. *Throughout this chapter we ignore the marginal excess tax burden.*

This chapter also provides brief explanations of common types of market failures including monopoly, externalities, information asymmetries, public goods, and addictive goods. The reason for discussing market failures is that their presence provides the *prima facie* rationale for most, although not all, proposed government interventions that are assessed through CBA. If markets worked perfectly, then Pareto efficiency would be obtained without government intervention: a set of prices would arise that distributes resources to firms and goods to individuals in such a way that it would not be possible to

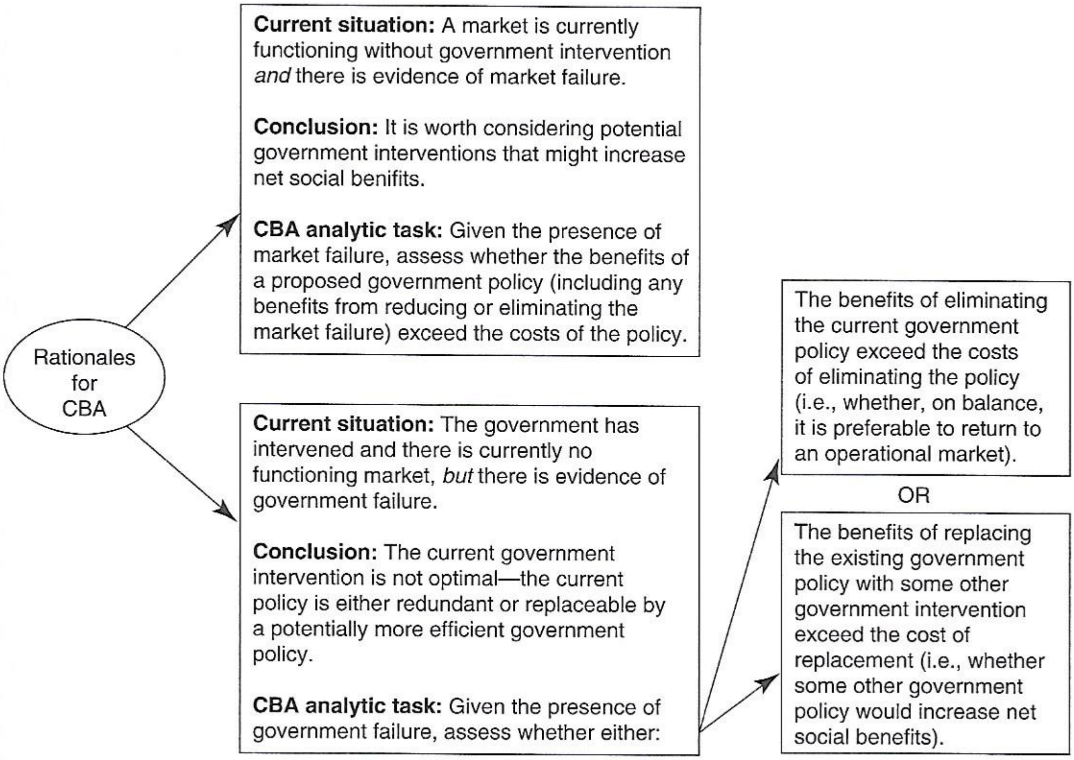



**FIGURE 4-1** How to Consider Market and Government Failure in CBA

find a reallocation that would make at least one person better off without also making at least one other person worse off. Furthermore, as shown in Chapter 3, such an outcome would maximize net social benefits. It is only when markets fail that allocative efficiency grounds exist for government interventions. However, no more than a *prima facie* case exists. It is up to CBA to demonstrate that a specific intervention is worthwhile from society's perspective. CBA may also be used to assess existing government policies. In this case, the analyst is essentially attempting to determine whether the current policy is inefficient and, therefore, exhibits "government failure."[1]

Figure 4-1 summarizes the analytic steps to follow depending on whether the analyst observes market failure, government failure, or both.

## PRACTICAL VERSUS CONCEPTUALLY CORRECT MEASURES OF BENEFITS AND COSTS

In most CBAs, the measures of benefits and costs actually used differ somewhat from the conceptually correct measures. One purpose of examining the conceptually correct measures of the benefits and costs of a government policy is so they can serve as a benchmark against which the measures used in actual CBAs can be compared. So that we can focus on this objective in this and the next chapter, we ignore the practical problems inherent in actually deriving demand and supply curves needed to measure benefit and costs, an issue we take up in detail in Part III. Instead, we focus on how the conceptually correct measures of benefits and costs would be obtained *if* the necessary curves were known.

Before turning to the conceptually correct measures, it is helpful to examine why they often differ from the measures used in actual CBAs. A fundamental reason is that it is often convenient to use observed prices in valuing benefits and costs. However, as illustrated later in this chapter, whenever a government policy involves the production of a public good, or an externality or monopoly power is present, market prices may not provide good indicators of the social value of benefits or costs. There are other situations in which a market price does not even exist. For example, persons entering a U.S. National Park pay a fee, but this fee is set by the National Park Service, not by the market. Consequently, it is unlikely that it bears a strong relation to the value of the benefits visitors actually receive from visiting the parks. Thus, a continuum exists. At one end of this continuum are values that can be measured in terms of prices that are set in well-functioning, competitive markets. At the other end is the complete absence of markets that can be used to value benefits and costs resulting from a government policy.

When observed prices fail to reflect the social value of a good accurately or observed prices do not exist, an approach called *shadow pricing* is often used to measure some benefits or costs. That is, analysts adjust observed prices or assign values when appropriate observed prices do not exist, thereby finding in "the shadows," needed values that are not readily observable. They attempt to come as close as possible to measuring the value that those receiving benefits from a government project place on them or the lost value to those who incur costs. For example, prices charged by paper factories may understate the true social cost of paper if the production process generates pollution. Given such circumstances, an analyst conducting a CBA may adjust the market price upward to account for the negative externality resulting from the pollution. Another important example of shadow pricing is the considerable effort that economists have put into attempting to place an appropriate value on human life. Also, economists have also put much work into trying to determine the social value of recreational areas such as public parks. We indicate many other situations in this chapter when shadow pricing is required and at several junctures suggest approaches that can be taken toward obtaining shadow prices. In Chapters 14–17, we describe these and other techniques to obtain shadow prices in more detail.

Although numerous shadow pricing techniques exist, it is still frequently the case that the measures of benefits and costs used in actual studies differ from their conceptually correct counterparts. There are several reasons for this:

1. As discussed in Chapter 11, errors are sometimes made in CBA. In some instances, for example, the distinction between the measure being used and the conceptually correct measure is sufficiently subtle that it is inadvertently overlooked. In such instances, those conducting the study may be unaware that their results are incorrect and thus do not attempt to use appropriate shadow pricing techniques.
2. It is often difficult to derive an appropriate shadow price. In some studies, consequently, the difference between the actual and the correct measure may be potentially serious, but it is technically infeasible or beyond the time and resources avail-

able to those conducting the study to do much about it. In the most extreme instances, even determining the conceptually correct measures of value is so complex and daunting as to put it beyond the grasp of analysts. Even when shadow prices are used, the resulting measures of benefits and costs may vary from their conceptually correct counterparts. When this is the case, it is at least incumbent upon those conducting the study to point out why and how the study results may be biased.

3. There may be reason to think that the differences between the actual and the correct measures are sufficiently minor such that the study results are not much affected. In such instances, shadow pricing may not be necessary.

## ALUING OUTCOMES: WILLINGNESS TO PAY (WTP)

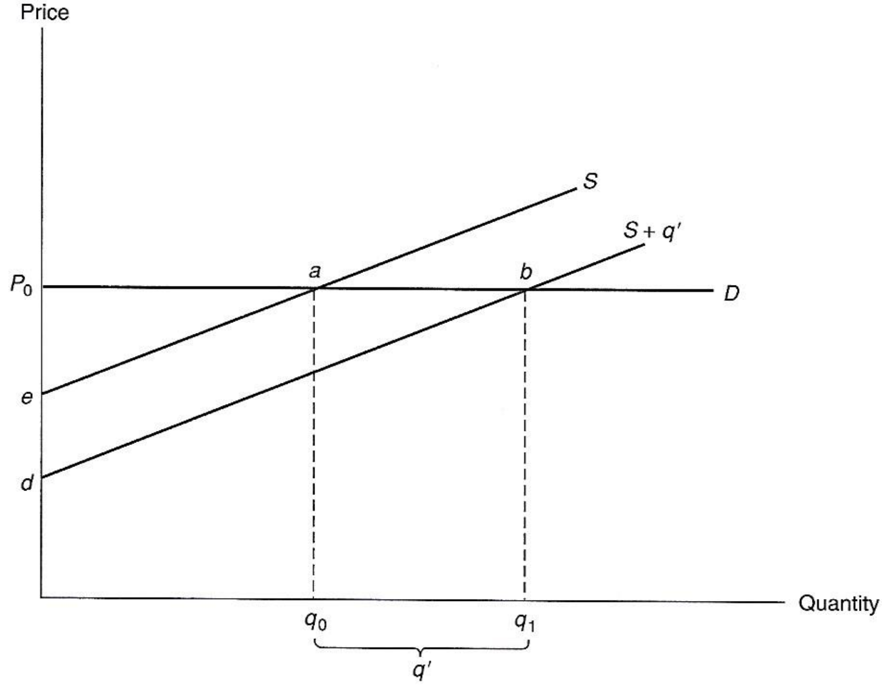
The valuation of policy outcomes should be based on the concept of WTP. Some people like a policy impact and are willing to pay for it. Other people do not like the same impact and are willing to pay to avoid it. *Benefits are the sums of the maximum amounts people would be willing to pay to gain outcomes that they view as desirable; costs are the sums of the maximum amounts that people would be willing to pay to avoid outcomes they view as undesirable.*[2] Estimating changes in social surpluses that occur in relevant markets enables us to take account of these costs and benefits. In the discussion that follows, we distinguish between changes in surplus that take place in efficient markets and those that occur in inefficient or distorted markets where market or government failures are found. This discussion also focuses on *gross benefits*, rather than *net benefits*, because it usually ignores the inputs the government must purchase to carry out policies. Measurement of the social cost of these resources is discussed in the following section. Net benefits would be obtained by subtracting the costs of these inputs from gross benefits. Thus, as used in this section, the word "costs" refers to negative changes resulting from a policy, not the expenses on inputs the government must purchase to carry out the policy.

### Valuing Benefits in Efficient Markets

Valuation of gross benefits is relatively straightforward when a policy affects the supply curves of goods in efficient markets. Under these circumstances, the rule is as follows: *the gross social benefits of a policy equal the net government revenue generated by the policy (exclusive of project costs) plus the resulting changes in consumer surplus and producer surplus.*

We examine two common situations where this rule is applicable. First, we consider policies that directly affect the quantity of a good available to consumers. For example, a publicly operated childcare center shifts the supply curve to the right, as it results in more child care being offered to consumers at each price. This often (but not always) reduces prices, resulting in benefits to consumers. Second, we consider policies that shift the supply curve down by altering the price or availability of some input used to produce the good. An example is deepening a harbor so that it accommodates larger ships, thus reducing the cost of transporting bulk commodities to and from the port for shipping companies. This results in direct reductions in costs to producers.

