CHAPTER 3

Microeconomic Foundations of Cost-Benefit Analysis

Microeconomic theory provides the basic technical foundations for CBA. Th chapter begins with a review of the major concepts of microeconomic theory a they apply to the measurement of social costs and benefits. Most of these co cepts should be at least somewhat familiar from your previous exposure to econom After that we move to welfare economics, which concerns the normative evaluatio markets and of policies. We explain how to use microeconomic theory to assess bene costs, and net social benefits in CBA.

For purposes of simplicity, we assume the presence of perfect competiti throughout this chapter. Specifically, we assume that there are so many buyers an sellers in the market that no one can individually affect prices, that buyers an sellers can easily enter and exit the market, that the goods sold are homogeneo (i.e., identical), that there is an absence of transaction costs, that information is pe fect, and that private costs and benefits are identical to social costs and benefits (i. there are no externalities). Chapter 4 considers how to measure benefits and co when some of these assumptions do not hold; that is, various forms of market failu are present.

DEMAND CURVES

An individual's *ordinary demand curve* (schedule) indicates the quantities of a goo that the individual wishes to purchase at various prices. The market demand curve the horizontal sum of all individual demand curves. It indicates the aggregate quan ties of a good that all individuals in the market wish to purchase at various prices.

In contrast, a market *inverse demand curve,* which is illustrated by line *D* in Figure 3-1, has price as a function of quantity. The vertical axis (labeled Price) ca be interpreted as the highest price someone is willing to pay for an additional un of the good. A standard assumption in economics is that demand curves slop downward. The rationale for this assumption is based on the principle o *diminishing marginal utility*; each additional unit of the good is valued slightly le by each consumer than the preceding unit. For that reason, each consumer is willin to pay less for another unit than for the preceding unit. Indeed, at some point, eac consumer would be unwilling to pay anything for an additional unit; his or her de mand would be sated.

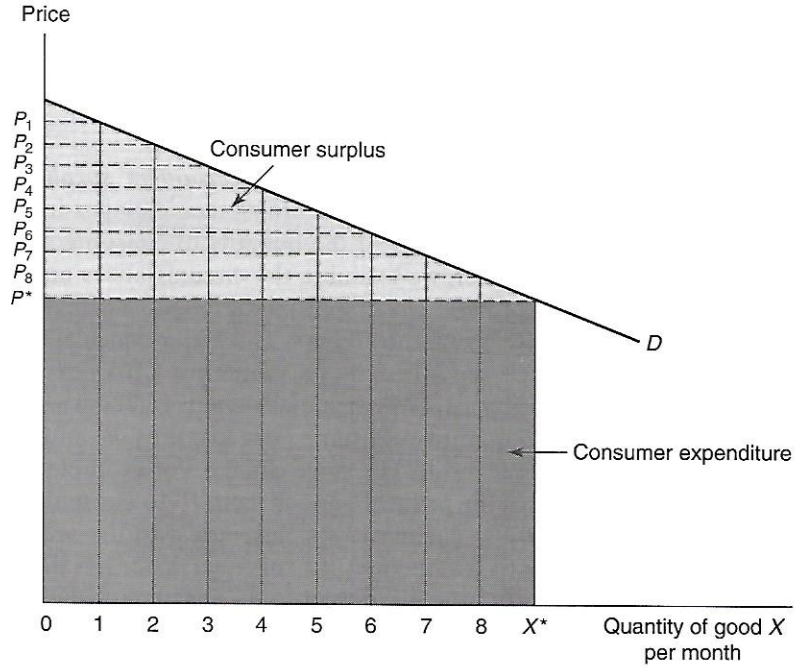

FIGURE 3-1 Consumers' Total Benefits and Consumer Surplus

In Figure 3-1 one member of society is willing to pay a price of P_1 for one unit of good X. Also, there is a person (possibly the same person who is willing to pay P_1 for the first unit) who would pay P_2 for a second unit of good X, and there is someone who would pay P_3 for a third unit of X, and so forth.[1] Each additional unit is valued at an amount given by the height of the inverse demand curve. The sum of all these willingness to pay amounts equals the total willingness to pay (WTP) for the good by all the members of society. It is approximately equivalent to summing the unit-wide rectangles under the demand curve. For X^* units it equals the area under the inverse demand curve from the origin to X^*, which is represented by the sum of the light and dark shaded areas.

As stated in Chapter 2, WTP is an appropriate measure of the benefit of a good or service. Since, P_1 measures the marginal benefit of the first unit, P_2 measures the marginal benefit of the second unit, and so on, the sum of X^* marginal benefits measures the *total benefits* (B) society would obtain from consuming X^* units of good X.[2] Thus, the area under the demand curve, which consists of the sum of the lightly and darkly shaded areas, measures the *total benefits* (B) society would receive from consuming X^* units of good X.

Consumer Surplus and Changes in Consumers' Surplus

In a competitive market consumers pay the market price, which we denote as P^*. Thus, consumers spend P^*X^*, represented by the darkly shaded area, to consume X^* units. The *net benefit* to consumers equals the total benefits (B) less consumers' actual expenditures

(P^*X^*). This lightly shaded area, which equals the area below the demand curve but above the price line, is called *consumer surplus (CS)*:

$$CS = B - P^*X^* \quad (3.1)$$

Consumer surplus (sometimes called *consumers' surplus*) is one of the basic concepts used in CBA. Under most circumstances, changes in consumer surplus can be used as a reasonable measure of the benefits to consumers of a policy change. In the appendix to this chapter, we examine the circumstances under which changes in consumer surplus do provide close approximations to willingness-to-pay values and the circumstances under which they do not. The major conclusion is that, in most instances, such approximations are sufficiently accurate for CBA purposes.

