Chapter 9
The Analysis of Competitive Markets

■ Review Questions

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

Deadweight loss refers to the benefits lost by consumers and/or producers when markets do not operate efficiently. The term deadweight denotes that these are benefits unavailable to any party. A price ceiling set below the equilibrium price in a perfectly competitive market will result in a deadweight loss because it reduces the quantity supplied by producers. Both producers and consumers lose surplus because less of the good is produced and consumed. The reduced (ceiling) price benefits consumers but hurts producers, so there is a transfer from one group to the other. The real culprit, then, and the primary source of the deadweight loss, is the reduction in the amount of the good in the market.

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

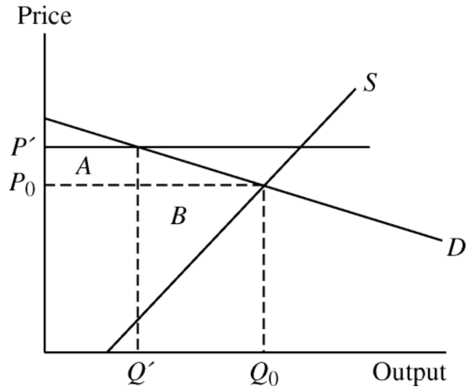
When the supply curve is completely inelastic, it is vertical. In this case there is no deadweight loss because there is no reduction in the amount of the good produced. The imposition of the price ceiling transfers all lost producer surplus to consumers. Consumer surplus increases by the difference between the market-clearing price and the price ceiling times the market-clearing quantity. Consumers capture all decreases in total revenue, and no deadweight loss occurs.

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

If the supply curve is highly inelastic a price ceiling will usually increase consumer surplus because the quantity available will not decline much, but consumers get to purchase the product at a reduced price. If the demand curve is inelastic, on the other hand, price controls may result in a net loss of consumer surplus because consumers who value the good highly are unable to purchase as much as they would like. (See Figure 9.3 on page 321 in the text.) The loss of consumer surplus is greater than the transfer of producer surplus to consumers. So consumers are made better off when demand is relatively elastic and supply is relatively inelastic, and they are made worse off when the opposite is true.

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.

With a minimum price set above the market-clearing price, some consumer surplus is transferred to producers because of the higher price, but some producer surplus is lost because consumers purchase less. If demand is highly elastic, the reduction in purchases can offset the higher price producers receive, making producers worse off. In the diagram below, the market-clearing price and quantity are P_0 and Q_0. The minimum price is set at P', and at this price consumers demand Q'. Assuming that suppliers produce Q' (and not the larger quantity indicated by the supply curve), producer surplus increases by area A due to the higher price, but decreases by the much larger area B because the quantity demanded drops sharply. The result is a reduction in producer surplus. Note that if suppliers produce more than Q', the loss in producer surplus is even greater because they will have unsold units.



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

Municipal authorities usually regulate the number of taxis through the issuance of licenses or medallions. When the number of taxis is less than it would be without regulation, those taxis in the market may charge a higher-than-competitive price.

State authorities usually regulate the number of liquor licenses. By requiring that any bar or restaurant that serves alcohol have a liquor license and then limiting the number of licenses available, the state limits entry by new bars and restaurants. This limitation allows those establishments that have a license to charge a higher-than-competitive price for alcoholic beverages.

Federal authorities usually regulate the number of acres of wheat or corn in production by creating acreage limitation programs that give farmers financial incentives to leave some of their acreage idle. This reduces supply, driving up the price of 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 farmers money?

Price supports and acreage limitations cost society more than the dollar cost of these programs because the higher price that results in either case will reduce quantity demanded and hence consumer surplus, leading to a deadweight loss because farmers are not able to capture the lost surplus. Giving farmers money does not result in any deadweight loss but is merely a redistribution of surplus from one group to the other.

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

Changes in domestic consumer and producer surpluses are the same under import quotas and tariffs. There will be a loss in (domestic) total surplus in either case. However, with a tariff, the government can collect revenue equal to the tariff times the quantity of imports, and these revenues can be redistributed in the domestic economy to offset some of the domestic deadweight loss. Thus there is

less of a loss to the domestic society as a whole with a tariff. With an import quota, foreign producers can capture the difference between the domestic and world price times the quantity of imports. Therefore, with an import quota, there is a loss to the domestic society as a whole. If the national government is trying to minimize domestic welfare loss, it should use a tariff.

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?

The burden of a tax and the benefits of a subsidy depend on the elasticities of demand and supply. If the absolute value of the ratio of the elasticity of demand to the elasticity of supply is small, the burden of the tax falls mainly on consumers. If the ratio is large, the burden of the tax falls mainly on producers. Similarly, the benefit of a subsidy accrues mostly to consumers (producers) if the ratio of the elasticity of demand to the elasticity of supply is small (large) in absolute value.

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

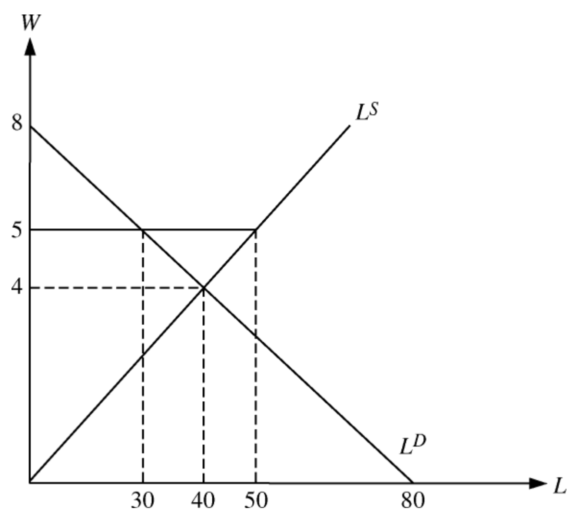
A tax creates deadweight loss by artificially increasing price above the free market level, thus reducing the equilibrium quantity. This reduction in quantity reduces consumer as well as producer surplus. The size of the deadweight loss depends on the elasticities of supply and demand and on the size of the tax. The more elastic supply and demand are, the larger will be the deadweight loss. Also, the larger the tax, the greater the deadweight loss.

