CHAPTER 9

The Analysis of Competitive Markets

In Chapter 2 we saw how supply and demand curves can help us describe and understand the behavior of competitive markets. In Chapters 3 to 8, we saw how these curves are derived and what determines their shapes. With this foundation, we return to supply-demand analysis and show how it can be applied to a wide variety of economic problems-problems that might concern a consumer faced with a purchasing decision, a firm faced with a long-range planning problem, or a government agency that has to design a policy and evaluate its likely impact.

We begin by showing how consumer and producer surplus can-be used to study the *welfare effects* of a government policy-in other words, who gains and who loses from the policy, and by how much. We also use consumer and producer surplus to demonstrate the *efficiefícy* of a competitive market-why the equilibrium price and quantity in a competitive market maximizes the aggregate economic welfare of producers and consumers.

Then we apply supply-demand analysis to a variety of problems. Very few markets in the United States have been untouched by government interventions of one kind or another, so most of the problems that we will study deal with the effects of such interventions. Our objective is not simply to solve these problems, but to show you how to use the tools of economic analysis to deal with others like them on your own. We hope that by working through the examples we provide, you will see how to calculate the response of markets to changing economic conditions or government policies and to evaluate the resulting gains and losses to consumers and producers.

9.1 Evaluating the Gains and Losses from Government Policies-Consumer and ProducerSurplus

We saw at the end of Chapter 2 that a price ceiling causes the quantity of a good demanded to rise (consumers want to buy more, given the lower price) and the quantity supplied to fall (producers are not willing to supply as much given the lower price), so that a shortage results. Of course, those consumers who can still buy the good will be better off because they will now pay less. (Presumably, this was the objective of the policy in the first place.) But if we also take into account those who cannot obtain the good, how much better off are consumers *as a whole.* Might they be worse off? And if we lump consumers and producers together, will their total welfare be greater or lower, and by how much? To answer questions like these, we need a way to measure the gains and losses from government interventions and the changes in market price and quantity such interventions cause.

Our method is to calculate the changes in *consumer andproducer surplus* that result from an intervention. In Chapter 4 we saw that *consumer surplus* measures the aggregate net benefit that consumers obtain from a competitive market. In Chapter 8 we saw how*producer surplus* measures the aggregate net benefit to producers. Here we will see how to apply consumer and producer surplus to a variety of problems.

Review of Consumer and Producer Surplus

In an unregulated, competitive market, consumers and producers buy and sell at the prevailing market price. But remember, for some consumers the value of the good *exceeds* this market price; they would pay more for the good if they had to. *Consumer surplus* is the total benefit or value that consumers receive beyond what they pay for the good.

For example, suppose the market price is $5 per unit, as in Figure 9.1. Some consumers probably value this good very highly and would pay much more than $5 for it. Consumer A, for example, would pay up to $10 for the good. However, because the market price is only $5, he enjoys a net benefit of $5-the $10 value he places on the good, less the $5 he must pay to obtain it. Consumer B values the good somewhat less highly. She would be willing to pay $7, and thus enjoys a $2 net benefit. Finally, Consumer C values the good at exactly the market price, $5. He is indifferent between buying or not buying the good, and if the market price were one cent higher,

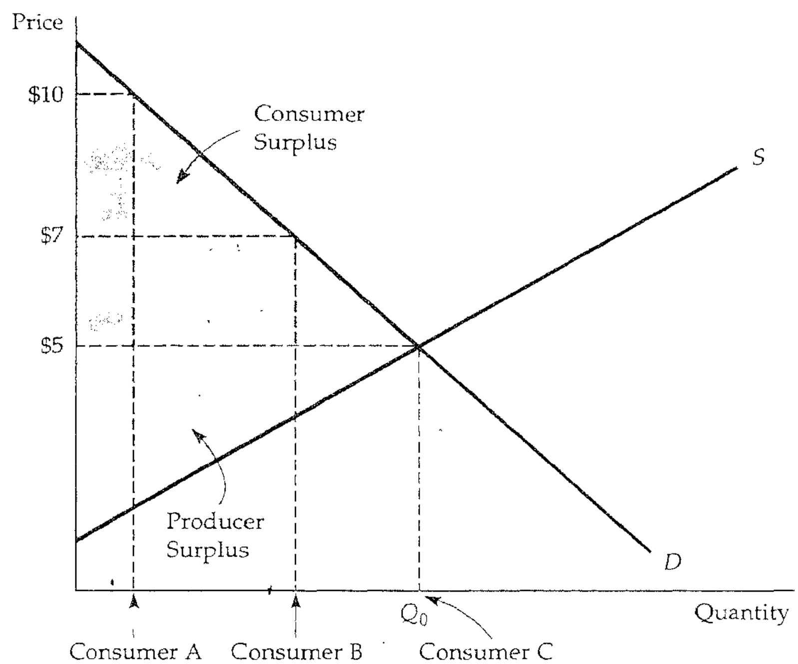

FIGURE 9.1 Consumer and Producer Surplus. Consumer A would pay $10 for a good whose market price is $5, and therefore enjoys a benefit of $5. Consumer B enjoys a benefit of $2, and Consumer C, who values the good at exactly the market price, enjoys no benefit. Consumer surplus, which measures the total benefit to all consumers, is the shaded area between the demand curve and the market price. Producer surplus measures the total profits of producers, plus rents to factor inputs. It is the area between the supply curve and the market price. Together, consumer and producer surplus measure the welfare benefit of a competitive market-

he would forgo the purchase. Consumer C therefore obtains no net benefit.[1]

For consumers in the-aggregate, consumer surplus is the *area between the demand curve and the market price* (i.e., the red shaded area in Figure 9.1). And because consumer surplus measures the total net benefit to consumers, we can measure the gain or loss to consumers from a government intervention by measuring the resulting change in consumer surplus.

Producer surplus is the analogous measure for producers. Some producers are producing units at a cost just equal to the market price. Other units, however, could be produced for less than the market price, and would still be produced and sold even if the market price were lower. Producers therefore enjoy a benefit-a surplus-from selling those units. For each unit, this surplus

[1] Of course, some consumers value the good at *less* than $5- These consumers make up the part of the demand curve to the right of the equilibrium quantity Q_0 and will not purchase the good.

is the difference between the market price the producer receives and the marginal cost of producing this unit.

For the market as a whole, producer surplus is *the area above the supply curve up to the market price;* this is the benefit that lower-cost producers enjoy by selling at the market price. In Figure 9.1 it is the blue triangle. And because producer surplus measures the total net benefit to producers, we can measure the gain or loss to producers from a government intervention by measuring the resulting change in producer surplus.

Application of Consumer and Producer Surplus

To see how consumer and producer surplus can be used to evaluate government policies, let us return to the example of *price controls* that we first encountered toward the end of Chapter 2. Recall that by depressing production and increasing demand, price controls create excess demand.

Figure 9.2 replicates Figure 2.19, except that it also shows the changes in consumer and producer surplus that result from the government price, con-

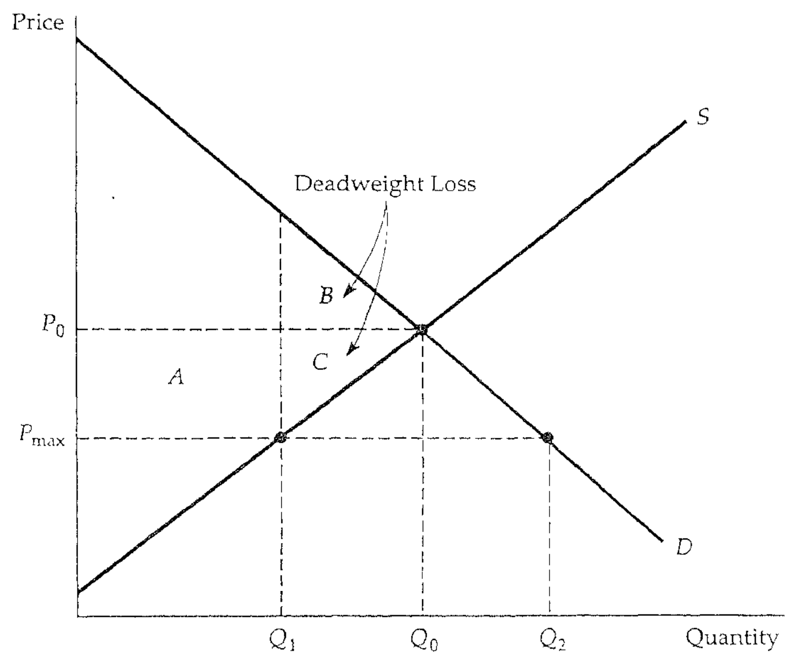

FIGURE 9.2 Change in Consumer and Producer Surplus from Price Controls. The price of a good has been regulated to be no higher than P_{max}, which is below the market-clearing price P_0. The gain to consumers is the difference between rectangle *A* and triangle *B*. The loss to producers is the sum of rectangle *A* and triangle *C*. Triangles *B* and *C* together measure the deadweight loss from price controls.

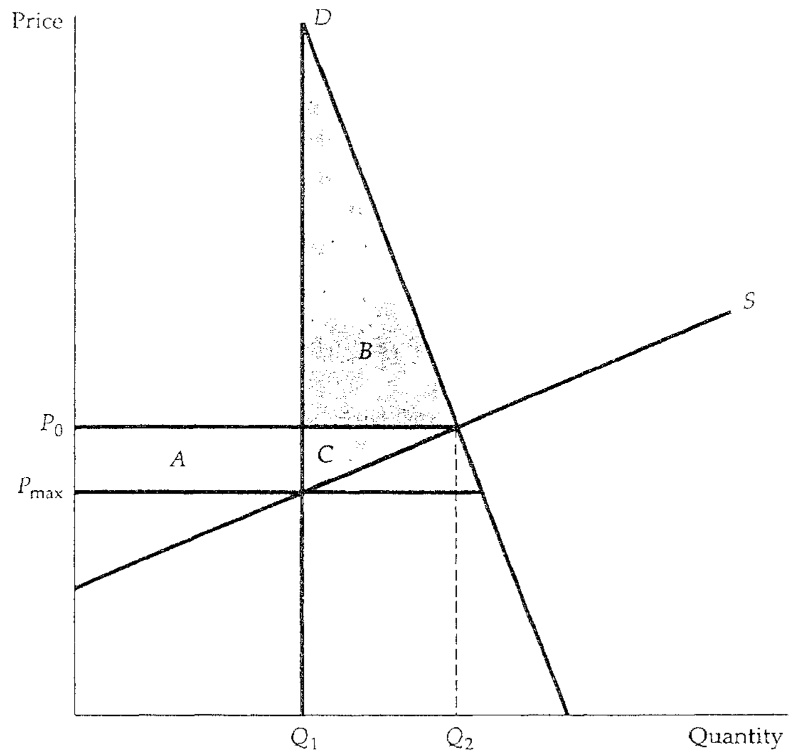

FIGURE 9.3 Effect of Price Controls When Demand Is Inelastic. If demand is sufficiently inelastic, triangle B can be larger than rectangle A. In this case, consumers suffer a net loss from price controls.

trol policy. Some consumers have been rationed out of the market because of price controls, and production and sales fall from Q_0 to Q_1. Those consumers who can still purchase the good can now do so at a lower price, so they enjoy an *increase* in consumer surplus, which is given by tan-shaded rectangle A. However, some consumers can no longer buy the good. Their *loss* of consumer surplus is given by shaded triangle *B*. The net change in consumer surplus is therefore *A* - *B*. In Figure 9.2, rectangle A is larger than triangle B, so the net change in consumer surplus is positive.

What about the change in producer surplus? Those producers who are still in the market and producing quantity-Q_1 are now receiving a lower price. They have lost the producer surplus given by rectangle A. However, total production has also dropped. This represents an additional loss of producer surplus and is given by triangle *C* Therefore, the total change in producer surplus is -*A* - C. Producers clearly lose as a result of price controls.

Is this loss to producers from price controls offset by the gain to consumers? No-as Figure 9.2 shows, price controls result in a net loss of total surplus, which we call a *deadweight loss.* Recall that the change in consumer surplus is

$A - B$ and that the change in producer surplus is $-A - C$, so the *total* change in surplus is $(A - B) + (-A - C) = -B - C$. We thus have a deadweight loss, which is given by the two triangles B and C in Figure 9.2. This deadweight loss is an inefficiency caused by price controls; the loss of producer surplus exceeds the gain in consumer surplus.

If politicians value consumer surplus more highly than producer surplus, this deadweight loss may not carry much political weight. However, if the demand curve is very inelastic, price controls can result in a *net loss of consumer surplus,* as Figure 9.3 shows. In that figure, triangle *B,* which measures the loss to consumers who have been rationed out of the market, is larger than rectangle A, which measures the gain to consumers able to buy the good. Here, consumers value the good highly, so those who are rationed out suffer a large loss.

The demand for gasoline is fairly inelastic in the short run (but much more elastic in the long run). During the summer of 1979, gasoline shortages resulted from oil price controls that prevented domestic gasoline prices from increasing to rising world levels. Consumers spent hours waiting in line to buy gasoline. This was a good example of price controls making consumers—the group the policy was presumably intended to protect-worse off.

EXAMPLE 9.1 PRICE CONTROLS AND THE NATURAL GAS SHORTAGE

In Example 2.8 in Chapter 2, we saw that during the 1970s price controls created a large excess demand for natural gas. But how much did consumers gain from those controls, how much did producers lose, and what was the deadweight loss to the country? We can answer these questions by calculating the resulting changes in consumer and producer surplus.