To see how the concept of consumer surplus can be used in CBA, suppose that initially the price and quantity consumed are given by P^* and Q^*, respectively, and then consider a policy that results in a price change. For example, as shown in Figure 3-2(a), a policy that reduces the price of good X from P^* to P_1 would result in a benefit to consumers (an increase in consumer surplus) equal to the area of the shaded trapezoid P^*ABP_1. This benefit results because existing consumers pay a lower price for the X^* units they previously purchased, and some consumers gain from the consumption of $X_1 - X^*$ additional units. Similarly, as shown in Figure 3-2(b), a policy that increases the price of good X from P^* to P_2 would impose a "cost" on consumers (a loss in consumer surplus) equal to the area of the shaded trapezoid P_2ABP^*.

Suppose that a policy results in a price decrease, as in Figure 3-2(a). Let $\Delta P = P_1 - P^* < 0$ denote the change in price and let $\Delta X = X_1 - X^* > 0$ denote the change in the

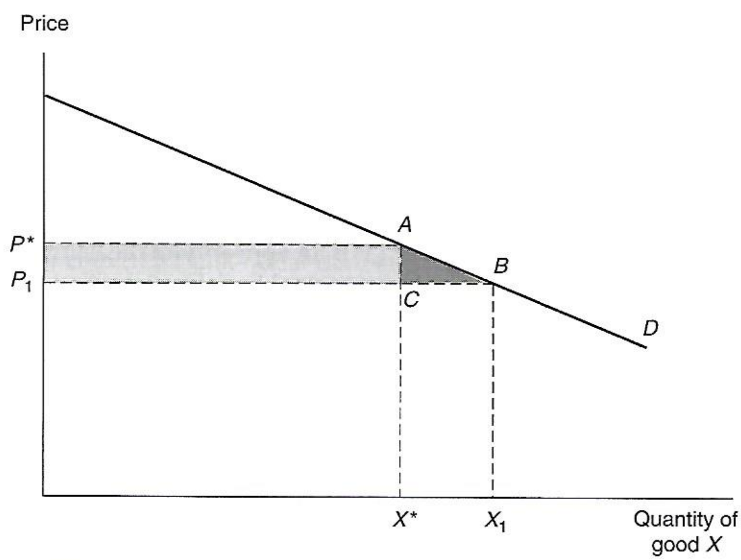

FIGURE 3-2(a) Change in Consumer Surplus Due to a Price Decrease

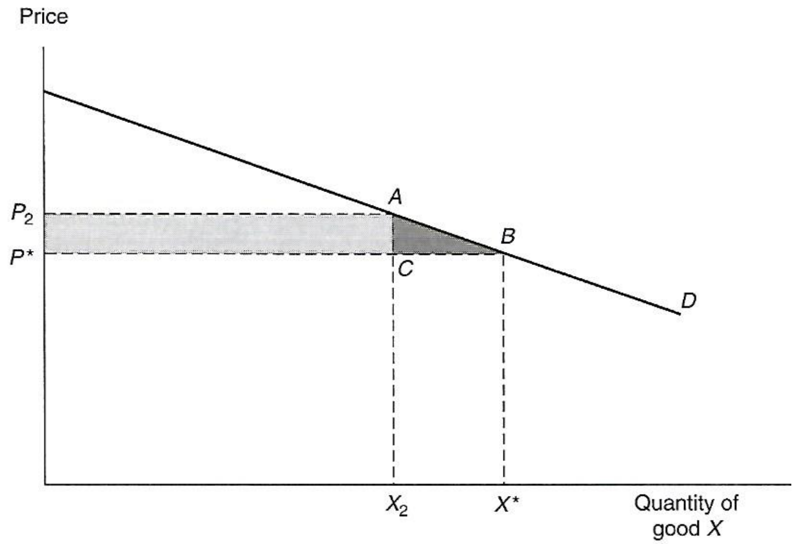

FIGURE 3-2(b) Change in Consumer Surplus Due to a Price Increase

quantity of good X consumed. If the demand curve is linear, then the change in consumer surplus, ΔCS, can be readily computed by the following formula:

$$\Delta CS = -(\Delta P)(X^*) - \tfrac{1}{2}(\Delta X)(\Delta P) \qquad \textbf{(3.2)}$$

If the price of X increases by $\Delta P = P_2 - P^* > 0$, as in Figure 3-2(b), the quantity of good X consumed changes by $\Delta X = X_2 - X^* < 0$ and if the demand curve is linear, then the change in consumer surplus, ΔCS, can also be readily computed from equation (3.2). In fact, this formula usually provides a good approximation to the change in consumer surplus even if the demand curve is not linear.

Sometimes the analyst may not know the demand curve and, therefore, may not know directly how many units will be demanded after a price change, but she may know the (own) *price elasticity of demand,* E_d. The price elasticity of demand is defined as the percentage change in quantity demanded that results from a 1 percent increase in price. Formally:[3]

$$E_d = \frac{P}{X}\frac{dX}{dP} \qquad \textbf{(3.3a)}$$

Because demand curves slope downward, the price elasticity of demand is always negative. All things being equal, as the slope of the demand curve *increases* (i.e., it becomes steeper—more negative), the elasticity *decreases* (become more negative). This is cumbersome. To simplify, we follow economists' usual practice of talking about an elasticity as if it were positive, in effect taking the absolute value. We say that the elasticity *increases* as the slope of the ordinary demand curve *increases.* Also, the more responsive quantity is to a change in price, we say that demand is more elastic. Noneconomists may find this a bit confusing at first, but everyone soon gets used to it.