■ Exercises

1. From time to time, Congress has raised the minimum wage. Some people suggested that a government subsidy could help employers finance the higher wage. This exercise examines the economics of a minimum wage and wage subsidies. Suppose the supply of low-skilled labor is given by $L^S = 10w$, where L^S is the quantity of low-skilled 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 $L^D = 80 - 10w$.

a. What will be the free-market wage rate and employment level? Suppose the government sets a minimum wage of $5 per hour. How many people would then be employed?

In a free-market equilibrium, $L^S = L^D$. Solving yields $w = \$4$ and $L^S = L^D = 40$. If the minimum wage is \$5, then $L^S = 50$ and $L^D = 30$. The number of people employed will be given by the labor demand, so employers will hire only 30 million workers.



b. Suppose that instead of a minimum wage, the government pays 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?

Let w_s denote the wage received by the sellers (i.e., the employees), and w_b the wage paid by the buyers (the firms). The new equilibrium occurs where the vertical difference between the supply and demand curves is $1 (the amount of the subsidy). This point can be found where

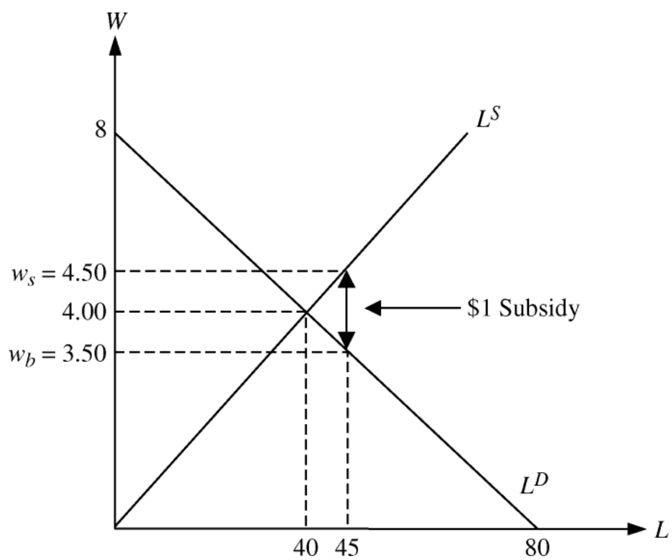
$$L^D(w_b) = L^S(w_s), \text{ and}$$

$$w_s - w_b = 1.$$

Write the second equation as $w_b = w_s - 1$. This reflects the fact that firms pay $1 less than the wage received by workers because of the subsidy. Substitute for w_b in the demand equation: $L^D(w_b) = 80 - 10(w_s - 1)$, so

$$L^D(w_b) = 90 - 10w_s.$$

Note that this is equivalent to an upward shift in demand by the amount of the $1 subsidy. Now set the new demand equal to supply: $90 - 10w_s = 10w_s$. Therefore, $w_s = \$4.50$, and $L^D = 90 - 10(4.50) = 45$. Employment increases to 45 (compared to 30 with the minimum wage), but wage drops to $4.50 (compared to $5.00 with the minimum wage). The net wage the firm pays falls to $3.50 due to the subsidy.



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?

Equate supply and demand and solve for Q: $10 - Q = Q - 4$. Therefore $Q = 7$ thousand widgets.

Substitute Q into either the demand or the supply equation to obtain P.

$$P = 10 - 7 = \$3.00,$$

or

$$P = 7 - 4 = \$3.00.$$

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?

With the imposition of a $1.00 tax per unit, the price buyers pay is $1 more than the price suppliers receive. Also, at the new equilibrium, the quantity bought must equal the quantity supplied. We can write these two conditions as

$$P_b - P_s = 1$$

$$Q_b = Q_s.$$

Let Q with no subscript stand for the common value of Q_b and Q_s. Then substitute the demand and supply equations for the two values of P:

$$(10 - Q) - (Q - 4) = 1$$

Therefore, $Q = 6.5$ thousand widgets. Plug this value into the demand equation, which is the equation for P_b, to find $P_b = 10 - 6.5 = \$3.50$. Also substitute $Q = 6.5$ into the supply equation to get $P_s = 6.5 - 4 = \$2.50$.

The tax raises the price in the market from $3.00 (as found in part a) to $3.50. Sellers, however, receive only $2.50 after the tax is imposed. Therefore the tax is shared equally between buyers and sellers, each paying $0.50.

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 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?

Now the two conditions that must be satisfied are

$$P_s - P_b = 1$$

$$Q_b = Q_s.$$

As in part b, let Q stand for the common value of quantity. Substitute the supply and demand curves into the first condition, which yields

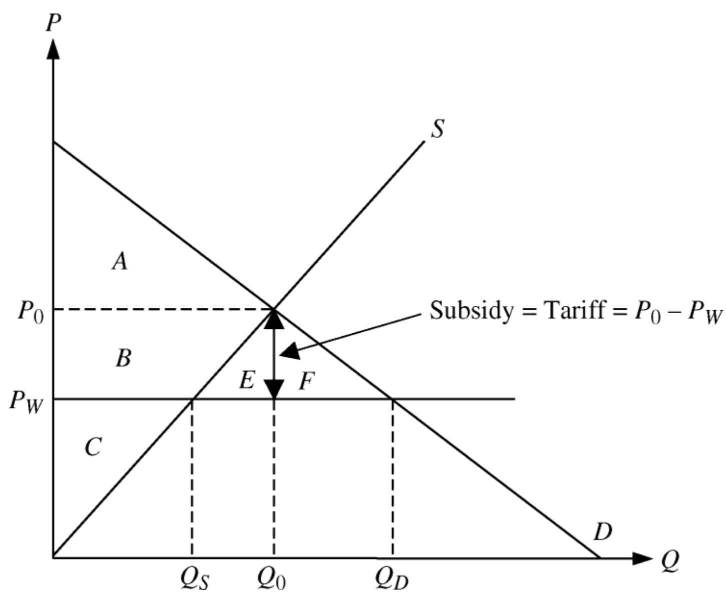
$$(Q - 4) - (10 - Q) = 1.$$

Therefore, $Q = 7.5$ thousand widgets. Using this quantity in the supply and demand equations, suppliers will receive $P_s = 7.5 - 4 = \$3.50$, and buyers will pay $P_b = 10 - 7.5 = \$2.50$. The total cost to the government is the subsidy per unit multiplied by the number of units. Thus the cost is ($1)(7.5) = $7.5 thousand, or $7500.