Again, we base our analysis on the numbers for 1975 and calculate the gains and losses that apply to that year. Refer to Example 2.8, where we showed that the supply and demand curves can be approximated as follows:

$$\textit{Supply:} \quad Q_S = 14 + 2P_G + 0.25P_O$$

$$\textit{Demand:} \quad Q_D = -5P_G + 3.75P_O$$

where Q_S and Q_D are the quantities supplied and demanded, each measured in trillions of cubic feet (Tcf), P_G is the price of natural gas in dollars per thousand cubic feet ($/mcf), and P_O is the price of oil in dollars per barrel ($/b). As the reader can verify by setting Q_S equal to Q_D, and using a price of oil of $8 per barrel, the equilibrium free market price and quantity are $2 per mcf and 20 Tcf, respectively. Under the regulations, however, the maximum allowable price was $1 per mcf

Figure 9.4 shows these supply and demand curves and free market and regulated prices. Rectangle A and triangles B and C measure the changes in consumer and producer surplus resulting from price controls. By calculating the

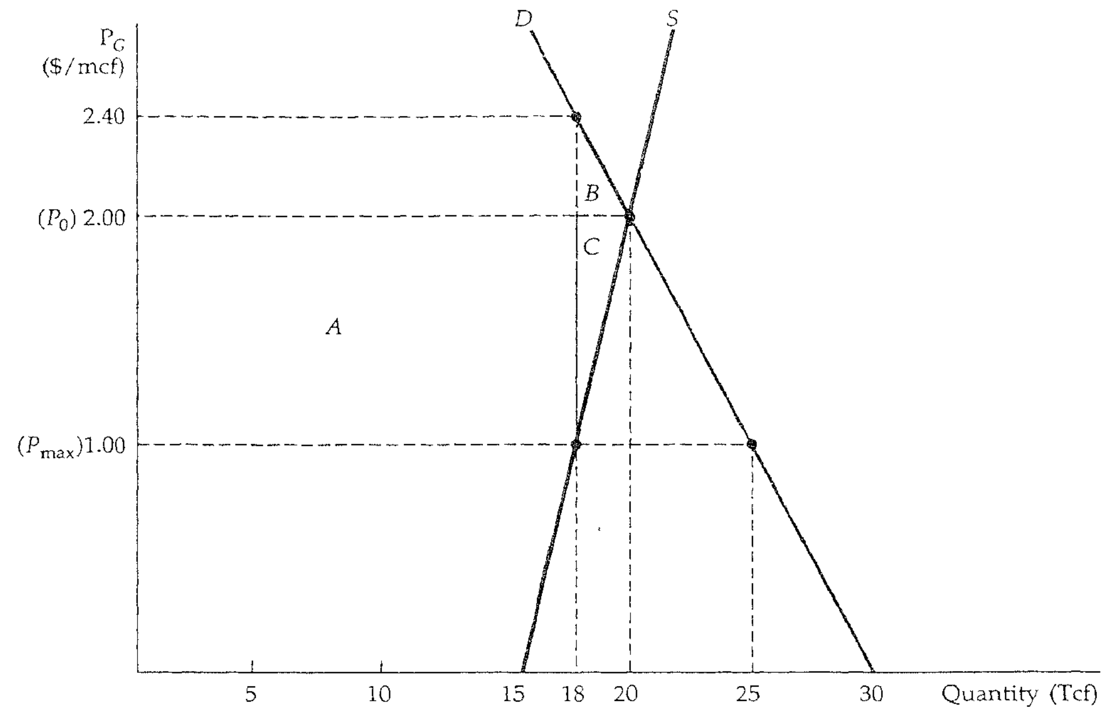

FIGURE 9.4 Effects of Natural Gas Price Controls. The market-clearing price of natural gas is $2 per mcf, and the maximum allowable price is $1. A shortage of 25 - 18 = 7 trillion cubic feet results. The gain to consumers is rectangle *A* minus triangle *B*, and the loss to producers is rectangle *A* plus triangle *C*.

areas of the rectangle and triangles, we can determine the gains and losses from controls.

To do the calculations, first note that 1 Tcf is equal to 1 billion mcf. (We must put the quantities and prices in common units.) Also, by substituting the quantity 18 Tcf into the equation for the demand curve, we can determine that the vertical line at 18 Tcf intersects the demand curve at a price of $2.40 per mcf. Then we can calculate the areas as follows:

$$A = (18 \text{ billion mcf}) \times (\$1/\text{mcf}) = \$18 \text{ billion}$$

$$B = (\tfrac{1}{2}) \times (2 \text{ billion mcf}) \times (\$0.40/\text{mcf}) = \$0.4 \text{ billion}$$

$$C = (\tfrac{1}{2}) \times (2 \text{ billion mcf}) \times (\$1/\text{mcf}) = \$1 \text{ billion}$$

(The area of a triangle is one-half the product of its altitude and its base.)

The 1975 change in consumer surplus resulting from price controls was therefore $A - B = 18 - 0.4 = \$17.6$ billion. The change in producer surplus was $-A-C=-18-1= -\$19$ billion. And finally, the deadweight loss for the year was $-B - C = -0.4 - 1 = -\$1.4$ billion.

The amount $1.4 billion per year is a significant loss to society, but in fact this number understates the true loss resulting from natural gas price controls. Our analysis was a *partial equilibrium* one, which means that it ignored the spillover effects that natural gas shortages had on other markets. For example, during the 1970s much of the excess demand for natural gas (25 - 18 = 7 Tcf) wound up as a greater demand for oil and oil products. This increased both American dependence on imported oil and the losses resulting from domestic price controls on oil. Calculating these additional losses is beyond the scope of this example, but you should be aware of them.

9.2 The Efficiency of a. Competitive Market

We just saw how price controls create a deadweight loss: When the government requires that producers charge a price below that which clears the market, economic efficiency (the *aggregate* welfare of consumers and producers taken together) is reduced. Of course, this does not mean that such a policy is bad; it may achieve objectives that policymakers and the public think are important. However, the policy has an efficiency cost-taken together, producer and consumer surplus are reduced by the amount of the deadweight loss.

One might think that if the only objective is to achieve economic efficiency, a competitive market is better left alone. This is sometimes, but not always, the case. In two situations government intervention can increase the total welfare of consumers and producers in an otherwise competitive market. The first is when the actions of either consumers or producers result in costs or benefits that do not show up as part of the market price. Such costs or benefits are called *externalities* because they are "external" to the market. An example of an externality is the cost to society of environmental pollution by a producer of industrial chemicals. Without government intervention, such a producer will have no incentive to consider the social cost of this pollution. We examine externalities and the proper government response to them in Chapter 18.

Market failure is the second situation in which government intervention can improve on the outcome of a freely functioning competitive market. Loosely speaking, market failure means that prices fail to provide the proper signals to consumers and producers, so that the market does not operate as we have described it. For example, market failure can occur when consumers lack information about the quality or nature of a product, and therefore cannot make utility-maximizing purchasing decisions. Government intervention (e.g., requiring "truth in labeling") may then be desirable. Market failure and its implications are discussed in Chapters 17 and 18.

Without externalities or market failure, an unregulated competitive market does lead. to the economically efficient output level. To see this, let us consider what happens if price is constrained to be something other than the equilibriummarket-clearingprice.

We have already examined the effects of a price ceiling (i.e., a price held below the market-clearing one). Production falls (from Q_0 to Q_0 in Figure 9.5), and there is a corresponding loss of total surplus (the deadweight loss triangles *B* and *C* in the figure). Too little is produced, and consumers and producers in the aggregate are worse off.

Now suppose instead that the government required the price to be *above* the market-clearing one, say, P_2 instead of P_0. As Figure 9.6 "shows, producers would like to produce more at this higher price (Q_2 instead of Qo), but consumers will now buy less (Q_3 instead of Q_0). H we assume that producers produce only what can be sold, the market output level will be Q3, and again, there is a net loss of total surplus. In Figure 9.6, rectangle *A* now represents a transfer from consumers to producers (who now receive a higher price), but triangles *B* and *C* are again a deadweight loss. Because of the higher price, some consumers are no longer buying the good (a loss of consumer surplus given by triangle *B*), and some producers are no longer producing it (a loss of producer surplus given by triangle C).

In fact, the deadweight loss triangles *B* and C in Figure 9.6 give an optimistic assessment of the efficiency cost of policies that force price above market-clear-

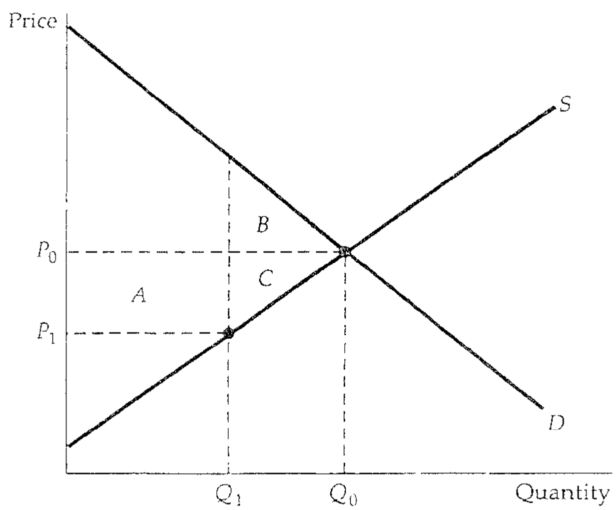

FIGURE 9.5 Welfare Loss When Price Is Held Below Market-Clearing Level. When price is regulated to be no higher than P_1, the deadweight loss given by triangles *B* and *C* results.

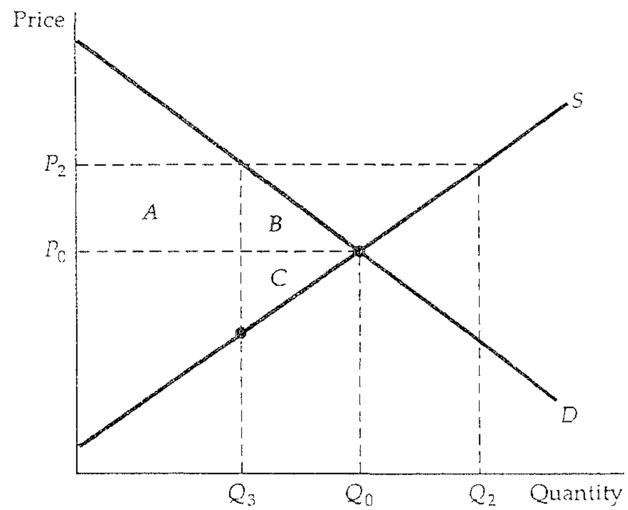

FIGURE 9.6 Welfare Loss When Price Is Held Above Market-Clearing Level. When price is regulated to be no lower than P_2, only Q_3 will be demanded. If Q_3 is produced, the deadweight loss is given by triangles *B* and *C*. At price P_2, producers would like to produce more than Q_3. If they do, the deadweight loss will be even larger.

ing levels. Some producers, enticed by the high price P_2, might increase their capacity and output levels, which would result in unsold output. (This happened in the airline industry when fares were regulated to be above market-clearing levels by the Civil Aeronautics Board.) Or to satisfy producers, the government might buy up unsold output to maintain production at Q_2 or close to it. (This is what happens with U.S. agriculture.) In both cases the total welfare loss will significantly exceed triangles *B* and *C*.

We will examine minimum prices, price supports, and related policies in some detail in the next few sections. Besides showing how supply-demand analysis can be used to understand and assess these policies, we will see how deviations from the competitive market equilibrium lead to efficiency costs.

EXAMPLE 9.2 THE MARKET FOR HUMAN KIDNEYS

Should people have the right to sell parts of their bodies? Congress believes the answer is no. In 1984 it passed the National Organ Transplantation Act, which prohibits the sale of organs for transplantation. Organs may only be donated.

Although the law prohibits their sale, it does not make organs valueless. Instead, it prevents those who supply organs (living persons or the families of the deceased) from reaping their economic value. It also creates a shortage of organs. Each year about 8000 kidneys, 20,000 corneas, and 1200 hearts are transplanted in the United States, but there is considerable excess demand for these organs, and many potential recipients must do without them. Some potential recipients die as a result.

To understand the effects of this law, *let's* consider the supply and demand for kidneys. First the supply curve. Even at a price of zero (the effective price under the 1984 act), donors supply about 8000 kidneys per year. But many other people who need kidney transplants cannot obtain them because of a lack of donors. It has been estimated that 4000 more kidneys would be supplied if the price were $20,000. This implies the following linear supply curve:[2]

$$\textit{Supply: } Q_S = 8000 + 0.2P$$

It is expected that at a price of $20,000 the demand for kidneys would be 12,000 per year. Like supply, demand is relatively price inelastic; a reasonable estimate for the elasticity of demand at the $20,000 price is -0.33. This implies the following linear demand curve:

$$\textit{Demand: } Q_D = 16{,}000 - 0.2P$$

These supply and demand curves are plotted in Figure 9.7, which shows the market-clearing price and quantity of $20,000 and 12,000, respectively.

[2] The supply curve is of the form $Q = a + bP$. When $P = 0$, $Q = 8000$, so $a = 8000$. If P = $20,000, Q = 12,000, so $b = (12{,}000 - 8000)/20{,}000 = 0.2$. At a price of $20,000 the elasticity of supply is 0.33.

