5 Valuing Impacts in Output Markets

Chapter 3 presents the basic microeconomic foundations of cost–benefit analysis. As discussed there, the change in allocative efficiency (i.e., the change in social surplus) due to a new project or a change in government policy depends on changes in consumer surplus, producer surplus, and net government revenues. This chapter and the next two illustrate how changes in these variables could be estimated if the pertinent market demand and supply curves were known.

One can think about a government project as using inputs, such as materials and labor, and transforming them into outputs, such as better-educated people or a new subway. Thus, a new project has output market impacts and input market impacts. If a city builds a new subway system, the main output markets are the markets for subway trips. In addition, we consider the effects of pollution and other externalities associated with the policy or project as outputs even though there are no markets for these "goods." Building the subway requires inputs, such as the land the stations occupy, the materials used to build the subway stations and, of course, labor. These goods or services are called factor inputs. Markets for these inputs are "upstream" of the output markets. The effects of a new government project or policy on these input markets should be taken into account. A policy may also have "knock-on" or indirect effects that occur "downstream." For example, a new subway or a new subway station may affect the market for housing near to the station or may affect the market for gasoline if some commuters switch from driving to riding the new subway. Such markets are called "secondary markets." In sum, analysts need to consider the impacts of a government policy on output markets, input markets, and secondary markets.

The change in allocative efficiency due to a new project or a change in government policy, ΔSS, equals the sum of the changes in social surpluses that arise in the three markets discussed above:

$$\Delta SS = \Delta SS_O + \Delta SS_I + \Delta SS_S \tag{5.1}$$

where ΔSS_0, ΔSS_I and ΔSS_S denote changes in the social surplus occurring in the output, input, and secondary markets, respectively.

Equation (3.12b) includes the net change in government surplus (government cash flow) as a single term equal to change in government revenues from the policy, ΔR, minus change in government expenditures on the policy, ΔE.[1] It is useful to think about government revenues as occurring in the output markets because that is where they are

collected and government expenditures as occurring in the input markets because that is where the money is spent. Thus, the change in social surplus in the output market equals:

$$\Delta SS_O = \gamma_g \Delta R + \Delta CS_o + \Delta PS_o \tag{5.2}$$

where ΔCS_o and ΔPS_o denote the changes in consumer surplus and producer surplus in the output markets, respectively, and γ_g equals one plus the marginal excess tax burden. It is natural to interpret the change in social surplus in the output market as measuring the primary (gross) benefits of a policy. Analogously, the change in social surplus in the input market equals:

$$\Delta SS_I = -\gamma_g \Delta E + \Delta CS_I + \Delta PS_I \tag{5.3}$$

where ΔCS_I and ΔPS_I denote the changes in consumer surplus and producer surplus in the input markets. It is natural to interpret the change in social surplus in the input market as measuring the opportunity costs of a policy. Finally, the change in social surplus in the secondary markets equals:

$$\Delta SS_S = \Delta CS_S + \Delta PS_S \tag{5.4}$$

where ΔCS_S and ΔPS_S denote the changes in consumer surplus and producer surplus in the secondary markets. It is natural to interpret the change in social surplus in the secondary market as measuring the secondary or indirect benefits or costs of a policy. This chapter focuses on valuing impacts in output markets, given by Equation (5.2). Chapter 6 focuses on valuing impacts in input markets, given by Equation (5.3), and Chapter 7 focuses on valuing impacts in secondary markets, given by Equation (5.4). In these chapters we assume for convenience that the marginal excess tax burden equals zero so that $\gamma_g = 1$.

This chapter begins with a brief discussion of shadow pricing. Next, it discusses valuing impacts in efficient markets, followed by a discussion about how to value impacts in distorted markets where market failures are found. We provide 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 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 be allocatively efficient and 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. If a particular intervention is already in place, the analyst can perform a CBA to determine whether or not the current policy is inefficient and, therefore, exhibits "government failure."[2]

5.1 Shadow Pricing

For the most part, this chapter and the following two chapters explain how to value impacts if the necessary market demand and supply curves were known. Often we use market prices as a measure of value. However, a market price may be distorted. For example, persons entering a US National Park pay a fee, but this fee is set by the National Park Service, not by the market. Consequently, it is unlikely that this fee bears a strong relation to the value of the benefits visitors actually receive from visiting the park. Also, prices charged by paper factories may understate the true social cost of paper if the production process generates pollution. In some situations the market price may not even exist. For example, no market provides a direct estimate of the value of human life. 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, analysts adjust observed prices or assign values that are as close as possible to the theoretically correct social values. The resultant prices are called *shadow prices* because they are not directly observable in any market. Economists have put much work into trying to determine the shadow price of many "goods" that are needed in CBA, including estimates of the shadow price of the value of a statistical life saved or of the social cost of various pollutants. Chapters 14, 15, and 16 describe several techniques to obtain shadow prices, while Chapter 17 provides estimates of important shadow prices. Shadow prices may be necessary in valuing impacts in any market.