Given the initial price and quantity, P^* and X^*, and defining ΔX and ΔP as the changes in quantities and prices, then the price elasticity of demand approximately equals:

$$E_d = \frac{P^*}{X^*}\frac{\Delta X}{\Delta P} \tag{3.3b}$$

Substituting equation (3.3b) into equation (3.2) and rearranging provides the following expression for the change in consumer surplus due to a price change:

$$\Delta CS = -X^*\Delta P - \frac{E_d X^*(\Delta P)^2}{2P^*} \tag{3.4}$$

Taxes

Taxes are very important in CBA because governments have to finance their projects, and taxation is a main source of financing. Let us now suppose that the price increase from P^* to P_2 shown in Figure 3-2(b) results from a government-imposed excise tax, where each unit of X is taxed by an amount equal to the difference between the old and the new price $(P_2 - P^*)$. In this case, the rectangular part of the trapezoid in Figure 3-2(b), P_2ACP^*, represents the tax revenue collected. It can be viewed as a *transfer* from consumers of X to the government. It is called a transfer because, from the perspective of society as a whole, its net impact is zero: consumers pay the tax, but this cost is offset by an identical benefit received by the government.[4]

The triangular part of the trapezoid, ABC, is a cost of the tax, however. It represents lost consumer surplus for which there is no offsetting benefit accruing to some other part of society. This pure loss in consumer surplus is an example of *deadweight loss*.[5] It results from a distortion in economic behavior from the competitive equilibrium. The tax causes some consumers to purchase less output than they would in the absence of the tax because, inclusive of the tax, the price now exceeds those consumers' WTP. Those consumers, who in the absence of the tax would collectively have purchased $X^* - X_2$ units of the good, and received the consumer surplus represented by the triangular area, ABC, lose this consumer surplus.

It follows from equation (3.4) that the deadweight loss resulting from a price change is given approximately by:

$$\Delta DWL = -\frac{E_d X^*(\Delta P)^2}{2P^*} \tag{3.5}$$

If the change in price is due to a unit tax, t, then the deadweight loss is:

$$\Delta DWL = -\frac{E_d X^* t^2}{2P^*} \tag{3.6}$$

There will always be a deadweight loss if a government imposes a tax on a good sold in a competitive market. Of particular interest is the amount of the *leakage*, which equals the ratio of the deadweight loss due to the tax to the amount of tax revenue collected. If the price increase in Figure 3-2(b) is due to a tax, the leakage equals area ABC divided by area P_2ACP^*, which equals:

$$\text{Leakage} = -\frac{E_d t}{2P^*(1 + \Delta X/X^*)} \tag{3.7}$$

If the change in output is relatively small, then the following simple formula provides a very slight overestimate of the leakage:

$$\text{Leakage} = -\frac{E_d t}{2P^*} \tag{3.8}$$

The implications of this result for CBA are discussed later in this chapter in the section on government surplus.

SUPPLY CURVES

In CBA, as Chapter 2 pointed out, costs are opportunity costs. Figure 3-3 presents a standard U-shaped *marginal cost (MC)* curve for an individual firm, where costs are opportunity costs. This curve pertains to costs in the short run, when at least one factor of production, for example capital, is fixed. We later consider the long run where all factors

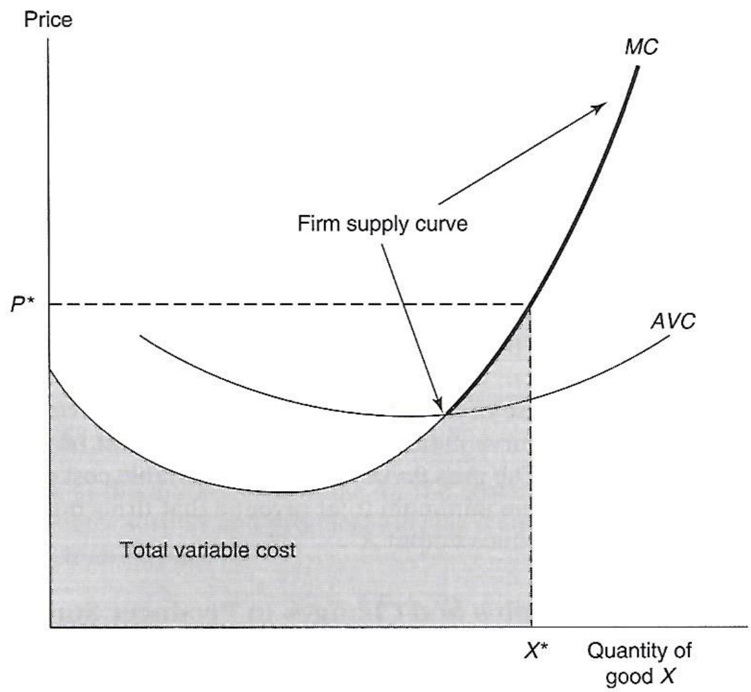

FIGURE 3-3 Individual Firm's Supply Curve

of production can vary. As is well known, the *MC* curve passes through the firm's *average variable cost (AVC)* curve at its lowest point, as shown in Figure 3-3. The rising part of the *MC* curve reflects *diminishing marginal returns*—the phenomenon that, given at least one fixed factor of production (say, capital), diminishing factor returns must eventually occur as output expands and increasing amounts of the variable factors of production (say, labor) are used with the fixed factor(s), or it reflects rising opportunity costs of a variable factor of production as more units of that factor are employed.

Just as the demand curve indicates the marginal benefit of each additional unit of a good consumed, the supply curve indicates the marginal cost of each additional unit of the good produced. Thus, the area under the firm's marginal cost curve represents the firm's *total variable cost* (*VC*) of producing a given amount of good X, say X^*.

The upward-sloping segment of the firm's marginal cost curve above the firm's *AVC* corresponds to the *firm's supply curve* in a competitive market. If the price were lower than the firm's average variable cost, then the firm could not cover its average variable cost and would shut down, rather than produce any output. At a price above average variable cost, however, the upward-sloping segment of the marginal cost curve determines how much output the firm will produce at any given price. For example, at a price of P^*, the firm would maximize profit by producing at X^*. If it produced more output than X^*, it would take in less in additional revenue than the additional cost it would incur. If it produced less output than X^*, it would lose more in revenue than it would save in costs.