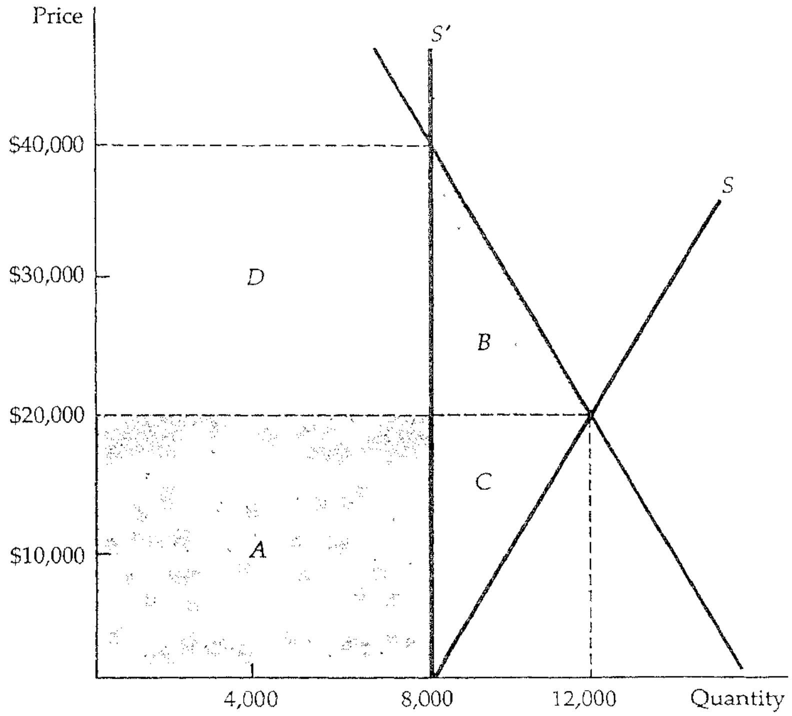

FIGURE 9.7 The Market for Kidneys,and Effect of the 1984 National Organ Transplantation Act. The market-clearing price is $20,000; at this price, about 12,000 kidneys per year would be supplied. The 1984 act effectively makes the price zero. About 8000 kidneys per year are still donated; this constrained supply is shown as S'. The loss to suppliers is given by rectangle *A* and triangle *C*. If consumers received kidneys at no cost, their gain would be given by rectangle *A* less triangle *B*. In practice, kidneys are often rationed on the basis of willingness to pay, and many recipients pay most or all of the $40,000 price that clears the market when supply is constrained. Rectangles *A* and D measure the total value of kidneys when supply is constrained.

Because the 1984 act prohibits the sale of kidneys, supply is limited to 8000 (the number of kidneys that people donate). This constrained supply is shown as the vertical line S'. How does this affect the welfare of kidney suppliers and recipients?

First consider suppliers. Those who provide kidneys fail to receive the $20,000 each kidney is worth, a loss of surplus represented by rectangle *A*, and equal to (8000)($20,000) = $160 million. Also, some people who would supply kidneys if they were paid for them do not, and they lose an amount of surplus represented by triangle C, and equal to (½)(4000)($20,000) = $40 million. So the total loss to suppliers is $200 million.

What about recipients? Presumably the 1984 act intended to treat the kidney as a gift to the recipient. In this case, those recipients who obtain kidneys *gain* rectangle A ($160 million) because they do not have to pay the $20,000. Those who cannot obtain kidneys lose surplus of an amount given by triangle *B* and equal to $40 million. This implies a net increase in the surplus of recipients of $160 - $40 = $120 million. It also implies a deadweight loss equal to the areas of triangles *B* and *C* (i.e., $80 million).

This deadweight loss number underestimates the true efficiency cost of the policy. First, kidneys will not necessarily be allocated to those who value them most highly. Second, with excess demand, there is no way to ensure that recipients will receive their kidneys as gifts, as the 1984 act intends. In practice, kidneys are often rationed on the basis of willingness to pay, and many recipients end up paying all or most of the $40,000 price that is needed to clear the market when supply is constrained to 8000. A good part of the value of the kidneys-rectangles *A* and *D* in the figure-is then captured by hospitals and middlemen. As a result, the law reduces the surplus of recipients, as well as of suppliers.[3]

There are, of course, arguments in favor of prohibiting the sale of organs.[4] One argument stems from the problem of imperfect information; if people receive payment for organs, they may hide adverse information about their health histories. This argument is probably most applicable to the sale of blood, where there is a possibility of transmitting hepatitis, AIDS, or other viruses. But even here screening (at a cost that would be included in the market price) may be more efficient than prohibiting sales. This issue has been central to the debate in the United States over blood policy

A second argument is that it is simply unfair to allocate a basic necessity of life on the basis of ability to pay. This argument transcends economics. However, two points should be kept in mind. First, when the price of a good that has a significant opportunity cost is forced to zero, there is bound to be a reduced supply and excess demand. Second, it is not clear why live organs should be treated differently from close substitutes; artificial limbs, for example, are for sale, but real kidneys are not.

Many complex ethical and economic issues are involved in the sale of organs. These issues are important, and this example is not intended to sweep them away Economics, the dismal science, simply shows us that human or-

[3] According to the *New York Times* ("The Body's Value Has Gone Up," Sept. 8,1986), in 1984-1985 many hospitals were performing nearly 30 percent of kidney transplants on foreigners who were allowed to jump the queue of Americans, and who were charged surgeons' and hospital fees nearly twice as high as for Americans. In 1989 Britain passed a similar law banning the sale of human organs, and this has led to the same problems. For further analyses of these efficiency costs, see Dwane L. Barney and R. Larry Reynolds, "An Economic Analysis of Transplant Organs," *Atlantic Economic Journal* 17 (September 1989): 12-20, and David L. Kaserman and A. H. Barnett, "An Economic Analysis of Transplant Organs: A Comment and Extension/' *Atlantic Economic Journal* 19 (June 1991): 57-64.

[4] For discussions of the strengths and weaknesses of these arguments, see Susan Rose-Ackerman, "Inalienability and the Theory of Property Rights."*Columbia Law Review 85* (June 1985): 931-969, and Roger D. Blair and David L. Kaserman, "The Economics and Ethics of Alternative Cadaveric Organ Procurement Policies," *Yale Journal on Regulation 8* (Summer 1991): 403-452.

gans have economic value that cannot be ignored, and that prohibiting their sale imposes a cost on society that must be weighed against the benefits.

9.3 *Minimum Prices*

As we have seen, government policy sometimes seeks to *raise* prices above market-clearing levels, rather than lower them. Examples include the former regulation of the airlines by the Civil Aeronautics Board, the minimum wage law, and a variety of agricultural policies. (Most import quotas and tariffs also have this intent, as we will see in Section 9.5.) One way to raise price above the market-clearing level is by direct regulation-simply make it illegal to charge a price lower than a specific minimum level.

Look back to Figure 9.6. If producers correctly anticipate that they can sell only the lower quantity Q_3 the net welfare loss will be given by triangles B and C. But as we explained, producers might not limit their output to Q_3. What happens if producers think they can sell all they want at the higher price, and produce accordingly?

This situation is illustrated in Figure 9.8, where P_{min} denotes a minimum price set by the government. The quantity supplied is now Q_2, and the quantity demanded is Q_3, the difference representing an excess, unsold supply. Now let us follow the resulting changes in consumer and producer surplus.

Those consumers who still purchase the good must now pay a higher price and so suffer a loss of surplus, which is given by rectangle A in Figure 9.8. Some consumers have also dropped out of the market because of the higher price, with a corresponding loss of surplus given by triangle B. The total change in consumer surplus is -therefore

$$\Delta CS = -A - B$$

Consumers clearly are worse off as a result of this policy.

What about producers? They receive a higher price for the units they sell, which results in an increase of surplus, given by rectangle A. (Rectangle A represents a transfer of money from consumers to producers.) But the drop in sales from Q_0 to Q_3. results in a loss of surplus, which is given by triangle C. Finally, consider the cost to producers of expanding production from Q_0 to Q_2- Because they sell only Q3, there is no revenue to cover the cost of producing $Q_2 - Q_3$. This cost is the area under the supply curve from Q_3 to Q_2, and is represented by the shaded trapezoid D.[5] So unless producers re-

[5] Remember that the supply curve is the aggregate marginal cost curve for the industry. The supply curve therefore gives us the additional cost of producing each incremental unit, so the area under the supply curve from Q_3 to Q_2 is the cost of producing the quantity $Q_2 - Q_3$.

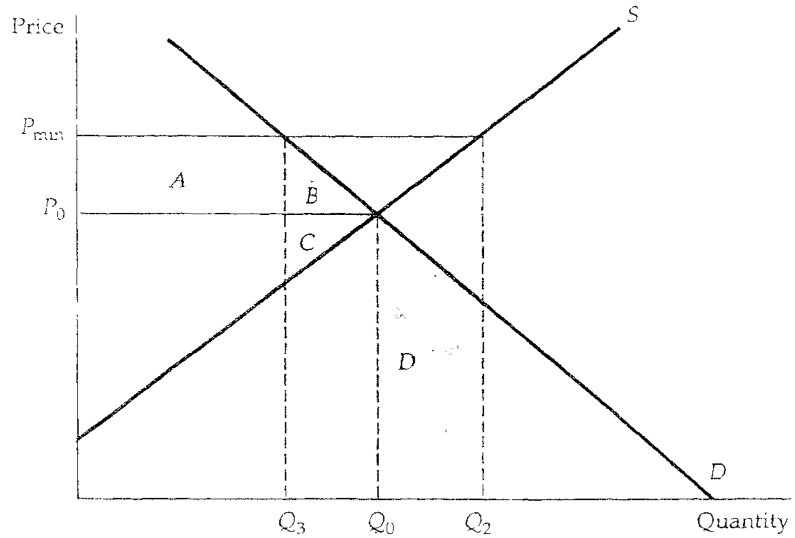

FIGURE 9.8 Price Minimum. Price is regulated to be no lower than P_{min} Producers would like to supply Q_2, but consumers will buy only Q_3. If producers indeed produce Q_2, the amount Q_2 - $Q3$ will go unsold and the change in producer surplus will be *A* - *C* - *D*. In this case, producers as a group may be worse off.

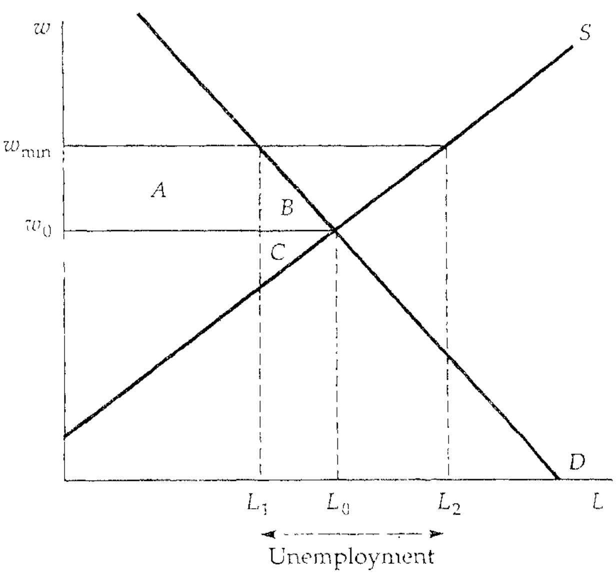

FIGURE 9.9 The Minimum Wage. The market-clearing wage is w_0, but firms are not allowed to pay less than w_{min}. This results in unemployment of an amount L_2 – L_1, and a deadweight loss given by triangles *B* and *C*.

spond to unsold output by cutting production, the total change in producer surplus is

$$\Delta PS = A - C - D$$

Given that trapezoid D can be large, a minimum price can even result in a net loss of surplus to producers alone! As a result, this form of government intervention can reduce producers' profits because of the cost of excess production.

Another example of a government-imposed price minimum is the minimum wage law. This is illustrated in Figure 9.9, which shows the supply of labor and the demand for labor. The wage is set at w_{min}, a level higher than the market-clearing wage w_0. As a result, those workers who can find jobs obtain a higher wage. However, some people who want to work will be unable to. The policy results in unemployment, which in the figure is L_2 - L_1.

EXAMPLE 9.3 AIRLINE REGULATION

During 1976-1981 the airline industry in the United States changed dramatically. Until that time fares and routes had been tightly regulated by the Civil Aeronautics Board (CAB). The CAB set most fares well above what would have prevailed in a free market. It also restricted entry, so that many routes were served by only one or two airlines. But in 1976 the CAB started to liberalize fare regulation. In 1977 it approved the first "Super Saver" fares. In 1978 it allowed airlines to set fares as much as 10 percent above or 50 percent below a CAB standard fare, and in 1980 this range was expanded to give airlines unlimited downward flexibility and more upward flexibility over fares. Also, shortly after passage of the Airline Deregulation Act in October 1978, the CAB allowed airlines to serve any routes they wished, and since then many new airlines have begun service. By 1981 the industry had been completely deregulated, and the CAB itself was dissolved in 1982.

Many airline executives feared that deregulation would lead to chaos in the industry, with competitive pressure causing sharply reduced profits and bankruptcies. After all, the original rationale for CAB regulation was to provide "stability" for an industry that was considered vital to the U.S. economy. And one might think that by holding price above its market-clearing level, profits would be higher than they would be in a free market.

