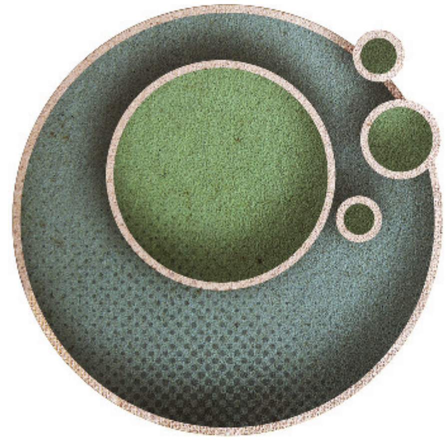
CHAPTER 16

General Equilibrium and Economic Efficiency



For the most part, we have studied individual markets in isolation. But markets are often interdependent: Conditions in one can affect prices and outputs in others either because one good is an input to the production of another good or because two goods are substitutes or complements. In this chapter, we see how a *general equilibrium analysis* can be used to take these interrelationships into account.

We also expand the concept of economic efficiency that we introduced in Chapter 9, and we discuss the benefits of a competitive market economy. To do this, we first analyze economic efficiency, beginning with the exchange of goods among people or countries. We then use this analysis of exchange to discuss whether the outcomes generated by an economy are equitable. To the extent that these outcomes are deemed inequitable, government can help redistribute income.

We then go on to describe the conditions that an economy must satisfy if it is to produce and distribute goods efficiently. We explain why a perfectly competitive market system satisfies those conditions. We also show why free international trade can expand the production possibilities of a country and make its consumers better off. Most markets, however, are not perfectly competitive, and many deviate substantially from that ideal. In the final section of the chapter (as a preview to our detailed discussion of market failure in Chapters 17 and 18), we discuss some key reasons why markets may fail to work efficiently.

16.1 General Equilibrium Analysis

So far, our discussions of market behavior have been largely based on **partial equilibrium analysis**. When determining the equilibrium prices and quantities in a market using partial equilibrium analysis, we presume that activity in one market has little or no effect on other markets. For example, in Chapters 2 and 9, we presumed that the wheat market was largely independent of the markets for related products, such as corn and soybeans.

CHAPTER OUTLINE

LIST OF EXAMPLES

partial equilibrium analysis Determination of equilibrium prices and quantities in a market independent of effects from other markets.

Often a partial equilibrium analysis is sufficient to understand market behavior. However, market interrelationships can be important. In Chapter 2, for example, we saw how a change in the price of one good can affect the demand for another if they are complements or substitutes. In Chapter 8, we saw that an increase in a firm's input demand can cause both the market price of the input and the product price to rise.

general equilibrium analysis Simultaneous determination of the prices and quantities in all relevant markets, taking feedback effects into account.

Unlike partial equilibrium analysis, **general equilibrium analysis** *determines the prices and quantities in all markets simultaneously*, and it explicitly takes feedback effects into account. A *feedback effect* is a price or quantity adjustment in one market caused by price and quantity adjustments in related markets. Suppose, for example, that the U.S. government taxes oil imports. This policy would immediately shift the supply curve for oil to the left (by making foreign oil more expensive) and raise the price of oil. But the effect of the tax would not end there. The higher price of oil would increase the demand for and then the price of natural gas. The higher natural gas price would in turn cause oil demand to rise (shift to the right) and increase the oil price even more. The oil and natural gas markets will continue to interact until eventually an equilibrium is reached in which the quantity demanded and quantity supplied are equated in both markets.

In practice, a complete general equilibrium analysis, which evaluates the effects of a change in one market on *all* other markets, is not feasible. Instead, we confine ourselves to two or three markets that are closely related. For example, when looking at a tax on oil, we might also look at markets for natural gas, coal, and electricity.

Two Interdependent Markets—Moving to General Equilibrium

To study the interdependence of markets, let's examine the competitive markets for DVD rentals and movie theater tickets. The two markets are closely related because DVD players give most consumers the option of watching movies at home as well as at the theater. Changes in pricing policies that affect one market are likely to affect the other, which in turn causes feedback effects in the first market.

Figure 16.1 shows the supply and demand curves for DVDs and movies. In part (a), the price of movie tickets is initially $6.00; the market is in equilibrium at the intersection of D_M and S_M. In part (b), the DVD market is also in equilibrium with a price of $3.00.

Now suppose that the government places a tax of $1 on each movie ticket purchased. The effect of this tax is determined on a partial equilibrium basis by shifting the supply curve for movies upward by $1, from S_M to S^*_M in Figure 16.1 (a). Initially, this shift causes the prices of movies to increase to $6.35 and the quantity of movie tickets sold to fall from Q_M to Q'_M. This is as far as a partial equilibrium analysis takes us. But we can go further with a general equilibrium analysis by doing two things: (1) looking at the effects of the movie tax on the market for DVDs, and (2) seeing whether there are any feedback effects from the DVD market to the movie market.

In §2.1, we explain that two goods are substitutes if an increase in the price of one leads to an increase in the quantity demanded of the other.

The movie tax affects the market for DVDs because movies and DVDs are *substitutes.* A higher movie price shifts the demand for DVDs from D_V to D'_V in Figure 16.1 (b). In turn, this shift causes the rental price of DVDs to increase from $3.00 to $3.50. Note that a tax on one product can affect the prices and sales of other products—something that policymakers should remember when designing tax policies.

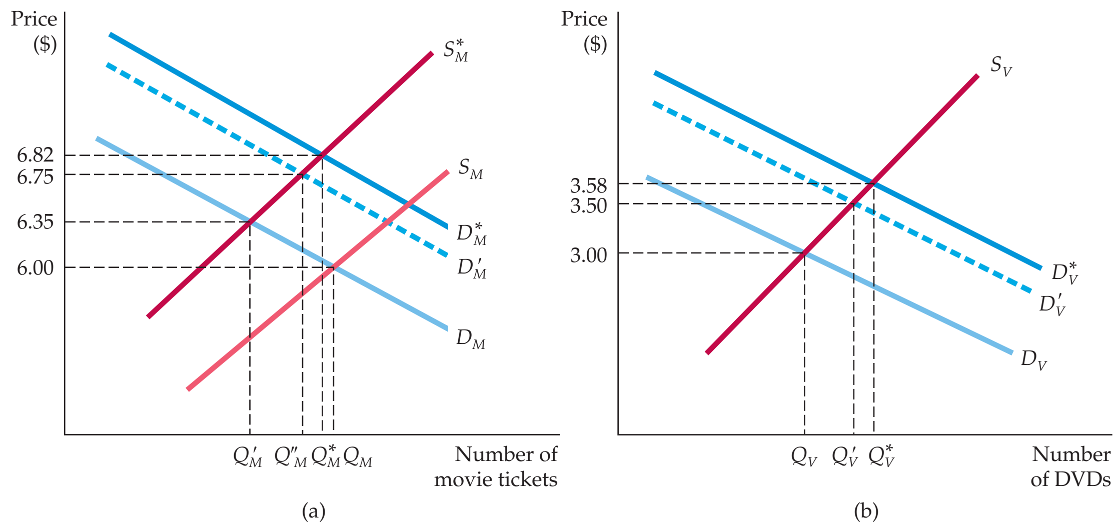


FIGURE 16.1
TWO INTERDEPENDENT MARKETS: (A) MOVIE TICKETS AND (B) DVD RENTALS

When markets are interdependent, the prices of all products must be simultaneously determined. Here a tax on movie tickets shifts the supply of movies upward from S_M to S^*_M, as shown in **(a)**. The higher price of movie tickets ($6.35 rather than $6.00) initially shifts the demand for DVDs upward (from D_V to D'_V), causing the price of DVDs to rise (from $3.00 to $3.50), as shown in **(b)**. The higher video price feeds back into the movie ticket market, causing demand to shift from D_M to D'_M and the price of movies to increase from $6.35 to $6.75. This continues until a general equilibrium is reached, as shown at the intersection of D^*_M and S^*_M in **(a)**, with a movie ticket of $6.82, and the intersection of D^*_V and S_V in **(b)**, with a DVD price of $3.58.