3. Japanese rice producers have extremely high production costs, due in part 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?

We have to make some assumptions to answer this question. If you make different assumptions, you may get different answers. Assume that initially the Japanese rice market is open, meaning that foreign producers and domestic (Japanese) producers both sell rice to Japanese consumers. The world price of rice is P_W. This price is below P_0, which is the equilibrium price that would occur in the Japanese market if no imports were allowed. In the diagram below, S is the domestic supply, D is the domestic demand, and Q_0 is the equilibrium quantity that would prevail if no imports were allowed. The horizontal line at P_W is the world supply of rice, which is assumed to be perfectly elastic. Initially Japanese consumers purchase Q_D rice at the world price. Japanese farmers supply Q_S at that price, and $Q_D - Q_S$ is imported from foreign producers.

Now suppose the Japanese government pays a subsidy to Japanese farmers equal to the difference between P_0 and P_W. Then Japanese farmers would sell rice on the open market for P_W plus receive the subsidy of $P_0 - P_W$. Adding these together, the total amount Japanese farmers would receive is P_0 per pound of rice. At this price they would supply Q_0 pounds of rice. Consumers would still pay P_W and buy Q_D. Foreign suppliers would import $Q_D - Q_0$ pounds of rice. This policy would cost the government $(P_0 - P_W)Q_0$, which is the subsidy per pound times the number of pounds supplied by Japanese farmers. It is represented on the diagram as areas $B + E$. Producer surplus increases from area C to $C + B$, so $\Delta PS = B$. Consumer surplus is not affected and remains as area $A + B + E + F$. Deadweight loss is area E, which is the cost of the subsidy minus the gain in producer surplus.



Instead, suppose the government imposes a tariff rather than paying a subsidy. Let the tariff be the same size as the subsidy, $P_0 - P_W$. Now foreign firms importing rice into Japan will have to sell at the world price plus the tariff: $P_W + (P_0 - P_W) = P_0$. But at this price, Japanese farmers will supply Q_0, which is exactly the amount Japanese consumers wish to purchase. Therefore there will be no imports, and the government will not collect any revenue from the tariff. The increase in producer surplus equals area B, as it is in the case of the subsidy. Consumer surplus is area A, which is less than it is under the subsidy because consumers pay more (P_0) and consume less (Q_0). Consumer surplus decreases by $B + E + F$. Deadweight loss is $E + F$: the difference between the decrease in consumer surplus and the increase in producer surplus.

Under the assumptions made here, it seems likely that producers would not have a strong preference for either the subsidy or the tariff, because the increase in producer surplus is the same under both policies. The government might prefer the tariff because it does not require any government expenditure. On the other hand, the tariff causes a decrease in consumer surplus, and government officials who are elected by consumers might want to avoid that. Note that if the subsidy and tariff amounts were smaller than assumed above, some tariffs would be collected, but we would still get the same basic results.

4. In 1983, the Reagan Administration introduced a new agricultural program called the Payment-in-Kind Program. To see 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.

Equating demand and supply, $Q^D = Q^S$,

$$28 - 2P = 4 + 4P, \text{ or } P = \$4.00 \text{ per bushel.}$$

To determine the equilibrium quantity, substitute $P = 4$ into either the supply equation or the demand equation:

$$Q^S = 4 + 4(4) = 20 \text{ billion bushels}$$

and

$$Q^D = 28 - 2(4) = 20 \text{ billion bushels.}$$

b. Now suppose the government wants to lower the supply of wheat by 25% 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 vast government reserves accumulated 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?

Because the free-market supply by farmers is 20 billion bushels, the 25% reduction required by the new Payment-In-Kind (PIK) Program means that the farmers now produce 15 billion bushels. To encourage farmers to withdraw their land from cultivation, the government must give them 5 billion bushels of wheat, which they sell on the market, so 5 billion bushels are indirectly supplied by the government.

Because the total quantity supplied to the market is still 20 billion bushels, the market price does not change; it remains at \$4 per bushel. Farmers gain because they incur no costs for the 5 billion bushels received from the government. We can calculate these cost savings by taking the area under the supply curve between 15 and 20 billion bushels. These are the variable costs of producing the last 5 billion bushels that are no longer grown under the PIK Program. To find this area, first determine the prices when $Q = 15$ and when $Q = 20$. These values are $P = \$2.75$ and $P = \$4.00$. The total cost of producing the last 5 billion bushels is therefore the area of a trapezoid with a base of $20 - 15 = 5$ billion and an average height of $(2.75 + 4.00)/2 = 3.375$. The area is $5(3.375) =$ \$16.875 billion, which is the amount farmers gain under the program.

The PIK program does not affect consumers in the wheat market because they purchase the same amount at the same price as they did in the free-market case.

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?

Taxpayers gain because the government does not incur costs to store or destroy the wheat. Although everyone seems to gain from the PIK program, it can only last while there are government wheat reserves. The program assumes that land removed from production may be restored to production when stockpiles of wheat are exhausted. If this cannot be done, consumers may eventually pay more for wheat-based products. Another potential problem is verifying that the land taken out of production is in fact capable of producing the amount of wheat paid to farmers under the PIK program. Farmers may try to game the system by removing less productive land.

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 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.**

   If the quantities demanded and supplied are very responsive to price changes, then a government program that doubles the price of jelly beans could easily cost more than $50 million. In this case, the change in price will cause a large change in quantity supplied, and a large change in quantity demanded. In Figure 9.5.a.i, the cost of the program is ($1)($Q_S - Q_D$). If $Q_S - Q_D$ is larger than 50 million, then the government will pay more than $50 million. If instead supply and demand are relatively inelastic, then the increase in price would result in small changes in quantity supplied and quantity demanded, and ($Q_S - Q_D$) would be less than $50 million as illustrated in Figure 9.5.a.ii.