Deregulation did lead to major changes in the industry. Some airlines merged or went out of business as new airlines entered the industry. And although prices fell considerably (to the benefit of consumers), profits overall did not fall much because the CAB'S minimum prices had caused inefficiencies and artificially high costs. The effect of minimum prices is illustrated in Figure 9.10, where P_0 and Q_0 are the market-clearing price and quantity, P_{min} is the minimum price set by the CAB, and Q_1 is the amount demanded at this higher price. The problem was that at price P_{min} airlines wanted to supply a

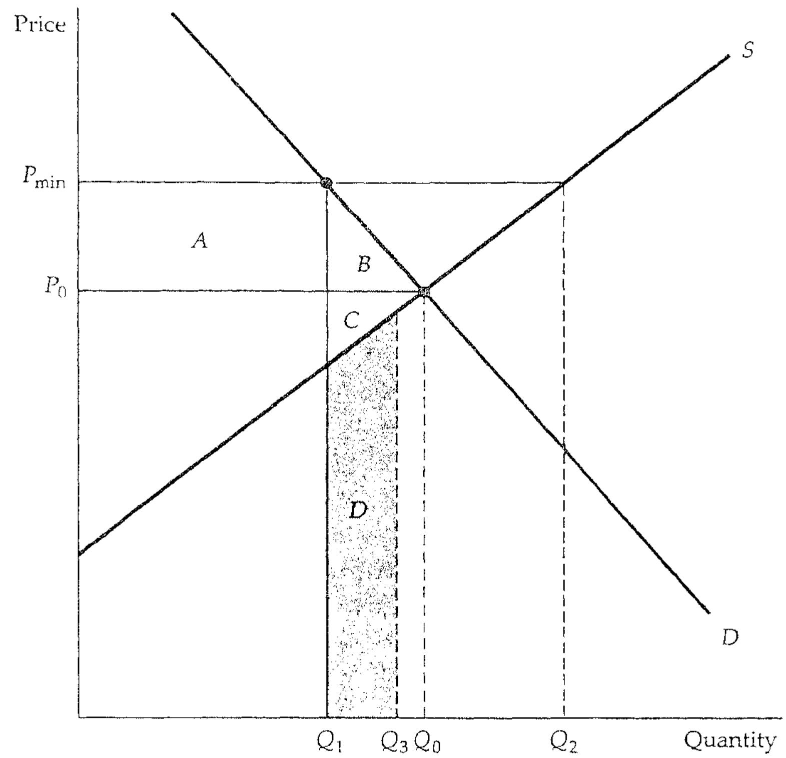

FIGURE 9.10 Effect of Airline Regulation by the Civil Aeronautics Board. At price P_{min}, airlines would like to supply Q_2, well above the quantity Q_1 that consumers will buy. Here they supply Q_3. Trapezoid *D* is the cost of unsold output. Airline profits may have been lower as a result of regulation because triangle *C* and trapezoid *D* can together exceed rectangle *A*. In addition, consumers lose *A* + *B*.

quantity Q_2, much larger than Q_1. And although they did not expand output to Q_2, they did expand it well beyond Q_1-to Q_3 in the figure-hoping to sell this quantity at the expense of competitors. As a result, load factors (the percentage of seats filled) were low, and so were profits. (Trapezoid *D* measures the cost of unsold output.)

Table 9.1 gives some key numbers that illustrate the evolution of the industry. The number of carriers increased dramatically after deregulation, as did passenger load factors, while the passenger-mile rate (the revenue per passenger-mile flown) fell slightly in real (inflation-adjusted) terms from 1975 to 1982. And what about costs? The real cost index indicates that even after adjusting for inflation, costs increased by about 25 percent from 1975 to 1982. But this was due to the sharp increase in fuel costs (caused by the increase in oil prices) that occurred during this period, and it had nothing to do with deregulation. The last line in Table 9.1 is the real cost index after adjusting for fuel

TABLE 9.1 Airline Industry Data[6]

	1970	1975	1980	1982	1985	1990
Number of carriers	35	33	72	89	86	60
Passenger load factor (%)	50	54	59	59	61	62
Passenger-mile rate (constant 1975 dollars)	.085	.077	.074	.071	.062	.055
Real cost index (1975 = 100)	86	100	120	125	110	102
Real cost index corrected for fuel cost increases	95	100	101	96	103	100

cost increases. This is what costs would have been had oil prices increased only at the rate of inflation. This *index fell* during the period.

What, then, did airline deregulation do for consumers and producers? As new airlines entered the industry and fares went down, consumers clearly benefited. (The increase in consumer surplus is given by rectangle A and triangle B in Figure 9.10[7]) As for the airlines, they had to learn to live in a more competitive-and therefore more turbulent-environment, and some firms did not survive. But overall, airlines became so much more cost-efficient that producer surplus may have increased. The total welfare gain from deregulation was positive, and quite large.[8]

9.4 *Price Supports and Production Quotas*

Besides imposing a minimum price, the government can increase the price of a good in other ways. Much of American agricultural policy is based on a system of *price supports,* often combined with incentives to reduce or restrict production. In this section we examine how these policies work and their impact on consumers, producers, and the federal budget.

[6] Source: Department of Commerce, *U.S. Statistical Abstract,* 1986, 1989, 1992.

[7] The benefit to consumers was somewhat smaller than this because *quality* declined as planes became more crowded and delays and cancellations multiplied.

[8] Studies of the effects of deregulation include John M. Trapani and C. Vincent Olson, "An Analysis of the Impact of Open Entry on Price and the Quality of Service in the Airline Industry," *Review of Economics and Statistics* 64 (Feb. 1982): 118-138; David R. Graham, Daniel P Kaplan, and David S. Sibley, "Efficiency and Competition in the Airline Industry," *Bell Journal of Economics* (Spring 1983): 118-138, S. Morrison and Clifford Whinston, *The Economic Effects of Airline Deregulation* (Washington, D.C.: Brookings Institution, 1986); and Nancy L. Rose, "Profitability and Product Quality: Economic Determinants of Airline Safety Performance," *Journal of Political Economy* 98 (Oct. 1990): 944-964.

Price Supports

In the United States, price supports aim to increase the prices of dairy products, tobacco, corn, peanuts, and so on, so that the producers of those goods can receive higher incomes. One way to do this is for the government to set a support price P_s, and then buy up whatever output is needed to keep the market price at this level. Figure 9-11 illustrates this. Let us examine the resulting gains and losses to producers, consumers, and the government.

At price P_s, consumer demand falls to Q_1, but supply increases to Q_2. To maintain this price and avoid having inventories pile up in producer warehouses, the government must buy the quantity $Q_8 = Q_2 - Q_1$. In effect the government adds its demand Q_8 to the demand of consumers, and producers can sell all they want at price P_s.

Those consumers who purchase the good must pay the higher price P_s instead of P_0, and so they suffer a loss of consumer surplus given by rectangle A. Other consumers no longer buy the good or buy less of it, and their loss of surplus is given by triangle B. So as with the minimum price that we examined above, consumers lose, in this case by an amount

$$\Delta CS = -A - B$$

On the other hand, producers gain (which is why such a policy is implemented). Producers are now selling a larger quantity Q_2 instead of Q_0, and at a higher price P_s. Observe from Figure 9.11 that producer surplus increases by the amount

$$\Delta PS = A + B + D$$

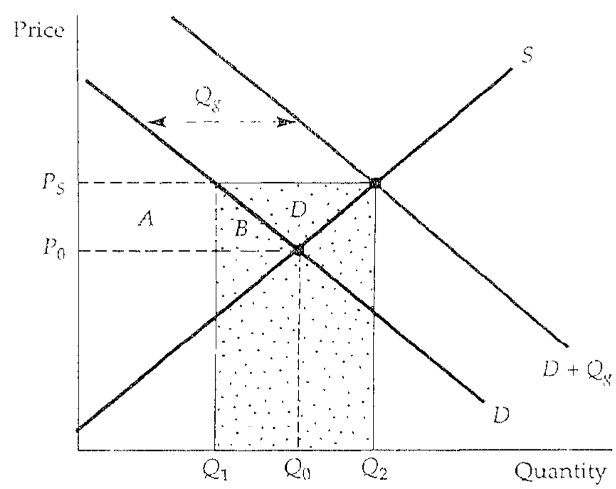

FIGURE 9.11 Price Supports. To maintain a price P_s above the market-clearing price P_0, the government buys a quantity Q_8. The gain to producers is $A + B + D$. The loss to consumers is $A + B$. The cost to the government is the speckled rectangle $P_s(Q_2 - Q_1)$.

But there is also a cost to the government (which must be paid for by taxes, and so is ultimately a cost to consumers). That cost is $(Q_2 - Q_1)P_s$, which is what the government must pay for the output it purchases. In Figure 9.11 this is the large speckled rectangle. (This cost may be reduced if the government can "dump" some of its purchases-i.e., sell them abroad at a low price. But this hurts the ability of domestic producers to sell in foreign markets, and it is domestic producers that the government is trying to please in the first place.)

What is the total welfare cost of this policy? To find out, we add the change in consumer surplus to the change in producer surplus and then subtract the cost to the government. Hence the total change in welfare is

$$\Delta CS + \Delta PS - \text{Cost to Govt.} = D - (Q_2 - Q_1)P_s$$

In terms of Figure 9.11, society as a whole is worse off by an amount given by the large speckled rectangle, less triangle *D*.

As we will see in Example 9.4, this welfare loss can be very large. But the most unfortunate part of this policy is that there is a much more efficient way to make farmers better off. If the objective is to give farmers an additional income equal to $A + B + D$, it is far less costly to society to give them this money 'directly, rather than via price supports- Since consumers are losing $A + B$ anyway with price supports, by paying farmers directly, society saves the large speckled rectangle, less triangle *D*. Then why doesn't the government make farmers better off by simply giving them money? Perhaps because price supports are a less obvious giveaway, and therefore politically more attractive.[9]

Production Quotas

Besides entering the market and buying up output, thereby increasing total demand, the government can also cause the price of a good to rise by *reducing supply*. It can do this by decree-the government simply sets quotas on how much each firm can produce. By setting the appropriate quotas, the price can then be forced up to any arbitrary level.

This is exactly how many city governments maintain high taxi fares. They limit total supply by requiring each taxicab to have a medallion, and then limit the total number of medallions. Who gains from this? Taxicab companies that own the valuable medallions. Who loses? The consumer, of course.[10]

[9] In practice, price supports for many agricultural commodities are effected through nonrecourse loans. The loan rate is in effect a price floor. If during the loan period market prices are not sufficiently high, farmers can forfeit their grain to the government (specifically to the Commodity Credit Corporation) *asfull paymentfor the loan.* And, of course, farmers have the incentive to do this unless the market price rises above the support price.

[10] For example, as of 1990 New York City had not issued any new taxi medallions for half a century. Only 11,800 taxis were permitted to cruise the city's streets, the same number as in 1937! As a result, in 1990 a medallion could be sold for about $119/000. It shouldn't be a surprise, then, that the city's taxicab companies have vigorously opposed phasing out medallions in favor of an open system. Washington, D.C. has such an open system: An average taxi ride there costs about half of what it does in New York, and taxis are far more available.

Another example of such a policy is the control of liquor licenses by state governments. By requiring any bar or restaurant that serves alcohol to have a liquor license and then by limiting the number of licenses, entry by new restaurateurs is limited, which allows those who have the licenses to earn higher prices and profit margins.

In U.S. agricultural policy, output is reduced by incentives rather than outright quotas. *Acreage limitation programs* give farmers financial incentives (in the form of direct income transfers) to leave some of their acreage idle. Figure 9.12 shows how prices can be increased by reducing supply in this way. Note that by limiting the acreage planted, the supply curve becomes completely inelastic at the quantity Q_1, and the market price is increased from P_0 to P_s.

Figure 9.12 also shows the changes in consumer and producer surplus resulting from this policy. Again, the change in consumer surplus is

$$\Delta CS = -A - B$$

Farmers now receive a higher price for the production Q_1, which corresponds to a gain in surplus of rectangle *A*. But because production is reduced from Q_0 to Q_1, there is a loss of producer surplus corresponding to triangle *C*. Finally, farmers receive money from the government as an incentive to reduce production.' Thus, the total change in producer surplus is now

$$\Delta PS = A - C + \text{Payments for not producing}$$

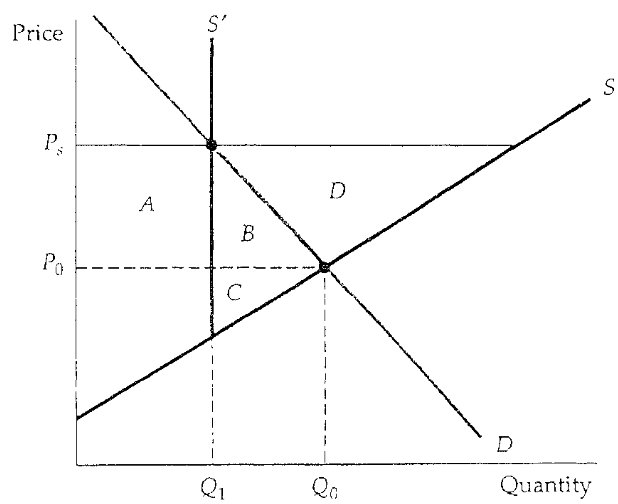

FIGURE 9.12 Acreage Limitations. To maintain a price P_s above the market-clearing price P_0, the government gives producers a financial incentive to reduce output to Q_1. For the incentive to work, it must be at least as large as $B + C + D$, the additional profit earned by planting, given the higher price Ps. The cost to the government is therefore at least $B + C + D$.

The cost to the government is a payment sufficient to give farmers an incentive to reduce output to Q_1. That incentive must be at least as large as $B + C + D$ because that is the additional profit that could be made by planting^ *given the higher price P_s.* (Remember that the higher price P_s gives farmers an incentive to produce *more,* but the government is trying to get them to produce *less.) So* the cost to the government is at least $B + C + D$ and the total change in producer surplus is therefore

$$\Delta PS = A - C + B + C + D = A + B + D$$

This is the same change in producer surplus as with price supports maintained by government purchases of output. (Refer to Figure 9.11.) Farmers, then, should be indifferent between the two policies because they end up gaining the same amount of money from each. Likewise, consumers lose the same amount of money.

But which policy costs the government more? The answer depends on whether the sum of triangles $B + C + D$ in Figure 9.12 is larger or smaller than $(Q_2 - Q_1)P_s$ (the large speckled rectangle) in Figure 9.11. Usually it will be smaller, so that an acreage limitation program costs the government (and society) less than price supports maintained by government purchases.