5.2 Valuing Impacts in Efficient Markets

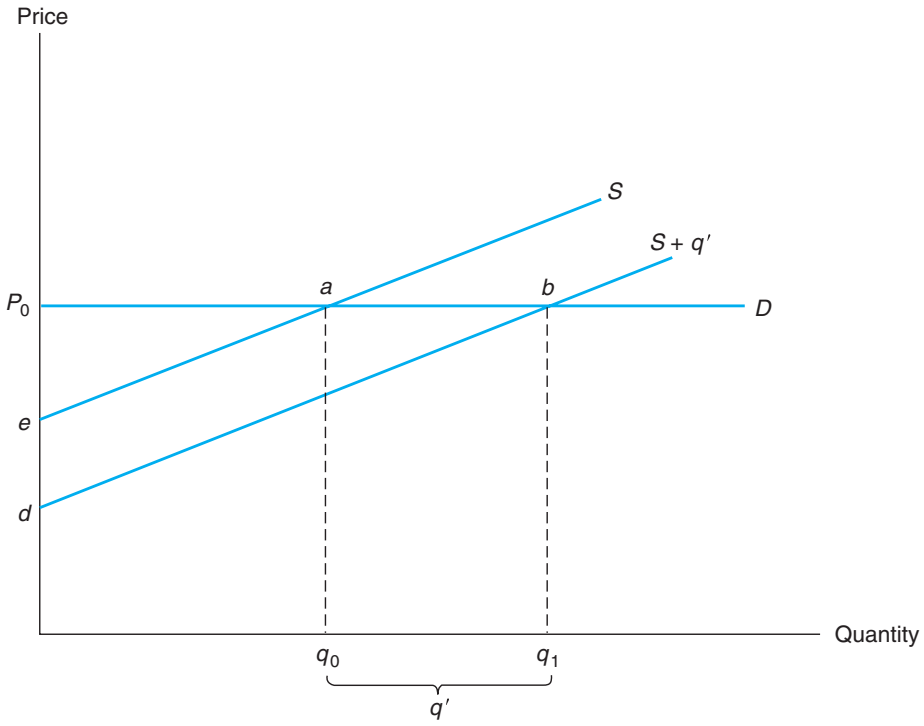
We examine two common situations. First, we consider policies that directly affect the quantity of a good available to consumers. For example, a publicly operated childcare center shifts the supply curve to the right, as it results in more child care being offered to consumers at each price. This often (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.

5.2.1 *Direct Increase in Supply Available to Consumers*

Suppose the government directly increases the supply of a good in a well-functioning market, but the increase is so small that the price of the good is unaffected. 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.

Figure 5.1 shows the impacts when a project directly increases the available supply of a good in a 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. Assuming 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. This rectangle also, of course, represents a cost to those consumers who purchase the good. Because the demand curve represents willingness to pay, this "cost" is exactly offset by gains that these persons enjoy in consuming the good and, consequently, can be ignored in our analysis: there is no change in consumer surplus. Therefore, the revenues received by the government are the only benefits that accrue from the project selling q' units in the market.