As indicated in Chapter 2, the concept of opportunity cost is critical to CBA. The cost of a policy or project reflects the opportunity costs incurred by various members of society to implement the policy. Consequently, the cost curve in Figure 3-3 is drawn under the assumption that the owners of all the resources the firm uses are paid prices equal to the opportunity costs of the resources. For such factors as capital and entrepreneurship, the opportunity cost include a *normal return*,[6] reflecting their best alternative use.[7]

Market Supply Curve

The *market supply curve*, which is illustrated in Figure 3-4, can be derived by summing horizontally the supply curves of all the individual firms in a market. It indicates the total supply available to the market at each price. For example, at price P_1 firms in aggregate are willing to supply X_1 units. Because individual firm supply curves are based on marginal cost, the market supply curve also reflects marginal cost. For example, the marginal cost of the X_1th unit is P_1. This explains why the firms are willing to supply X_1 units at price P_1.

As in the case of the marginal cost curves for individual firms, the area under the market supply curve indicates the total variable cost of producing a given amount of output, say X^*. The area $0abX^*$ is the total variable cost of supplying X^* units. Put another way, it is the minimum total revenue that firms must receive before they would be willing to produce output X^*.

Producer Surplus and Changes in Producer Surplus

Suppose that the market price of a good is P^* and, consequently, firms supply X^* units. Their revenue in dollars would be P^*X^*, which corresponds to the rectangular area $0P^*bX^*$ in Figure 3-4. Their total variable cost (*TVC*) would be $0abX^*$, the darkly

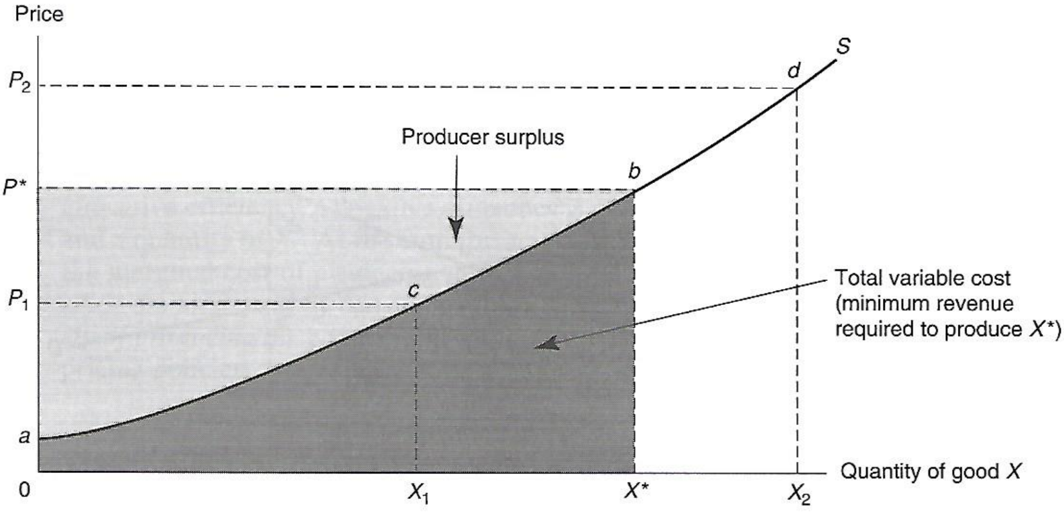

FIGURE 3-4 Market Supply Curve

shaded area in Figure 3-4. The difference between these two areas, the lightly shaded area aP^*b, is called *producer surplus (PS):*

$$PS = P^*X^* - TVC \tag{3.9}$$

Producer surplus measures the benefit going to firms (or their factors of production). It equals the difference between actual revenues and the minimum total revenue that firms in the market represented in Figure 3-4 must receive before they would be willing to produce X^* units at a price of P^*.

Producer surplus is the supply-side equivalent to consumer surplus. Just as changes in prices resulting from government policies have impacts on consumers that can be valued in terms of changes in consumer surplus, price changes also result in impacts on producers that can be valued in terms of changes in producer surplus. For example, referring again to Figure 3-4, a decrease in the market price from P^* to P_1 decreases producer surplus by P^*bcP_1 to P_1ca, and an increase in price from P^* to P_2 increases producer surplus by P_2dbP^* to P_2da.

SOCIAL SURPLUS AND ALLOCATIVE EFFICIENCY[8]

Let us now look at the market as a whole. In the absence of impacts on government, the sum of consumer surplus and producer surplus is called *social surplus (SS);* sometimes it is called *total surplus:*

$$SS = CS + PS \tag{3.10}$$

Social surplus is illustrated in Figure 3-5, which depicts both a market demand curve and a market supply curve in the same graph. In this graph, which once again is drawn under the assumption of perfect competition, equilibrium occurs at a price of P^* and a