Still, even an acreage limitation program is more costly to society than simply handing the farmers money, the total change in welfare ($\Delta CS + \Delta PS$ - Cost to Govt.) under the acreage limitation program is

$$\Delta \text{Welfare} = -A - B + A + B + D - B - C - D = -B - C$$

Society would clearly be better off in efficiency terms if the government simply gave the farmers $A + B + D$, leaving price and output alone. Farmers would then gain $A + B + D$, the government would lose $A + B + D$, for a total welfare change of zero, instead of a loss of $B + C$. However, economic efficiency is not always the objective of government policy.[11]

EXAMPLE 9.4 SUPPORTING THE PRICE OF WHEAT

In Example 2.3 of Chapter 2, we began to examine the market for wheat in the United States. Using simple linear demand and supply curves, *we* found that the market-clearing price of wheat was about $3.46 in 1981, but it fell io about $1.80 by 1985 because of a large drop in export demand. In fact, gov-

[11] In 1983 the Reagan administration introduced the *Payment-in-K.ind Program* (PIK), under which producers who had already reduced acreage under the Reduced Acreage Program could keep fallow an additional 30 percent of their base acreage. A corn producer, for example, would then he given corn directly from government reserves at an amount equal to 80 percent of the normal yield on the number of fallow acres. The farmer could then sell that corn in the market for cash. The objective of P1K was to remove more land from production (thereby maintaining higher prices by reducing output), and reduce government stocks of grain, which had been growing rapidly. Unfortunately the program did not deal with the inherent inefficiency of price supports.

ernment price support programs kept the actual price of wheat much higher-about \$3.70 in 1981, and about \$3.20 in 1985. How did these programs work, how much did they end up costing consumers, and how much did they add to the federal deficit?

First, let us examine the market in 1981. In that year there were no effective limitations on the production of wheat, and price was increased by government purchases. How much would the government have had to buy to get the price from \$3.46 to \$3.70? To answer this, first write the equations for supply, and for total (domestic plus export) demand:

$$\textit{1981 Supply:} \quad Q_S = 1800 + 240P$$

$$\textit{1981 Demand:} \quad Q_D = 3550 - 266P$$

By equating supply and demand, you can check that the market-clearing price is \$3.46, and that the quantity produced is 2630 million bushels. Figure 9.13 illustrates this.

To increase the price to \$3.70, the government must buy a quantity of wheat Q_g. *Total* demand (private plus government) will then be

$$\textit{1981 Total Demand:} \quad Q_{DT} = 3550 - 266P + Q_g$$

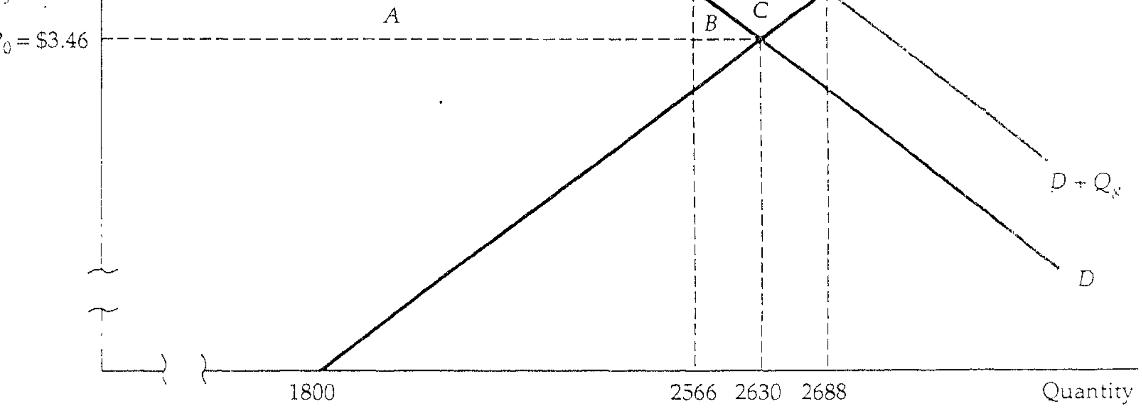

FIGURE 9.13 The Wheat Market in 1981. By buying 122 million bushels of wheat, the government increased the market-clearing price from \$3.46 per bushel to \$3.70.

Now equate supply with this total demand:

$$1800 + 240P = 3550 - 266P + Q_8$$

or

$$Q8 = 506P - 1750$$

This equation can be used to determine the required quantity of government wheat purchases Q_8 as a function of the desired support price P. So to achieve a price of \$3.70, the government must buy

$$Q_8 = (506)(3.70) - 1750 = 122 \text{ million bushels}$$

Note in Figure 9.13 that these 122 million bushels are the difference between supply at the \$3.70 price (2688 million bushels) and private demand (2566 million bushels). The figure also shows the gains and losses to consumers and producers. Recall that consumers lose rectangle A and triangle *B*. You can verify that rectangle *A* is (3.70 - 3.46)(2566) = \$616 million, and triangle *B* is (½)(3.70 - 3.46)(2630 - 2566) = \$8 million, so the total cost to consumers is \$624 million.

The cost to the government is the \$3.70 it pays for the wheat times the 122 million bushels it buys, or \$452 million. The total cost of the program is then \$624 + \$452 = \$1076 million. Compare this with the gain to producers, which is rectangle A plus triangles *B* and C. You can verify that this gain is \$638 million.

Price supports for wheat were clearly expensive in 1981. To increase the surplus of farmers by \$638 million, consumers and taxpayers together had to pay \$1076 million. But in fact taxpayers paid even more. Wheat producers were also given subsidies of about 30 cents per bushel,, which adds up to another \$806 million.

In 1985 the situation became even worse because of the drop in export demand. In that year the supply and demand curves were as follows:

1985 Supply: $Q_S = 1800 + 240P$

1985 Demand: $Q_D = 2580 - 194P$

You can verify that the market-clearing price and quantity were \$1.80 and 2232 million bushels, respectively.

To increase the price to \$3.20, the government bought wheat and imposed a production quota of about 2425 million bushels. (Farmers who wanted to take part in the subsidy program-and most did-had to agree to limit their acreage.) Figure 9.14 illustrates this situation. At the quantity 2425 million bushels, the supply curve becomes vertical. Now to determine how much wheat Q_8 the government had to buy, set this quantity of 2425 equal to total demand:

$$2425 = 2580 - 194P + Q_8$$

or

$$Q_8 = -155 + 194P$$

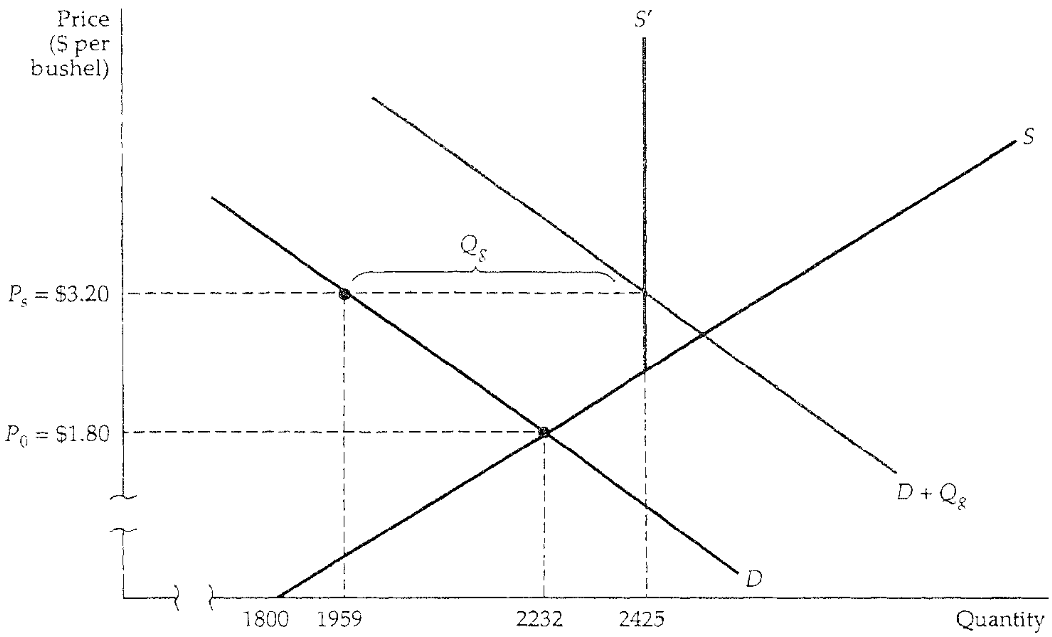

FIGURE 9.14 The Wheat Market in 1985. In 1985 the demand for wheat was much lower than in 1981, so the market-clearing price was only $1.80. To increase the price to $3.20, the government bought 466 million bushels and also imposed a production quota of 2425 million bushels.

Substituting $3.20 for *P*, we see that Q_g must be 466 million bushels. This cost the-government ($3.20)(466) = $1491 million.

Again, this is not the whole story. The government also provided a subsidy of 80 cents per bushel, so that producers again received about $4.00 for their wheat.[12] Since 2425 million bushels were produced, that subsidy cost an additional $1940 million. In all, U.S. wheat programs cost taxpayers nearly $3.5 billion in 1985.

Of course, there was also a loss of consumer surplus and a gain of producer surplus. You can calculate what they were.[13]

[12] The administration later decided to reduce the support price but increase the direct income subsidy, so farmers came out about the same. Was this a sensible change?

[13] In 1990, agricultural programs were estimated to cost American taxpayers more than $20 billion, and to result in a loss of consumer surplus of about $24 billion. See J. Bovard, "Farm Subsidies: Milking Us Dry," *New York Times,* July 20, 1990.

9.5 *Import Quotas and Tariffs*

Many countries use import quotas and tariffs to keep the domestic price of a product above world levels and thereby enable the domestic industry to enjoy higher profits than it would under free trade. As we will see, the cost to society from this protection can be high, with the loss to consumers exceeding the gain to domestic producers.

Without a quota or tariff, a country will import a good when its world price is below the market price that would prevail if there were no imports. Figure 9.15 illustrates this. S and D are the domestic supply and demand curves. If there were no imports, the domestic price and quantity would be P_0 and Q_0, which equate supply and demand. But the world price P_w is below P_0, so domestic consumers have an incentive to purchase from abroad, which they will do if imports are not restricted. How much will be imported? The domestic price will fall to the world price P_w, and at this lower price domestic produc-

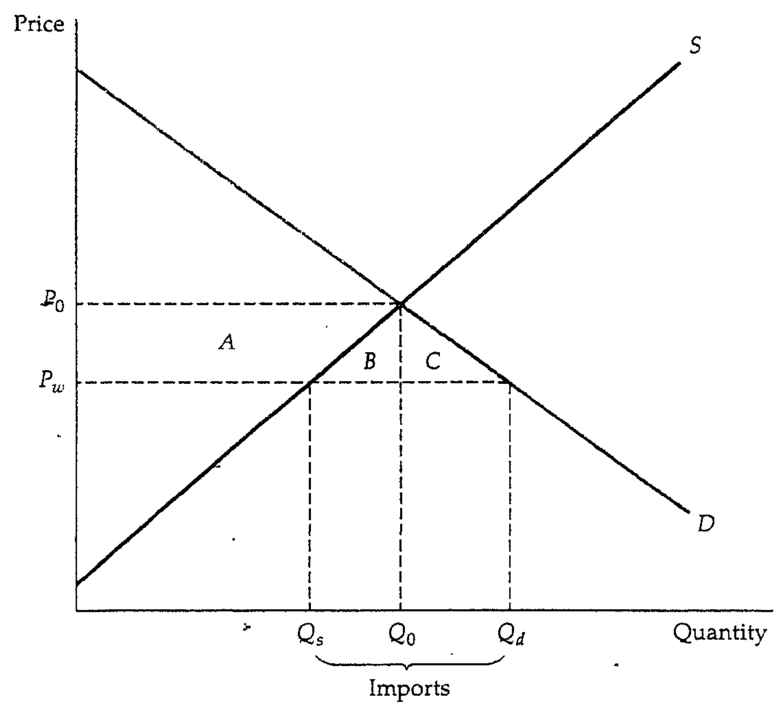

FIGURE 9.15 Import Tariff or Quota That Eliminates Imports. In a free market, the domestic price equals the world price P_w. A total Q_d is consumed, of which Q_s is supplied domestically,and the rest imported. By eliminating imports, the price is increased to Po. The gain to producers is trapezoid A. The loss to consumers is $A + B + C$, so the deadweight loss is $B + C$.

tion will fall to Q_s, and domestic consumption will rise to Q_d. Imports are then the difference between domestic consumption and domestic production, $Q_d - Q_s$.

Now suppose the government, bowing to pressure from the domestic industry, eliminates imports by imposing a quota of zero (i.e., forbidding any importation of the good). What are the gains and losses from such a policy?

With no imports allowed, the domestic price will rise to Po. Consumers who still purchase the good (in quantity Qo) will pay more and will lose an amount of surplus given by trapezoid A and triangle B. Also, given this higher price, some consumers will no longer buy the good, so there is an additional loss of consumer surplus, given by triangle C. The total change in consumer surplus is therefore

$$\Delta CS = -A - B - C$$

What about producers? Output is now higher (Q_0 instead of Q_d) and is sold at a higher price (P_0 instead of P_w). Producer surplus therefore increases by the amount of trapezoid A:

$$\Delta PS = A$$

The change in total surplus, $\Delta CS + \Delta PS$,, is therefore $-B$ - C. Again, there is a deadweight loss-consumers lose more than producers gain.

Imports could also be reduced to zero by imposing a large enough tariff. The tariff would have to be equal to or greater than the difference between Po and P_w. With a tariff of this size, there will be no imports and therefore no government revenue from tariff collections, so the effect on consumers and producers would be the same as with a quota.

More often, government policy is designed to reduce, but not eliminate, imports. Again, this can be done with either a tariff or a quota, as Figure 9.16 shows. With free trade the domestic price will equal the world price P_w, and imports will be Q_d - Q_s. Now suppose a tariff of T dollars per unit is imposed on imports. Then the domestic price will rise to P^* (the world price plus the tariff); domestic production will rise; and domestic consumption will fall.