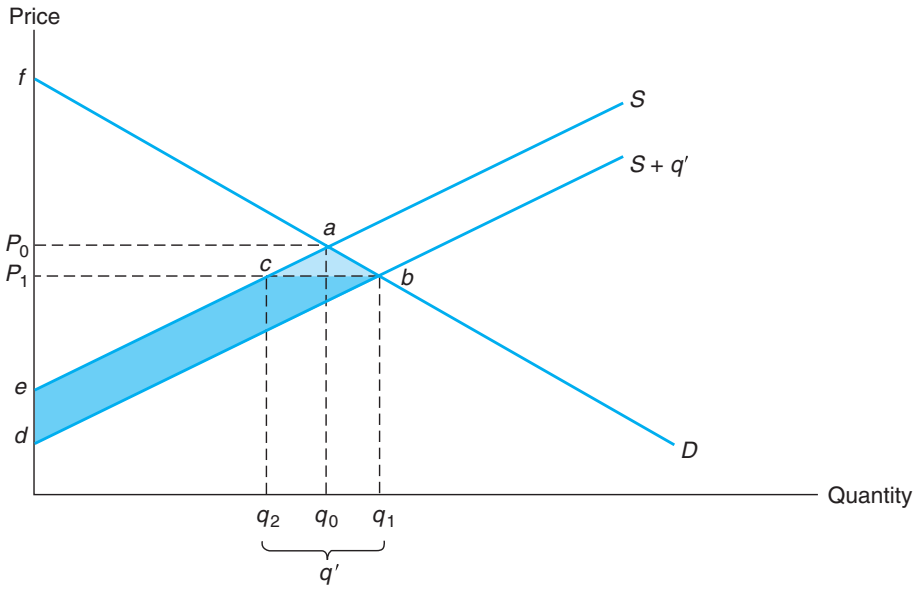
Social surplus change (ignoring costs of project inputs to the government):
Project (a): Direct increase in supply of q'—gain of project revenue equal to area of rectangle q_0abq_1
Project (b): Supply schedule shift through cost reduction for producers—gain of trapezoid *abde*

Figure 5.1 Measuring impacts in an efficient market with no price effects.

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 enjoy an increase in consumer surplus. Figure 5.2 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 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 the lightly shaded triangle abc. 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 incremental benefit from the government selling q' units in the market.

What benefits would accrue if the additional 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 5.1, 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. Therefore, as before, the incremental benefit would equal q_0abq_1.

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 5.2. Under



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 5.2 Measuring impacts in an efficient market with price effects.

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 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, gains 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 5.2. 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.

5.2.2 *Direct Reduction in Costs to Producers*

We now turn to a different type of public-sector project, such as harbor deepening, which lowers the private sector's cost of supplying a market. Figure 5.2 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 gain from the project.

5.3 Valuing Impacts in Distorted Markets

If market or government failures distort the relevant output market, 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 second endnote.[6]

5.3.1 *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 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 5.3, 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 medium dark 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]

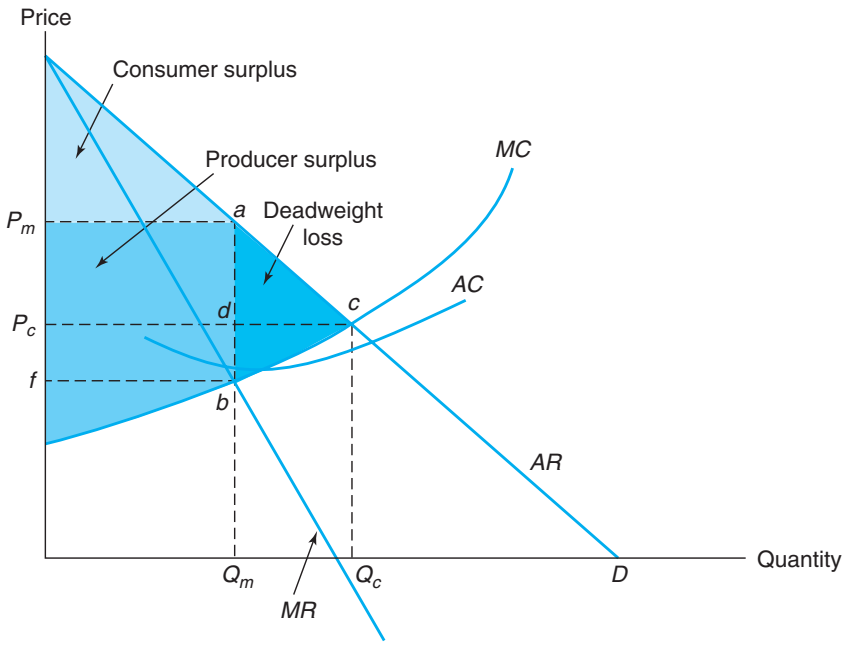


Figure 5.3 Monopoly.

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 5.3, where the marginal cost curve intersects the marginal benefit curve (demand curve). The "lost" social surplus, which is the deadweight loss resulting from monopoly, is represented in Figure 5.3 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 5.3 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 was reached, 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.