**Direct Increases in Supply Available to Consumers.** Figure 4-2 shows the gross benefits that result when a project directly increases the available supply of a good in a

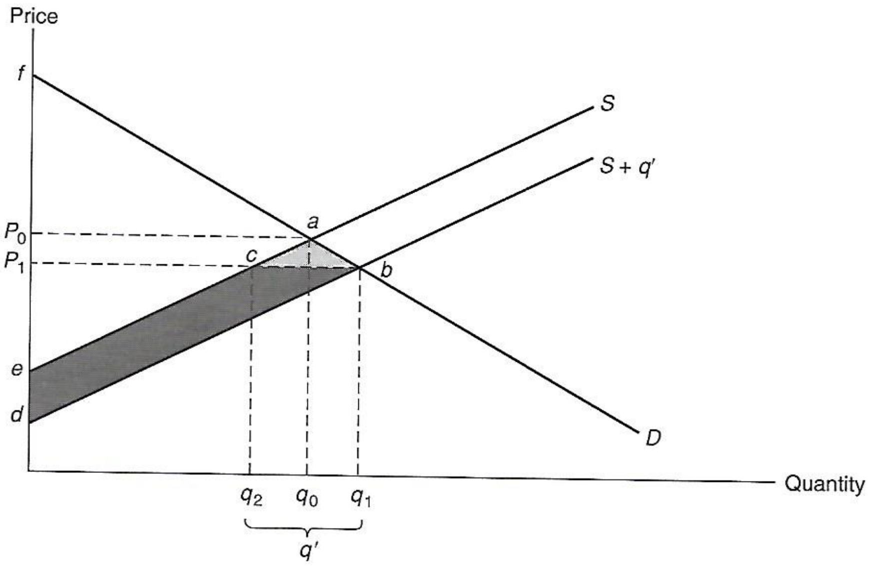



Social surplus change (ignoring costs of project inputs to the government):
Project (a): Direct increase in supply of $q'$—gain of project revenue equal to area of rectangle $q_0abq_1$
Project (b): Supply schedule shift through cost reduction for producers—gain of trapezoid *abde*

**FIGURE 4-2** Measuring Benefits in an Efficient Market with No Price Effects

well-functioning market, but the increase is so small that the price of the good is unaffected. If the government sells the additional units of the good at the market price, then it may be treated like other competitors in an efficient market. Hence, as shown in the figure, it faces a horizontal demand curve, *D*, for the good at the market price, $P_0$. If the project directly adds a quantity, $q'$, to the market, then the supply curve as seen by consumers shifts from *S* to $S + q'$.[3] Because the demand curve is horizontal, the price of the good and, hence, consumer surplus and producer surplus are unaffected by the shift in the supply curve. However, if consumers purchase the additional units of the good, the government receives revenue equal to $P_0$ times $q'$, the area of rectangle $q_0abq_1$. The rectangle $q_0abq_1$ also, of course, represents a cost to those consumers who purchase the good. This "cost," however, is exactly offset by benefits that these persons enjoy in consuming the good and, consequently, can be ignored in our analysis. Therefore the revenues received by the government are the only gross benefits that accrue from the project selling $q'$ units in the market.

If the government adds a sufficiently large quantity of a good to a market so that the price of the good is reduced, however, then consumers will benefit. Figure 4-3 illustrates this possibility by showing a downward-sloping demand curve, *D*. The intersection of the demand curve and the supply curve, *S*, indicates the equilibrium price, $P_0$, prior to the




Social surplus change (ignoring costs of project inputs to the government):
Project (a): Direct increase in supply of q′—gain of triangle *abc* plus project revenue equal to area of rectangle $q_2cbq_1$
Project (b): Supply schedule shift through cost reductions for producers—gain of trapezoid *abde*

**FIGURE 4-3** Measuring Benefits in an Efficient Market

project. The equilibrium price of the good falls to $P_1$ after the government provides the $q'$ units of the good. This time, because of the reduction in the price facing consumers, there is a gain in consumer surplus corresponding to the area of trapezoid $P_0abP_1$. Because private-sector suppliers continue to operate on the original supply curve, *S*, the output they sell falls from $q_0$ to $q_2$, and they suffer a loss of producer surplus equal to the area of trapezoid $P_0acP_1$. Thus, the net gain in surplus among private actors (consumers and producers) equals the area of triangle *abc*, which is lightly shaded. In addition, the government receives revenues from the project equal to the area of rectangle $q_2cbq_1$. The sum of project revenues and the gain in social surplus in the market equals area $q_2cabq_1$, which is the total gross benefit from the project selling $q'$ units in the market.

What benefits would accrue if $q'$ units of the good were instead distributed free to selected consumers? If the price of the good does not change, as in the situation depicted in Figure 4-2, then the answer is straightforward: as a result of receiving $q'$ units of the good free, consumers gain surplus equal to the area of rectangle $q_0abq_1$, an area that exactly corresponds to the revenues that would have accrued had the project's output been sold.

The answer is more complex if the $q'$ units of the good are distributed free, but the increase in supply causes its price to fall. This situation is shown in Figure 4-3. Under these circumstances, if the $q'$ units are given only to those consumers who would have valued these units at $P_1$ or higher, then the project's gross benefit measure is again exactly the same as it would have been had the output been sold. As before, the reduction in price from $P_0$ to $P_1$ results in an increase in social surplus equal to area *abc*. With free distribution, however, no revenue accrues to the project. Instead, as a result of receiving $q'$ units of the good free, consumers enjoy an additional surplus equal to the area of rectangle $q_2cbq_1$. Thus, total gross benefits from the project once again equal the area of trapezoid $q_2cabq_1$.

It is more likely, however, that if $q'$ units of the good are distributed for free, some would go to consumers who are located below point *b* on the market demand curve shown in Figure 4-3. In other words, some units would be distributed to some consumers in greater quantities than they would have purchased at price $P_1$. If these consumers keep the excess units, then area $q_2cabq_1$ overestimates the project's benefit because these persons value their marginal consumption of these units at less than $P_1$. Area $q_2cabq_1$ approximates project benefits, however, if recipients of the excess units sell them to others who would have been willing to buy them at a price of $P_1$ (provided the transaction costs associated with the sale of the excess units are zero).

Suppose, for example, that a project provides previously stockpiled gasoline free to low-income consumers during an oil supply disruption (an in-kind subsidy). Some low-income households will find themselves with more gasoline than they would have purchased on their own at price $P_1$; therefore, they will try to sell the excess. Doing so will be relatively easy if access to the stockpiled gasoline is provided through legally transferable coupons; it would obviously be more difficult if the gasoline had to be physically taken away by the low-income households. If the gasoline coupons could be costlessly traded among consumers, then we would expect the outcome to be identical to one in which the gasoline is sold in the market and the revenue given directly to low-income consumers.

**Reductions in Costs to Producers.** We now turn to a different type of public-sector project: one, such as harbor deepening, which lowers the private sector's cost of supplying a market. Figure 4-3 can again be used to analyze this situation. In this case, however, the supply curve shifts to $S + q'$, not because the project directly supplies $q'$ to the market, but rather because reductions in marginal costs allow private-sector firms to offer $q'$ additional units profitably at each price.[4] As in the case of direct supply of $q'$, the new equilibrium price is $P_1$. Thus, the gain in consumer surplus corresponds to the area of trapezoid $P_0abP_1$. The change in producer surplus corresponds to the difference in the areas of triangle $P_0ae$ (the producer surplus with supply curve *S*) and triangle $P_1bd$ (the producer surplus with supply curve $S + q'$). Area $P_1ce$ is common to the two triangles and therefore cancels. Hence, producers enjoy a net gain in surplus equal to area *ecbd* minus area $P_0acP_1$. Adding this gain to the gain in consumer surplus, area $P_0abP_1$, means that the net gain to consumers and producers resulting from the project equals the area of trapezoid *abde*. (That is, area *ecbd* + area $P_0abP_1$ − area $P_0acP_1$ = area *ecbd* + area *abc* = area *abde*.[5]) Because no project revenue is generated, area *abde* alone is the gross benefit of the project. Notice that because we once again ignore expenditures the government incurs in purchasing inputs needed to undertake the project, we are again measuring gross benefits rather than net benefits.

**Revenues as a Measure of Gross Benefits in Efficient Markets.** To private-sector producers of goods or services, project revenues are a natural measure of gross benefits. However, while revenues figure prominently in the computation of producer surplus, they generally do not equate to gross consumer benefits. There are, however, two situations in which it is appropriate to use revenues as gross benefits.

The first situation, which is discussed above, occurs when the government sells a good in an undistorted market without affecting the market price. For example, a government may have surplus office equipment that it sells in sufficiently small quantities that the market price of office equipment does not change. The assumption of a negligible effect on price is more reasonable for goods traded in large, national markets than for goods traded in small, local markets. It is also more reasonable for homogeneous goods, such as surplus equipment, than for heterogeneous goods, such as land, which may differ in desirability from one parcel to another.

Second, revenues can be used as a measure of gross consumer benefits when changes in consumer surplus are zero. This may occur when a project exports all of its output. The North East Coal Development Project, which we discuss in Chapter 6, provides an example. The primary beneficiaries (besides the Canadian federal government) were the mining and transportation companies. Their producer surplus increase is legitimately computed as the difference between their additional revenues and their additional costs, that is, as their incremental profits. However, as this project would supply coal to Japanese customers only, Table 6-5 does not include any consumer surplus benefits for Canadians. The consumer surplus would accrue to foreigners and, therefore, should not be counted in the CBA if the analyst takes a Canadian perspective.

In practice, government often sells goods when markets are distorted or when the sale has an impact on the price of the good. For example, electricity may not be available to residents of a remote town unless the government sponsors the construction of an electric power transmission line. Here, introduction of electricity effectively reduces the price from infinity to the user fee charged. In these situations, government or firm revenues are an especially poor measure of gross benefits.

## Valuing Benefits in Distorted Markets

If market or government failures distort the relevant product market, then project benefits should continue to be measured as changes in consumer surplus plus producer surplus resulting from the project plus net government revenues generated by the project. However, complications arise in determining the correct surplus changes. We illustrate these complications by examining five different types of market failures: monopoly, information asymmetry, externalities, public goods, and addictive goods. We do not attempt to provide a comprehensive discussion of market failures in this chapter, just an overview. For a comprehensive discussion, we recommend a book by David Weimer and Aidan Vining, which is cited in the first endnote.[6]

**Monopoly.** It is useful to examine monopoly first because it is an excellent example of a topic introduced in Chapter 3: a deviation from the competitive equilibrium that results in a deadweight loss and, hence, reduces social surplus.[7] One key to understanding monopoly is to recognize that because, by definition, a monopolist is the only firm in its market, it views the market demand curve as the demand curve for its output.

Because market demand curves slope downward, if the monopolist sells all its output at the same price, then it can sell an additional unit of output only by reducing the price on every unit it sells. Consequently, the monopolist's marginal revenue—the

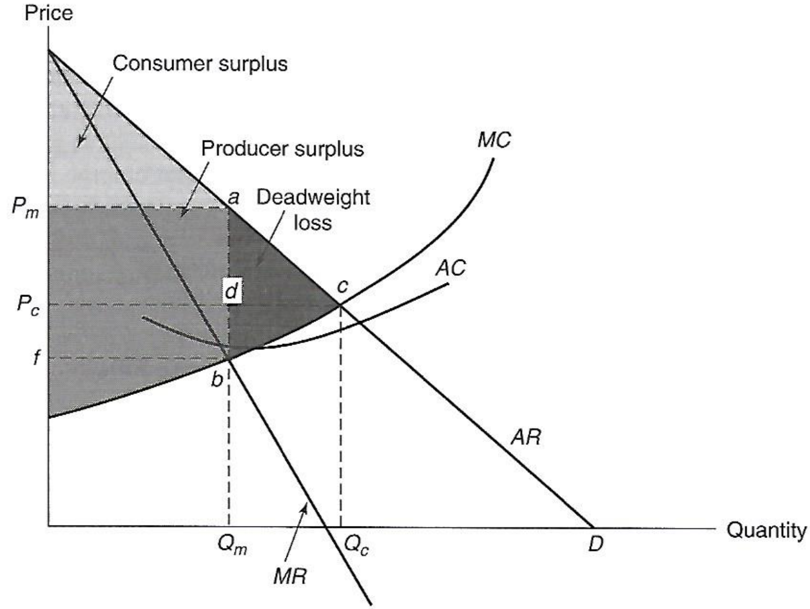



**FIGURE 4-4** Monopoly

additional revenue it receives for each additional unit of output it sells—is less than the selling price of that unit. For example, if a monopolist could sell four units of output at a price of $10 but must reduce its price to $9 in order to sell five units, its revenue would increase from $40 to $45 as a result of selling the fifth unit. Therefore, the $5 in marginal revenue it receives from the fifth unit is less than the $9 selling price of the unit. Thus, as shown in Figure 4-4, the monopolist's marginal revenue curve, denoted *MR*, is located below its demand curve, denoted *AR*.

Given this situation, the monopolist would maximize profit by producing at $Q_m$, where its marginal cost equals its marginal revenue. The price it can charge is determined by what people are willing to pay for those units, which is given by the demand curve it faces. At the output level $Q_m$ it would set its price equal to $P_m$.