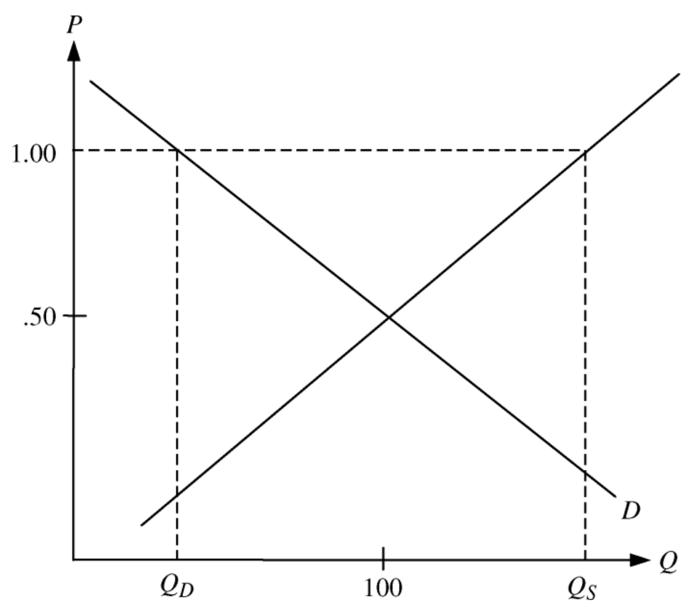


Figure 9.5.a.i

We can determine the combinations of supply and demand elasticities that yield either result. The elasticity of supply is $E_S = (\%\Delta Q_S)/(\%\Delta P)$, so the percentage change in quantity supplied is $\%\Delta Q_S = E_S(\%\Delta P)$. Since the price increase is 100% (from $0.50 to $1.00), $\%\Delta Q_S = 100E_S$. Likewise, the percentage change in quantity demanded is $\%\Delta Q_D = 100E_D$. The gap between Q_D and Q_S in percentage terms is $\%\Delta Q_S - \%\Delta Q_D = 100E_S - 100E_D = 100(E_S - E_D)$. If this gap is exactly 50% of the current 100 million pounds of jelly beans, the gap will be 50 million pounds, and the cost of the price support program will be exactly $50 million. So the program will cost $50 million if $100(E_S - E_D) = 50$, or

$(E_S - E_D) = 0.5$. If the difference between the elasticities is greater than one half, the program will cost more than \$50 million, and if the difference is less than one half, the program will cost less than \$50 million. So the supply and demand can each be fairly inelastic (for example, 0.3 and –0.4) and still trigger a cost greater than \$50 million.

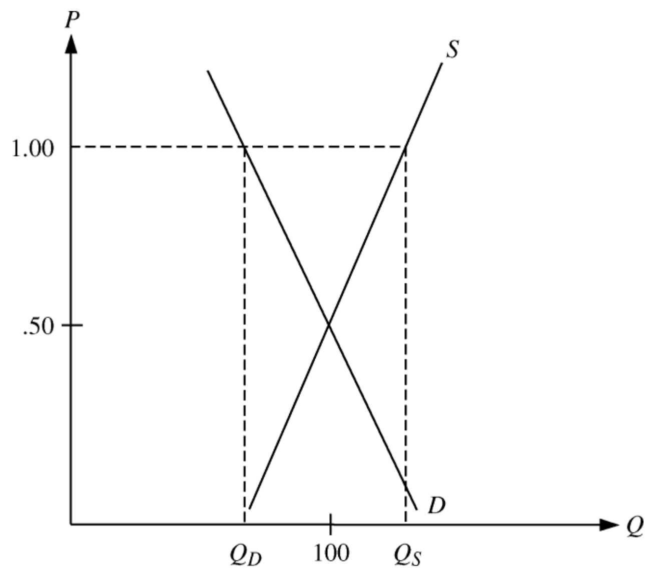


Figure 9.5.a.ii

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.

When the demand curve is perfectly inelastic, the loss in consumer surplus is \$50 million, equal to (\$0.50)(100 million pounds). This represents the highest possible loss in consumer surplus, so the loss cannot be more than \$50 million per year. If the demand curve has any elasticity at all, the loss in consumer surplus will be less than \$50 million. In Figure 9.5.b, the loss in consumer surplus is area *A* plus area *B* if the demand curve is the completely inelastic *D* and only area *A* if the demand curve is *D*′.

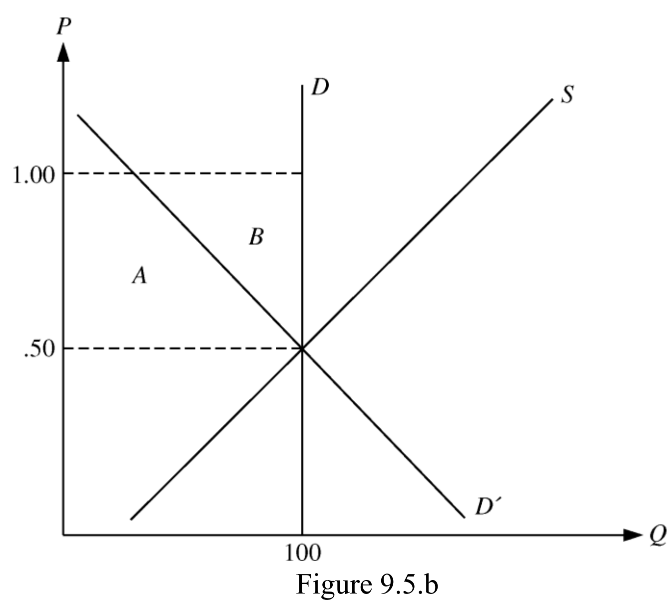


Figure 9.5.b

6. In Exercise 4 in Chapter 2 (page 62), we examined a vegetable fiber traded in a competitive world market and imported into the United States at a world price of $9 per pound. U.S. domestic supply and demand for various price levels are shown in the following table.