5.3.2 *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 5.4, these large fixed costs cause average costs to fall over a large range of output. Put another way, and as shown in Figure 5.4, (long-run)

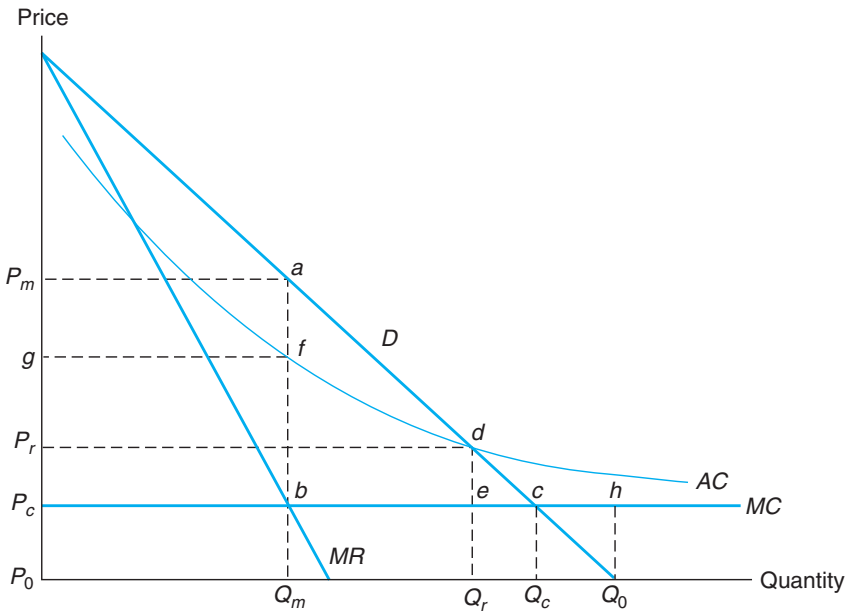


Figure 5.4 Natural monopoly.

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.

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 monopolist, 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 5.4 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, some 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*. However, deadweight loss is not completely eliminated. In other words, society could 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. However, 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.

5.3.3 *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 5.5, 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]

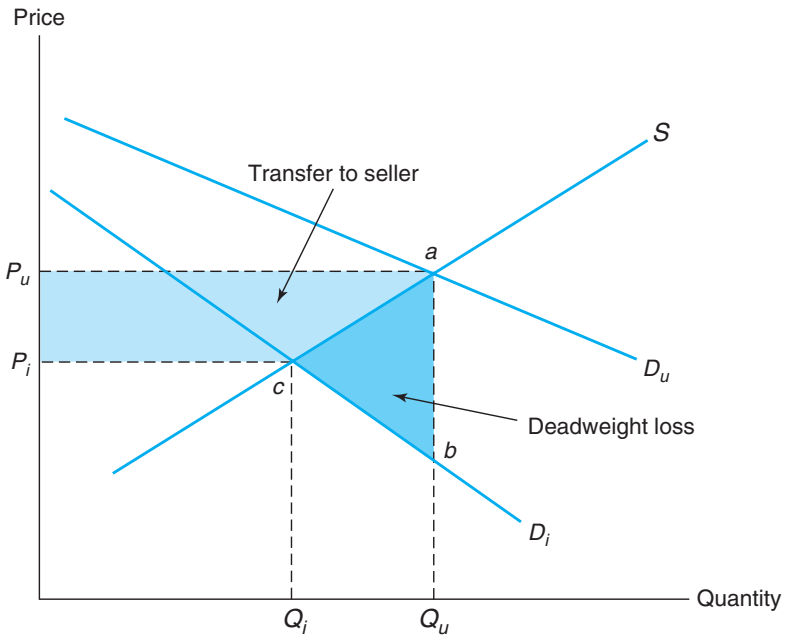


Figure 5.5 Information asymmetry.

Figure 5.5 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 lighter-shaded trapezoidal $P_u acP_i$. 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 darker-shaded triangle area *abc*.

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.

5.3.4 *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 byproduct 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 5.6 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 extent of this distance 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 5.6 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 5.6 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