As before, the social surplus generated by the output produced and sold by the monopolist is represented graphically by the area between the demand curve, which reflects the marginal benefit to society, and the marginal cost curve that is to the left of the intersection of the marginal revenue and marginal cost curves. This is the sum of consumer surplus plus producer surplus. The consumer surplus, which is captured by buyers, is the lightest shaded area above the price line. The producer surplus, which is captured by the monopolist, is the darker shaded area below the price line.

Although the term *monopolist* is sometimes used pejoratively, in a CBA any increase in producer surplus received by a monopolist that results from a government policy is counted as a benefit of the policy. The rationale is that owners of monopolies, like consumers and the owners of competitive firms, are part of society; therefore, benefits accruing to them "count."[8]

Notice that, unlike the perfectly competitive case, social surplus is not maximized if the monopolist is left to its own devices. This is because the monopolist maximizes profits, not net social benefits. Net social benefits are maximized at point *c* on Figure 4-4, where the marginal cost curve intersects the marginal benefit curve (demand curve). The "lost" social surplus, which is called the deadweight loss of monopoly, is represented in Figure 4-4 by the darkly shaded triangular area *abc*. Were it possible for the government to break up the monopoly into a large number of competing firms, each firm would produce where price equals MC.[9] In Figure 4-4 this occurs where industry output and price are $Q_c$ and $P_c$, which are sometimes referred to as the "competitive" output and price. If this competitive outcome resulted, two things would happen: first, the deadweight loss would disappear and social surplus would increase by the area *abc*. In CBA, this would count as a benefit of the government's actions. Second, because the competitive price, $P_c$, is less than the monopolistic price, $P_m$, consumers would capture that part of the monopolist's producer surplus that is represented by the rectangular area $P_m adP_c$. In CBA, this is viewed as a transfer.

**Natural Monopoly.** So far, we have been focusing on a general form of monopoly. We now turn to a specific type of monopoly: *natural monopoly*. The essential characteristic of a natural monopoly is that it enjoys *economies of scale* over a wide range of output. Usually, its fixed costs are very large relative to its variable costs; public utilities, roads, and bridges all provide good examples. As shown in Figure 4-5, these large fixed costs cause average costs to fall over a large range of output. Put another way, and as shown in Figure 4-5, (long run) average costs exceed (long run) marginal costs over what we term the *relevant range of output*, which is the range between the first unit of output and the amount consumers would demand at a zero price, $Q_0$.

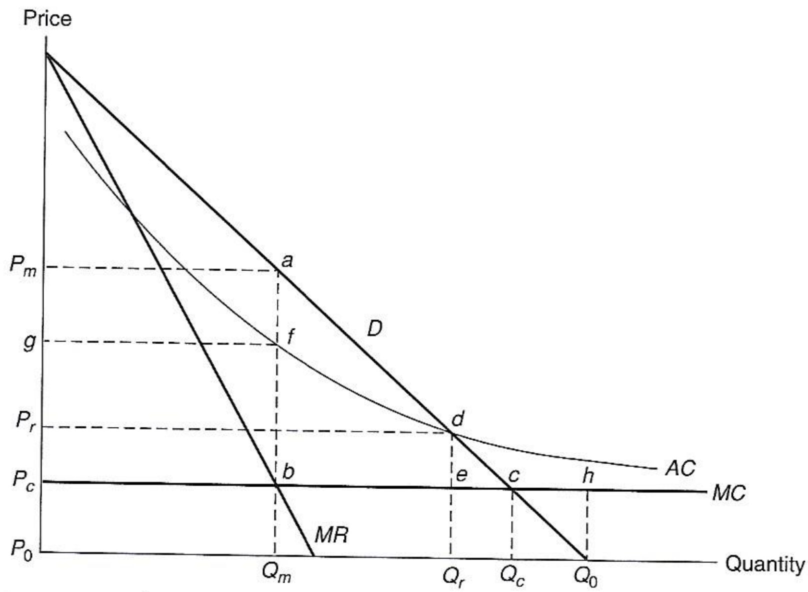



**FIGURE 4-5** Natural Monopoly

In principle, marginal costs could be rising or falling over the relevant output range, but for the sake of simplicity, we have drawn the marginal cost curve as horizontal. The important point is that (long run) marginal costs are less than (long run) average costs over the relevant range, so that average costs fall over the relevant range of output as output increases. As a result, one firm, a natural monopoly, can provide a given amount of output at a lower average cost than could two or more firms.

In these circumstances, it is reasonable for the government to permit a monopoly to exist. If it does, however, it must decide whether to regulate the monopoly, and if it regulates it, what type of policies to invoke. To make our discussion of these policies as concrete as possible, we will assume that the natural monopoly represented in Figure 4-5 is a road and that output is the number of cars that travel the road. Although most roads are built under government contract and operated by the government, they could instead be built and operated by private-sector firms under various regulatory frameworks. In fact, several roads have been built by private companies or public–private partnerships over the past 200 years.[10]

The government could follow one of four policies. The first is simply to allow the road-operating authority, whether a private-sector firm or a government agency, to maximize profits. As discussed previously, profits are maximized at output $Q_m$, where marginal cost equals marginal revenue. The road-operating authority could obtain this output level by charging a toll (i.e., a price) set at $P_m$. However, under this policy, output is restricted below the competitive level of $Q_c$, and willingness to pay, $P_m$, exceeds marginal costs, $P_c$. This results in a deadweight loss equal to area *abc*. The policy is also unattractive politically because it typically permits substantial monopoly profits, corresponding to area $P_m afg$.

An alternative policy that is often used in regulating natural monopolies is to require the road-operating authority to set its price at $P_r$, where the average cost curve crosses the demand curve. This policy eliminates monopoly profits by transferring social surplus from the road-operating authority to persons using the road. It also expands output, increasing social surplus and reducing deadweight loss from area *abc* to area *dec*. Thus, as compared to allowing the road-operating authority to maximize profits, society receives a benefit from the policy that corresponds to area *adeb*. But deadweight loss is not completely eliminated. In other words, society could potentially benefit still further if output could be expanded.

The third policy alternative does this by requiring the road construction and operating authority to set its price at $P_c$, where the marginal cost curve intersects the demand curve—in other words, by requiring competitive market pricing. This completely eliminates the deadweight loss, thereby maximizing net social benefits. But a problem exists with this policy: price is below average costs; hence, revenues no longer cover costs. As a result, tax money must be used to subsidize the road construction and operating authority.

The fourth policy alternative is the one most often used in the case of roads: to allow free access, or in other words, to charge a zero price. In this case, output would expand to $Q_0$, the point at which the demand curve intersects the horizontal axis. The problem with this policy is that output expands to a level at which marginal costs exceed marginal benefit (i.e. WTP). This results in a deadweight loss equal to the triangular area $chQ_0$. Moreover, because no tolls are collected directly from road users, the entire construction and operating costs of the road must be paid through government subsidies obtained from taxes.

**Information Asymmetry.** The term *information asymmetry* implies that information about a product or a job may not be equal on both sides of a market. For example, sellers may have more information concerning how well made or safe a product is than buyers, doctors may know more about needed care than patients, or employers may know more about job-related health risks than their workers.

The implications of information asymmetry are easy to show in a diagram. To do this, we focus on the case in which sellers of a product have more information than buyers. Such a situation is represented in Figure 4-6, which shows two demand curves. One of these curves, $D_i$, represents how many units of the product buyers would desire if they had full information concerning it, while the other demand curve, $D_u$, indicates how many units they actually desire, given their lack of full information.[11] In other words, the two demand curves represent, respectively, consumers' WTP with and without full information concerning the product. They indicate that if buyers had full information, their WTP would be lower.[12]

Figure 4-6 shows that there are two effects of information asymmetry. First, by raising the price and the amount of the good purchased, information asymmetry increases producer surplus and reduces consumer surplus, resulting in a transfer from consumers to sellers. This transfer is shown by the trapezoidal area $P_uacP_i$. Second, by increasing the amount of the good sold relative to the full information case, information asymmetry results in a deadweight loss, which is shown as the triangular area *abc*.

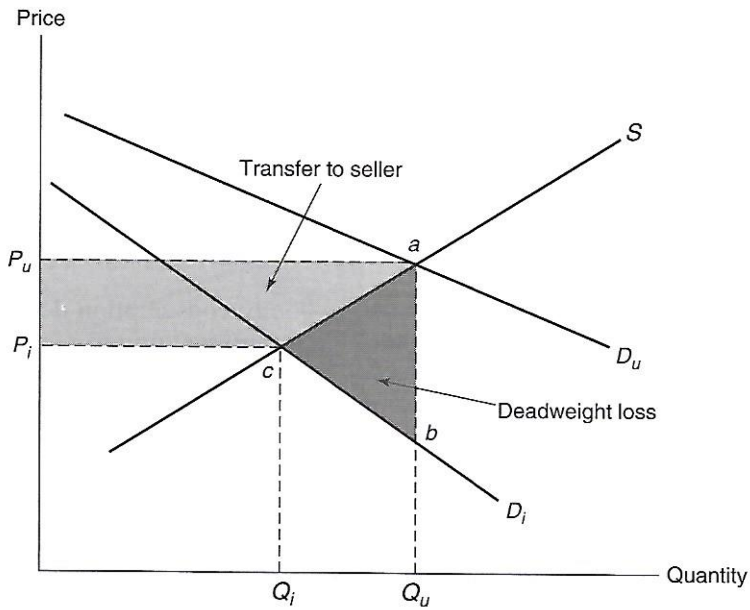



**FIGURE 4-6** Information Asymmetry

These two effects, especially the second one, suggest a rationale for the government to intervene by providing the missing information. If the government does this effectively, society will benefit because deadweight loss is reduced. In addition, there will be a transfer of surplus (back) from sellers to buyers. However, there are also costs associated with the government obtaining and disseminating information. These costs, which do not explicitly appear in the diagram, may be sizable.[13] Hence, for a government information program to have positive net benefits, and not just positive gross benefits, the deadweight loss associated with the lack of information in the absence of government intervention must usually be substantial.

It is useful to discuss the circumstances under which information asymmetry is sufficiently important that the benefits from government intervention are likely to exceed the costs. This largely depends upon two factors: first, the ease with which consumers can obtain the information for themselves; and second, whether third parties that could provide the missing information are likely to arise through market forces. To discuss these factors, it is helpful to distinguish among three types of products: (1) search goods, (2) experience goods, and (3) post-experience goods.[14]

*Search goods* are products with characteristics that consumers can learn about by examining them prior to purchasing them. For example, a student who needs a notebook for a class can go to the bookstore and easily learn pretty much everything he or she wants to know about the characteristics of alternative notebooks. Under such circumstances, information asymmetry is unlikely to be serious.

*Experience goods* are products about which consumers can obtain full knowledge, but only after purchasing and experiencing them. Examples are tickets to a movie, a meal at a new restaurant, a new television set, and a house. At least to a degree, information asymmetry concerning many such products takes care of itself. For example, once consumers have been to a restaurant, they acquire some information concerning the expected quality of the meal should they eat there again. Warranties, which are typically provided for televisions and many other major consumer durables, serve a similar purpose. In addition, market demand for information about experience goods often prompts third parties to provide information for a fee. This reduces information asymmetry. For example, newspaper reviews provide information about movies and restaurants; in the United States, *Consumer Reports* provides information about many goods; and inspection services examine houses for perspective buyers.

In the case of *post-experience goods,* consumption does not necessarily reveal information to consumers. Government intervention to reduce information asymmetry associated with post-experience goods is most likely to be efficiency-enhancing because learning through individual action does not always occur. Examples of this situation include adverse health effects associated with a prescription drug and a new automobile with a defective part. Employee exposure to an unhealthy chemical at work is similar. In these cases, information asymmetry may persist for long periods of time, even after the health of some people has been ruined. Moreover, because the needed information is often expensive to gather and individuals may be unwilling to pay for it, third parties may not provide the necessary information. Under these circumstances, there may be a strong rationale for government intervention.