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 questions about the U.S. market:

a. Confirm that the demand curve is given by $Q_D = 40 - 2P$, and that the supply curve is given by $Q_S = \frac{2}{3}P$.

To find the equation for demand, we need to find a linear function $Q_D = a + bP$ so that the line it represents passes through two of the points in the table such as (15, 10) and (12, 16). First, the slope, b, is equal to the "rise" divided by the "run,"

$$\frac{\Delta Q}{\Delta P} = \frac{10-16}{15-12} = -2 = b.$$

Second, substitute for b and one point, e.g., (15, 10), into the linear function to solve for the constant, a:

$$10 = a - 2(15), \text{ or } a = 40.$$

Therefore, $Q_D = 40 - 2P$.

Similarly, solve for the supply equation $Q_S = c + dP$ passing through two points such as (6, 4) and (3, 2). The slope, d, is

$$\frac{\Delta Q}{\Delta P} = \frac{4-2}{6-3} = \frac{2}{3}.$$

Solving for c:

$$4 = c + \left(\frac{2}{3}\right)(6), \text{ or } c = 0.$$

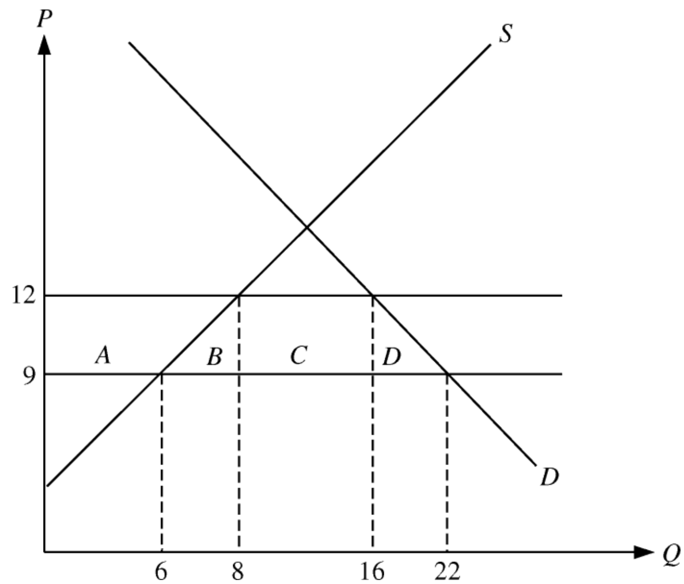
Therefore, $Q_S = \left(\frac{2}{3}\right)P$.

b. Confirm that if there were no restrictions on trade, the United States would import 16 million pounds.

If there were no trade restrictions, the world price of $9.00 would prevail in the United States. From the table, we see that at $9.00 domestic supply would be 6 million pounds. Similarly, domestic demand would be 22 million pounds. Imports provide the difference between domestic demand and domestic supply, so imports would be 22 – 6 = 16 million pounds.

c. If the United States imposes a tariff of $3 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?

With a $3.00 tariff, the U.S. price will be $12 (the world price plus the tariff). At this price, demand is 16 million pounds and U.S. supply is 8 million pounds, so imports are 8 million pounds (16 – 8). The government will collect $3(8) = $24 million, which is area *C* in the diagram below. To find deadweight loss, we must determine the changes in consumer and producer surpluses. Consumers lose area *A* + *B* + *C* + *D* because they pay the higher price of $12 and purchase fewer pounds of the fiber. U.S. producers gain area *A* because of the higher price and the greater quantity they sell. So the deadweight loss is the loss in consumer surplus minus the gain in producer surplus and the tariff revenue. Therefore, DWL = *B* + *D* = 0.5(12 – 9)(8 – 6) + 0.5(12 – 9)(22 – 16) = $12 million.



d. 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?

With an import quota of 8 million pounds, the domestic price will be $12. At $12, the difference between domestic demand and domestic supply is 8 million pounds, i.e., 16 million pounds minus 8 million pounds. Note you can also find the equilibrium price by setting demand equal to supply plus the quota so that

$$40 - 2P = \frac{2}{3}P + 8.$$

The cost of the quota to consumers is equal to area *A* + *B* + *C* + *D* in the figure above, which is the reduction in consumer surplus. This equals

$$(12 - 9)(16) + (0.5)(12 - 9)(22 - 16) = \$57 \text{ million.}$$

The gain to domestic producers (increase in producer surplus) is equal to area *A*, which is

$$(12 - 9)(6) + (0.5)(8 - 6)(12 - 9) = \$21 \text{ million.}$$

7. The United States currently imports all of its coffee. The annual demand for coffee by U.S. consumers is given by the demand curve $Q = 250 - 10P$, where Q is quantity (in millions of pounds) and P is the market price per pound of coffee. World producers can harvest and ship coffee to U.S. distributors at a constant marginal (= average) cost of \$8 per pound. U.S. distributors can in turn distribute coffee for a constant \$2 per pound. The U.S. coffee market is competitive. Congress is considering a tariff on coffee imports of \$2 per pound.

a. If there is no tariff, how much do consumers pay for a pound of coffee? What is the quantity demanded?

If there is no tariff then consumers will pay \$10 per pound of coffee, which is found by adding the \$8 that it costs to import the coffee plus the \$2 that it costs to distribute the coffee in the United States. In a competitive market, price is equal to marginal cost. At a price of \$10, the quantity demanded is 150 million pounds.

b. If the tariff is imposed, how much will consumers pay for a pound of coffee? What is the quantity demanded?

Now add \$2 per pound tariff to marginal cost, so price will be \$12 per pound, and quantity demanded is $Q = 250 - 10(12) = 130$ million pounds.

c. Calculate the lost consumer surplus.

Lost consumer surplus is $(12 - 10)(130) + 0.5(12 - 10)(150 - 130) = \$280$ million.

d. Calculate the tax revenue collected by the government.

The tax revenue is equal to the tariff of \$2 per pound times the 130 million pounds imported. Tax revenue is therefore \$260 million.

e. Does the tariff result in a net gain or a net loss to society as a whole?

There is a net loss to society because the gain (\$260 million) is less than the loss (\$280 million).