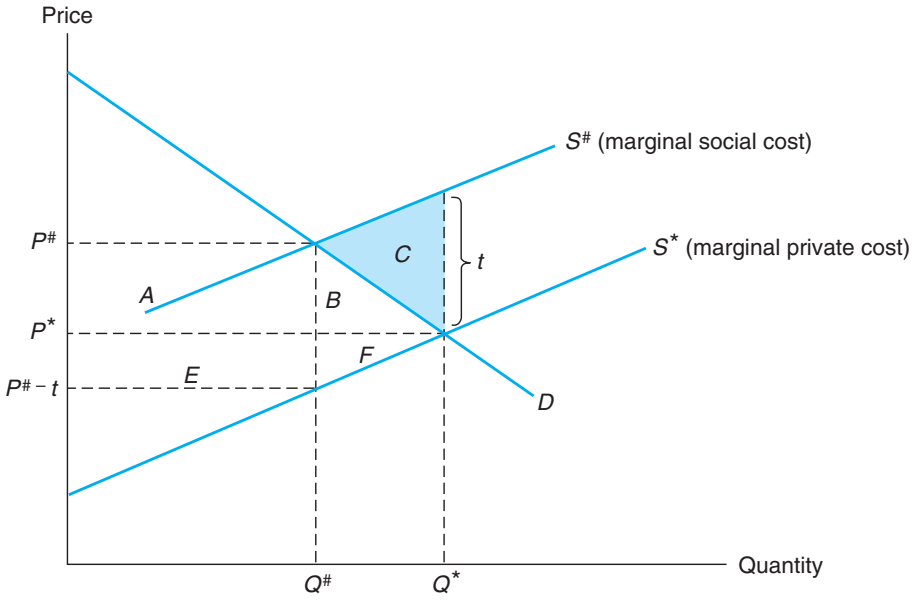


Figure 5.6 Negative externality.

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]

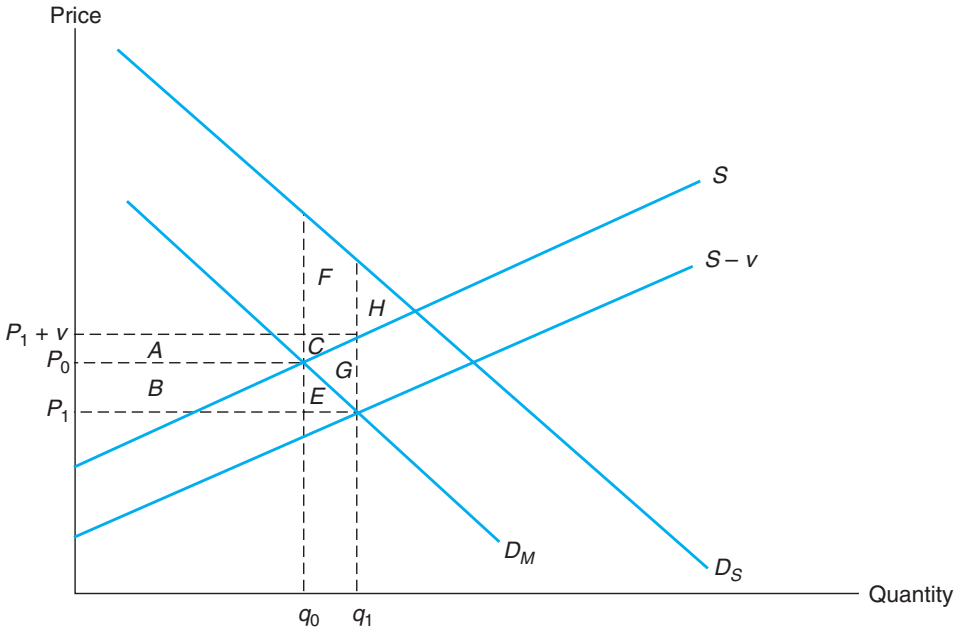
Figure 5.6 implies that the benefits and costs of the government's tax policy are distributed unequally among different groups in the economy. These are displayed in the following social accounting ledger.

	Gains	Losses	Change
Consumers of good		A + B	–(A + B)
Producers of good		E + F	–(E + F)
Third-party consumers	B + C + F		B + C + F
Government revenue	A + E		A + E
Society			C

Because the tax 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 have to pay the tax), they lose producer surplus equal to areas *E* and *F*. On the other hand, because of the reduction in the number of units produced 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*. The areas *A, B, E*, and *F* represent transfers from one group to another. Therefore, the benefit of the tax policy, given by the change in revenue plus the changes in consumer surplus and producer surplus, equals area *C*, as shown in the social accounting ledger above. This area corresponds to the deadweight loss eliminated by the tax policy. To compute the *net* social surplus from the tax, the cost of administering it would have to be subtracted from the benefit represented by *C*.

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 5.7, 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,



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 5.7 Social benefits for direct supply of a good with a positive externality.

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 the poor neighborhood? As implied by Figure 5.7, when the vouchers become available, residents of the poor neighborhood 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 program benefits: the area of trapezoid $C + F$. This benefit results because the program succeeds in eliminating part (although not all) of the deadweight loss in the market for extermination services.