**Externalities.** An *externality* is an effect that production or consumption has on third parties—people not involved in the production or consumption of the good. It is a by-product of production or consumption for which there is no market. Indeed, externalities are sometimes referred to as the problem of "missing markets." Examples include pollution caused by a factory and the pleasure derived from a neighbor's beautiful garden. Externalities may occur for a wide variety of reasons. For example, some result because a particular type of manufacturing technology is used (e.g., air pollution caused by smokestack industry). Others arise because of interdependencies (or synergies) between producers and consumers or different groups of producers (e.g., beekeepers who unintentionally provide pollination services for nearby fruit growers). Still other externalities occur because of networks (e.g., the larger the number of persons who purchase a particular type of automobile, the greater the number of qualified service garages available to each owner). Because the number of externalities is enormous, a careful CBA should first be conducted before the government intervenes to correct any specific externality.[15]

We first examine a negative externality (i.e., one that imposes social costs) and then a positive externality (i.e., one that produces benefits). Figure 4-7 illustrates a market in which the production process results in a negative externality, such as air or water pollution. The supply curve, $S^*$, reflects only the private marginal costs incurred by the suppliers of the good, while the second supply curve, $S^\#$, incorporates the costs that the negative externality imposes on third parties, as well as the private marginal costs incurred by suppliers. The vertical distance between these two curves, measured over the quantity of the good purchased, can be viewed as the amount those subjected to the negative externality would be willing to pay to avoid it. In other words, it represents the costs imposed by the externality on third parties. The length of this distance

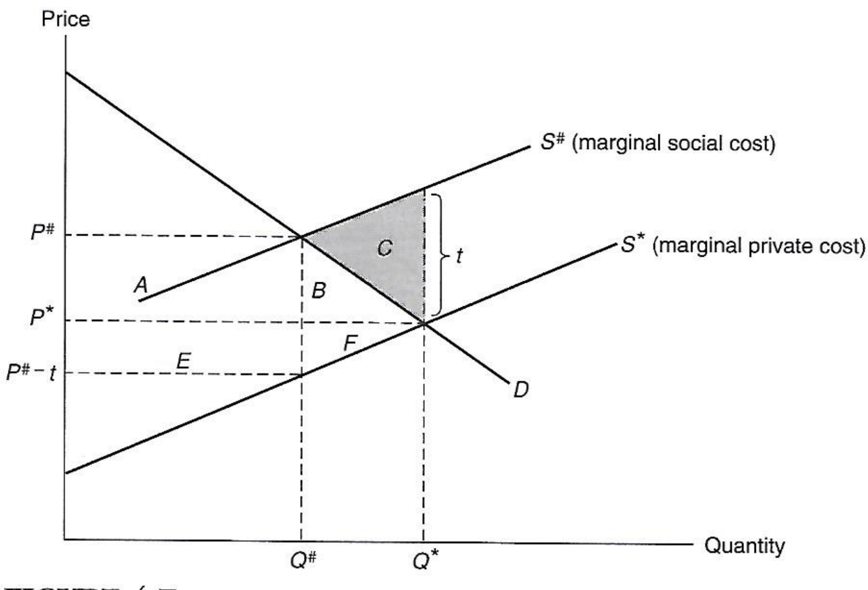



**FIGURE 4-7** Negative Externality

depends in part upon whether the market somehow compensates third parties for the negative externality. For example, it would be smaller if homeowners were able to purchase their houses at lower prices because of pollution in their neighborhood than if they were not.

Figure 4-7 indicates that, if left to its own devices, the market sets too low a price for the good ($P^* < P^\#$) because it fails to take account of the cost to third parties of producing the good. As a result, too much output is produced ($Q^* > Q^\#$). This causes deadweight loss, which is represented by the shaded triangular area labeled *C*. This deadweight loss reflects the fact that for each unit of additional output produced in excess of $Q^\#$, marginal social costs (shown by the supply curve $S^\#$) increasingly exceed marginal social benefits (shown by the demand curve *D*).

The standard technique for reducing deadweight loss resulting from negative externalities is to impose taxes.[16] For example, the suppliers of the good represented in Figure 4-7 could be required to pay a tax, *t*, on each unit they sell, with the tax set equal to the difference between marginal social costs and marginal social benefits (shown in the figure as the vertical distance at $Q^*$ between the two supply curves). As production costs would now include the tax, the supply curve of sellers, $S^*$, would shift upward to $S^\#$. Consequently, the price paid by consumers would increase from $P^*$ to $P^\#$, the net price received by producers would fall from $P^*$ to $P^\# - t$, and output produced and sold would fall from $Q^*$ to $Q^\#$. Note that pollution associated with the good would be reduced, but not completely eliminated, because the good would continue to be produced, although in smaller amounts.[17]

Figure 4-7 implies that the benefits and costs of the government's tax policy are distributed unequally among different groups in the economy. These are displayed in the following social accounting ledger.

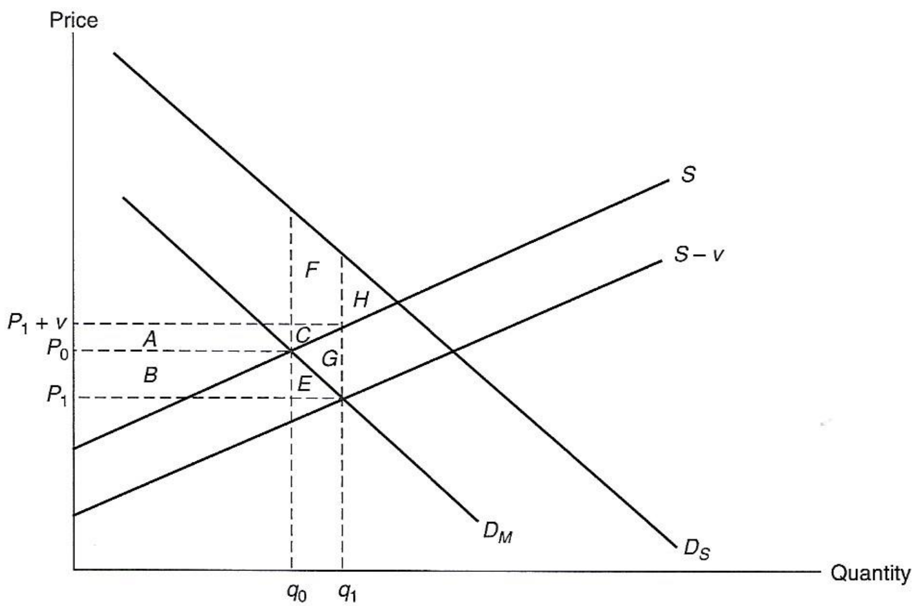
| | *Benefits* | *Costs* |
|---|---|---|
| Consumers of good | | $A + B$ |
| Producers of good | | $E + F$ |
| Third parties | $B + C + F$ | |
| Government revenue | $A + E$ | |
| Social benefit | $C$ | |

Because the policy causes consumers to pay a higher price for less of the good, they lose surplus equal to areas *A* and *B*. Similarly, because the tax causes producers to sell less of the good but increases their production costs, they lose producer surplus equal to areas *E* and *F*. On the other hand, because of the reduction in production of the good and, hence, in pollution, third parties receive benefits from the policy equal to areas *B*, *C*, and *F*. Finally, the government receives tax revenues equal to areas *A* and *E*. Because areas *A*, *B*, *E*, and *F* represent transfers from one group to another, only area *C* can be counted as a gain to society as a whole from the tax policy. This area corresponds to the deadweight loss eliminated by the tax policy. To compute the *net* social benefit of the tax, the cost of administering it would have to be subtracted from the reduction in deadweight loss.

Now let us look at an example of a positive externality, a program that subsidizes the purchase of rodent extermination services in a poor neighborhood. One mechanism for doing this is to provide residents with vouchers that are worth a certain number of dollars, $\$v$, for each unit of extermination services they purchase. After subtracting the face value of these vouchers from what they charge neighborhood residents for their services, exterminators would then be reimbursed the face value of the voucher by the government.

By increasing the use of extermination services, such a program may result in a positive externality: the fewer the rodents in the neighborhood, the easier it is for residents in adjoining neighborhoods to control their own rodent populations. This situation is illustrated in Figure 4-8, where the market demand curve, $D_M$, is shown as understating the social demand curve, $D_S$. The area between these two demand curves represents the WTP for the extermination voucher program by residents of adjoining neighborhoods, assuming they had knowledge of the potential benefits from the program to them. Thus, the market equilibrium price, $P_0$, and quantity, $q_0$, are both too low from the social perspective, resulting in deadweight loss equal to $C + F + H$.

What are the social benefits of a program that distributes vouchers worth $\$v$ per unit of extermination service to the residents of a poor neighborhood? As implied by Figure 4-8, when the vouchers become available, residents of the poor neighborhood




| | |
|---|---|
| Gain to consumers in target neighborhood: | $B + E$ |
| Gain to persons in nearby neighborhood: | $C + G + F$ |
| Gain to producers: | $A + C$ |
| Program costs: | $A + B + C + G + E$ |
| Net benefits: | $C + F$ |

**FIGURE 4-8** Social Benefits for Direct Supply of a Good with a Positive Externality

face a supply curve that is below the original market supply curve, $S$, by \$$v$. As a consequence of a voucher-induced shift in the supply curve, neighborhood residents increase their purchases of extermination services from $q_0$ to $q_1$, paying an effective price of $P_1$. Consumers in the targeted neighborhood enjoy a surplus gain equal to the area of trapezoid $B + E$; producers, who now receive a higher supply price of $P_1 + v$, enjoy a surplus gain equal to the area of trapezoid $A + C$; and people in the surrounding neighborhoods, who enjoy the positive externality, gain surplus equal to the area of parallelogram $C + G + F$, the area between the market and social demand curves over the increase in consumption. The program must pay out \$$v$ times $q_1$ in subsidies, which equals the area of rectangle $A + B + C + G + E$. Subtracting this program cost from the gains in social surplus in the market yields gross program benefits: the area of trapezoid $C + F$.[18] This benefit results because the program succeeds in eliminating part (although not all) of the deadweight loss in the market for extermination services.

**Public Goods.** Once produced, public goods—for example, flood control projects or national defense—are available for everyone. No one can or, indeed, should be excluded from enjoying their benefits. In this sense, public goods may be regarded as a special type of positive externality. Similar to other positive externalities, private markets, if left to their own devices, tend to produce less public goods than is socially optimal. Pure public goods have two key characteristics: they are nonexcludable, and they are nonrivalrous.

A good is nonexcludable if it is impossible, or at least highly impractical, for one person to prevent others from consuming it. If it is supplied to one consumer, it is available for all consumers, a phenomenon sometimes called *jointness in supply*. For example, it would be very difficult for a user of the light emitted from a particular streetlight to prevent others from using that light. In contrast, most private goods are excludable. For instance, a purchaser of a hamburger can exclude others from taking a bite unless overcome by physical force.

The reason nonexcludability causes market failure is easy to see. Once a nonexcludable good such as street lighting or national defense exists, it is available for everyone to use. Because people cannot be excluded from using it, a *free-rider problem* results. As a consequence, there is not sufficient incentive for the private sector to provide it. Usually it must be publicly provided, if it is going to be provided at all.

Nonrivalry implies that one person's consumption of a good does not prevent someone else from also consuming it; consequently, more than one person can obtain benefits from a given level of supply at the same time. For example, one person's use of a streetlight to help him see at night does not diminish the ability of another person to use the same light. But if one person eats a hamburger, another cannot consume the same hamburger. The hamburger is rivalrous; a streetlight is nonrivalrous. Thus, unlike the hamburger, even if it were feasible to exclude a second person from using street lighting, it would be inefficient to do so because the marginal cost of supplying lighting to the second person is zero.