8. A particular metal is traded in a highly competitive world market at a world price of \$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 $Q^S = 2/3P$, 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?

With a \$9 tariff, the price of the imported metal in the U.S. market would be \$18; the \$9 tariff plus the world price of \$9. The \$18 price, however, is above the domestic equilibrium price. To determine the domestic equilibrium price, equate domestic supply and domestic demand:

$$\frac{2}{3}P = 40 - 2P, \text{ or } P = \$15.$$

Because the domestic price of $15 is less than the world price plus the tariff, $18, there will be no imports. The equilibrium quantity is found by substituting the price of $15 into either the demand or supply equation. Using demand,

$$Q^D = 40 - (2)(15) = 10 \text{ million ounces.}$$

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?

With the voluntary restraint agreement, the difference between domestic supply and domestic demand would be limited to 8 million ounces, i.e., $Q^D - Q^S = 8$. To determine the domestic price of the metal, set $Q^D - Q^S = 8$ and solve for P:

$$(40 - 2P) - \frac{2}{3}P = 8, \text{ or } P = \$12.$$

At a U.S. domestic price of $12, $Q^D = 16$ and $Q^S = 8$; the difference of 8 million ounces will be supplied by imports.

9. Among the tax proposals regularly considered by Congress is an additional tax on distilled liquors. The tax would not apply to beer. The price elasticity of supply of liquor is 4.0, and the 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 consumers? Why?

The fraction of the tax borne by consumers is given in Section 9.6 as $\frac{E_S}{E_S - E_D}$, where E_S is the own-price elasticity of supply and E_D is the own-price elasticity of demand. Substituting for E_S and E_D, the pass-through fraction is

$$\frac{4}{4 - (-0.2)} = \frac{4}{4.2} \approx 0.95.$$

Therefore, just over 95% of the tax is passed through to consumers because supply is highly elastic while demand is very inelastic. So liquor consumers will bear almost all the burden of the tax.

b. Assuming that beer supply is infinitely elastic, how will the new tax affect the beer market?

With an increase in the price of liquor (from the large pass-through of the liquor tax), some consumers will substitute away from liquor to beer because the cross-elasticity is positive. This will shift the demand curve for beer outward. With an infinitely elastic supply for beer (a horizontal supply curve), the equilibrium price of beer will not change, and the quantity of beer consumed will increase.

10. In Example 9.1 (page 322), we calculated the gains and losses from price controls on natural gas and found that there was a deadweight loss of $5.68 billion. This calculation was based on a price of oil of $50 per barrel.

a. If the price of oil were $60 per barrel, what would be the free-market price of gas? How large a deadweight loss would result if the maximum allowable price of natural gas were $3.00 per thousand cubic feet?

From Example 9.1, we know that the supply and demand curves for natural gas can be approximated as follows:

$$Q_S = 15.90 + 0.72P_G + 0.05P_O$$

and

$$Q_D = 0.02 - 1.8P_G + 0.69P_O,$$

where 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).

With the price of oil at $60 per barrel, these curves become,

$$Q_S = 18.90 + 0.72P_G$$

and

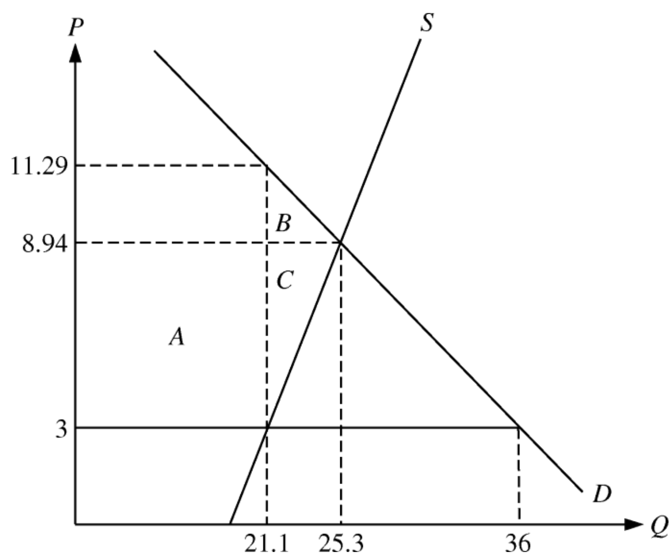
$$Q_D = 41.42 - 1.8P_G.$$

Setting quantity demanded equal to quantity supplied, find the free-market equilibrium price:

$$18.90 + 0.72P_G = 41.42 - 1.8P_G, \text{ or } P_G = \$8.94.$$

At this price, the equilibrium quantity is 25.3 trillion cubic feet (Tcf).

If a price ceiling of $3 is imposed, producers would supply only 18.9 + 0.72(3) = 21.1 Tcf, although consumers would demand 41.42 – 1.8(3) = 36.0 Tcf. See the diagram below. Area *A* is transferred from producers to consumers. The deadweight loss is *B* + *C*. To find area *B* we must first determine the price on the demand curve when quantity equals 21.1. From the demand equation, 21.1 = 41.42 – $1.8P_G$. Therefore P_G = $11.29. Area *B* equals (0.5)(25.3 – 21.1)(11.29 – 8.94) = $4.9 billion, and area *C* is (0.5)(25.3 – 21.1)(8.94 – 3) = $12.5 billion. The deadweight loss is 4.9 + 12.5 = $17.4 billion.



b. What price of oil would yield a free-market price of natural gas of $3?

Set the original supply and demand equal to each other, and solve for P_O.

$$15.90 + 0.72P_G + 0.05P_O = 0.02 - 1.8P_G + 0.69P_O$$

$$0.64P_O = 15.88 + 2.52P_G$$

Substitute \$3 for the price of natural gas. Then

$$0.64P_O = 15.88 + 2.52(3), \text{ or } P_O = \$36.63.$$

11. Example 9.6 (page 342) describes the effects of the sugar quota. In 2011, imports were limited to 6.9 billion pounds, which pushed the domestic price to 36 cents per pound. Suppose imports were expanded to 10 billion pounds.

a. What would be the new U.S. domestic price?