5.3.5 *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 fewer public goods than is socially optimal. Pure public goods have two key characteristics: they are non-excludable, and they are non-rivalrous.

A good is non-excludable 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 non-excludability causes market failure is easy to see. Once a non-excludable 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.

Non-rivalry 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. However, if one person eats a hamburger, another cannot consume the same hamburger. The hamburger is rivalrous; a streetlight is non-rivalrous. 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 non-rivalry 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 non-rivalrous 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 5.8 displays two graphs: one for the rivalrous good (hamburger) and one for the non-rivalrous 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 non-rivalrous good is derived by adding the demand curves for individual consumers vertically rather than horizontally.

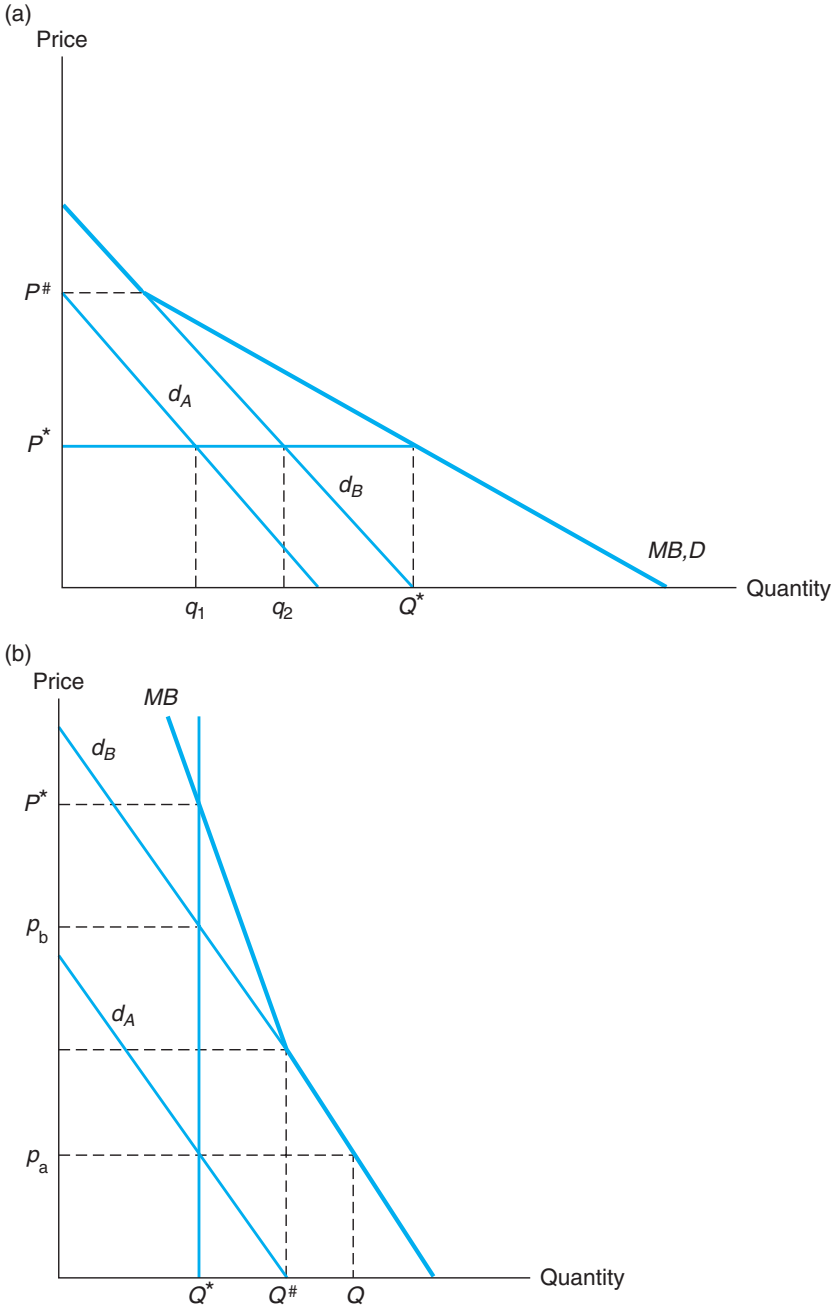


Figure 5.8a Rivalrous good (e.g., hamburger).
Figure 5.8b Non-rivalrous good (e.g., streetlight).