The reason nonrivalry causes market failure can be examined by contrasting how a *total marginal benefit curve,* a curve that reflects the incremental benefits to consumers from each additional unit of a good that is available for their consumption, is derived for a rivalrous good with how such a curve is derived for a nonrivalrous good. To do this graphically as simply as possible, we assume that there are only two potential consumers of each of the two goods. Thus, Figure 4-9a displays two graphs: one for

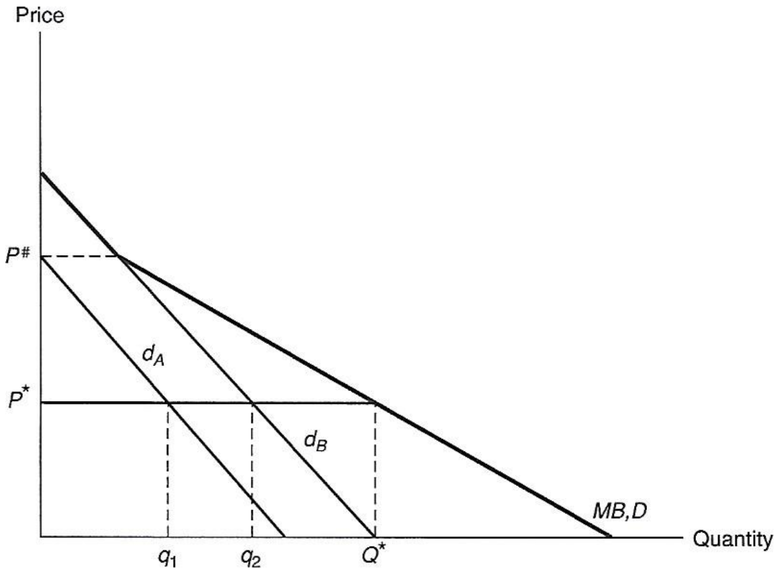



**FIGURE 4-9a** Rivalrous Good (e.g., hamburger)

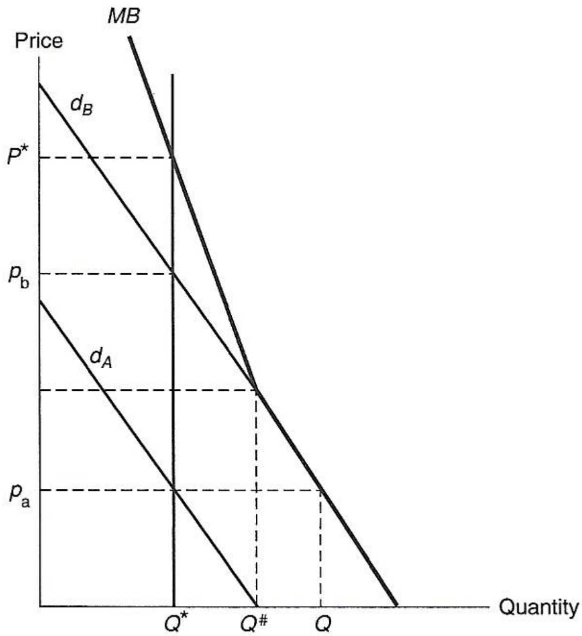



**FIGURE 4-9b** Nonrivalrous Good (e.g., streetlight)

the rivalrous good (hamburger) and one for the nonrivalrous good (streetlight). Each graph contains three curves: a demand curve representing consumer A's WTP ($d_A$), a demand curve representing consumer B's WTP ($d_B$), and a total marginal benefit ($MB$) curve, which is derived from the demand curves for the two consumers.

The total marginal benefit curve for the rivalrous good is equivalent to a market demand curve. To derive this curve, the two demand curves for individual consumers are summed horizontally. For example, at a price of $P^*$, consumer A would want to consume $q_1$ and consumer B would want $q_2$ of the good. Total market demand for the good at a price of $P^*$ is equal to $q_1 + q_2$, a total of $Q^*$. Thus, WTP for (or equivalently, marginal benefits from) the last unit of the total of $Q^*$ units consumed is $P^*$. Notice that until the price falls below $P^{\#}$, the marginal benefit curve would correspond to B's demand curve because A would not demand any of the good.

In contrast, the total marginal benefit curve for the nonrivalrous good is derived by adding the demand curves for individual consumers vertically rather than horizontally. At an output level of $Q^*$, for example, total WTP (i.e., the total marginal benefits from the last unit of the good that is made available) is equal to $p_a + p_b$ or $P^*$. Notice that at output levels above $Q^{\#}$, consumer A's WTP falls to zero and, consequently, the marginal benefit curve corresponds to consumer B's demand curve.

The reason the demand curves for individual consumers must be summed horizontally in the presence of rivalry and vertically in its absence can be clarified through use of a numerical example. If at a price of $2 consumer B wanted to buy two hamburgers and consumer A one hamburger, then total demand would equal three hamburgers—the horizontal sum of demands at a particular price. But if at a price of $1,000, B wanted two streetlights on the block on which he and A both lived, but A wanted only one, then two streetlights would completely satisfy the demands of both. Thus, the total demand for a nonrivalrous good cannot be determined by summing the quantity of the good each consumer desires at a given price. It must be determined instead by summing each consumer's WTP for a given quantity of the good. Hence, although A and B have a different WTP for the two streetlights, their total WTP for the two streetlights can be determined by adding A's WTP for two lights to B's.

The distinction between how the total demand for rivalrous and nonrivalrous goods is determined has an important implication. In the case of the rivalrous good, consumers will reveal to the market how much they want. For example, if the price of hamburgers is set at $P^*$, consumer A will actually purchase $q_1$ of the good and consumer B will actually purchase $q_2$. But in the case of a nonrivalrous good, no market mechanism exists that causes consumers to reveal how many units they would purchase at different prices. For example, if the price of streetlight is at $p_b$, consumer B would be willing to purchase $Q^*$ of the good. But if B did that, A would not purchase any because, as a result of B's purchase, he could consume all he wanted. In other words, A would free ride on B. Because of this free-rider problem, B might refuse to make any purchase until A agreed to make some sort of contribution.[19]

When only a small group of people is involved, they may be able to work out the free-rider problems caused by the nonexcludability and nonrivalry of public goods through negotiations. For example, a neighborhood association might make arrangements for installing and paying for streetlights. But too much or too little of the good may be produced. For example, if consumers A and B are to be charged for streetlights on the basis of their WTP, each will probably try to convince the other that they place a low value on streetlights regardless of how they actually value them. It is therefore difficult to determine where the total marginal benefit curve for a public good is located, even if only a small group of people is involved. When a large group of people share a good that is nonexcludable and nonrivalrous, such as national defense, negotiations become impractical. Consequently, if the good is going to be produced at all, the government must almost certainly intervene by either producing the good itself or subsidizing its production.

Because streetlighting is both nonrivalrous in consumption and nonexcludable, it is close to being a pure public good. Other goods may be either nonrivalrous or nonexcludable, but not both. For example, an uncrowded road is essentially nonrivalrous in nature. One person's use of it does not keep another from using it. Yet, it is excludable. Individuals could be required to pay a toll to use it. Thus, it is sometimes called a *toll good*. Fish in international waters provide an example of a good that is rivalrous but nonexcludable. Fish and fishers move around so it is difficult to preclude fishers from catching a particular type of fish, for example, tuna. But if a fisher catches a tuna, then that tuna is no longer available to other fishers. This type of good is called an *open access resource*. Goods that are either nonrivalrous or nonexcludable, but not both, exhibit some, but not all of the characteristics of public goods. However, for the sake of brevity, we have focused on pure public goods, which are both nonrivalrous and nonexcludable. Examples of goods that are close to being pure public goods are streetlights, flood control, national defense, and crime deterrence resulting from police patrolling the streets.

As suggested by the preceding analysis, because of both nonrivalry and nonexcludability, actual markets for pure public goods are unlikely to exist. However, marginal benefit and marginal cost curves, which are analogous to market demand and supply curves, do exist. We have already shown how to derive a marginal benefit curve for a public good. And, as in the case of a private good, the marginal cost curve for a public good simply reflects the costs of producing each incremental unit of the good. Social welfare is maximized when marginal benefits equal marginal costs, while deadweight loss results at either smaller or larger output amounts. However, because of the absence of a true market, little or none of a pure public good would be produced without government intervention, or at least some sort of negotiation process. Thus, in the absence of government intervention or negotiations, society would forgo social surplus resulting from consumption of the good. Even if the government does intervene or negotiations do take place, there is nonetheless no guarantee that output of the good will be at the point where marginal benefits equal marginal costs because the marginal benefit curve for a pure public good is inherently unknowable. As a consequence, too much or too little of it may be produced. However, as described in Chapter 15, techniques exist that can be used to obtain information about WTP for public goods.

**Intrapersonal Externalities: Consumption under Addiction.** For some people, the consumption of a particular good today increases their demand for its consumption in the future. For example, exposure to classical music during childhood may contribute to a demand for such music in adulthood. Economic models of addictive goods assume that the amount demanded at any time depends on the amount of previous consumption. *Rational addiction* occurs when consumers fully take account of the future effects of their current consumption.[20] If current consumption is myopic or fails to take account of future risks, then addiction is not rational. For example, some children may fail to anticipate the consequences of tobacco addiction during their adulthood or some adults may fail to anticipate the risk that their casual gambling may become a disruptive compulsion. Such cases involve *negative intrapersonal externalities*—harm imposed by current consumers on their future selves.

*The presence of negative intrapersonal externalities brings into question the appropriateness of using changes in consumer surplus measured under market demand curves as the basis for assessing the benefits of alternative policies.* On the one hand, the demand curve reveals the marginal willingness of the market to pay for additional units of the good. On the other hand, the satisfaction from addictive consumption may not actually make consumers better off—it avoids the pain of abstinence but does not provide as much happiness as would alternative consumption in a nonaddicted state. The stated desire and costly efforts made by many adult smokers to quit smoking suggests that they perceive benefits from ending their addiction. In other words, they wish they had not been addicted by their younger selves.

A plausible approach to measuring consumer surplus in the presence of undesirable addiction involves assessing consumer surplus using unaddicted demand curves.[21] Figure 4-10 illustrates the approach taking as an example addicted, or so-called problem, gamblers. It shows two demand curves: $D_A$, the demand curve for gambling in the presence of the addiction, and $D_R$, the demand curve for the same group of addicted gamblers if they were instead like the majority of recreational gamblers who enjoy gambling but do not have a strong compulsion to gamble that leads them to regret

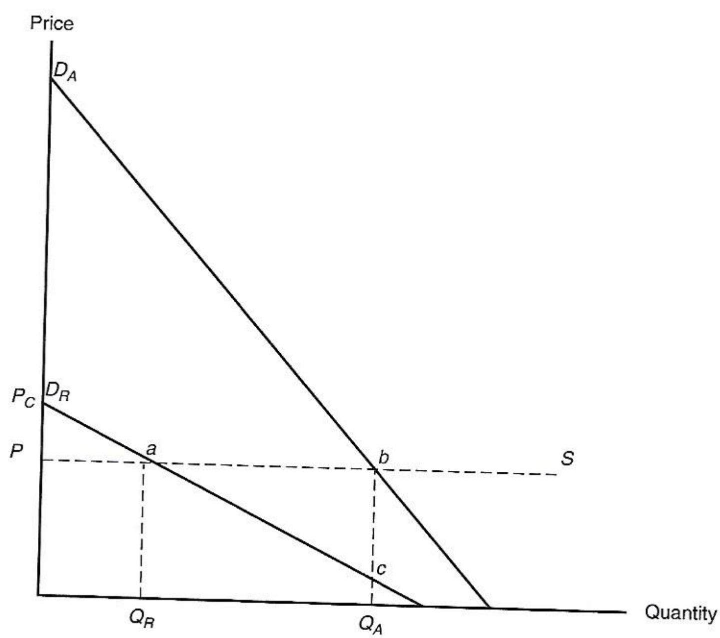



**FIGURE 4-10** Consumer Surplus in the Presence of Gambling Addiction

their gambling behaviors. The quantity of gambling demanded by these addicted gamblers at price $P$ is $Q_A$. If they were not addicted, however, then they would consume only $Q_R$ at that price. $Q_A$ minus $Q_R$ is the excess consumption due to the addiction. Consumption up to level $Q_R$ involves a positive consumer surplus of $PaP_C$. The consumption from $Q_R$ to $Q_A$ involves expenditures of $Q_RabQ_A$ but consumer value equal to only $Q_RacQ_A$ as measured under their recreational demand curve, resulting in a loss equal to area *abc*. Overall, participation in this market by these addicted gamblers yields consumer surplus equal to $PaP_C - abc$. If a policy resulted in these addicted gamblers becoming unaddicted recreational gamblers, then a surplus gain of *abc* would result.