What about the market for movies? The original demand curve for movies presumed that the price of DVDs was unchanged at $3.00. But because that price is now $3.50, the demand for movies will shift upward, from D_M to D'_M in Figure 16.1 (a). The new equilibrium price of movies (at the intersection of S^*_M and D'_M) is $6.75, instead of $6.35, and the quantity of movie tickets purchased has increased from Q'_M to Q''_M. Thus a partial equilibrium analysis would have underestimated the effect of the tax on the price of movies. The DVD market is so closely related to the market for movies that to determine the tax's full effect, we need a general equilibrium analysis.

Reaching General Equilibrium

Our analysis is not yet complete. The change in the market price of movies will generate a feedback effect on the price of DVDs that, in turn, will affect the price of movies, and so on. In the end, we must determine the equilibrium prices and quantities of *both* movies and DVDs *simultaneously*. The equilibrium movie price of $6.82 is given in Figure 16.1 (a) by the intersection of the equilibrium supply and demand curves for movie tickets (S^*_M and D^*_M). The equilibrium DVD price of $3.58 is given in Figure 16.1 (b) by the intersection of the equilibrium supply and demand curves for DVDs (S_V and D^*_V). These are the correct general equilibrium prices because the DVD market supply and demand curves have been drawn *on the assumption that the price of movie tickets is $6.82.* Likewise, the movie ticket curves have been drawn *on the assumption that the price of DVDs is $3.58.* In other words, both sets of curves are consistent with the prices in related markets, and we have no reason to expect that the supply and demand curves in either market will shift further. To find the general equilibrium prices (and quantities) in practice, we must simultaneously find two prices that equate quantity demanded and quantity supplied in all related markets. For our two markets, we need to find the solution to four equations (supply of movie tickets, demand for movie tickets, supply of DVDs, and demand for DVDs).

Note that even if we were only interested in the market for movies, it would be important to account for the DVD market when determining the impact of a movie tax. In this example, partial equilibrium analysis would lead us to conclude that the tax will increase the price of movie tickets from $6.00 to $6.35. A general equilibrium analysis, however, shows us that the impact of the tax on the price of movie tickets is greater: It would in fact increase to $6.82.

Recall from §2.1 that two goods are complements if an increase in the price of one leads to a decrease in the quantity demanded of the other.

Movies and DVDs are substitute goods. By drawing diagrams analogous to those in Figure 16.1, you should be able to convince yourself that if the goods in question are *complements*, a partial equilibrium analysis will *overstate* the impact of a tax. Think about gasoline and automobiles, for example. A tax on gasoline will cause its price to go up, but this increase will reduce demand for automobiles, which in turn reduces the demand for gasoline, causing its price to fall somewhat.

EXAMPLE 16.1 THE GLOBAL MARKET FOR ETHANOL

High crude oil prices, harmful emissions, and growing dependency on volatile foreign oil supplies have led to a growing interest in alternative fuel sources such as ethanol. Ethanol is a clean-burning, high-octane fuel produced from renewable resources such as sugar cane and corn. It is highly touted as a means of reducing automobile emissions and of responding to concerns about global warming. There is a high degree of interdependence between the production and sale of Brazilian ethanol (from sugar cane) and ethanol produced in the United States (from corn). We will see that U.S. regulation of its ethanol market had significant effects on the Brazilian market, which in turn has had a feedback effect on the market in the United States. Although this interdependence has in all likelihood benefited U.S. producers, it also had adverse consequences for U.S. consumers, Brazilian producers, and, probably, Brazilian consumers.

The world ethanol market is dominated by Brazil and the United States, which accounted for over 80 percent of world production in 2005.[1] Ethanol is not new; the Brazilian government started promoting ethanol in the mid-1970s as a response to rising oil prices and declining sugar prices, and the program has flourished. By 2015, about 50 percent of all Brazilian automobile fuel was ethanol, a response to the skyrocketing growth in the demand for flex-fuel cars, which can run on any mixture of ethanol and gasoline. U.S. ethanol production was first encouraged by the Energy Tax Act of 1978, which provided for tax exemptions for ethanol-gasoline blends. Later, the Energy Policy Act of 2005 required that U.S. fuel production include a minimum amount of renewable fuel each year—a stipulation which essentially mandated a baseline level of ethanol production. By the end of 2010, over 90 percent of gasoline sold in the United States contained a blend of up to 10 percent ethanol.

[1]This example is based on Amani Elobeid and Simla Tokgoz, "Removing Distortions in the U.S. Ethanol Market: What Does It Imply for the United States and Brazil?" *American Journal of Agricultural Economics* 90(4), (November 2008): 918–32.

The U.S. and Brazilian ethanol markets are closely tied to each other. As a consequence, the U.S. regulation of its own ethanol market can significantly affect Brazil's market. This global interdependence was made evident by the Energy Security Act of 1979, by which the U.S. offered a tax credit of $0.51 per gallon of ethanol to spur alternatives to gasoline. Moreover, to prevent foreign ethanol producers from reaping the benefits of this tax credit, the U.S. government imposed a $0.54 per gallon tax on imported ethanol. The policy has been highly effective: The U.S. has devoted more and more of its corn harvest to ethanol production, while Brazilian imports (which are made from sugar cane) have declined. While this policy has benefited corn producers, it is not in the interests of U.S. ethanol consumers. While the percentages have varied over time as exchange rates have changed, it has been estimated that Brazil can export ethanol for approximately 15 percent less than it costs to produce a gallon of ethanol from Iowa corn.[2] Thus American consumers would benefit if the tax and subsidy were removed—a move that would increase the imports of the cheaper sugar cane-based ethanol from Brazil.

Figure 16.2 shows the predicted changes in the ethanol market if U.S. tariffs were completely removed in 2012. The top green line in Figure 16.2 (a) estimates Brazil's ethanol exports without U.S. tariffs