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 demand at a particular price. However, 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 non-rivalrous 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 non-rivalrous 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 non-rivalrous 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.[18]

When only a small group of people is involved, they may be able to work out the free-rider problems caused by the non-excludability and non-rivalry 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 shares a good that is non-excludable and non-rivalrous, 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 non-rivalrous in consumption and non-excludable, it is close to being a pure public good. Examples of other goods that are close to being pure public goods are flood control, national defense, and crime deterrence resulting from police patrolling the streets. Other goods may be either non-rivalrous or non-excludable,

but not both. For example, an uncrowded road is essentially non-rivalrous 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 non-excludable. Fish and fishers move around so it is difficult to preclude fishers from catching a particular species of fish, for example, tuna. However, 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 non-rivalrous or non-excludable, 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 non-rivalrous and non-excludable.

As suggested by the preceding analysis, because of both non-rivalry and non-excludability, 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 16, techniques exist that can be used to obtain information about WTP for public goods.

5.3.6 *Addictive Goods: Intrapersonal Externalities*

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.[19] 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 non-addicted 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.[20] Figure 5.9 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 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 deadweight loss equal to area abc. Overall, participation in this market by these addicted gamblers yields consumer surplus equal to

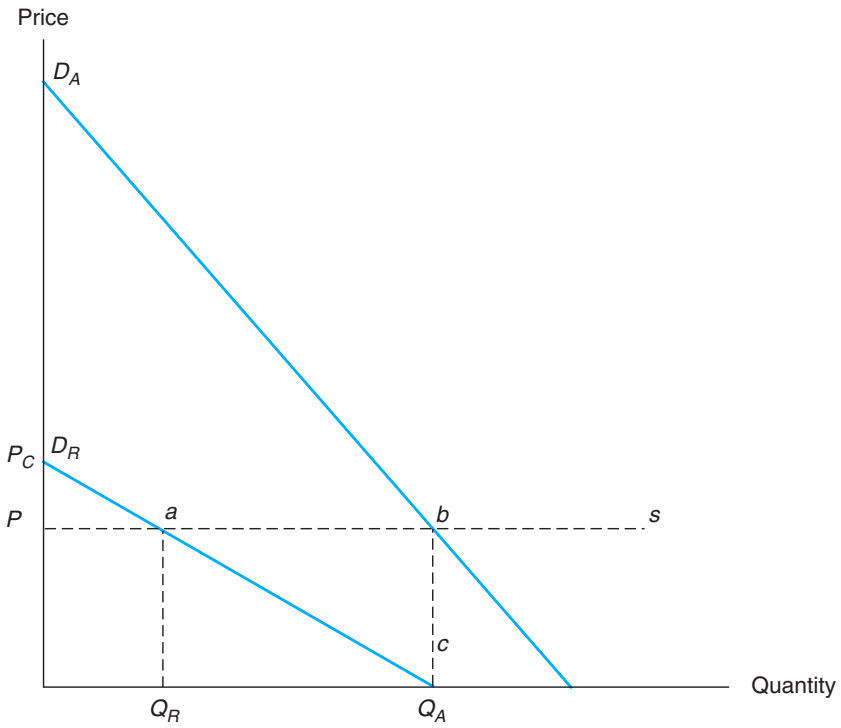


Figure 5.9 Consumer surplus in the presence of gambling addiction.

$PaP_C - abc$. 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).[21]

5.4 Conclusions

This chapter has shown that the gains and losses 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. The chapter demonstrates how policies to correct five prominent types of market failures – monopoly, information asymmetries, externalities, public goods, and addictive goods – can be analyzed within a CBA framework.

The chapter focused on output markets, the markets in which policy interventions take place. The following chapter considers factor markets in which 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 Chapter 7.

Exercises for Chapter 5

1. 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 45,000 cars per week will use the highway stretch.

   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 social change in surplus attributable to the increase in the toll? (Hint: the toll increase will cause the supply curve, not the demand curve, to shift.)

2. 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 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 net social 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.

Notes

1. Usually, ΔR takes into account the cost of collecting the revenues.

2. For a detailed examination of government failures, see David L. Weimer and Aidan R. Vining, *Policy Analysis: Concepts and Practice*, 6th edn (New York, NY: Taylor & Francis, 2017).

3. A change in price only causes a movement along the supply curve, a change in quantity supplied. However, a project that provides more of a good increases the supply of the good, resulting in a shift of the supply curve.

4. This assumes, of course, that the market is sufficiently competitive and the firms in it are sufficiently efficient that all of the cost savings are passed on to consumers in the form of a price decrease.