The Australian Productivity Commission applied this approach to estimate consumer surplus losses and gains from the Australian gambling industry. It estimated a consumer surplus gain for recreational gamblers (97.9% of all gamblers) to be between AU$2.7 billion and AU$4.5 billion annually but a consumer surplus loss of almost AU$2.7 billion annually for problem gamblers (2.1% of all gamblers).[22]

## [VA]LUING INPUTS: OPPORTUNITY COSTS

Public policies usually require resources (i.e., inputs) that could be used to produce other goods or services instead. Public works projects such as dams, bridges, highways, and subway systems, for example, require labor, materials, land, and equipment. Similarly, social service programs typically require professional employees, computers, telephones, and office space; wilderness preserves, recreation areas, and parks require at least land. Once resources are devoted to these purposes, they obviously are no longer available to produce other goods and services. Almost all public policies incur opportunity costs. Conceptually, these costs equal the value of the goods and services that would have been produced had the resources used in carrying them out been used instead in the best alternative way. These opportunity costs, as seen in Chapter 3, are represented by areas under supply curves. These areas are the theoretically appropriate measures of the costs of the inputs.

As a practical matter, the most obvious and natural way to measure the value of the resources used by a project is simply as the direct budgetary outlay needed to purchase them. Under certain circumstances, the direct budgetary outlay is also identical to the conceptually appropriate opportunity cost measure, but under other circumstances, it is not. To determine when it is and is not permissible to use budgetary outlays, we compare the conceptually appropriate measure of costs with the direct budgetary outlay measure of costs in three alternative market situations: (1) when the market for a resource is efficient (i.e., there are no market failures) and purchases of the resource for the project will have a negligible effect on the price of the resource; (2) when the market for the resource is efficient, but purchases for the project will have a noticeable effect on prices; and (3) when the market for the resource is inefficient (i.e., there is a market failure). As will be seen, in the first of these situations, budgetary expenditures usually accurately measure project opportunity costs; in the second situation, budgetary outlays often only slightly overstate project opportunity costs; and in the third situation, expenditures may substantially overstate or understate project opportunity costs.

Before beginning, it may be helpful to make a general point concerning opportunity costs: the relevant determination is what must be given up today and in the future, *not* what has already been given up. The latter costs are *sunk* and, unlike variable costs, are not represented by the areas under supply curves. In CBA, the extent to which costs are sunk depends importantly on whether an *ex ante, ex post,* or *in medias res* analysis is being conducted. For instance, suppose that you are asked to evaluate a decision to complete a bridge after construction has already begun. What is the opportunity cost of the steel and concrete that is already in place? It is not the original expenditure made to purchase them. Rather, it is the value of these materials in their current best alternative use. This value is most likely measured by the maximum amount for which the steel and concrete could be sold as scrap. Conceivably, the cost of scrapping the materials may exceed their value in any alternative use so salvaging them would not be justified. Indeed, if salvage is still necessary, perhaps for environmental or other reasons, then the opportunity cost of the materials will be negative (and thus counted as a benefit, an avoided cost) when calculating the net gains of continuing construction. In situations where resources that have already been purchased have exactly zero scrap value (the case of labor already expended, for instance), the costs are entirely sunk and are not relevant to decisions concerning future actions.

## Measuring Opportunity Costs in Efficient Markets with Negligible Price Effects

**Perfectly Elastic Supply Curves.** An example of this is when a government agency running a training program for unemployed workers purchases pencils for trainees. Assuming an absence of failures in the market for pencils, and that the agency buys only a small proportion of the total pencils sold in the market, the agency is realistically viewed as facing a horizontal supply curve for pencils. Thus, the agency's purchases will have a negligible effect on the price of pencils; it can purchase additional pencils at the price they would have cost in the absence of the training program.

This situation is depicted in Figure 4-11. If a project purchases $q'$ units of the input factor represented in the diagram (e.g., pencils), the demand curve, $D$, would shift horizontally to the right by $q'$. As implied by the horizontal supply curve, marginal costs remain unchanged and, hence, the price remains at $P_0$. The area under the supply curve represents the opportunity cost of the factor and $P_0$ is the opportunity cost of one additional unit of the factor. Consequently, the opportunity cost to society of the $q'$ additional units of the factor needed by the project is simply the original price of the factor times the number of units purchased (i.e., $P_0$ times $q'$). In Figure 4-11, this is represented by the shaded rectangle $abq_1q_0$. Thus, the amount that the agency must pay to purchase additional pencils equals the opportunity cost of the resources used to produce them. In other words, if the $q'$ units of the factor were not used for purposes of the project, then $P_0$ times $q'$ worth of goods could be produced elsewhere in the economy.

What is important about the situation just described is that the social cost of the units of the factor needed by the project, the shaded rectangular area in Figure 4-11, is identical to the budgetary outlay required to purchase the units; both are equal to $P_0$ times $q'$. Because most factors have neither steeply rising nor declining marginal cost curves, *it is often reasonable to presume that expenditures required for project inputs*

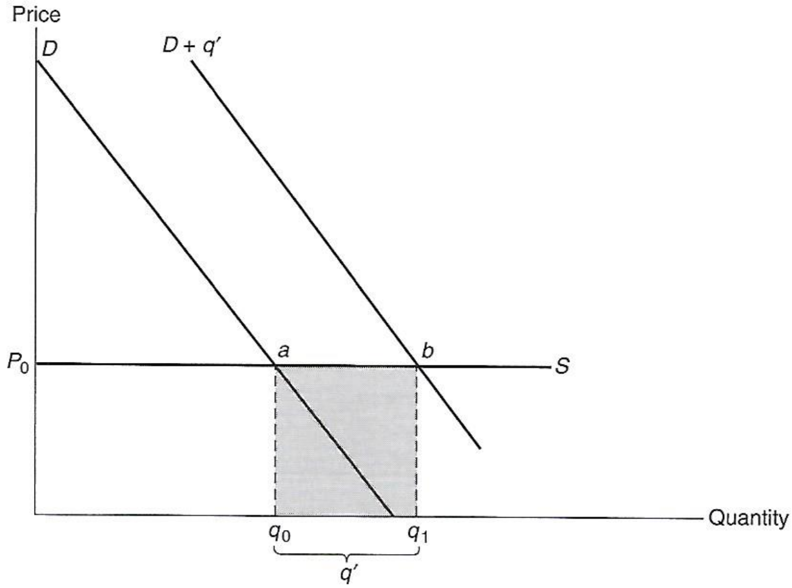



**FIGURE 4-11** Opportunity Costs with No Price Effects

*equal their social costs*. This is the case when the quantity of the resource purchased makes only a small addition to the total demand for the resource, and where, in addition, there is no reason to suspect the existence of significant market failures.

**Perfectly Inelastic Supply Curves.** In contrast to pencils, let us now examine a government purchase of a parcel of land for a park. We assume that, unlike the pencils, the quantity of land in a specified area is fixed at $A$ acres. Thus, the government faces a vertical rather than horizontal supply curve. In addition, we assume that if the government does not purchase the land, it will be sold in one-acre parcels to private buyers who will build houses on it.

This situation is represented in Figure 4-12, where $S$ is the supply curve and $D$ the private-sector demand curve. If the owners of the land sell it in the private market, they receive the amount represented by the rectangle $PbA0$. Now let us assume that the government secures all $A$ units of the land at the market price through its eminent domain powers, paying owners the market price of $P$. Thus, the government's budgetary cost is represented in Figure 4-12 by area $PbA0$.

Here, however, the government's budgetary outlay understates the opportunity cost of removing the land from the private sector. The reason is that the potential private buyers of the land lose consumer surplus (triangle $aPb$ in Figure 4-12) as a result of the government taking away their opportunity to purchase land, a real loss that is not included in the government's purchase price. The full cost of the land if it is purchased by the government is represented in Figure 4-12 by all of the area under the demand curve to the left of the vertical supply curve, area $abA0$, not only the rectangular area below the price line.[23]

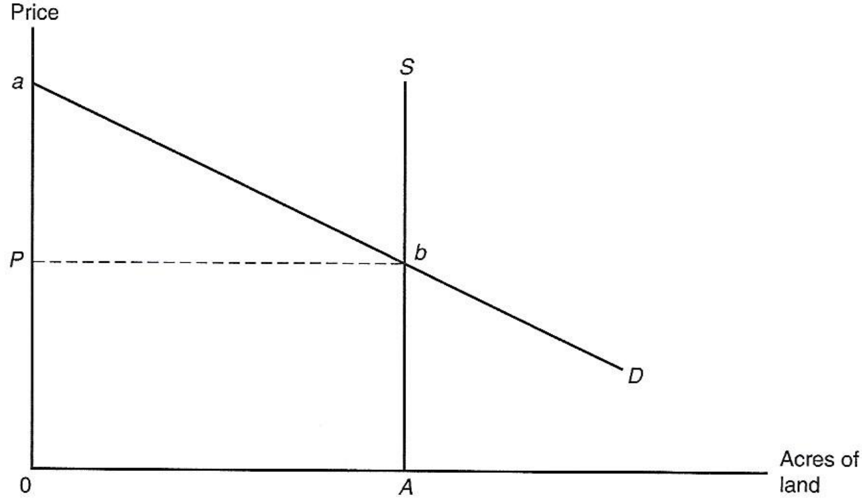



**FIGURE 4-12** Opportunity Costs with Inelastic Supply Curve

## Measuring Opportunity Costs in Efficient Markets with Noticeable Price Effects

It is possible that even when a resource required by a project is purchased in an essentially efficient market, such a large quantity is required that its price is bid up. This could occur, for example, if the construction of a very large dam requires massive amounts of concrete. In such a situation, the project should be viewed as facing an upward-sloping supply curve for the resource input. Such a supply curve is illustrated in Figure 4-13. In this example, project purchases of $q'$ units of the resource would shift the demand curve, $D$, to the right. Because the supply curve, $S$, is upward sloping, the equilibrium price rises from $P_0$ to $P_1$, indicating that the large purchase causes the marginal cost of the resource to rise. The price increase causes the original buyers in the market to decrease their purchases from $q_0$ to $q_2$. However, total purchases, including those made by the project, expand from $q_0$ to $q_1$. Thus, the $q'$ units of the resource purchased by the project come from two distinct sources: (1) units bid away from their previous buyers, and (2) additional units sold in the market.

Total project expenditures on the resource are equal to $P_1$ times $q'$. In Figure 4-13, these expenditures are represented by areas $B + C + G + E + F$, which together form a rectangle. Unlike the case where the price of the resource does not change, however, this expenditure does not correspond to the opportunity cost of using $q'$ units of the resource. The price change must be taken into account in computing the opportunity cost. In doing this, the general rule is that *opportunity cost equals expenditure less (plus) any increase (decrease) in consumer surplus or producer surplus occurring in the factor market.* In other words, budgetary outlays on a resource do not equal opportunity costs when the outlays cause a change in consumer surplus or producer surplus in the market for the resource.

To understand why, first look at the areas labeled $A$ and $B$ in Figure 4-13. These two areas represent a decrease in the consumer surplus of the original buyers because of the price increase. However, sellers gain more in producer surplus as a result of the price in-

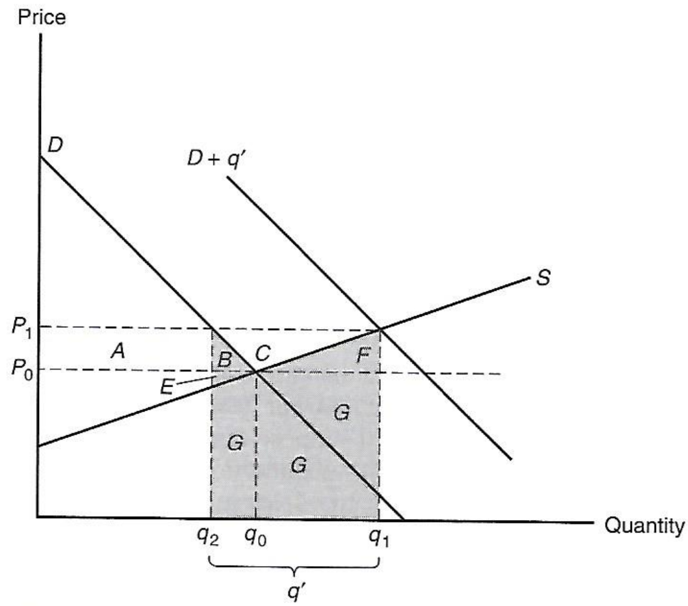



**FIGURE 4-13** Opportunity Costs with Price Effects

crease than the original buyers lose—a gain represented by areas $A + B + C$. Part of the gain in producer surplus, the area represented by $A+B$, merely offsets the loss in consumer surplus and, hence, is a transfer from buyers to sellers. However, area $C$ represents a gain in producer surplus that partially offsets the social cost resulting from increased government expenditure on the resource.[24] To measure the social cost of the project's purchase of the resource, this net gain in producer surplus must be subtracted from the project's total budgetary outlay on the resource, areas $B + C + G + E + F$. Thus, the net social cost of the project's purchase of $q'$ units of the resource is represented by areas $B + G + E + F$. The effects of the purchase are summarized in the following social accounting ledger.[25]

| | *Benefits* | *Costs* |
|---|---|---|
| Original buyers | | $A + B$ |
| Sellers | $A + B + C$ | |
| Project expenditures | | $B + C + G + E + F$ |
| Net social cost | | $B + G + E + F$ |

The basic point is that when prices change the budgetary outlay does not equal the social cost. In the example shown in Figure 4-13, they differ by area $C$. As an examination of the figure suggests, however, unless the rise in prices is quite substantial, this area will be small relative to total budgetary cost. This suggests that in many instances budgetary outlay will provide a good approximation of true social cost.