In Figure 9.16 this tariff leads to a change of consumer surplus given by

$$\Delta CS = -A - B - C - D$$

The change in producer surplus is again

$$\Delta PS = A$$

Finally, the government will collect revenue in the amount of the tariff times the quantity of imports, which is rectangle D. The total change in welfare, ΔCS plus ΔPS plus the revenue to the government, is therefore $-A - B - C - D + A + D = -B - C$. Triangles B and C again represent the deadweight loss from restricting imports. (B represents the loss from domestic overproduction, and C the loss from too little consumption.)

Suppose the government uses a quota instead of a tariff to restrict imports: Foreign producers can only ship a specific quantity (Q'_d - Q'_s in Figure 9.16)

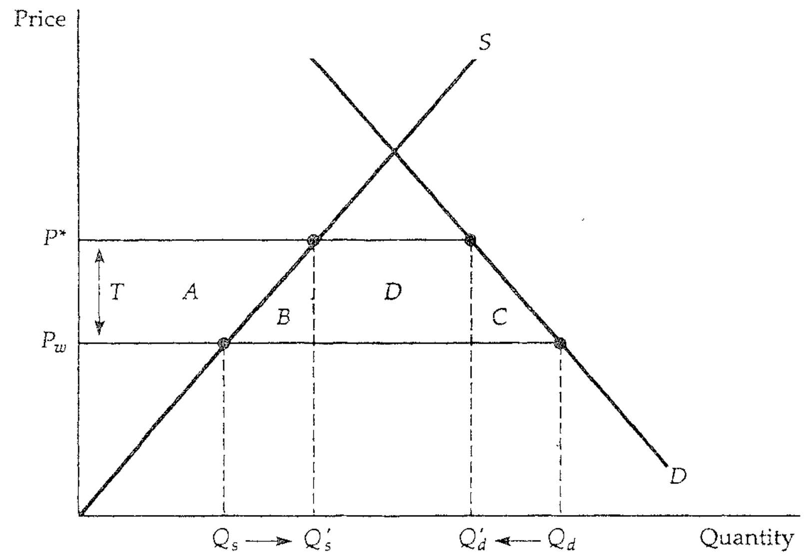

FIGURE 9.16 Import Tariff or Quota (general case). By reducing imports, the domestic price is increased from Pw to P*. This can be achieved by a quota, or by a tariff T = P* - Pw. Trapezoid A is again the gain to domestic producers. The loss to consumers is A+B+C+D.Ifa tariff is used, the government gains D, the revenue from the tariff, so the net domestic loss is B + C. If a quota is used instead, rectangle D becomes part of the profits of foreign producers, and the net domestic loss is B + C + D.

to the United States. Foreign producers can then charge the higher price P* for their U.S. sales. The changes in U.S. consumer and producer -surplus will be the same as with the tariff, but instead of the U.S. government collecting the revenue given by rectangle *D*, this money will go to the foreign producers as higher profits. Compared with the tariff, the United States as a whole will be even worse off, losing *D* as well as the deadweight loss B and C.[14]

This is exactly what happened with automobile imports from Japan in the 1980s. The Reagan administration, under pressure from domestic automobile producers, negotiated "voluntary" import restraints, under which the Japanese agreed to restrict their shipments of cars to the United States. The Japanese could therefore sell those cars that were shipped at a price higher than the world level and capture a higher profit margin on each one. The United States would have been better off by simply imposing a tariff on these imports.

[14] Alternatively, an import quota can be maintained by rationing imports to U.S. importing firms or trading companies. These middlemen would have the rights to import a fixed amount of the good each year. These rights are valuable because the middleman can buy the product on the world market at price P_w and then sell it at price P^*.The aggregate value of these rights is therefore given by rectangle D. If the government *sells* the rights for this amount of money, it can capture the same revenue it would receive with a tariff. But if these rights are given away, as sometimes happens, the money will go instead as a windfall to middlemen.

EXAMPLE 9.5 THE SUGAR QUOTA

In recent years the world price of sugar has been as low as 4 cents per pound, while the United States price has been above 25 cents per pound. Why? By restricting imports the U.S. government protects the $3 billion domestic sugar industry, which would virtually be put out of business if it had to compete with low-cost foreign producers. This has been good news for U.S. sugar producers. It has even been good news for some foreign sugar producers-those whose successful lobbying efforts have given them big shares of the quota. But like most policies of this sort, it has been bad news for consumers.

To see just how bad, let's look at the sugar market in 1989. Here are the relevant data for that year:

U.S. production:	13.7 billion pounds
U.S. consumption:	17.5 billion pounds
U.S. price:	23 cents per pound
World price:	12.5 cents per pound

At these prices and quantities, the price elasticity of U.S. supply is 1.54, and the price elasticity of U.S. demand is -0.3.[15]

We will fit linear supply and demand curves to these data, and then use them to calculate the effects of the quotas. You can verify that the following U.S. supply curve is consistent with a production level of 13.7 billion pounds, a price of 23 cents per pound, and a supply elasticity of 1.54[16]:

$$\textit{U.S. Supply:}\quad Q_S = -7.46 + 0.92P$$

where quantity is measured in billions of pounds and price in cents per pound. Similarly, the -0.3 demand elasticity together with the data for U.S. consumption and U.S. price give the following linear demand curve:

$$\textit{U.S. Demand:}\quad Q_D = 22.8 - 0.23P$$

These supply and demand curves are plotted in Figure 9.17. At the 12.5 cent world price, U.S. production would have been only 4 billion pounds, and U.S. consumption would have been about 20 billion pounds, most of this imports. But fortunately for U.S. producers, imports were limited to only 3.8 billion pounds, which pushed the price up to 23 cents.

[15] These data and elasticity estimates are based on Morris E. Morkre and David G. Tarr, *Effects of Restrictions on United States Imports: Five Case Studies and Theory,* U.S. Federal Trade Commission Staff Report, June 1981, and *F. M.* Scherer, "The United States Sugar Program/' Kennedy School of Government Case Study, Harvard University, 1992. For a general discussion of sugar quotas and other aspects of U.S. agricultural policy, see D. Gale Johnson, *Agricultural Policy and Trade* (New York: New York University Press, 1985); and Gail L. Cramer and Clarence W. Jensen, *Agricultural Economics and Agribusiness* (New York: Wiley, 1985).

[16] Turn to Section 2.5 of Chapter 2 to review how to fit linear supply and demand functions to data of this kind.

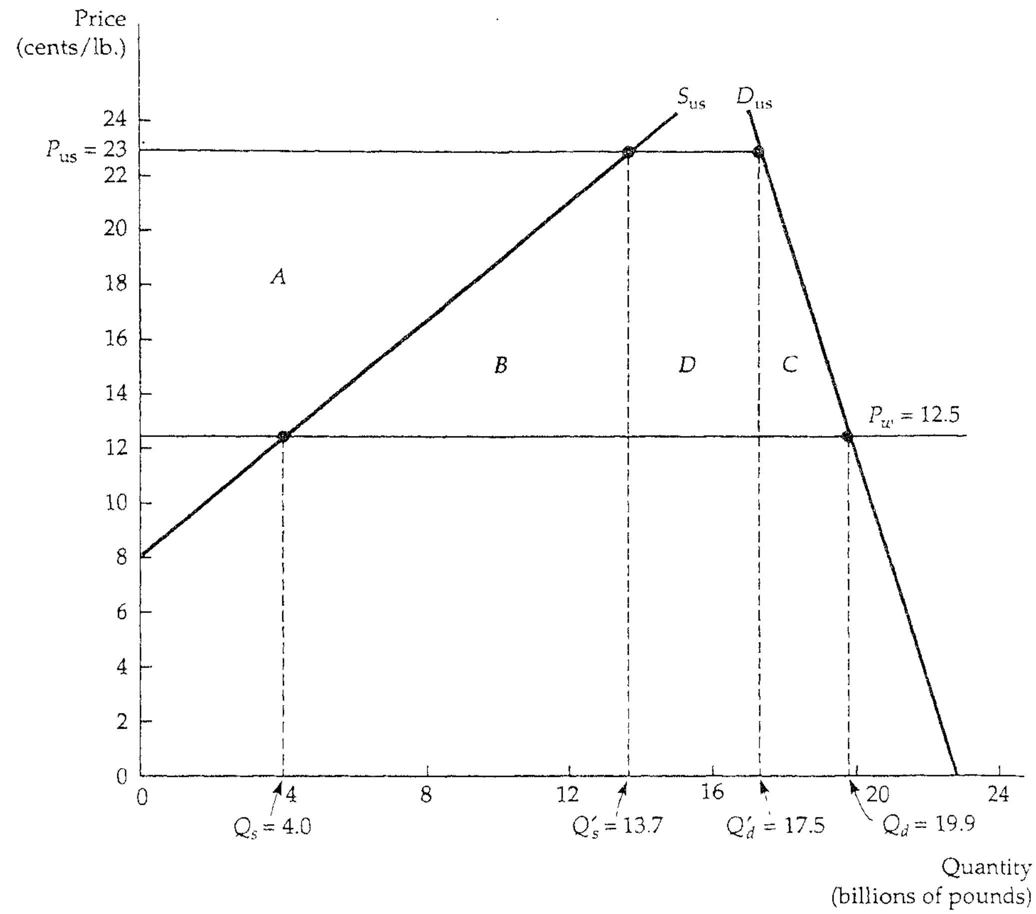

***FIGURE* 9.17 Impact of Sugar Quota in 1989.** At the world price of 12.5 cents per pound, about 20 billion pounds of sugar would have been consumed in the United States, of which all but 4 billion pounds would have been imported. By restricting imports to 3.8 billion pounds, the U.S. price was increased to 23 cents. The cost to consumers, $A + B + C + D$, was about $2 billion. The gain to domestic producers was trapezoid A, $929 million. Rectangle D, $399 million, was a gain to those foreign producers who obtained quota allotments. Triangles B and C represent the deadweight loss of $635 million.

What did this cost U.S. consumers? The lost consumer surplus is given by the sum of trapezoid A, triangles B and C, and rectangle D. You should go through the calculations to verify that trapezoid A is equal to $929 million, triangle B to $509 million, triangle C to $126 million, and rectangle D to $399 million, so that the total cost to consumers in 1989 was -about $2 billion.

How much did producers gain from this policy? Their increase in surplus is given by trapezoid A (i.e., $929 million). The $399 million of rectangle D was a gain for those foreign producers who succeeded in obtaining large allotments of the quota because they received a higher price for their sugar. Triangles B and C represent a deadweight loss of $635 million.

9.6 *The Impact of a Tax or Subsidy*

What would happen to the price of widgets if the government imposed a $1 tax on every widget sold? Many people would answer that the price would increase by a dollar, with consumers now paying a dollar more per widget than they would have paid without the tax. But this answer is wrong.

Or consider the following question. The government wants to impose a 50 cent per gallon tax on gasoline and is considering two methods of collecting the tax. Under Method 1, the owner of each gas station would deposit the tax money (50 cents times the number of gallons sold) in a locked box, for a government agent to collect. Under Method 2 the consumer would pay the tax (50 cents times the number of gallons purchased) directly to the government. Which method costs the consumer more? Many people would answer that Method 2 does, but this answer is also wrong.

The burden of a tax (or the benefit of a subsidy) falls partly on the consumer and partly on the producer. Furthermore, it really does not matter who puts the money in the collection box (or sends the check to the government)-Methods 1 and 2 above both cost the consumer the same amount of money. As we will see, the share of a tax borne by consumers depends on the shapes of the supply and demand curves, and in particular on the relative elasticities of supply and demand. As for our first question, a $1 tax on widgets would indeed cause the price of widgets to rise, but usually by *less* than a dollar, and sometimes by *much* less. To understand why, let us use supply and demand curves to see how consumers and producers are affected when a tax is imposed on a product, and what happens to price and quantity.

For simplicity we will consider a *specific tax*-a tax of a certain amount of money *per unit sold.* This is in contrast to an *ad valorem* (i.e., proportional) tax, such as a state sales tax. (The analysis of an ad valorem tax is roughly the same and yields the same qualitative results.) Examples of specific taxes include federal and state taxes on gasoline and cigarettes.

Suppose the government imposes a tax of t cents per unit on widgets. Assuming everyone obeys the law, the government must then receive t cents for every widget sold. *This means that the price the consumer pays must exceed the net price the seller receives by t cents.* Figure 9.18 illustrates this simple accounting relationship-and its implications. Here, P_0 and Q_0 represent the market price and quantity *before* the tax is imposed. P_b is the price that consumers pay, and P_s is the net price that sellers receive *after* the tax is imposed. Note that $P_b - P_s = t,$ so the government is happy.

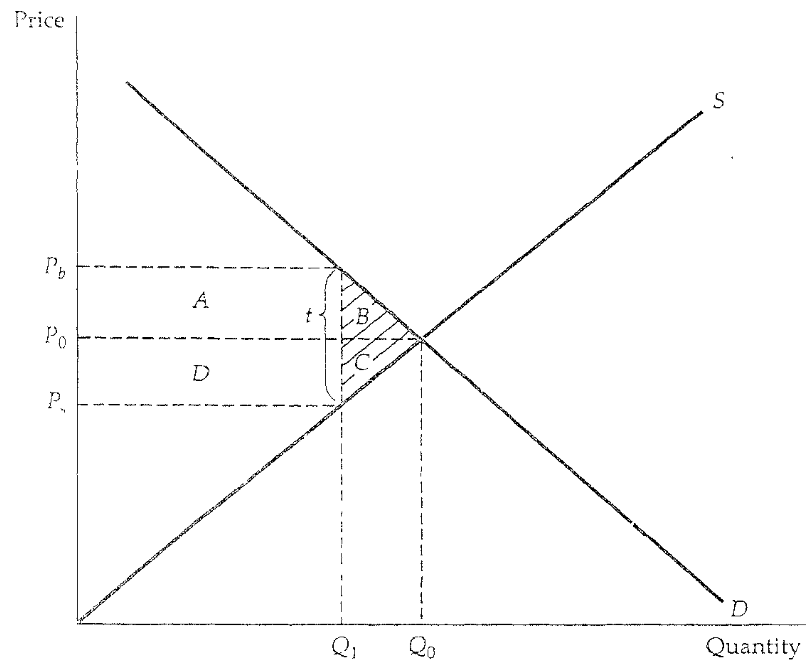

FIGURE 9.18 incidence of a Tax. Pb is the price (including the tax) paid by buyers. Ps is the price that sellers receive, net of the tax. Here the burden of the tax is split about evenly between buyers and sellers. Buyers lose A + B, sellers lose D + C, and the government earns A + D in revenue. The deadweight loss is B + C.