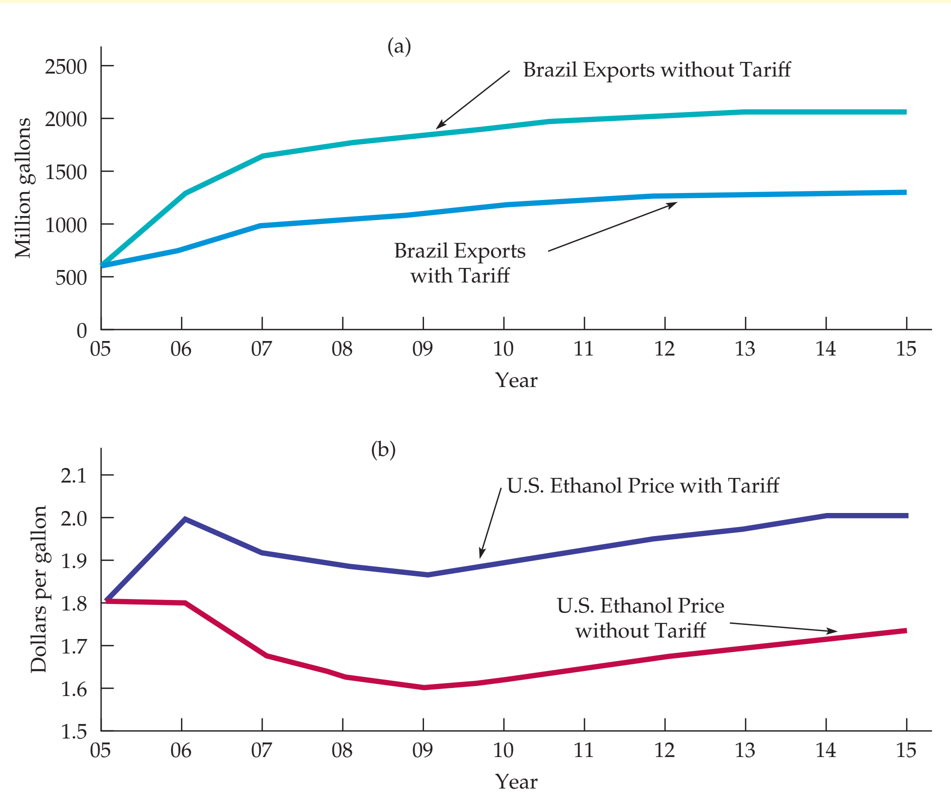


FIGURE 16.2
REMOVING THE ETHANOL TARIFF ON BRAZILIAN EXPORTS

If U.S. tariffs on ethanol produced abroad were to be removed, Brazil would export much more ethanol to the United States, displacing much of the more expensive corn-based ethanol produced domestically. As a result, the price of ethanol in the U.S. would fall, benefiting U.S. consumers.

[2]See Christine L. Crago et al., "Competitiveness of Brazilian Sugarcane Ethanol Compared to U.S. Corn Ethanol," *Energy Policy* 38 (11), (June 2010): 7404–15.

in place, and the blue line represents Brazil's exports with U.S. tariffs in place. Figure 16.2 (b) shows the price of ethanol in the United States with and without the tariff. As you can see, Brazilian ethanol exports would increase dramatically if the tariffs were removed and U.S. consumers will benefit. This would also be advantageous to Brazilian producers and consumers.

The adverse incentive created by U.S. tariffs does not tell the entire story about ethanol and interdependent markets. In 1984, Congress passed the Caribbean Basin Initiative (CBI)—tax legislation designed to foster economic development in Caribbean countries. Under the CBI, ethanol processed in those countries, up to 60 million gallons a year, receives duty-free status. In response, Brazil invested in several ethanol dehydration plants in the Caribbean in order to export their sugar-based ethanol to the United States without paying the 54-cent per gallon tariff.

The U.S. government continued to impose tariffs on foreign ethanol, despite the resulting economic inefficiencies. In addition, Congress increased the subsidies to U.S. corn producers by raising the tax credit on ethanol. By the end of 2011, when the existing U.S. tax credits and tariffs were finally removed (while legislation that mandated the use of ethanol-blended gasoline remained), these subsidies had cost U.S. taxpayers around $20 billion. Why such generosity to U.S. corn producers? Because those corn producers, mostly in Iowa, have used campaign contributions and intensive lobbying to protect their self-interest. By 2014, 40 percent of the U.S. corn crop was being used to produce ethanol. These policies helped to make the United States the world's largest ethanol supplier, despite the cost to U.S. taxpayers and consumers and the fact that Brazil produces ethanol at substantially less than the cost of U.S. production.

EXAMPLE 16.2 "CONTAGION" ACROSS STOCK MARKETS AROUND THE WORLD

Stock markets around the world tend to move together, a phenomenon sometimes referred to as "contagion." For example, the 2008 financial crisis led to sharp stock market declines in the United States, which in turn were mirrored by stock market declines in Europe, Latin America, and Asia. This tendency of stock markets around the world to move together is illustrated by Figure 16.3, which shows the three major stock market indices in the United States (the S&P 500), the United Kingdom (the FTSE), and Germany (the DAX). The S&P includes 500 U.S. companies with the highest market value listed on the New York Stock Exchange and the NASDAQ. The FTSE (fondly described as the "footsie") has 100 of the largest U.K. companies on the London Stock Exchange, and the DAX has the 30 largest German companies on the Frankfurt Stock Exchange. (Each stock market index was set to 100 in 1984.) You can see that the overall pattern of stock price movements was the same in all three countries. Why do stock markets tend to move together?

There are two fundamental reasons, both of which are manifestations of general equilibrium. First, stock (and bond) markets around the world have become highly integrated. Someone in the United States, for example, can easily buy or sell stocks that are traded in London, Frankfurt, or elsewhere in the world. Likewise, people in Europe and Asia can buy and sell stocks most anywhere in the world. As a result, if U.S. stock prices fall sharply and become relatively cheap compared to European and Asian stocks, European and Asian investors will sell some of their stocks and buy U.S. stocks, pushing down European and Asian stock prices. Thus any external shocks that affect stock prices in one country will have the same directional effect on prices in other countries.

The second reason is that economic conditions around the world tend to be correlated, and economic conditions are an important determinant of stock prices. (During a recession, corporate profits fall, which causes stock prices to fall.) Suppose that the United States goes into a deep recession (as it did in 2008). Then Americans will consume less and U.S. imports will fall. But U.S. imports are the exports of other countries, so those exports will fall, reducing economic output and employment in those countries. Thus a recession in the United States can lead to a recession in Europe, and vice versa. This is another effect of general equilibrium that leads to "contagion" across stock markets.

FIGURE 16.3
STOCK PRICES IN THE UNITED STATES AND EUROPE

Three stock market indices—the S&P 500 in the United States, the FTSE in the United Kingdom, and the DAX in Germany—are plotted together, scaled so that each starts at 100 in 1984. The indices tend to move together, increasing and decreasing at about the same time.

Data from www.worldbank.org

Economic Efficiency

In Chapter 9 we saw that a competitive market is economically efficient because it maximizes aggregate consumer and producer surplus. This is what we normally mean when we use the term *economic efficiency*. But, how does this important concept of economic efficiency apply when we take into account the interrelationship of markets, whether open to free trade or restricted, whether market-oriented or planned, and whether highly regulated or not? Fortunately, there is a concept of economic efficiency that applies when there is no market at all, but instead people simply trade with each other. The rest of this chapter and, to some extent the remaining chapters in the book, address these questions about economic efficiency and evaluate their implications.

The analysis that follows is somewhat more complex than what has gone before; we are now focusing on the interplay of multiple markets with multiple entities competing against each other or trading with each other. Moreover, there are important equity implications that flow from the workings of competitive markets in general equilibrium, and we need to consider those equity issues. To avoid losing many of our readers along the way, our strategy is to build the theoretical analysis slowly and step by step.

We will focus on two, rather than many countries (each represented by a different individual consumer or producer), and two, rather than many, goods and services. Furthermore, we'll start in Section 16.2 with a model of exchange in which there is no production. (We'll introduce production later.) We will also initially assume that the two individuals (representing two countries) have some endowment of goods (say, food and clothing), which they trade with each other. These trades are the result of bargaining, rather than competitive market outcomes, and they occur because trading makes both individuals better off. We will define a new efficiency concept that is particularly useful in analyzing this kind of exchange. Later (in Section 16.4) we'll introduce production, and in so doing revisit another efficiency concept—*technical efficiency*. You may recall that we first discussed technical efficiency in Chapter 6 when we introduced the concept of a production function. Finally, we will move on to the analysis of the workings of competitive markets (Section 16.6). Along the way, we will pause to treat important issues relating to equity (Section 16.3) and international trade (Section 16.5). At times the models we present may seem too simplistic to inform our real-world experiences, but rest assured they can be generalized, and their implications are both broad and profound.