If the price of an input does go up substantially, however, then the budgetary cost must be adjusted for CBA purposes. If the demand and supply curves are linear (or approximately linear), then the amount of this adjustment, which is the area represented by $C$, can be readily calculated. It equals the amount of the factor purchased for the project, $q'$, multiplied by $1/2(P_1 - P_0)$, half the difference between the new and the old prices.[26] The opportunity cost of purchasing the resource for the project can also be computed directly by multiplying the amount purchased by the average of the new and old prices, $1/2(P_1 + P_0)(q')$.[27] The average of the new and old prices is a shadow price; it reflects the social opportunity cost of purchasing the resource more accurately than either the old price or the new price alone.

The social cost of using a resource for a project or program does not necessarily depend upon the mechanism that a government uses to obtain it. Suppose, for example, that instead of paying the market price for $q'$ units of the resource represented in Figure 4-13, the government instead first orders supplying firms to increase their prices to the original buyers in the market from $P_0$ to $P_1$, thereby causing sales to these buyers to fall from $q_0$ to $q_2$. Next suppose that the government orders these firms to supply $q'$ units to the government at the additional cost required to produce them. The social surplus loss resulting from the price increase to the original buyers is area $B + E$, which is the deadweight loss attributable to the increase in price. The social opportunity cost of producing the additional $q'$ units of the resource for the government, which in this case corresponds to the government's budgetary expenditure, is the trapezoidal area $G + F$. Thus, the total social cost that results from the government's directive is $B + G + E + F$. This social cost is exactly the same as the social cost that results when the government purchases the resource in the same manner as any other buyer in the market. Notice, however, that this time the government's budgetary outlay, $G + F$, is smaller, rather than larger, than the social opportunity cost of using the resource.

## Measuring Costs in Inefficient Markets

As indicated in Chapter 3, in an efficient market, price equals marginal social cost. Whenever price does not equal marginal social cost, allocative inefficiency results. A variety of circumstances can lead to inefficiency: absence of a working market, market failures (e.g., public goods, externalities, natural monopolies, markets with few sellers, and information asymmetries), and distortions due to government interventions (such as taxes, subsidies, regulations, price ceilings, and price floors). Any of these distortions can arise in factor markets, complicating the estimation of opportunity cost.

Because of space limitations, it is possible to examine only three distortions here. First, we consider the situation in which the government purchases an input at a price below the factor's opportunity cost. Second, we examine the case in which the government hires from a market in which there is unemployed labor. Third, we explore the situation in which the government purchases inputs for a project from a monopolist. In each of these situations, shadow pricing is needed to measure accurately the opportunity cost of the input.

**Purchases at Below Opportunity Costs.** Consider a proposal to establish more courts so that more criminal trials can be held. Budgetary costs include the salaries of judges and court attendants, rent for courtrooms and offices, and perhaps expenditures for additional correctional facilities (because the greater availability of trial capacity leads to more imprisonment). For these factors, budgetary costs may correspond well to social opportunity costs. However, the budget may also include payments to jurors, payments that typically just cover commuting expenses. If any compensation is paid to jurors for their time, then it is usually set at a nominal *per diem* not related to the value of their time as reflected, perhaps, by their wage rates. Thus, budgetary outlay to jurors almost certainly understates the opportunity cost of jurors' time. Consequently, some form of shadow pricing is necessary. A better estimate of jurors' opportunity cost is, for example, their commuting expenses plus the number of juror-hours times either the average or the median pre-tax hourly wage rate for the locality. The commuting expenses estimate should include the actual resource costs of transporting jurors to the court, not just out-of-pocket expenses. The hourly pre-tax wage rate times the hours spent on jury duty provides a measure of the value of goods forgone because of lost labor, although several criticisms of it are discussed in Chapter 14.

**Hiring Unemployed Labor.** We have stressed that assessing opportunity costs in the presence of market failures or government interventions requires a careful accounting of social surplus changes. Analysis of the opportunity cost of workers hired for a government project who would otherwise be unemployed illustrates the kind of effort that is required.

Let us examine the opportunity costs of labor in a market in which minimum wage laws, union bargaining power, or some other factor creates a wage floor that keeps the wage rate above the market-clearing level and, consequently, there is unemployed labor.[28] Notice that we are focusing here on a very specific form of unemployment: that which occurs when the number of workers who desire jobs at the wage paid in a particular labor market exceed the number of workers employers are willing to hire at that wage. Workers who are unemployed for this reason are sometimes said to be *in surplus*. We focus on surplus workers so that we can examine their opportunity costs when they are hired for a government project. This issue is of particular importance because there are government projects that are specifically designed to put surplus workers to work and numerous other projects that are likely to hire such workers. Of course, there are other forms of unemployment than the type considered here. For example, some persons are briefly unemployed while they move from one job to another.

Before discussing how the opportunity cost of surplus labor might be measured, it may be useful to consider more explicitly the extent to which the labor hired to work on a government project reduces the number of unemployed workers.[29] Consider, for example, a project that hires 100 workers. How many fewer workers will be unemployed as a result? In considering this question, it is important to recognize that the project does not have to hire directly from the ranks of the unemployed. Even if the project hires 100 previously employed persons, this will result in 100 job vacancies, some of which may be filled by the unemployed. If the unemployment rate for the type of workers hired for the project (as determined by their occupation and geographic location) is very high (say, over 10 or 15%), the number of unemployed workers may fall by nearly 100. But if the unemployment rate for the workers is low (say, below 5%), most of the measured unemployed are probably between jobs rather than in surplus. As a consequence, the project is likely to cause little reduction in the number of persons who are unemployed. Instead the project will draw its workforce from those

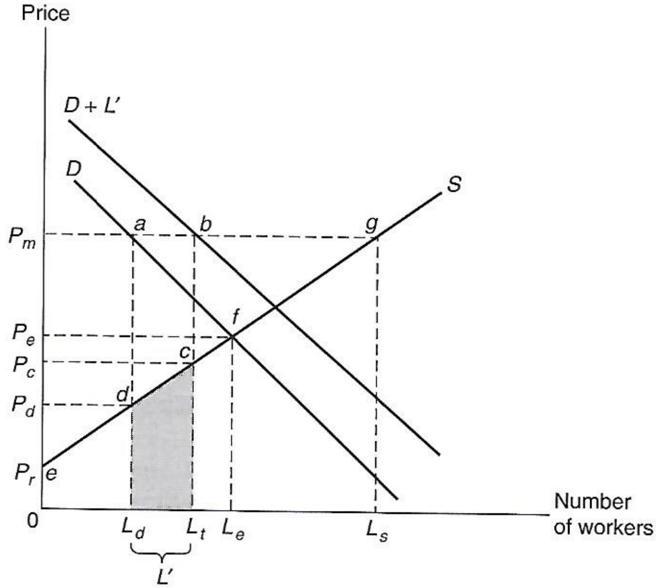



**FIGURE 4-14** Opportunity Costs with a Price Floor

employed elsewhere or out of the labor force. At rates of unemployment between 5 and 10 percent, the reduction in the number of unemployed persons will probably be well under 100 but substantially above zero.

Figure 4-14 depicts a situation in which a government project reduces unemployment. In this figure, the pre-project demand curve for labor, $D$, and the supply curve for labor, $S$, intersect at $P_e$, the equilibrium price in the absence of the wage floor, $P_m$. At the wage floor, $L_s$, workers desire employment, but only $L_d$ workers are demanded so that $L_s - L_d$ workers are in surplus and thus unemployed. Now imagine that $L'$ workers are hired for a government project at a wage of $P_m$. This shifts the demand curve to the right by $L'$. As long as $L'$ is less than the number of unemployed laborers, the price remains at the floor.

We now consider five alternative measures of the social cost of hiring the $L'$ unemployed workers. All five of these measures are subject to criticism. Indeed, it is not obvious that, as a practical matter, it is possible to obtain an accurate value of the social cost of hiring the unemployed. However, some of the alternative measures described here are far better approximations of the true social cost than others.

1. **Measure A.** It is sometimes suggested that because the unemployed are not working, there are zero opportunity costs in putting them to work. This treats the unemployed, however, as if their time is valueless. This is clearly inappropriate on two grounds. First, many unemployed persons are in fact engaged in productive enterprises such as job search, child care, and home improvements. Second, even if they were completely at leisure, leisure itself has value to those who are enjoying it. Consequently, few, if any, unemployed persons are willing to work at a zero wage. Indeed, the supply curve in Figure 4-14 represents the value that various individuals, both those who are employed and those who are unemployed, place on

their time when they are not employed. For example, an individual located at point *f* would only be willing to accept employment at a price of $P_e$ or greater. Thus, $P_e$ provides a measure of the value that this person places on his or her time. In other words, his or her opportunity cost of giving up leisure time to work is $P_e$. Similarly, individuals located on the supply curve at points *c* and *d* value their time at $P_c$ and $P_d$, respectively. No individual is willing to work at a price below $P_r$, and, as $P_r$ has a positive value, Figure 4-14 implies that the opportunity cost of hiring the unemployed must be above zero.

2. **Measure B.** Figure 4-14 indicates that total budgetary expenditure on labor for this project is $P_m$ times $L'$, which equals the area of rectangle $abL_tL_d$. This budgetary outlay for labor, however, is likely to overstate substantially the true social cost of hiring workers for the project. As implied by the supply curve in Figure 4-14, although employed workers are paid a price of $P_m$, most would be willing to work for less. This difference between the value they place on their time, as indicated by the supply curve, and $P_m$, the price they are actually paid while employed, is producer (i.e., worker) surplus, which may be viewed as a transfer to the workers from the government agency hiring them. To obtain a measure of the social cost of hiring workers for the project, this producer surplus must be subtracted from the budgetary expenditure on labor. Measure B fails to do this.
3. **Measure C.** As the project expands employment in the market represented by Figure 4-14 from $L_d$ to $L_t$, one might assume that the trapezoid *abcd* represents producer surplus enjoyed by the newly hired. Given this assumption, one would subtract area *abcd* from area $abL_tL_d$ to obtain a measure of the social cost of hiring workers for the project. Thus, the social cost would be measured as the shaded trapezoid $cdL_dL_t$, the area under the supply curve between $L_d$ and $L_t$. This shaded area would equal the opportunity cost of the newly hired workers—that is, the value of the time they give up when they go to work.
4. **Measure D.** One shortcoming of measure C is that it is implicitly based on an assumption that all the unemployed persons hired for the project value their time at less than $P_c$ and at greater than $P_d$. In other words, this approach assumes that these workers are all located between points *c* and *d* on the supply curve. However, there is no basis for such an assumption. Indeed, it is quite likely that some of the hired unemployed persons value their time at well above $P_c$ and that others value their time at well under $P_d$. In fact, the figure implies that unemployed persons who value their time as low as $P_r$ and as high as $P_m$ would be willing to work on the project because the project would pay them a price of $P_m$. Thus, perhaps, a better assumption is that the unemployed persons who would actually get hired for the project are distributed more or less equally along the supply curve between points *e* and *g*, rather than being confined between points *d* and *c*. This assumption implies that the unemployed persons who are hired for the project value their time by no more than $P_m$, by no less than $P_r$, and, on average, by $1/2(P_m + P_r)$. Thus, the social cost of hiring $L'$ workers for the project would be computed as equal to $1/2(P_m + P_r)(L')$.
5. **Measure E.** One practical problem with using measure D in an actual CBA is that the value of $P_r$, the lowest price at which any worker represented in Figure 4-14 would be willing to accept employment, is unlikely to be known. Given this, some

> assumption about the value of $P_r$ must be made. One possible, and perhaps not unreasonable, assumption is that the supply curve passes through the origin and, hence, the value of $P_r$ equals zero. The fact that the probabilities of illness, divorce, and suicide all increase with unemployment, while job skills deteriorate, suggest that $P_r$ could, in practice, be very low for at least some unemployed persons. If we once again assume that the unemployed persons who are hired for the project are distributed more or less equally along the supply curve between the point at which it intersects the vertical axis and point *g*, then this implies that the unemployed persons who are hired for the project value their time by no more than $P_m$, by no less than zero, and, on average, by $\frac{1}{2}(P_m + 0) = \frac{1}{2}P_m$. Hence, the social cost of hiring workers for the project would be computed as $\frac{1}{2}P_m(L')$. Note that the estimate provided by this computation is equal to half the government's budgetary outlay. While this cost estimate would be smaller and almost certainly less accurate than that computed using measure D, it is usually easier to obtain.