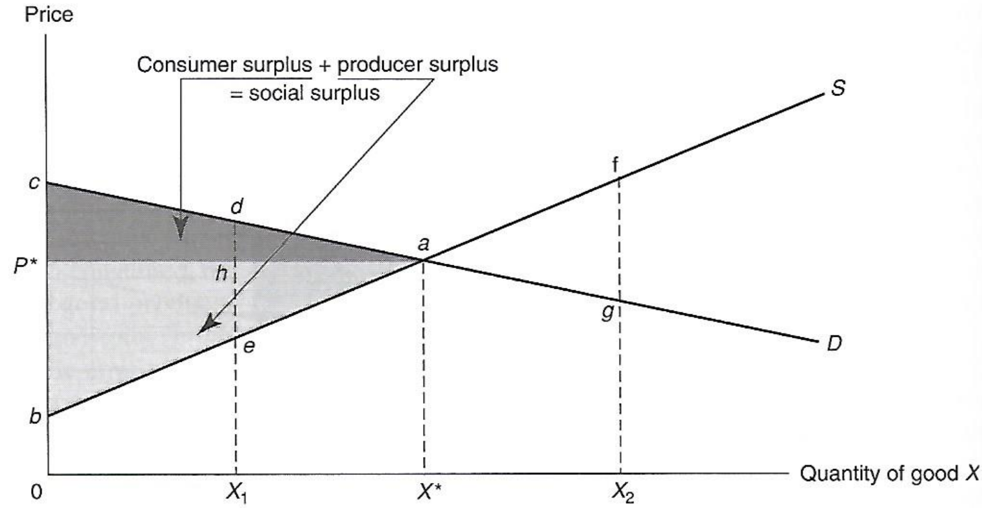

FIGURE 3-5 Social Surplus

quantity of X^*. Consumer surplus is the area *caP**, producer surplus is the area *P*ab*, and social surplus is the sum of these areas, *cab*.

Now, net social benefits equals the difference between total consumer benefits and total producer costs. Total consumer benefits equal the area under the demand curve, *caX*0*, while total costs equal total variable costs, the area under the supply curve, *baX*0*.[9] The difference is the area *cab*. This formulation makes it clear that social surplus equals net social benefits.

Remembering that the demand curve reflects marginal benefits (MB) and the supply curve reflects marginal cost (MC), at the competitive equilibrium demand equals supply and marginal benefits equals marginal cost. Therefore, net social benefits are maximized.[10] Thus, in a well-functioning, perfectly competitive market net social benefits and social surplus are maximized. The outcome is *Pareto efficient*: it is not possible to make someone better off without making someone else worse off. We also say that it is *allocatively efficient* (or *economically efficient*) because social surplus is maximized. The fact that a competitive equilibrium is economically efficient is referred to as the first fundamental theorem of welfare economics, clearly reflecting its importance.

In a perfectly competitive market, anything that interferes with the competitive process will reduce allocative efficiency. Suppose, for example, government policy causes output to be restricted to X_1, due, for example, to output quotas. At least some people will be worse off relative to output level X^*. The loss in social surplus at X_1 would equal the triangular area *dae*—the area between the demand curve (*MB*) and the supply curve (*MC*) from X_1 to X^*. Similarly, the loss in social surplus at X_2 would equal the triangular area *afg*—the area between the demand curve and the supply curve from X^* to X_2. These deadweight losses reflect reductions in social surplus relative to what would be attained in a competitive market (at X^*). Any government policy that moves the market away from the perfectly competitive equilibrium increases deadweight loss and reduces social surplus. Thus, it is only in the presence of market failures that government should consider intervening in a market. Such market failures, however, provide only a *prima facie* reason to intervene. One must do CBA to decide whether to intervene. Potentially, a government policy that moves a distorted market toward the perfectly competitive equilibrium produces net social benefits by increasing social surplus and reducing deadweight loss.

For policy purposes, it is important to note the relationship between price and allocative efficiency. Allocative efficiency is maximized in Figure 3-5 at a price of P^* and a quantity of X^*. At the equilibrium point, a, the price paid by consumers equals the marginal cost of producing the good. *Allocative efficiency can be obtained only when the price paid by consumers for a good equals the marginal social cost to society of producing the good.*[11] This important result can be used to formulate efficient pricing policies.

Profits and Factor Surplus

The above formula that measures producer surplus, equation (3.9), is not entirely satisfactory two reasons. First, the formula excludes firms' *fixed costs.* Thus far we have focused on short-term effects where some factors of production were fixed. While some government policies do not change firms' fixed costs, other policies do change them. For example, if the government makes a one-time purchase of concrete to build a road extension, the fixed costs of the firms that provide the concrete would probably not change and the above formulas would apply. On the other hand, for a large, long-term project, such as the Three Gorges Dam in China, all the factors of production (including the number of concrete trucks) would vary. In this situation, changes in fixed costs should be included in the measure of social surplus. We need a way to do this. Note, by the way, if as is usual we focus on annual benefits and annual costs, then the fixed costs may have to be amortized over their useful life or the life of the project. Second, whether or not we include fixed costs, but especially if we do include them, it is easier for most people to think about *profits* than producer surplus.

Fortunately, there is an easy way to deal with both of these concerns. Producer surplus equals *profits* (π) plus *Ricardian rents* going to factors of production, which we call *factor surplus (FS)*.[12] An example of a Ricardian rent is the return going to a particularly productive plot of land in a competitive agricultural market. The farmer may rent this land in which case the rents go to the landlord from whom he rents it or he may own the land in which case he gets them. Or, in a market with minimum wages, rents may go to workers. In either case, we can rewrite equation (3.10) as:

$$SS = CS + \pi + FS \qquad \textbf{(3.11a)}$$

The incremental net social benefit (ΔSS) of a change in policy is given by:

$$\Delta SS = \Delta CS + \Delta\pi + \Delta FS \qquad \textbf{(3.11b)}$$

Much of Canadian competition policy concerns whether proposed mergers should be allowed to go ahead. In these cases, the effect on employees, ΔFS, is assumed to be zero, and the key issue boils down to whether the potential reduction in consumer surplus, ΔCS, is more than offset by increases in profits, $\Delta\pi$. A firm making this argument in a merger hearing is said to be using the "efficiency defense."[13]