How do we determine what the market quantity will be after the tax is imposed, and how much of the tax is borne by consumers and how much by producers? First, remember that what consumers care about is the price that they must pay: P_b. The amount that consumers will buy is given by the demand curve; it is the quantity that we read off of the demand curve given a price P_b,. Similarly, what producers care about is the net price they receive. P_s. Given P_s, the quantity they will produce is read off the supply curve. Finally, we know that the quantity that producers sell must equal the quantity that consumers buy-a single quantity is bought and sold. The solution, then, is to find the quantity that corresponds to a price of P_b on the demand curve, and a price of P_s on the supply curve, such that the difference P_b - P_s is equal to the tax *t*. In Figure 9.18 this quantity is shown as Q_1.

Who bears the burden of the tax? In Figure 9.18, this burden is shared roughly equally by consumers and producers. The market price (the price consumers must pay) rises by half of the tax. And the price that producers receive falls by roughly half of the tax.

As Figure 9.18 shows, *four conditions* must be satisfied after the tax is in place. *First,* the quantity sold and the buyer's price P_b must lie on the demand curve (because consumers are interested only in the price they must pay). *Second,* the quantity sold and the seller's price P_s must lie on the supply curve (because producers are concerned only with the amount of money they receive net of the tax). *Third,* the quantity demanded must equal the quantity supplied (Q_1 in the figure). *And fourth,* the difference between the price the buyer pays and the price the seller receives must equal the tax t. These conditions can be summarized by the following four equations:

$$Q_D = Q_D(P_b) \tag{9.1a}$$

$$Q_S = Q_S(P_s) \tag{9.1b}$$

$$Q_D = Q_S \tag{9.1c}$$

$$P_b - P_s = t \tag{9.1d}$$

If we know the demand curve $Q_D(P_b)$, the supply curve $Q_S(P_s)$, and the size of the tax t, *we* can solve these equations for the buyers' price P_b, the sellers' price P_s, and the total quantity demanded and supplied. This task is not as difficult as it might seem, as we demonstrate in Example 9.6.

Figure 9.18 also shows that a tax results in a *deadweight loss.* Because buyers pay a higher price, there is a change in consumer surplus given by

$$\Delta CS = -A - B$$

And because sellers now receive a lower price, there is a change in producer surplus given by

$$\Delta PS = -C - D$$

Government tax revenue is tQ_1, the sum of rectangles A and D. The total change in welfare, ΔCS plus ΔPS plus the revenue to the government, is therefore $-A - B - C - D + A + D = -B - C$. Triangles B and C represent the deadweight loss from the tax.

In Figure 9.18 the burden of the tax is shared almost evenly between consumers and producers, but this is not always the case. If demand is relatively inelastic and, supply is relatively elastic, the burden of the tax will fall mostly on consumers. Figure 9.19a shows why: It takes a relatively large increase in price to get consumers to reduce demand by even a small amount, whereas only a small price decrease is needed to reduce the quantity producers supply. For example, because cigarettes are addictive, the elasticity of demand is small (about -0.3), so federal and state cigarette taxes are borne largely by consumers.[17] Figure 9.19b shows the opposite case: If demand is relatively elastic and supply is relatively inelastic, the burden of' the tax will fall mostly on producers.

So even if we have only estimates of the elasticities of demand and supply at a point or for a small range of prices and quantities, as opposed to the entire demand and supply curves, we can still roughly determine who will bear

[17] See Daniel A. Sumner and Michael K. Wohlgenant, "Effects of an Increase in the Federal Excise Tax on Cigarettes," *American Journal ofAgricultural Economics* 67 (May 1985): 235-242.

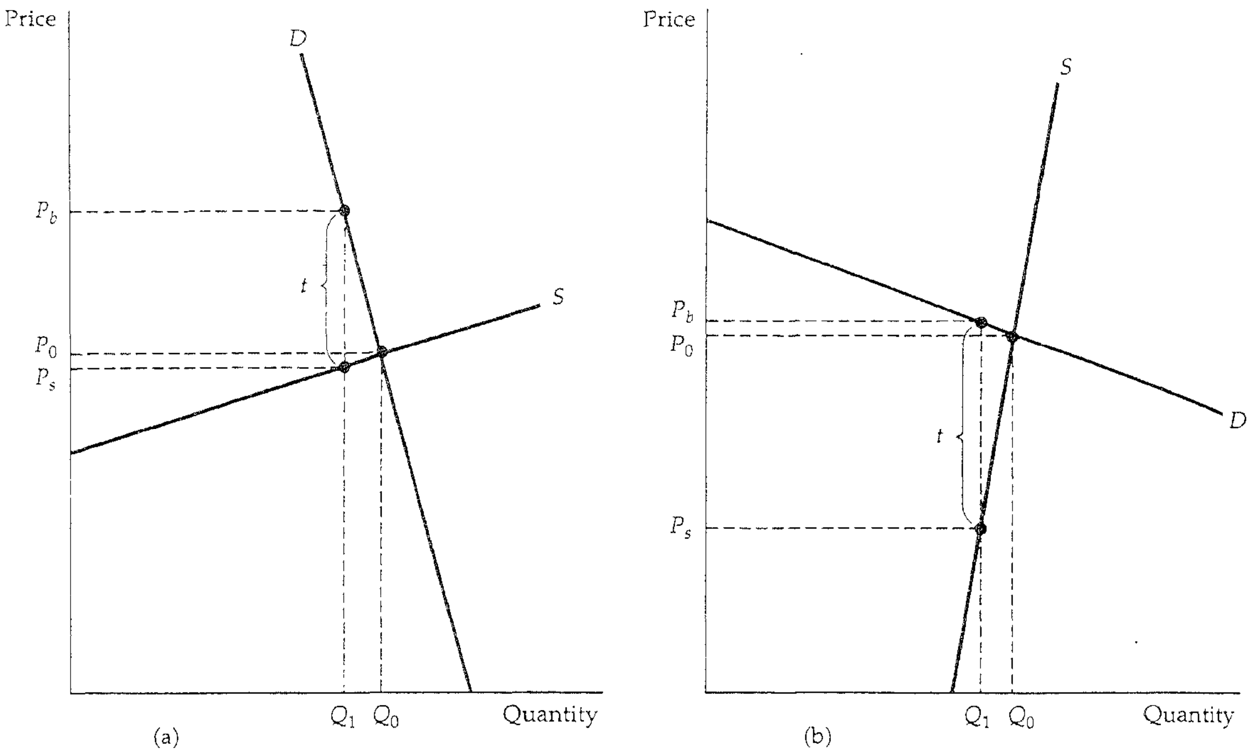

FIGURE 9.19 Impact of a Tax Depends on Elasticities of Supply and Demand. (a) If demand is very inelastic relative to supply, the burden of the tax falls mostly on buyers. (b) If demand is very elastic relative to supply, it falls mostly on sellers.

the greatest burden of a tax (whether the tax is actually in effect or is only under discussion as a policy option). In general, *a tax falls mostly on the buyer if* E_d/E_s *is small, and mostly on the seller if* E_d/E_s *is large.*

In fact, we can calculate the .percentage of the tax borne by producers and by consumers, using the following "pass-through" formula:

$$\text{Pass-through fraction} = E_s/(E_s - E_d)$$

This formula tells us what fraction of the tax is passed through to consumers in the form of higher prices.[18] For example, when demand is totally inelastic, so that E_d is zero, the pass-through fraction is 1, and all the tax is borne by consumers. And when demand is totally elastic, the pass-through fraction is zero, and producers bear all the tax.

A *subsidy* can be analyzed in much the same way as a tax-in fact, you can think of a subsidy as a *negative tax.* With a subsidy, the sellers' price *exceeds* the

[18] The fraction'of the tax borne byproducers is given by: $-E_d/(E_s - E_d)$.

buyers' price, and the difference between the two is the amount of the subsidy. As you would expect, the effect of a subsidy on the quantity produced and consumed is just the opposite of the effect of a tax-the quantity will increase.

Figure 9.20 illustrates this. At the presubsidy market price P_0, the elasticities of supply and demand are roughly equal; as a result, the benefit of the subsidy is shared roughly equally between consumers and producers. As with a tax, this is not always the case. In general, *the benefit of a subsidy accrues mostly to consumers if* E_d/E_s *is small, and mostly-to producers if* E_d/E_s *is large.*

As with a tax, given the supply curve, the demand curve, and the size of the subsidy s, one can solve for the resulting prices and quantity. The same four conditions apply for a subsidy as for a tax, but now the difference between the sellers' price and the buyers' price is equal to the subsidy. Again, we can write these conditions algebraically:

$$Q_D = Q_D(P_b) \quad (9.2a)$$

$$Q_S = Q_S(P_s) \quad (9.2b)$$

$$Q_D = Q_S \quad (9.2c)$$

$$P_s - P_b = s \quad (9.2d)$$

To make sure you understand how to analyze the impact of a tax or subsidy, you might find it helpful to work through one or two examples, such as Exercises 9.2 and 9.12 at the end of this chapter

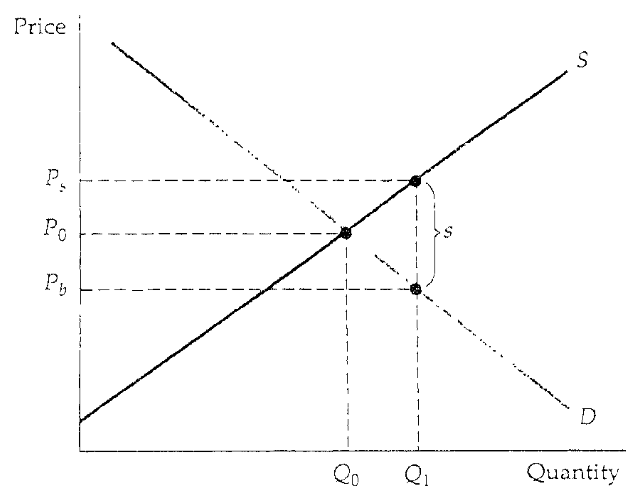

FIGURE 9.20 Subsidy. A subsidy can be thought of as a negative tax. Like a tax, the benefit of a subsidy is split between buyers and sellers, depending on the relative elasticities of supply and demand.

EXAMPLE 9.6 A TAX ON GASOLINE

During the 1980 presidential campaign, John Anderson, an independent candidate, proposed a 50 cent per gallon tax on gasoline. The idea or a gasoline tax, both to raise government revenue and to reduce oil consumption and U.S. dependence on oil imports, has been widely discussed since then, and became part of the Clinton Administration's 1993 budget package. Let's see how a 50 cent tax would affect the price and consumption of gasoline.

We will do this analysis in the setting of market conditions during the middle of 1986-when gasoline was selling for about $1 per gallon, and total consumption was about 100 billion gallons per year (bg/yr).[19] We will also use intermediate-run elasticities (i.e., -elasticities that would apply to a period or about three to six years after a price change).

A reasonable number for the intermediate-run elasticity of gasoline demand is -0.5 (see Example 2.4 in Chapter 2). We can use this elasticity figure, together with the $1 and 100 bg/yr price and quantity numbers, to calculate a linear demand curve for gasoline. (See Chapter 2, Section 2.5, to review how to do this.) You can verify that the following demand curve fits these data:

$$\textit{Gasoline Demand:} \quad Q_D = 150 - 50P$$

Gasoline is refined from crude oil, some of which is produced domestically and some imported. (Some gasoline is also imported directly.) The supply curve for gasoline will therefore depend on the world price of oil, on domestic oil supply, and on the cost of refining. The details are beyond the scope of this example, but a reasonable number for the elasticity of supply is 0.4. You should verify that this elasticity, together with the $1 and 100 bg/yr price and quantity, gives the following linear supply curve:

$$\textit{Gasoline Supply:} \quad Q_S = 60 + 40P$$

You should also verify that these demand and supply curves imply a market price of $1 and quantity of 100 bg/yr.

We can use these linear demand and supply curves to calculate the effect of a 50 cents per gallon tax. First, we write the four conditions that must hold, as given by equations (9.1a-d):

$Q_D = 150 - 50P_b$ (Demand)

$Q_S = 60 + 40P_S$ (Supply)

$Q_D = Q_S$ (Supply must equal demand)

$P_b - P_S = 0.50$ (Government must receive 50 cents/galion)

Now combine the first three equations to equate supply and demand:

[19] Of course, this price varied across regions and grades of gasoline, but we can ignore this here. Quantities of oil and oil products are often measured in barrels; there are 42 gallons in a barrel, so the 1986 quantity figure could also be written as 2.4 billion barrels per year.

$$150 - 50Pb = 60 + 40Ps$$

We can rewrite the last of the four equations as $P_b = P_s + 0.50$, and substitute this for P_b in the above equation:

$$150 - 50(P_s + 0.50) = 60 + 40P_s$$

Now we can rearrange this and solve for Ps:

$$50P_s + 40P_s = 150 - 25 - 60$$

$$90P_s = 65, \text{ or } P_s = .72$$

Remember that $P_b = P_s + 0.50$, so $P_b = 1.22$. Finally, we can determine the total quantity from either the demand or supply curve. Using the demand curve (and the price $P_b = 1.22$), we find that $Q = 150 - (50)(1.22) = 150 - 61$, or $Q = 89$ bg/yr. This represents an 11 percent decline in gasoline consumption. Figure 9.21 illustrates these calculations and the effect of the tax.