5. An alternative method of measuring the gain in social surplus is simply to compare total social surplus with and without the project. In the absence of the project, total social surplus would be represented by the triangular area *fae*, while in the presence of the project, total social surplus would be represented by the triangular area *fbd*. Subtracting the smaller triangle from the larger triangle, we again find that the net gain in social surplus equals the trapezoidal area *abde*.

6. For a theoretical treatment of externalities, public goods, and club goods, see Richard Corres and Todd Sandler, *The Theory of Externalities, Public Goods and Club Goods*, 2nd edn (New York, NY: Cambridge University Press, 1996).

7. There are, of course, other types of markets in which individual firms have market power – for example, those characterized by oligopoly or monopolistic competition. We focus on markets characterized by monopoly, and especially natural monopoly, because government intervention is most likely to occur in these markets.

8. Of course, foreign-owned firms, regardless of whether they are competitive or monopolistic, usually would not be given standing. Therefore, their benefits would not be counted in a CBA.

9. There are, of course, alternative policies that the government might adopt in response to the monopoly. For example, it might tax the monopolist's profits, regulate the prices the monopolist charges, or operate it as a state-owned enterprise.

10. For comprehensive analyses of public–private partnerships, see Anthony E. Boardman, Matti Siemiatycki and Aidan R. Vining, "The theory and evidence concerning public-private partnerships in Canada and elsewhere". SPP Briefing Paper 9.12, 2016; and Graeme A. Hodge, Carsten Greve and Anthony E. Boardman, *International Handbook on Public-Private Partnerships* (Cheltenham, UK: Edward Elgar, 2010).

11. In principle, it is possible that D_u could be to the left of D_i, rather than to the right of it as shown in Figure 5.5. This would occur if instead of desiring more of the product in the absence of information concerning it than they would with the information, consumers desire less of it. In practice, however, such situations are unlikely to continue for long because strong incentives would exist for sellers to eliminate such information asymmetry by providing buyers with the needed information, thereby increasing their demand for the product. When the actual demand curve is to the right of the fully informed demand curve, the incentive, in contrast, is for sellers to withhold the information.

12. The two demand curves are drawn closer together at high prices rather than at low prices to imply that at higher prices buyers would go to more trouble to obtain additional information about the product than they would at lower prices. Whether or not this is actually the case, however, is not essential to the analysis.

13. This is discussed more fully in Aidan R. Vining and David L. Weimer, "Information Asymmetry Favoring Sellers: A Policy Framework." *Policy Sciences*, 21(4), 1988, 281–303.

14. For a more extensive discussion of these three types of products, see Vining and Weimer, "Information Asymmetry Favoring Sellers: A Policy Framework."

15. For an entertaining discussion of possible misuses of the term "externality" and when intervention may or may not be appropriate for correcting externalities, see Virginia Postrel, "External Cost: The Dangers of Calling Everything Pollution." *Reason*, 1999.

16. This tax can be levied either in the traditional manner – that is, on the good itself – or, alternatively, by the government issuing transferable permits that, in effect, tax effluents emitted by firms, rather than the goods they produce. Under the latter approach, which is currently being used in the United States to control sulphur dioxide emissions, firms that have found ways to control their pollution relatively inexpensively can sell their permits to pollute to firms for which pollution control would be relatively more costly.

17. Indeed, when, as in the case illustrated in Figure 5.6, the tax is levied on the good, there is no special incentive for firms to reduce the amount of pollution resulting from their production process. However, when the effluent itself is taxed – for example, through use of the transferable pollution permits discussed in the previous endnote – such incentives do exist.

18. The free-rider problem is also closely linked to difficulties in remedying problems resulting from externalities. For example, because clean air is both non-rivalrous and non-excludable, in the absence of government

intervention, limited incentives exist for the private sector to produce clean air by reducing air pollution.

19. Gary S. Becker and Kevin M. Murphy, "A Theory of Rational Addiction." *Journal of Political Economy*, 96(4), 1988, 675–700.

20. Independent developments of this approach can be found in Fritz L. Laux, "Addiction as a Market Failure: Using Rational Addiction Results to Justify Tobacco Regulation." *Journal of Health Economics*, 19(4), 2000, 421–37; and Australian Productivity Commission, *Australia's Gambling Industries*, Inquiry Report No. 10, 26 1999, Appendix C, 11–13. Available at www.pc.gov.au/inquiry/gambling/finalreport/index.html.27.

21. Australian Productivity Commission, *Australia Gambling Industries*, chapter 5, p. 24.