In § 6.1, we explained that production functions describe technical efficiency as being achieved when a firm uses each combination of inputs as effectively as possible.

16.2 Efficiency in Exchange

exchange economy Market in which two or more consumers trade two goods among themselves.

We begin with an **exchange economy**, analyzing the behavior of two consumers who can trade either of two goods between themselves. (The analysis also applies to trade between two countries.) Suppose the two goods are initially allocated so that both consumers can make themselves better off by trading with each other. In this case, the initial allocation of goods is economically *inefficient.*

Pareto efficient allocation Allocation of goods in which no one can be made better off unless someone else is made worse off.

In a **Pareto efficient allocation** of goods, *no one can be made better off without making someone else worse off*. The term *Pareto efficiency* is named after the Italian economist Vilfredo Pareto, who developed the concept of efficiency in exchange. Notice, however, that Pareto efficiency is not the same as economic efficiency as we defined it in Chapter 9. With Pareto efficiency, we know that there is no way to improve the well-being of both individuals (if we improve one, it will be at the expense of the other), but we cannot be assured that this arrangement will maximize the joint welfare of both individuals.

Note that there is an *equity* implication of Pareto efficiency. It may be possible to reallocate the goods in a way that increases the *total* well-being of the two individuals, but leaves one individual worse off. If we can reallocate goods so that one individual is just slightly worse off but the other individual is much, much better off, wouldn't that be a good thing to do, even though it is not Pareto efficient? There is no simple answer to that question. Some readers might say yes, it would be a good thing to do, and other readers might say no, it wouldn't be fair. Your own answer to this question will depend on what you think is or is not equitable.

TABLE 16.1	THE ADVANTAGE OF TRADE		
INDIVIDUAL	INITIAL ALLOCATION	TRADE	FINAL ALLOCATION
James	7F, 1C	−1F, +1C	6F, 2C
Karen	3F, 5C	+1F, −1C	4F, 4C

The Advantages of Trade

In §3.1, we explain that the marginal rate of substitution is the maximum amount of one good that the consumer is willing to give up to obtain one unit of another good.

As a rule, voluntary trade between two people or two countries is mutually beneficial.[3] To see how trade makes people better off, let's look in detail at a two-person exchange, assuming that exchange itself is costless.

Suppose James and Karen have 10 units of food and 6 units of clothing between them. Table 16.1 shows that initially James has 7 units of food and 1 unit of clothing, and Karen 3 units of food and 5 units of clothing. To decide whether a trade would be advantageous, we need to know their preferences for food and clothing. Suppose that because Karen has a lot of clothing and little food, her marginal rate of substitution (MRS) of food for clothing is 3: To get 1 unit of food, she will give up 3 units of clothing. However, James's MRS of food for clothing is only 1/2: He will give up only 1/2 a unit of clothing to get 1 unit of food.

There is thus room for mutually advantageous trade because James values clothing more highly than Karen does, whereas Karen values food more highly than James does. To get another unit of food, Karen would be willing to trade up to 3 units of clothing. But James will give up 1 unit of food for 1/2 unit of clothing. The actual terms of the trade depend on the bargaining process. Among the possible outcomes are a trade of 1 unit of food by James for anywhere between 1/2 and 3 units of clothing from Karen.

Suppose Karen offers James 1 unit of clothing for 1 unit of food, and James agrees. Both will be better off. James will have more clothing, which he values more than food, and Karen will have more food, which she values more than clothing. Whenever two consumers' MRSs are different, there is room for mutually beneficial trade because the allocation of resources is inefficient: Trading will make both consumers better off. Conversely, to achieve economic efficiency, the two consumers' MRSs must be equal.

This important result also holds when there are many goods and consumers: *An allocation of goods is efficient only if the goods are distributed so that the marginal rate of substitution between any pair of goods is the same for all consumers.*

The Edgeworth Box Diagram

Edgeworth box Diagram showing all possible allocations of either two goods between two people or of two inputs between two production processes.

If trade is beneficial, which trades can occur? Which of those trades will allocate goods efficiently among customers? How much better off will consumers then be? We can answer these questions for any two-person, two-good example by using a diagram called an **Edgeworth box**.

[3]There are several situations in which trade may not be advantageous. First, limited information may lead people to believe that trade will make them better off when in fact it will not. Second, people may be coerced into making trades, either by physical threats or by the threat of future economic reprisals. Third, as we saw in Chapter 13, barriers to free trade can sometimes provide a strategic advantage to a country.

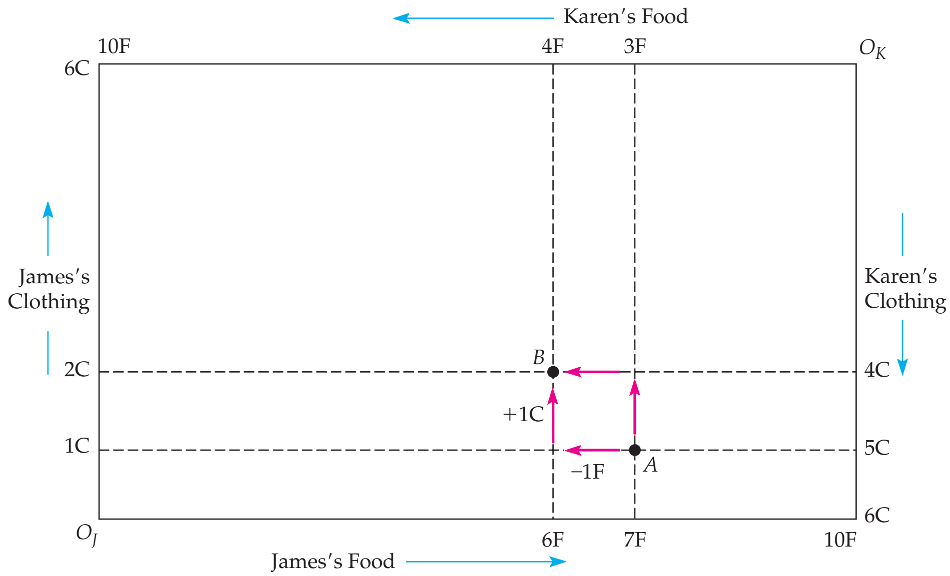


FIGURE 16.4
EXCHANGE IN AN EDGEWORTH BOX

Each point in the Edgeworth box simultaneously represents James's and Karen's market baskets of food and clothing. At *A*, for example, James has 7 units of food and 1 unit of clothing, and Karen 3 units of food and 5 units of clothing.

Figure 16.4 shows an Edgeworth box in which the horizontal axis describes the number of units of food and the vertical axis the units of clothing. The length of the box is 10 units of food, the total quantity of food available; its height is 6 units of clothing, the total quantity of clothing available.