The burden of this tax would be split roughly evenly between consumers and producers; consumers would pay about 22 cents per gallon more for the gasoline they bought, and producers would receive about 28 cents per gallon less. It should not be surprising, then, that both consumers and producers op-

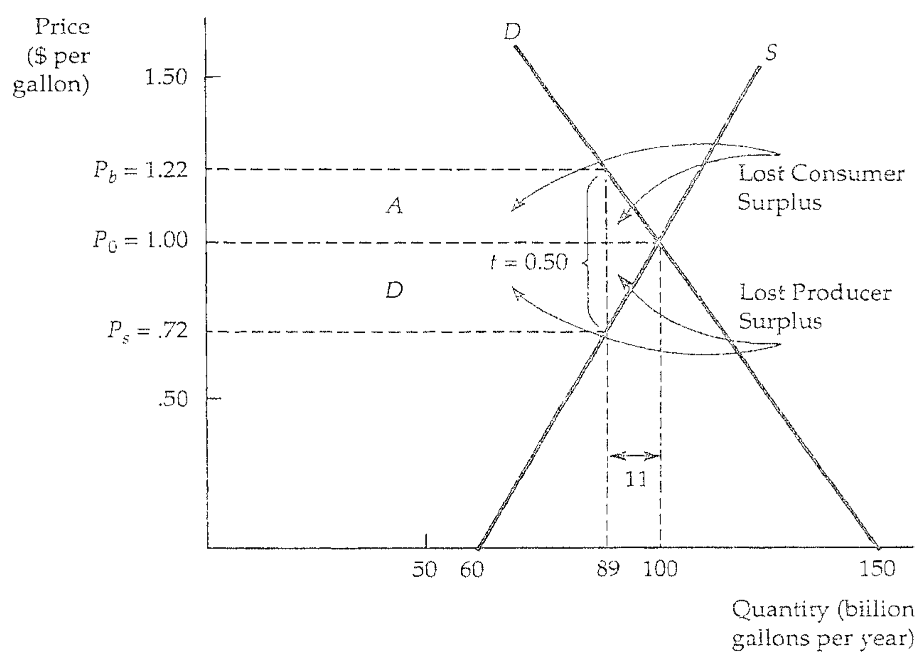

FIGURE 9.21 Impact of 50 Cent Gasoline Tax. The price of gasoline at the pump increases from \$1.00 per gallon to \$1.22, and the quantity sold falls from 100 to 89 billion gallons per year. The annual revenue from the tax of (0.50)(89) = \$44.5 billion. The *two* shaded triangles show the deadweight loss of \$2.75 billion per year.

posed such a tax, and politicians representing both groups fought the proposal every time it came up. But note that the tax would raise significant revenue for the government. The annual revenue from the tax would be $tQ = (0.50)(89) = \$44.5$ billion per year.

The cost to consumers and producers, however, will be more than the $44.5 billion in tax revenue. Figure 9.21 shows the deadweight loss from this tax as the two shaded triangles. The two rectangles *A* and *D* represent the total tax collected by the government, but the total loss of consumer and producer surplus is larger.

Before deciding whether a gasoline tax is desirable, it is important to know how large the resulting deadweight loss is likely to be. We can easily calculate this from Figure 9.21. Combining the two small triangles into one large one, we see that the area is

$$(\tfrac{1}{2}) \times (\$0.50/\text{gallon}) \times (11 \text{ billion gallons/year})$$
$$= \$2.75 \text{ billion per year}$$

This deadweight loss is about 6 percent of the government revenue resulting from the tax, and must be balanced against any additional benefits that the tax might bring.

Summary

1. Simple models of supply and demand can be used to analyze a wide variety of government policies. Specific policies that we have examined include price controls, minimum prices, price support programs, production quotas or incentive programs to limit output/ import tariffs and quotas, and taxes and subsidies.

2. In each case, consumer and producer surplus are used to evaluate the gains and losses to consumers and producers. Applying the methodology to natural gas price controls, airline regulation,price supports for wheat, and the sugar quota, we found that these gains and losses can be quite large.

3. When government imposes a tax or subsidy, price usually does not rise or fall by the full amount of the tax or subsidy Also, the incidence of a tax or subsidy is usually split between producers and consumers. The fraction that each group ends up paying or receiving depends on the relative elasticities of supply and demand.

4. Government intervention generally leads to a deadweight loss; even if consumer welfare and producer welfare are weighted equally, there will be a net loss from government policies that shifts welfare from one group to the other. In some cases this deadweight loss will be small, but in other cases-price supports and import quotas are examples-it is large. This deadweight loss is a form of economic inefficiency that must be taken into account when policies are designed and implemented.

5. Government intervention in a competitive market is not always a bad thing. Government-and the society it represents-might have other objectives besides economic efficiency. And there are situations in which government intervention can improve economic efficiency Examples are externalities and cases of market failure. These situations, and the way government can respond to them, are discussed in Chapters 17 and 18.

Questions for Review

1. What is meant by deadweight loss? Why does a price ceiling usually result in a deadweight loss?

2. Suppose the supply curve for a good was completely inelastic. If the government imposed a price ceiling below the market-clearing level, would a deadweight loss result? Explain.

3. How can a price ceiling make consumers better off? Under what conditions might it make them worse off?

4. Suppose the government regulates the price of a good to be no lower than some minimum level. Can such a minimum price make producers as a whole worse off? Explain.

5. How are production limits used in practice to raise the prices of the following goods or services: (i) taxi rides, (ii) drinks in a restaurant or bar, (iii) wheat or corn?

6. Suppose the government wants to increase farmers' incomes. Why do price supports or acreage limitation programs cost society more than simply giving the farmers money?

7. Suppose the government wants to limit imports of a certain good. Is it preferable to use an import quota or a tariff? Why?

8. The burden of a tax is shared by producers and consumers. Under what conditions will consumers pay most of the tax? Under what conditions will producers pay most of it? What determines the share of a subsidy that benefits consumers?

9. Why does a tax create a deadweight loss? What determines the size of this loss?

Exercises

1. Some people have suggested raising the minimum wage, perhaps with a government subsidy to employers to help finance the higher wage. This exercise examines the economics of a minimum wage and wage subsidies. Suppose the supply of labor is given by

$$L^S = 10w$$

where L_S is the quantity of labor (in millions of persons employed each year), and w is the wage rate (in dollars per hour). The demand for labor is given by

$$L^D = 60 - 10w$$

a. What will the free market wage rate and employment level be? Suppose the government sets a minimum wage of $4 per hour. How many people would then be employed?

b. Suppose that instead of a minimum wage, the government paid a subsidy of $1 per hour for each employee. What will the total level of employment be now? What will the equilibrium wage rate be?

2. Suppose the market for widgets can be described by the following equations:

Demand: $P = 10 - Q$

Supply: $P = Q - 4$

where P is the price in dollars per unit, and Q is the quantity in thousands of units. Then

a. What is the equilibrium price and quantity?
b. Suppose the government imposes a tax of $1 per unit to reduce widget consumption and raise government revenues. What will the new equilibrium quantity be? What price will the "buyer pay? What amount per unit will the seller receive?
c. Suppose the government has a change of heart about the importance of widgets to the happiness of the American public. The tax is removed, and a. subsidy of $1 per unit is granted to widget producers. What will the equilibrium quantity be? What price will the buyer pay? What amount per unit (including the subsidy) will the seller receive? What will be the total cost to the government?

3. Japanese rice producers have extremely high production costs, in part due to the high opportunity cost of land and to their inability to take advantage- of economies of large-scale production. Analyze two policies, intended to maintain Japanese rice production: (1) a per-pound subsidy to farmers for each pound of rice produced, or (2) a per-pound tariff on imported rice. Illustrate with supply-and-demand diagrams the equilibrium price and quantity, domestic rice production, government revenue or deficit, and deadweight loss from each policy. Which policy is the Japanese government likely to prefer? Which policy are Japanese farmers likely to prefer?

4. In 1983 the Reagan administration introduced a new agricultural program called the Payment-in-Kind Program. To examine how the program worked, let's consider the wheat market.
a. Suppose the demand function is $Q_D = 28 - 2P$ and the supply function is $Q_S = 4 + 4P$, where P is the price of wheat in dollars per bushel, and Q is the quantity in billions of bushels. Find the free-market equilibrium price and quantity.
b. Now suppose the government wants to lower the supply of wheat by 25 percent from the free-market equilibrium by paying farmers to withdraw land from production. However, the payment is made in wheat rather than in dollars-hence the name of the program. The wheat comes from the government's vast reserves that resulted from previous price support programs. The amount of wheat paid is equal to the amount that could have been harvested on the land withdrawn from production. Farmers are free to sell this wheat on the market How much is now produced by farmers? How much is indirectly supplied to the market by the government:? What is the new market price? How much do farmers gain? Do consumers gain or lose?
c. Had the government not given the wheat back to the farmers, it would have stored or destroyed it. Do taxpayers gain from the program? What potential problems does the program create?

5. About 100 million pounds of jelly beans are consumed in the United States each year, and the price has been about 50 cents per pound. However, jelly bean producers feel that their incomes are too low, and they have convinced the government that price supports are in order. The government will therefore buy up as many jelly beans as necessary to keep the price at $1 per pound. However, government economists are worried about the impact of this program, because they have no estimates of the elasticities of jelly bean demand or supply.
a. Could this program cost the government *more* than $50 million per year? Under what conditions? Could it cost *less* than $50 million per year? Under what conditions? Illustrate with a diagram.
b. Could this program cost consumers (in terms of lost consumer surplus) *more* than $50 million per year? Under what conditions? Could it cost consumers *less* than $50 million per year? Under what conditions? Again, use a diagram to illustrate.

6. A vegetable fiber is traded in a competitive world market, and the world price is $9 per pound. Unlimited quantities are available for import into the United States at this price. The U.S. domestic supply and demand for various price levels are shown below.

Price	U.S. Supply (million pounds)	U.S. Demand (million pounds)
3	2	34
6	4	28
9	6	22
12	8	16
15	10	10
18	12	4

Answer the following about the U.S. market:

a. What is the equation for demand? What is the equation for supply?
b. What is the price elasticity of demand at a price of $9? A price of $12?
c. What is the price elasticity of supply at a price of $9? A price of $12?
d. If there are no tariffs, quotas, or other trade restrictions in the United States, what will be the U.S. price and level of fiber imports?
e. If the United States imposes a tariff of $9 per pound, what will be the U.S. price and level of imports? How much revenue will the government earn from the tariff? How large is the deadweight loss?
f. If the United States has no tariff but imposes an import quota of 8 million pounds, what will be the U.S. domestic price? What is the cost of this quota for U.S. consumers of the fiber? What is the gain for U.S. producers?

7. A particular metal is traded in a highly competitive world market/ and the world price is $9 per ounce. Unlimited quantities are available for import into the United States at this price. The supply of this metal from domestic U.S. mines and mills can be represented by the equation $Q^S = \frac{2}{3}P$, where Q_S is U.S. output in million ounces, and P is the domestic price. The demand for the metal in the United States is $Q_D = 40 - 2P$, where Q_D *is* the domestic demand in million ounces.

In recent years the U.S. industry has been protected by a tariff of $9 per ounce. Under pressure from other foreign governments, the United States plans to reduce this tariff to zero. Threatened by this change, the U.S. industry is seeking a Voluntary Restraint Agreement that would limit imports into the United States to 8 million ounces per year.
a. Under the $9 tariff, what was the U.S. domestic price of the metal?
b. If the United States eliminates the tariff and the Voluntary Restraint Agreement is approved, what will be the U.S. domestic price of the metal?

8. Among the tax proposals regularly considered by Congress is an additional tax on distilled liquors. The tax would not apply to beer. The own-price elasticity of supply of liquor is 4.0, and the own-price elasticity of demand is -0.2. The cross-elasticity of demand for beer with respect to the price of liquor- is 0.1.
a. If the new tax is imposed, who will bear the greater burden, liquor suppliers or liquor con' sumers? Why?
b. How will the new tax affect the beer market/ assuming that beer supply is infinitely elastic?

9. In Example 9.1 we calculated the gains and losses from price controls on natural gas, and found that there was a deadweight loss of $1.4 billion. This calculation was based on a price of oil of $8 per barrel. If the price of oil had been $12 per barrel, what would the free-market price of gas be? How large a deadweight loss would have resulted if the maximum allowable price of natural gas had been $1.00 per thousand cubic feet?

10. Example 9.5 describes the effects of the sugar quota in 1989. At that time, imports were limited to 6.4 billion pounds, which pushed the price in the United States up to 22 cents per pound. Suppose imports had been limited to only 4 billion pounds and that the demand and supply functions were unchanged. What would the U.S. price have been as a result? By how much would domestic producers have gained and consumers have lost?

11. The domestic supply and demand curves for hula beans are as follows:

Supply: $P = 50 + Q$

Demand: $P = 200 - 2Q$

where P is the price in cents per pound, and Q is the quantity in millions of pounds. We are,a small country in the world hula bean market, where the current price (which will not be affected by anything we do), is 60 cents per pound. Congress is considering a tariff of 40 cents per pound. Find the domestic price of hula beans that will result if the tariff is imposed. Also compute the dollar gain or loss to domestic consumers, domestic producers, and government revenue from the tariff.

12. You know that if a tax is imposed on a particular product, the burden of the tax is shared by producers and consumers. You also know that the demand for automobiles is characterized by a stock adjustment process. Suppose a special 20 percent sales tax is suddenly imposed on automobiles. Will the share of the tax paid by consumers rise, fall, or stay the same over time? Explain briefly. Repeat for a 50-cents-per-gallon gasoline tax.