GOVERNMENT SURPLUS AND ALLOCATIVE EFFICIENCY

Thus far we have considered the effects of policies on consumers and producers. There is a third important sector in society—government. Impacts on government must also be included. Specifically we should include the net budget impacts on government, which is called *government surplus (GS)*. Financial inflows to government from taxes increase government surplus while financial outflows from expenditures decrease government surplus. When government surplus is not zero, social surplus becomes:

$$SS = CS + PS + GS \tag{3.12a}$$

The incremental net social benefit (ΔSS) of a change in policy is given by:

$$\Delta SS = \Delta CS + \Delta PS + \Delta GS \tag{3.12b}$$

In a competitive market, the *net social benefit of a project equals the net government revenue plus the resulting change in the sum of consumer surplus and producer surplus.* Often, government incurs all of the costs of a project and enjoys none of the financial benefits, for example, it may build rent-free housing for disabled people. To simplify, and consistent with our assumption of perfect competition, it is reasonable to assume in this situation that there is no change in producer surplus. The benefit is the change in consumer surplus, the cost is net government expenditure, and the net social benefit equals the benefits minus the costs. That is, $B = \Delta CS$, $C = -\Delta GS$, and $\Delta SS = NSB = B - C$.

Now suppose that government builds housing but charges a maket rent. As before, we assume that there is no change in producer surplus. There are two ways to compute the change in social surplus (or net social benefits). One way measures the benefit as the change in consumer surplus and the cost as the change in government expenditure (i.e., construction costs plus operating costs), as above. The rent paid is a transfer—a cost to consumers but a benefit to government. *The net effect of a transfer is zero. Thus, it may be ignored in the calculation of net social benefits. In fact, including the rent paid to government as part of government surplus would be a mistake.*

An alternative way to compute the NSB involves gross benefits. The *gross benefit* to consumers (B) equals the area under the inverse demand curve. From equation (3.1), $B = \Delta CS +$ Rents. The total cost to society equals the sum of the rents paid by consumers and the project expenditures paid by government. Therefore, the net social benefits are given by $NSB = B - C = \Delta CS -$ Construction costs—Operating expenses, which is the same as before.

This example makes it clear that there are often different ways to calculate net social benefits. In this example, it is possible to measure gross benefits that include consumer expenditures (e.g., rent) if this transfer is also included in the costs. Alternatively, one can focus on changes in consumer surplus, producer surplus and government surplus as expressed in equation (3.12b).

To illustrate direct estimation of equation (3.12b), suppose that initially the perfectly competitive market shown in Figure 3-6 is in equilibrium at a price of P^* and a quantity of X^*. Now suppose that a law is passed guaranteeing sellers a price of P_T. Such a policy has been utilized in otherwise competitive agricultural markets in the United States, such as those for corn and cotton, and is known as *target pricing*. At a

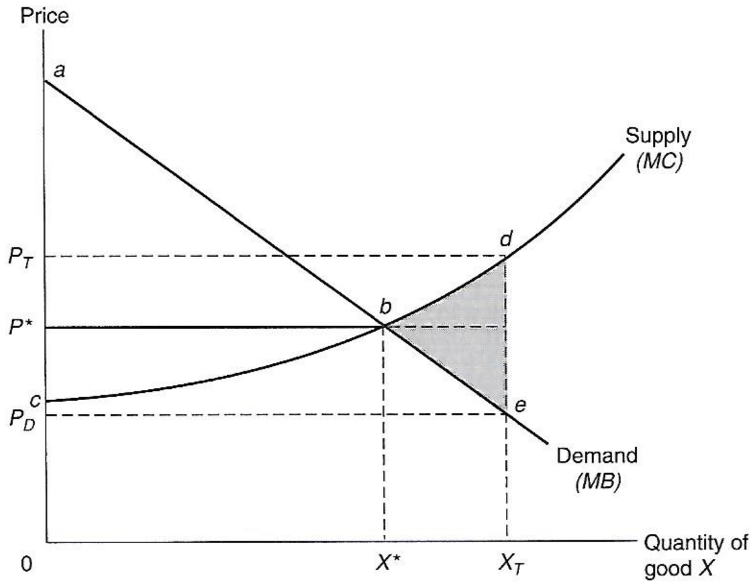

FIGURE 3-6 Target Pricing Example

target price of P_T, sellers desire to sell a quantity of X_T. However, buyers are willing to pay a price of only P_D for this quantity, so this becomes the effective market price. Under target pricing, the gap between P_T and P_D is filled by subsidies paid to sellers by the government. As the marginal cost of producing X_T exceeds marginal benefit for this quantity of good X, a social surplus loss (deadweight loss), corresponding to area *bde*, results from the policy.

Distributional Implications

The target pricing policy affects buyers, sellers, and the government differently. The incremental benefit, incremental cost, and change in social surplus (net benefit) to each of the three affected groups, and to society as a whole, are presented in a *social accounting ledger* in Table 3-1. Because buyers pay a price of only P_D under the policy, total consumer surplus increases from area abP^* to area aeP_D, a gain of P^*beP_D. Sellers receive an effective price of P_T, causing total producer surplus to increase from area P^*bc to area P_Tdbc, a gain of P_TdbP^*. Government provides subsidies represented by area P_TdeP_D. Subtracting the *GS* cost from the *CS* and *PS* gains, as suggested by equation (3.12), gives a deadweight loss resulting from the policy equal to area *bde*. Estimates of the actual social cost of agricultural price supports in the U.S. are provided in Exhibit 3-1.