In the Edgeworth box, each point describes the market baskets of *both* consumers. James's holdings are read from the origin at O_J and Karen's holdings in the reverse direction from the origin at O_K. For example, point *A* represents the initial allocation of food and clothing. Reading on the horizontal axis from left to right at the bottom of the box, we see that James has 7 units of food; reading upward along the vertical axis on the left of the diagram, we see that he has 1 unit of clothing. For James, therefore, *A* represents 7F and 1C. This leaves 3F and 5C for Karen. Karen's allocation of food (3F) is read from right to left at the top of the box diagram beginning at O_K; we read her allocation of clothing (5C) from top to bottom at the right of the box diagram.

We can also see the effect of trade between Karen and James. James gives up 1F in exchange for 1C, moving from *A* to *B*. Karen gives up 1C and obtains 1F, also moving from *A* to *B*. Point *B* thus represents the market baskets of both James and Karen after the mutually beneficial trade.

Efficient Allocations

A trade from *A* to *B* thus made both Karen and James better off. But is *B* an *efficient* allocation? The answer depends on whether James's and Karen's MRSs are the same at *B*, which depends in turn on the shape of their indifference curves. Figure 16.5 shows several indifference curves for both James and Karen.

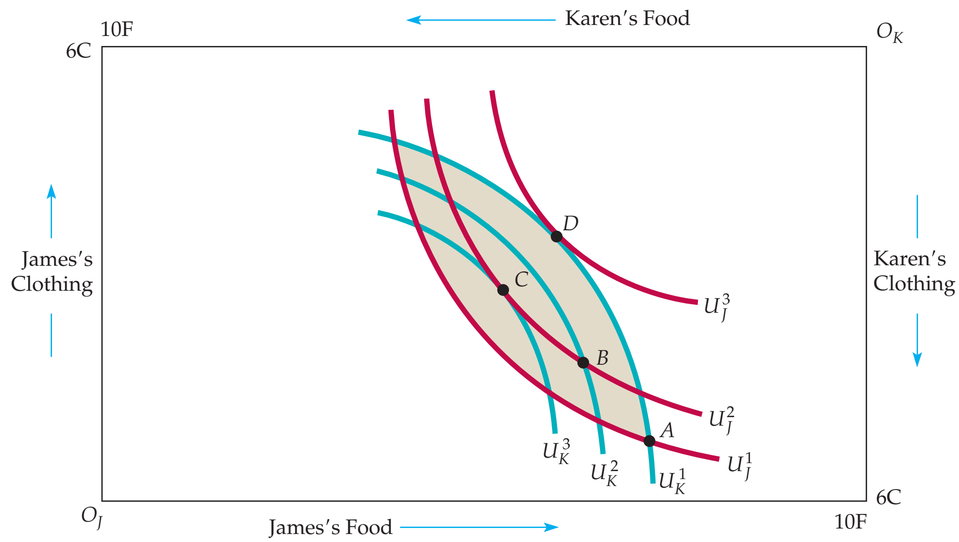


FIGURE 16.5
EFFICIENCY IN EXCHANGE

The Edgeworth box illustrates the possibilities for both consumers to increase their satisfaction by trading goods. If *A* gives the initial allocation of resources, the shaded area describes all mutually beneficial trades.

Because his allocations are measured from the origin O_J, James's indifference curves are drawn in the usual way. But for Karen, we have rotated the indifference curves 180 degrees, so that the origin is at the upper right-hand corner of the box. Karen's indifference curves are convex, just like James's; we simply see them from a different perspective.

Now that we are familiar with the two sets of indifference curves, let's examine the curves labeled U_J^1 and U_K^1 that pass through the initial allocation at *A*. Both James's and Karen's MRSs give the slope of their indifference curves at *A*. James's MRS of clothing for food is equal to 1/2, while Karen's is 3. The shaded area between these two indifference curves represents all possible allocations of food and clothing that would make both James and Karen better off than at *A*. In other words, it describes all possible mutually beneficial trades.

Starting at *A*, any trade that moved the allocation of goods outside the shaded area would make one of the two consumers worse off and should not occur. The move from *A* to *B* was mutually beneficial. But in Figure 16.5, *B* is not an efficient point because indifference curves U_J^2 and U_K^2 intersect. In this case, James's and Karen's MRSs are not the same and the allocation is not efficient. Starting at *B*, James would prefer to give up some food to obtain additional clothing. He would be willing to make any trade that left him no worse off and hopefully gave him some additional utility, and there are many trades that would do so. Karen, on the other hand, would be willing to give up some clothing to obtain more food, and there are many such trades that would make her better off. This situation illustrates an important point: *Even if a trade from an inefficient allocation makes both people better off, the new allocation is not necessarily efficient.*

Suppose that from *B* the additional trade is made, with James giving up another unit of food to obtain another unit of clothing and Karen giving up a unit of clothing for a unit of food. Point *C* in Figure 16.5 gives the new allocation. At *C*, the MRSs of both people are identical, because at point *C* the indifference curves are tangent. Trading food for clothing and thereby moving from point *B* to point *C* has allowed James and Karen to achieve a Pareto efficient outcome, and they will both be better off. When the indifference curves are tangent, one person cannot be made better off without making the other person worse off. Therefore, *C* represents an efficient allocation.

Of course, *C* is not the only possible efficient outcome of a bargain between James and Karen. For example, if James is an effective bargainer, a trade might change the allocation of goods from *A* to *D*, where indifference curve U_J^3 is tangent to indifference curve U_K^1. This allocation would leave Karen no worse off than she was at *A* and James much better off. And because no further trade is possible, *D* is an efficient allocation. Thus *C* and *D* are both efficient allocations, although James prefers *D* to *C* and Karen *C* to *D*. In general, it is difficult to predict the allocation that will be reached in a bargain because the end result depends on the bargaining abilities of the people involved.

The Contract Curve

We have seen that from an initial allocation many possible efficient allocations can be reached through mutually beneficial trade. To find *all possible efficient allocations of food and clothing* between Karen and James, we look for *all points of tangency between each of their indifference curves.* Figure 16.6 shows the **contract curve:** the curve drawn through all such efficient allocations.

contract curve Curve showing all efficient allocations of goods between two consumers, or of two inputs between two production functions.

The contract curve shows all allocations from which no mutually beneficial trade can be made. *These allocations are efficient because there is no way to reallocate*

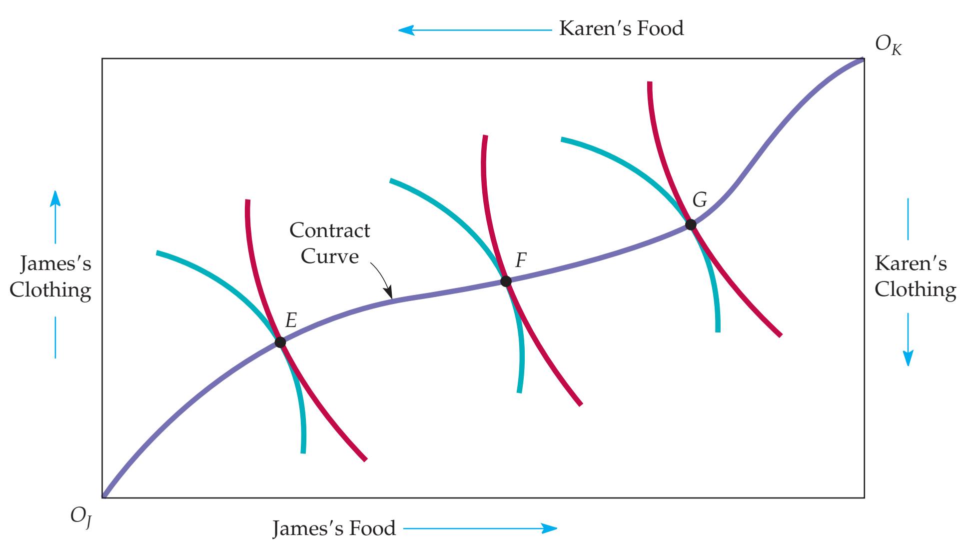


FIGURE 16.6
THE CONTRACT CURVE

The contract curve contains all allocations for which consumers' indifference curves are tangent. Every point on the curve is efficient because one person cannot be made better off without making the other person worse off.

goods to make someone better off without making someone else worse off. In Figure 16.5 three allocations labeled *E*, *F*, and *G* are Pareto efficient, although each involves a different distribution of food and clothing, because one person could not be made better off without making someone else worse off.