Example 9.6 gives equations for the total market demand for sugar in the U.S. and the supply of U.S. producers:

$$Q_D = 29.73 - 0.19P$$

$$Q_S = -7.95 + 0.66P.$$

The difference between the domestic quantities demanded and supplied, $Q_D - Q_S$, is the amount of imported sugar that is restricted by the quota. If the quota is increased to 10 billion pounds, then $Q_D - Q_S = 10$ and we can solve for P:

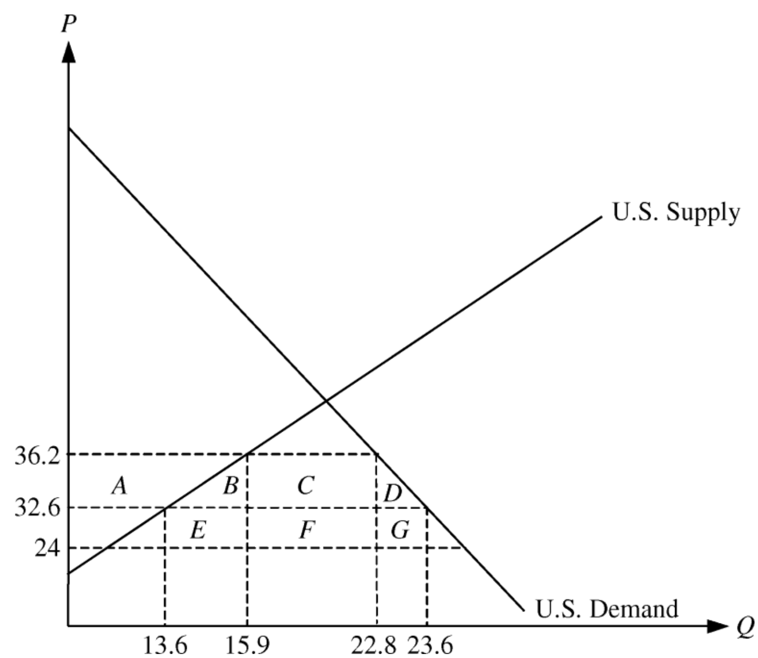
$$(29.73 - 0.19P) - (-7.95 + 0.66P) = 10$$

$$37.68 - 0.85P = 10$$

$$P = 32.6 \text{ cents per pound.}$$

At a price of 32.6 cents per pound, $Q_S = -7.95 + 0.66(32.6) = 13.6$ billion pounds, and $Q_D = Q_S + 10 = 13.6 + 10 = 23.6$ billion pounds.

b. How much would consumers gain and domestic producers lose?



The gain in consumer surplus is $A + B + C + D$. The loss to domestic producers is area A. The areas in billions of cents (i.e., tens of millions of dollars) are:

$A = (13.6)(36.2 - 32.6) + (0.5)(15.9 - 13.6)(36.2 - 32.6) = 53.10$

$B = (0.5)(15.9 - 13.6)(36.2 - 32.6) = 4.14$

$C = (22.8 - 15.9)(36.2 - 32.6) = 24.84$

$D = (0.5)(23.6 - 22.8)(36.2 - 32.6) = 1.44$

Thus, consumer surplus increases by 83.52, or \$835.2 million, while domestic producer surplus decreases by 53.1, or \$531 million.

c. What would be the effect on deadweight loss and foreign producers?

Domestic deadweight loss decreases by the difference between the increase in consumer surplus and the decrease in producer surplus, which is \$835.2 − 531.0 = \$304.2 million.

When the quota was 6.9 billion pounds, the profit earned by foreign producers was the difference between the domestic price and the world price (36.2 − 24) times the 6.9 billion units sold, for a total of 84.18, or \$841.8 million. When the quota is increased to 10 billion pounds, domestic price falls to 32.6 cents per pound, and profit earned by foreigners is (32.6 − 24)(10) = 86, or \$860 million. Profit earned by foreigners therefore increases by \$18.2 million. On the diagram above, this is area $(E + F + G) - (C + F) = E + G - C$. The deadweight loss of the quota, including foreign producer surplus, decreases by area $B + D + E + G$. Area $E = 19.78$ and $G = 6.88$, so the decrease in deadweight loss = 4.14 + 1.44 + 19.78 + 6.88 = 32.24, or \$322.4 million.

12. 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. The U.S. is a small producer 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.

To analyze the influence of a tariff on the domestic hula bean market, start by solving for domestic equilibrium price and quantity. First, equate supply and demand to determine equilibrium quantity without the tariff:

$$50 + Q = 200 - 2Q, \text{ or } Q_{EQ} = 50.$$

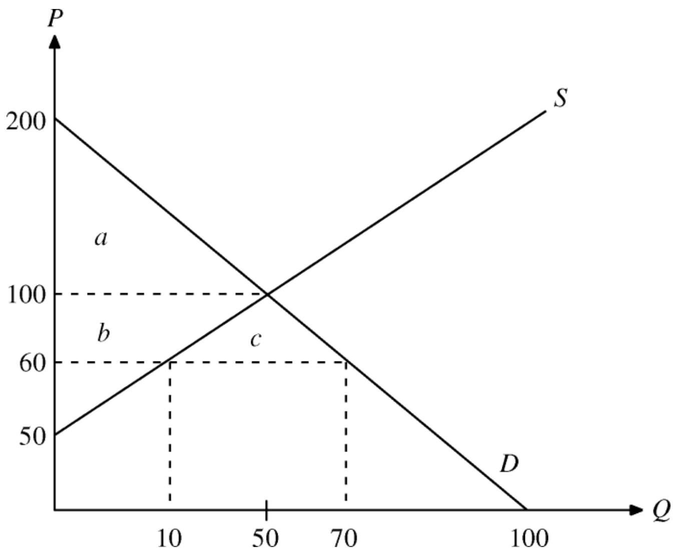
Thus the equilibrium quantity is 50 million pounds. Substituting Q_{EQ} of 50 into either the supply or demand equation to determine price, we find:

$$P_S = 50 + 50 = 100 \text{ and } P_D = 200 - (2)(50) = 100.$$

The equilibrium price P is \$1 (100 cents). However, the world market price is 60 cents. At this price, the domestic quantity supplied is $60 = 50 + Q_S$, or $Q_S = 10$, and similarly, domestic demand at the world price is $60 = 200 - 2Q_D$, or $Q_D = 70$. Imports are equal to the difference between domestic demand and supply, or 60 million pounds. If Congress imposes a tariff of 40 cents, the effective price of imports increases to \$1. At \$1, domestic producers satisfy domestic demand and imports fall to zero.