As shown in the right hand column of Table 3-1, the government subsidy ($P_T deP_D$) can be broken down into three areas: the consumer surplus gain, the producer surplus gain, and the deadweight loss. While area *bde* represents the net social loss from the policy, the remainder of the subsidy represent transfers from taxpayers to buyers and sellers. Because the benefits and costs associated with transfers are fully offsetting, they have no net impact on the change in social surplus as defined above in equation (3.12b).

this term should be an incremental cost to the Gov't

TABLE 3-1 Breakdown of Incremental Benefits, Incremental Costs, and Changes in Surpluses in Target Pricing Example

Group	*Incremental Benefit*	*Incremental Cost*	*Change in Surplus*
Consumers	P^*beP_D		P^*beP_D
Producers	$P_TdX_TO - P^*bX^*O$	bdX_TX^* [$-P_TdeP_D$]	P_TdbP^*
Government			$-P_TdeP_D$
Net (Social)			$-bde$

Earlier we introduced the idea of *leakage* when government raises funds. It may also occur when government spends money. Specifically, the proportion of each dollar given up by government that, as a result of a deadweight loss (and any administrative costs required to raise the funds), does not accrue as transfers to any other group (i.e., consumers or producers) is also called leakage. In this target pricing example, which ignores administrative costs, the leakage is $bde/P_T\, deP_D$. Obviously, 1 - leakage equals the proportion of the government subsidy that is transferred to consumers or producers.

Marginal Excess Tax Burden

Most government policies and projects require government expenditure. This expenditure has to be financed in some way. In this chapter, we have shown that an excise tax on a good usually results in deadweight loss. Taxes on individuals also generally result in a deadweight loss. Indeed, social surplus is usually (but not always) lost when government taxes consumers, taxpayers, or producers.

EXHIBIT 3-1

The magnitudes of the inefficiencies of agricultural price supports in the United States have at times been very large. For example, Gordon C. Rausser estimated the economic impacts of price support programs for wheat, corn, cotton, peanuts, and dairy products during the mid-1980s. He estimated additional annual costs to consumers of between \$3.27 billion and \$4.57 billion, annual transfers to producers of between \$12.8 billion and \$14.9 billion, and annual costs to taxpayers of between \$13.5 billion and \$15.7 billion. The annual net social cost of these effects on consumers, producers, and taxpayers was between \$1.9 billion and \$7.4 billion. That is, the social surplus loss of these policies was several billion dollars annually.

The Federal Agricultural Improvement and Reform Act of 1996, the so-called Freedom to Farm Act, called for phasing out price supports by 2002. Beginning in 1998 with falling world agricultural prices, Congress began reversing the phase-out of price supports. By fiscal year 2001 direct government subsidies to farmers had risen to \$20 billion annually.

Sources: Adapted from Gordon C. Rausser, "Predatory Versus Productive Government: The Case of U.S. Agricultural Policies," *Journal of Economic Perspectives* 6(3) 1992, 133–157; and David Orden, "Reform's Stunted Crop: Congress Re-Embraces Agricultural Subsidies," *Regulation* 25(1) 2002, 26–32.

Because there are numerous sources of deadweight loss in addition to taxes, economists refer to the deadweight loss that results specifically from a tax as *excess tax burden.* The change in deadweight loss resulting from raising an additional dollar of tax revenue is called the *marginal excess tax burden* (METB). The size of the METB depends on the magnitude of the behavioral response to a tax change, for example, the extent to which consumer purchases change due to an excise tax or the change in work hours due to a tax on earnings.[14] Exhibit 3-2 presents a hypothetical, but not implausible, illustration of computing the average social cost of taxing higher-income households and redistributing the money to lower-income households. In this illustration, it costs, on average, \$1.63 to transfer each dollar (i.e., the METB = 0.63). Our suggested estimates of the METB, which vary according to the nature of the tax, are given in Chapter 16.

Allocative Efficiency and the METB

Because raising government revenue through taxation inevitably involves a deadweight loss, changes in government revenue do not fully capture their efficiency implications. A program that costs the government a dollar actually costs society in aggregate (1 + METB). Similarly, a program that yields a dollar of government revenue allows it to avoid a dollar of taxation and therefore benefits society in aggregate (1 + METB). Taking this efficiency effect into account, equation (3.12) becomes:

$$SS = CS + PS + (1 + METB)GS \qquad \textbf{(3.13a)}$$

$$\Delta SS = \Delta CS + \Delta PS + (1 + METB)\Delta GS \qquad \textbf{(3.13b)}$$

In other words, in order to measure the allocative efficiency impacts of a project and to compute its net social benefits, government project expenditures and revenues should be multiplied by one plus the marginal excess tax burden.

EXHIBIT 3-2

The following table, which was adopted with modifications from a study by Edgar Browning, is based on a hypothetical society with only five households. The idea is to tax everyone to obtain \$1,350 in additional revenue and then distribute this equally to everyone. In effect, as shown in column 6, \$270 is transferred from the two richest households to the two poorest households. As shown in column 8, however, the real incomes of the two poorest households increase by \$240 in aggregate, whereas the real incomes of the three richest households decrease by \$390. Thus, it costs society \$390/\$240 = \$1.63 in lost income for every dollar transferred, ignoring administrative costs.

For purposes of the illustration, it is assumed that all households initially work 2,000 hours a year and face a marginal tax rate of 40 percent. Thus, as indicated in column 2, the gross before-tax hourly wage rate of household A is \$5 (\$10,000/2,000), but its after-tax net wage rate is only \$3 (\$5 × 0.6). The gross and net hourly wage rates for the remaining four households may be similarly computed. It is further assumed that the compensated labor supply elasticity for all households is 0.15, a value that is consistent with empirical estimates presented in Chapter 12. In other words, it is assumed that a 1 percent change in net wages, holding income constant,

(*continued*)

will cause households to change their hours worked by 0.15 percent.

Suppose now that the government introduces a separate income tax of 1 percent that increases each household's marginal tax rate from 40 to 41 percent. This reduces each household's net after-tax wage rate by 1.67 percent (i.e., 0.01/0.60 = 0.0167). As a consequence, hours worked fall by 0.25 percent (0.15 × 0.0167 × 0.0025), or 5 hours per year. Hence, as shown in column 3, earnings also fall by 0.25 percent.