Several properties of the contract curve may help us understand the concept of efficiency in exchange. Once a point on a contract curve, such as *E*, has been chosen, there is no way to move to another point on the contract curve, say *F*, without making one person worse off (in this case, Karen). Karen is worse off because she has less food and less clothing at F than she had at E. Without making further comparison between James's and Karen's preferences, we cannot compare allocations *E* and *F.* We simply know that both are efficient. In this sense, Pareto efficiency is a modest goal: It says that we should make all mutually beneficial exchanges, but it does not say which exchanges are best. Pareto efficiency can be a powerful concept, however. If a change will improve efficiency, it is in *everyone's* self-interest to support it.

We can frequently improve efficiency even when one aspect of a proposed change makes someone worse off. We need only include a second change, such that the *combined* set of changes leaves someone better off and no one worse off. Suppose, for example, that we eliminate the quota on steel imports into the United States. Although U.S. consumers would then enjoy lower prices and a greater selection of cars, some U.S. workers would lose their jobs. But what if eliminating the quota were combined with federal tax breaks and job relocation subsidies for steelworkers? In that case, U.S. consumers would be better off (after accounting for the cost of the job subsidies) and the workers no worse off. This would increase efficiency.

Consumer Equilibrium in a Competitive Market

In a two-person exchange, the outcome can depend on the bargaining power of the two parties. Competitive markets, however, have many actual or potential buyers and sellers. As a result, each buyer and seller takes the price of the goods as fixed and decides how much to buy and sell at those prices. We can show how competitive markets lead to efficient exchange by using the Edgeworth box to mimic a competitive market. Suppose, for example, that there are many Jameses and many Karens. This allows us to think of each individual James and Karen as a price taker, even though we are working with only a two-person box diagram.

Figure 16.7 shows the opportunities for trade when we start at the allocation given by point *A* and when the prices of both food and clothing are equal to 1. (The actual prices do not matter; what matters is the price of food relative to the price of clothing.) When the prices of food and clothing are equal, each unit of food can be exchanged for 1 unit of clothing. As a result, the price line *PP*' in the diagram, which has a slope of -1, describes all possible allocations that exchange can achieve.

Suppose each James decides to buy 2 units of clothing and sell 2 units of food in exchange. This would move each James from *A* to *C* and increase satisfaction from indifference curve U_J^1 to U_J^2. Meanwhile, each Karen buys 2 units of food and sells 2 units of clothing. This would move each Karen from *A* to *C* as well, increasing satisfaction from indifference curve U_K^1 to U_K^2.

We choose prices for the two goods so that the quantity of food demanded by each Karen is equal to the quantity of food that each James wishes to sell; likewise, the quantity of clothing demanded by each James is equal to the quantity of clothing that each Karen wishes to sell. As a result, the markets for food and

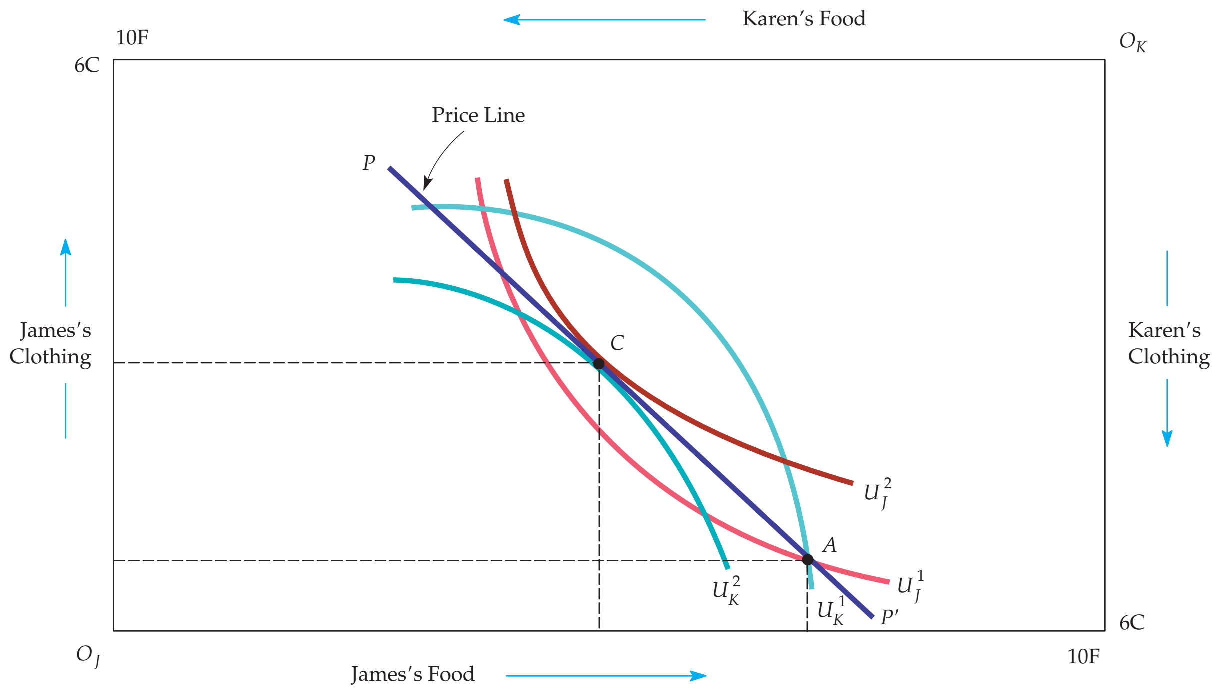


FIGURE 16.7
COMPETITIVE EQUILIBRIUM

In a competitive market the prices of the two goods determine the terms of exchange among consumers. If *A* is the initial allocation of goods and the price line *PP*′ represents the ratio of prices, the competitive market will lead to an equilibrium at *C*, the point of tangency of both indifference curves. As a result, the competitive equilibrium is efficient.

In §8.7, we explain that in a competitive equilibrium, price-taking firms maximize profit, and the price of the product is such that the quantity demanded is equal to the quantity supplied.

clothing are in equilibrium. An *equilibrium is a set of prices at which the quantity demanded equals the quantity supplied in every market*. This is also a *competitive equilibrium* because all suppliers and demanders are price takers.

Not all prices are consistent with equilibrium. For example, if the price of food is 3 and the price of clothing is 1, any exchange of clothing for food must be done on a 3-to-1 basis, i.e., 3 units of clothing must be given up to obtain 1 unit of food. But then each James will be unwilling to trade any clothing to get additional food because his MRS of clothing for food is only 1/2, i.e., he would only be willing to give up 1/2 a unit of clothing for 1 unit of food. Each Karen, on the other hand, would be happy to sell clothing to get more food but has no one to trade with. The market is therefore in *disequilibrium* because the quantities of food and clothing demanded are not equal to the quantities supplied.

excess demand When the quantity demanded of a good exceeds the quantity supplied.

excess supply When the quantity supplied of a good exceeds the quantity demanded.