As shown in the figure below, consumer surplus before the imposition of the tariff is equal to area $a + b + c$, or (0.5)(70)(200 – 60) = 4900 million cents, or \$49 million. After the tariff, the price rises to \$1.00 and consumer surplus falls to area a, or (0.5)(50)(200 – 100) = \$25 million, a loss of \$24 million. Producer surplus increases by area b, or (10)(100 – 60) + (0.5)(50 – 10)(100 – 60) = \$12 million.

Finally, because domestic production is equal to domestic demand at \$1, no hula beans are imported and the government receives no revenue. The difference between the loss of consumer surplus and the increase in producer surplus is deadweight loss, which in this case is equal to \$24 – 12 = \$12 million (area c).



13. Currently, the social security payroll tax in the United States is evenly divided between employers and employees. Employers must pay the government a tax of 6.2% of the wages they pay, and employees must pay 6.2% of the wages they receive. Suppose the tax were changed so that employers paid the full 12.4% and employees paid nothing. Would employees then be better off?

If the labor market is competitive (i.e., both employers and employees take the wage as given), then shifting all the tax onto employers will have no effect on the amount of labor employed or on employees' after tax wages. We know this because the incidence of a tax is the same regardless of who officially pays it. As long as the total tax doesn't change, the same amount of labor will be employed, and the wages paid by employers and received by employees (after tax) will not change. Hence, employees would be no better or worse off if employers paid the full amount of the social security tax.

14. 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% 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.

For products with demand characterized by a stock adjustment process, short-run demand is more elastic than long-run demand because consumers can delay their purchases of these goods in the short run. For example, when price rises, consumers may continue using the older version of the product that they currently own. However, in the long run, a new product will be purchased as the old one wears out. Thus the long-run demand curve is more inelastic than the short-run one.

Consider the effect of imposing a 20% sales tax on automobiles in the short and long run. The portion of the tax that will be borne by consumers is given by the pass-through fraction, $E_S/(E_S - E_D)$. Assuming that the elasticity of supply, E_S, is the same in the short and long run, as demand becomes less elastic in the long run, the elasticity of demand, E_D, will become smaller in absolute value. Therefore the pass-through fraction will increase, and the share of the automobile tax paid by consumers will rise over time.

Unlike the automobile market, the gasoline demand curve is not characterized by a stock adjustment effect. Long-run demand will be more elastic than short-run demand, because in the long run consumers can make adjustments such as buying more fuel-efficient cars and taking public transportation that will reduce their use of gasoline. As the demand becomes more elastic in the long run, the pass-through fraction will fall, and therefore the share of the gas tax paid by consumers will fall over time.

15. In 2011, Americans smoked 16 billion packs of cigarettes. They paid an average retail price of $5.00 per pack.

a. Given that the elasticity of supply is 0.5 and the elasticity of demand is –0.4, derive linear demand and supply curves for cigarettes.

Let the demand curve be of the general linear form $Q = a - bP$ and the supply curve be $Q = c + dP$, where a, b, c, and d are positive constants that we have to find from the information given above. To begin, recall the formula for the price elasticity of demand

$$E_P^D = \frac{P}{Q}\frac{\Delta Q}{\Delta P}.$$

We know the values of the elasticity, P, and Q, which means we can solve for the slope, which is $-b$ in the above formula for the demand curve.

$$-0.4 = \left(\frac{5.00}{16}\right)(-b)$$

$$b = 0.4\left(\frac{16}{5.00}\right) = 1.28.$$

To find the constant a, substitute for Q, P, and b in the demand curve formula: $16 = a - 1.28(5.00)$. Solving yields $a = 22.4$. The equation for demand is therefore $Q = 22.4 - 1.28P$. To find the supply curve, recall the formula for the elasticity of supply and follow the same method as above:

$$E_P^S = \frac{P}{Q}\frac{\Delta Q}{\Delta P}$$

$$0.5 = \left(\frac{5.00}{16}\right)(d)$$

$$d = 0.5\left(\frac{16}{5.00}\right) = 1.6$$

To find the constant c, substitute for Q, P, and d in the supply formula, which yields $16 = c + 1.6(5.00)$. Therefore $c = 8$, and the equation for the supply curve is $Q = 8 + 1.6P$.

b. Cigarettes are subject to a federal tax, which was about $1.00 per pack in 2011. What does this tax do to the market-clearing price and quantity?

The tax drives a wedge between supply and demand. At the new equilibrium, the price buyers pay, P_b, will be $1.00 higher than the price sellers receive, P_s. Also, the quantity buyers demand at P_b must equal the quantity supplied at price P_s. These two conditions are:

$$P_b - P_s = 1.00 \quad \text{and} \quad 22.4 - 1.28P_b = 8 + 1.6\,P_s.$$

Solving these simultaneously, P_s = $4.56 and P_b = $5.56. The new quantity will be Q = 22.4 − 1.28(5.56) = 15.3 billion packs. So the price consumers pay will increase from $5.00 to $5.56 (a 56-cent increase) and consumption will fall from 16 to 15.3 billion packs per year (a drop of 700 million packs per year).

c. How much of the federal tax will consumers pay? What part will producers pay?

Consumers pay $5.56 − 5.00 = $0.56 and producers pay the remaining $5.00 − 4.56 = $0.44 per pack. We could also find these amounts using the pass-through formula. The fraction of the tax paid by consumers is $E_S/(E_S - E_D) = 0.5/[0.5 - (-0.4)] = 0.5/0.9 = 0.56$. Therefore, consumers will pay 56% of the $1.00 tax, which is 56 cents, and suppliers will pay the remaining 44 cents.