Net additional tax revenue is given in column 4. For example, household A initially paid taxes of $4,000 ($10,000 × 0.4), while after the new income tax, it paid taxes of about $4,090 ($9,975 × 0.41), an increase of approximately $90. The total of $1,350 in additional tax revenue is divided equally, and $270 is distributed to each household. The net transfer (column 5 – column 4) is given in column 6.

Column 7 presents the total change in disposable income, which is obtained by adding columns 3 and 6. The net incomes of the three richest households have been reduced by $570 in aggregate, while the net incomes of the two poorest families have been increased by a total of only $195. But all families are now working less and enjoying more leisure. Assuming that the value of additional leisure equals the after-tax net wage rate, household A receives a leisure gain valued at $15 ($3 × 5 hours), household B receives a leisure gain valued at $30 ($6 × 5 hours), and so forth. The total change in real income (including the value of the gain in leisure) is given in column 8. The real incomes of households A and B increase by $240 in aggregate, while the incomes of households C, D, and E decrease by $390.

The Marginal Cost of Redistribution

Household (1)	*Initial (Gross) Earnings (2)*	*Net Change in Earnings (3)*	*Additional Tax Revenue* (4)*	*Transfer (5)*	*Net Transfer (6)*	*Change in Disposable Income (7)*	*Change in Real Income (8)*
A	10,000	−25	90	270	180	155	170
B	20,000	−50	180	270	90	40	70
C	30,000	−75	270	270	0	−75	−30
D	40,000	−100	360	270	−90	−190	−130
E	50,000	−125	450	270	−180	−305	−230
Total	150,000	−375	1,350	1,350	0	−375	−150

**These figures are rounded to the nearest* $10.

Source: Adapted from Edgar K. Browning, "The Marginal Cost of Redistribution," *Public Finance Quarterly* 21(1) 1993, 3–32, Table 1 at p. 5. Reprinted by permission of Sage Publications, Inc.

MEASURING CHANGES IN WELFARE

This chapter focuses on allocative efficiency and the measurement of net social benefits. Welfare, however, concerns allocative efficiency and *equity*. Conceptually, it is straightforward to generalize equation (3.13b) so that it measures changes in welfare:

$$\Delta W = \gamma_c \Delta CS + \gamma_p \Delta \pi + \gamma_f \Delta FS + \gamma_g \Delta GS \tag{3.14}$$

EXHIBIT 3-3

Boardman and colleagues estimated the welfare gains from the privatization of Canadian National (CN) Railway in 1995. This was one of the largest rail privatizations in history. A unique feature of the study is that the authors were able to create a more credible counterfactual than in other privatization studies based on cost data from Canadian Pacific Railway (CP). Boardman and colleagues argued that the benefit to consumers (shippers) was zero because a variety of evidence suggests that privatization had no impact on CN's or CP's prices or output. The sole factor of production of interest was employees. Employment decreased at CN following privatization, but the rate of decrease in employment was slower after 1992 than before 1992 (when the privatization was announced). Following privatization, wages and salaries at CN increased faster than at CP. Thus, there is no clear evidence that employees were better or worse off as a result of privatization. Attention focused on firms (and their shareholders) and the Canadian government. Using their preferred estimate of the counterfactual, Boardman and colleagues estimated that the increase in profits to foreign (non-Canadian) shareholders was \$4.46 billion, the increase in profits to Canadian shareholders was \$3.69 billion, and the increase in government surplus (to the Canadian government) was \$6.90 billion. Following usual practice in CBA and assigning equal welfare weights to profits and governments (i.e., $\gamma_p = \gamma_g = 1$) implies that the net social benefit equals \$15.06 billion. Assuming that only Canadians have standing suggests that the net social benefit to Canadians was \$10.59 billion (\$6.90 billion + \$3.69 billion). As noted in the text, however, there are efficiency arguments for setting $\gamma_g = 1 + \text{METB}$. Boardman and colleagues also argue that there are efficiency arguments for setting $\gamma_p = 1 +$ *shadow price of capital*, a topic that we discuss in detail in Chapter 10. They suggest $\gamma_g = 1.4$ and $\gamma_p = 1.16$, implying that the net benefit to Canadians of the privatization of CN equaled \$13.94 billion.

Source: Anthony E. Boardman, Claude Laurin, Mark A. Moore, and Aidan R. Vining, "A Cost-Benefit Analysis of the Privatization of Canadian National Railway," *Canadian Public Policy* 35(1) 2009, 59–83.

where γ_c, γ_p, γ_f, and γ_g are welfare weights for consumers, producers, factors of production, and government, respectively. These parameters can reflect efficiency or equity considerations.[15] If $\gamma_c = \gamma_p = \gamma_f = 1$ and $\gamma_g = 1 + \text{METB}$, then equation (3.14) becomes equation (3.13b), and it measures net social benefits. This can be justified on allocative efficiency grounds. Any other set of weights requires consideration of equity. This issue is discussed in more detail in Chapter 19. Some studies have used equation (3.14) to measure changes in welfare due to privatization as is illustrated in Exhibit 3-3.

CONCLUSIONS

The objective of CBA is more efficient allocation of resources. This chapter has reviewed the major principles from microeconomics and welfare economics that provide the technical foundation for cost-benefit analysis. The key concept is that in conducting a CBA one must estimate the changes in social surplus that result when new policies, programs, or projects are implemented. The change in social surplus provides a measure of the change in allocative efficiency (or net social benefits). Social surplus is often expressed as the sum of consumer surplus, producer surplus, and government surplus. However, projects have to be financed and are often financed by taxes, and all taxes create a deadweight loss. To account for the efficiency impacts of taxes, government inflows or outflows should be multiplied by 1 + METB.

This chapter assumes that markets are initially perfectly competitive. Chapters 4 and 5 make use of the concepts introduced in this chapter to develop measures of benefits and costs that are conceptually appropriate under numerous different circumstances.