This disequilibrium should be only temporary. In a competitive market, prices will adjust if there is **excess demand** in some markets (the quantity demanded of one good is greater than the quantity supplied) and **excess supply** in others (the quantity supplied is greater than the quantity demanded). In our example, each Karen's quantity demanded for food is greater than each James's willingness to sell it, whereas each Karen's willingness to trade clothing is greater than each James's quantity demanded. As a result of this excess quantity demanded for food and excess quantity supplied of clothing, we can expect the price of food to increase relative to the price of clothing. As the price changes, so will the quantities demanded by all those in the market. Eventually, the prices will adjust until an equilibrium is reached. In our example, the price of both food and clothing might be 2; we know from the previous analysis that when the price of clothing is equal to the price of food, the market will be in competitive equilibrium. (Recall that only relative prices matter; prices of 2 for clothing and food are equivalent to prices of 1 for each.)

Note the important difference between exchange with two people and an economy with many people. When only two people are involved, bargaining leaves the outcome indeterminate. However, when many people are involved, the prices of the goods are determined by the combined choices of demanders and suppliers of goods.

The Economic Efficiency of Competitive Markets

We can now understand one of the fundamental results of microeconomic analysis. We can see from point *C* in Figure 16.7 that *the allocation in a competitive equilibrium is Pareto efficient.* The key reason why this is so is that *C* must occur at the tangency of two indifference curves. If it does not, one of the Jameses or one of the Karens will not be achieving maximum satisfaction; he or she will be willing to trade to achieve a higher level of utility.

This result holds in an exchange framework and in a general equilibrium setting in which all markets are perfectly competitive. It is the most direct way of illustrating the workings of Adam Smith's famous *invisible hand*, because it tells us that the economy will automatically allocate resources in a Pareto efficient manner without the need for regulatory control. It is the independent actions of consumers and producers, who take prices as given, that allows markets to function in an economically efficient manner. Not surprisingly, the invisible-hand result is often used as the norm against which the workings of all real-world markets are compared. For some, the invisible hand supports the normative argument for less government intervention; they argue that markets are highly competitive. For others, the invisible hand supports a more expansive role for government; they reply that intervention is needed to make markets more competitive.

Whatever one's view of government intervention, most economists consider the invisible-hand result important. In fact, the result that a competitive equilibrium is Pareto efficient is often described as the first theorem of **welfare economics**, which involves the normative evaluation of markets and economic policy. Formally, the first theorem states the following:

welfare economics Normative evaluation of markets and economic policy.

> If everyone trades in the competitive marketplace, all mutually beneficial trades will be completed and the resulting equilibrium allocation of resources will be Pareto efficient.

Let's summarize what we know about a competitive equilibrium from the consumer's perspective:

1. Because the indifference curves are tangent, all marginal rates of substitution between consumers are equal.
2. Because each indifference curve is tangent to the price line, each person's MRS of clothing for food is equal to the ratio of the prices of the two goods.

To be as clear as possible, we will use the notation MRS_{FC} to denote the MRS *of food for clothing*. Then, if P_C and P_F are the two prices,

$$\text{MRS}^J_{FC} = P_F/P_C = \text{MRS}^K_{FC} \qquad \textbf{(16.1)}$$

To achieve a Pareto efficient allocation when there are many consumers (and many producers) is not easy. It can be done if all markets are perfectly competitive. But efficient outcomes can also be achieved by other means—for example, through a centralized system in which the government allocates all goods and services. The competitive solution is often preferred because it allocates resources with a minimum of information. All consumers must know their own preferences and the prices they face, but they need not know what is being produced or the demands of other consumers. Other allocation methods need more information, and as a result, they become difficult and cumbersome to manage.

16.3 Equity and Efficiency

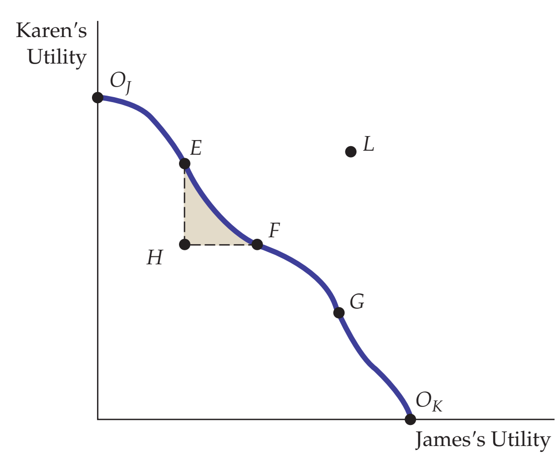
We have shown that different efficient allocations of goods are possible, and we have seen how a perfectly competitive economy generates a Pareto efficient allocation. But there are many Pareto efficient allocations, and some are likely to be more fair than others. How do we decide what is the most *equitable* allocation? That is a difficult question—economists and others disagree both about how to define *equity* and how to quantify it. Any such view would involve subjective comparisons of utility, and reasonable people could disagree about how to make these comparisons. In this section, we discuss this general point and then illustrate it in a particular case by showing that there is no reason to believe that the allocation associated with a competitive equilibrium will be equitable.

The Utility Possibilities Frontier

Recall that every point on the contract curve in our two-person exchange economy shows the levels of utility that James and Karen can achieve. In Figure 16.8 we put the information from the Edgeworth box in a different form. James's utility is measured on the horizontal axis and Karen's on the

FIGURE 16.8
UTILITY POSSIBILITIES FRONTIER

The utility possibilities frontier shows the levels of satisfaction that each of two people achieve when they have traded to an efficient outcome on the contract curve. Points *E*, *F*, and *G* correspond to points on the contract curve and are efficient. Point *H* is inefficient because any trade within the shaded area will make one or both people better off.



vertical axis. Every point in the Edgeworth box corresponds to a point in Figure 16.7 because every allocation generates utility for both people. Every movement to the right in Figure 16.8 represents an increase in James's utility, and every upward movement an increase in Karen's.

utility possibilities frontier Curve showing all efficient allocations of resources measured in terms of the utility levels of two individuals.

The **utility possibilities frontier** *represents all allocations that are Pareto efficient.* It shows the levels of satisfaction that are achieved when the two individuals have reached the contract curve. Point O_J is one extreme at which James has no goods and therefore zero utility, while point O_K is the opposite extreme at which Karen has no goods. Because all other points on the frontier, such as *E*, *F*, and *G*, correspond to points on the contract curve, one person cannot be made better off without making the other worse off. Point *H*, however, represents an inefficient allocation because any trade within the shaded area makes one or both parties better off. At *L*, both people would be better off, but *L* is not attainable because there is not enough of both goods to generate the levels of utility that the point represents.

It might seem reasonable to conclude that an allocation must be Pareto efficient to be equitable. Compare point *H* with *F* and *E*. Both *F* and *E* are efficient, and (relative to *H*) each makes one person better off without making the other worse off. We might agree, therefore, that it is inequitable to James or Karen or both for an economy to yield allocation *H* as opposed to *F* or *E.*

But suppose *H* and *G* are the only possible allocations. Is *G* more equitable than *H*? Not necessarily. Compared with *H*, *G* yields more utility for James and less for Karen. Some people may feel that *G* is more equitable than *H*; others may feel the opposite. We can conclude, therefore, that *one Pareto inefficient allocation of resources may be more equitable than another Pareto efficient allocation.*

The problem is how to define an equitable allocation. Even if we restrict ourselves to all points on the utility possibilities frontier, we can still ask which of these points is the most equitable. *The answer depends on what one thinks equity entails* and, therefore, on the interpersonal comparisons of utility that one is willing to make.

social welfare function Measure describing the well-being of society as a whole in terms of the utilities of individual members.