Given our preceding argument that nonwork time has a positive value, measure E is probably best viewed as providing an easily obtainable lower-bound estimate of the true project social costs for labor, while the project budgetary cost for labor, measure B, provides an upper-bound estimate.

**Purchases from a Monopoly.** We now turn to a final example of measuring the social cost of project or program purchases in an inefficient market—the purchase of an input supplied by a monopoly. In this circumstance, a government agency's budgetary outlay overstates the true social costs resulting from the purchase. This overstatement occurs because the price of the input exceeds the social cost of producing it. As a consequence, a substantial share of the revenues a monopolist receives are transfers or *monopoly rents*. Thus, in principle, a CBA should not use the budgetary outlay as a measure of social cost.

Figure 4-15 illustrates a government agency's purchase of an input from a monopoly. Prior to the purchase, the input is produced at level $Q_1$, where the monopolist's marginal cost and marginal revenue curves intersect. The price at $Q_1$, as determined by the demand curve, is $P_1$. Now, as a result of the agency's purchase of $Q'$ units, the monopolist's demand curve and marginal revenue curve shift to the right. The price of the input increases to $P_2$ and the quantity sold increases to $Q_2$. At the new higher price, the agency purchases a quantity equal to the distance between $Q_3$ and $Q_2$, while the original buyers in the market reduce the quantity they purchase by an amount equal to the distance between $Q_1$ and $Q_3$.

As in our previous examples, the direct budgetary cost of the agency's purchase equals the price times the quantity purchased: $P_2(Q_2 - Q_3)$. In Figure 4-15, this is represented by the rectangle between $Q_3$ and $Q_2$ and bounded by $P_2$ (i.e., areas $A + C + G + E$). However, these budgetary costs overstate the true social cost. To find the true social cost of the agency's purchase, one must examine the effects of the purchase on the monopolist and the original buyers of the input, as well as on the agency's revenues.

Because the monopolist sells more of the input at higher prices, its producer surplus increases. This increase has two parts: (1) that resulting from the higher price the monopolist now receives for the units that it previously sold (which is represented in

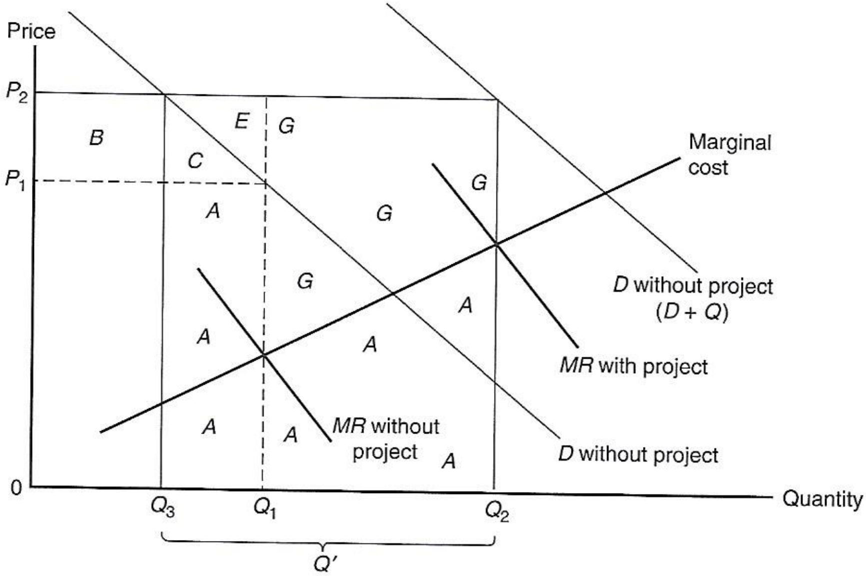



**FIGURE 4-15** Opportunity Costs When Buying from a Monopoly

Figure 4-15 by areas $B + C + E$), and (2) that resulting from the additional units that the monopolist now sells (area $G$). Thus, as can be seen from the figure, part of the cost to the agency, areas $C + G + E$, is a transfer to the monopolist.

Original buyers in the market are clearly worse off as a result of the agency's purchase because they now have to pay a higher price for the input. In measuring their loss of consumer surplus, it is the original demand curve that is pertinent because this is the curve that reflects the original buyers' WTP for the input. Thus, the total loss in consumer surplus by the original buyers, all of which is a transfer to the monopolist, is equal to areas $B + C$.

The following distributional accounting ledger summarizes the effects of the purchase:

| | *Benefits* | *Costs* |
|---|---|---|
| Original buyers | | $B + C$ |
| Monopolistic seller | $B + C + G + E$ | |
| Project expenditures | | $A + C + G + E$ |
| Net social cost | | $A + C$ |

The major conclusion of this analysis is that in the case of input purchases from a monopolist, budgetary expenditures are larger than the social costs. The reason is that the price the monopoly charges exceeds the marginal cost of producing the input. Consequently, in conducting a CBA, the government's budgetary cost should, in principle, be adjusted downward through shadow pricing. In practice, however, the error that would result from using the unadjusted budgetary expenditures would often not be very large.

As an examination of Figure 4-15 suggests, the size of the bias, areas $G + E$, depends on the extent to which the price the monopoly charges exceeds its marginal costs—in other words, on how much monopoly power it actually has. This, in turn, depends on how steeply sloped the demand curve is. Thus, before an analyst develops shadow prices, a sometimes difficult undertaking, he or she should ask whether it is really necessary to do so.

**The General Rule.** Other market distortions also affect opportunity costs in predictable ways. It is useful to summarize the direction of the bias created by some of these distortions. In factor markets in which supply is taxed, direct expenditure outlays overestimate opportunity cost; in factor markets in which supply is subsidized, expenditures underestimate opportunity cost. In factor markets exhibiting positive externalities of supply, expenditures overestimate opportunity cost; in factor markets exhibiting negative externalities of supply, expenditures underestimate opportunity costs. To determine opportunity costs in such cases, apply the rule: opportunity cost equals direct expenditures on the factor minus (plus) gains (losses) in producer surplus or consumer surplus occurring in the factor market.

## Conclusions

This chapter has shown that the benefits and costs associated with government programs and projects are appropriately determined by valuing the resulting changes in net government revenue flows, producer surplus, and consumer surplus. Even when the relevant demand and supply curves are known, great care must be exercised in order to measure the changes appropriately, especially when the relevant markets are distorted. Two types of relevant markets were considered: the market in which the policy intervention takes place and factor markets where the government purchases the inputs required by the program or project. These markets, primary markets, are the ones that are directly affected by a particular policy. Markets that are indirectly affected—secondary markets—are the focus of the following chapter.

## Exercises for Chapter 4

1. Consider a low-wage labor market. Workers in this market are not presently covered by the minimum wage, but the government is considering implementing such legislation. If implemented, this law would require employers in the market to pay workers a \$5 hourly wage. Suppose all workers in the market are equally productive, the current market-clearing wage rate is \$4 per hour, and that at this market-clearing wage there are 600 employed workers. Further suppose that under the minimum wage legislation, only 500 workers would be employed and 300 workers would be unemployed. Finally, assume that the market demand and supply curves are linear and that the market reservation wage, the lowest wage at which any worker in the market would be willing to work, is \$1.

   Compute the dollar value of the impact of the policy on employers, workers, and society as a whole.
2. Suppose the government is considering an increase in the toll on a certain stretch of highway from \$.40 to \$.50. At present, 50,000 cars per week use that highway stretch; after the toll is imposed, it is projected that only 40,000 cars per week will use the highway stretch.

a. Assuming that the marginal cost of highway use is constant (i.e., the supply curve is horizontal) and equal to \$.40 per car, what is the net cost to society attributable to the increase in the toll? (Hint: the toll increase will cause the supply curve, not the demand curve, to shift.)
b. Because of the reduced use of the highway, the government would reduce its purchases of concrete from 20,000 tons per year to 19,000 tons per year. Thus, if the price of concrete were \$25 per ton, the government's cost savings would be \$25,000. However, the government's reduced demand for concrete causes its market price to fall from \$25 to \$24.50 per ton. Moreover, because of this reduction in price, the purchases of concrete by nongovernment buyers increase by 300 tons per year. Assuming that the factor market for concrete is competitive, can the government's savings of \$25,000 be appropriately used as the measure of the social value of the cost savings that result from the government purchasing less concrete? Or would shadow pricing be necessary?

3. A country imports 3 billion barrels of crude oil per year and domestically produces another 3 billion barrels of crude oil per year. The world price of crude oil is \$90 per barrel. Assuming linear curves, economists estimate the price elasticity of domestic supply to be 0.25 and the price elasticity of domestic demand to be 0.1 at the current equilibrium.
   a. Consider the changes in social surplus that would result from imposition of a \$30 per barrel import fee on crude oil that would involve annual administrative costs of \$250 million. Assume that the world price will not change as a result of the country imposing the import fee, but that the domestic price will increase by \$30 per barrel. Also assume that only producers, consumers, and taxpayers within the country have standing. Determine the quantity consumed, the quantity produced domestically, and the quantity imported after the imposition of the import fee. Then estimate the annual social net benefits of the import fee.
   b. Economists have estimated that the marginal excess burden of taxation in the country is 0.25 (see Chapter 3). Reestimate the social net benefits assuming that 20 percent of the increase in producer surplus is realized as tax revenue under the existing tax system. In answering this question, assume that increases in tax revenues less the cost of administrating the import fee are used to reduce domestic taxes.
   c. The reduction in the country's demand for imports may affect the world price of crude oil. Assuming that the import fee reduces the world price from \$90 to \$80 per barrel, and thus, the after-tax domestic price is \$80 + \$30 = \$110 per barrel, a net increase in domestic price of \$20 per barrel, repeat the analysis done in parts a and b.

4. (Instructor-provided spreadsheet recommended.) A proposed government project in a rural area with 100 unemployed persons would require the hiring of 20 workers. The project would offer wages of \$12 per hour. Imagine that the reservation wages of the 100 unemployed fall between \$2 and \$20.
   a. Estimate the opportunity cost of the labor required for the project assuming that the government makes random offers to the 100 unemployed until 20 of them accept jobs. (First, generate a list of the reservation prices of 100 persons according to the formula \$2 + \$18$u$ where $u$ is a random variable distributed uniformly [0,1]. Second, work down the list to identify the first 20 workers with reservation wages less than \$12. Third, sum the reservation wages of these 20 workers to get the opportunity cost of the labor used for the project.)
   b. Estimate the opportunity cost of the labor required for the project assuming that the government can identify and hire the 20 unemployed with the lowest reservation wages.
   c. Repeat part a 15 times to get a distribution for the opportunity cost and compute its standard deviation.