SOCIAL WELFARE FUNCTIONS In economics, we often use a **social welfare function** to describe the well-being of society as a whole in terms of utilities of individual members. A social welfare function is useful when we want to evaluate policies that affect some members of society differently than others.

One such function, the *utilitarian*, weights everyone's utility equally and consequently maximizes the total utility of all members of society. Each social welfare function can be associated with a particular view about equity. But some views do not explicitly weight individual utilities and cannot therefore be represented by a social welfare function. For example, a market-oriented view argues that the outcome of the competitive market process is equitable because it rewards those who are most able and who work the hardest. If *E* is the competitive equilibrium allocation, for example, *E* would be deemed to be more equitable than *F*, even though goods are less equally allocated.

When more than two people are involved, the meaning of the word *equity* becomes even more complex. The *Rawlsian* view[4] considers a world in which people do not know in advance what their individual endowments will be. Rawls argues that, faced with a world in which you do not know your own "fate," you would opt for a system ensuring that the least well-off person in society will be treated reasonably well. Specifically, according to Rawls, *the most equitable allocation*

[4]See John Rawls, *A Theory of Justice* (New York: Oxford University Press, 1971).

TABLE 16.2	FOUR VIEWS OF EQUITY
1. Egalitarian—all members of society receive equal amounts of goods	
2. Rawlsian—maximize the utility of the least-well-off person	
3. Utilitarian—maximize the total utility of all members of society	
4. Market-oriented—the market outcome is the most equitable	

maximizes the utility of the least-well-off person in society. The Rawlsian perspective could be *egalitarian*—involving an equal allocation of goods among all members of society. But it need not be. Suppose that by rewarding more productive people more highly than less productive people, we can get the most productive people to work harder. This policy could produce more goods and services, some of which could then be reallocated to make the poorest members of society better off.

The four views of equity in Table 16.2 move roughly from most to least egalitarian. While the egalitarian view explicitly requires equal allocations, the Rawlsian puts a heavy weight on equality (otherwise, some people would be much worse off than others). The utilitarian is likely to require some difference between the best- and worst-off members of society. Finally, the market-oriented view may lead to substantial inequality in the allocations of goods and services.

Equity and Perfect Competition

A competitive equilibrium leads to a Pareto efficient outcome that may or may not be equitable. In fact, a competitive equilibrium could occur at any point on the contract curve, depending on the initial allocation. Imagine, for example, that the initial allocation gave all food and clothing to Karen. This would be at O_J in Figure 16.8, and Karen would have no reason to trade. Point O_J would then be a competitive equilibrium, as would point O_K and all intermediate points on the contract curve.

Because efficient allocations are not necessarily equitable, society must rely to some extent on government to achieve equity goals by redistributing income or goods among households. These goals can be reached through the tax system. For example, a progressive income tax whose funds are used for programs that benefit households proportionally to income will redistribute income from the wealthy to the poor. The government can also provide public services, such as medical aid to the poor (Medicaid), or it can transfer funds through such programs as food stamps.

The result that a competitive equilibrium can sustain every point on the contract curve is a fundamental result in microeconomics. It is important because it suggests an answer to a basic normative question: Is there a trade-off between equity and efficiency? In other words, must a society that wishes to achieve a more equitable allocation of resources necessarily operate in a manner that is Pareto efficient? The answer, which is given by the *second theorem of welfare economics*, tells us that redistribution need not conflict with economic efficiency. Formally, the second theorem states the following:

Recall from §3.1 that an indifference curve is convex if the MRS diminishes as one moves down along the curve.

> If individual preferences are convex, then every Pareto efficient allocation (every point on the contract curve) is a competitive equilibrium for some initial allocation of goods.

Literally, this theorem tells us that any equilibrium deemed to be equitable can be achieved by a suitable distribution of resources among individuals and that such a distribution need not in itself generate inefficiencies. Unfortunately, all programs that redistribute income in our society are economically costly. Taxes may encourage individuals to work less or cause firms to devote resources to avoiding taxes rather than to producing output. So, in effect, there is a trade-off between the goals of equity and efficiency, and hard choices must be made. Welfare economics, which builds on the first and second theorems, provides a useful framework for debating the normative issues that surround the equity–efficiency issue in public policy.

16.4 Efficiency in Production

Having described the conditions required to achieve an efficient allocation in the exchange of two goods, we now consider the efficient use of inputs in the production process. We assume that there are fixed total supplies of two inputs, labor and capital, which are needed to produce the same two products, food and clothing. Instead of only two people, however, we now assume that many consumers own the inputs to production (including labor) and earn income by selling them. This income, in turn, is allocated between the two goods.

This framework links the various supply and demand elements of the economy. People supply inputs to production and then use the income they earn to demand and consume goods and services. When the price of one input increases, the individuals who supply a lot of that input earn more income and consume more of one of the two goods. In turn, this increases the demand for the inputs needed to produce the good and has a feedback effect on the price of those inputs. Only a general equilibrium analysis can find the prices that equate supply and demand in every market.

Input Efficiency

To see how inputs can be combined efficiently, we must find the various combinations of inputs that can be used to produce each of the two outputs. A particular allocation of inputs into the production process is **technically efficient** if the output of one good cannot be increased without decreasing the output of another good. Because technical efficiency requires the appropriate combination of inputs, we will also call it input efficiency. Efficiency in production is not a new concept; in Chapter 6 we saw that a production function represents the maximum output that can be achieved with a given set of inputs. Here we extend the concept to the production of two goods rather than one.

technical efficiency Condition under which firms combine inputs to produce a given output as inexpensively as possible.

If input markets are competitive, a point of efficient production will be achieved. Let's see why. If the labor and capital markets are perfectly competitive, then the wage rate w will be the same in all industries. Likewise, the rental rate of capital r will be the same whether capital is used in the food or clothing industry. We know from Chapter 7 that if producers of food and clothing minimize production costs, they will use combinations of labor and capital so that the ratio of the marginal products of the two inputs is equal to the ratio of the input prices:

In §7.3, we explain that the rental rate is the cost per year for renting a unit of capital.

$$\mathrm{MP}_L/\mathrm{MP}_K = w/r$$

But we also showed that the ratio of the marginal products of the two inputs is equal to the marginal rate of technical substitution of labor for capital MRTS_{LK}. As a result,

$$\mathrm{MRTS}_{LK} = w/r \tag{16.2}$$

In §6.3, we explain that the marginal rate of technical substitution of labor for capital is the amount by which the input of capital can be reduced when one extra unit of labor is used, so that output remains constant.

Because the MRTS is the slope of the firm's isoquant, a competitive equilibrium can occur in the input market only if each producer uses labor and capital so that the slopes of the isoquants are equal to one another and to the ratio of the prices of the two inputs. As a result, *the competitive equilibrium is efficient in production.*

The Production Possibilities Frontier

production possibilities frontier Curve showing the combinations of two goods that can be produced with fixed quantities of inputs.

The **production possibilities frontier** shows the various combinations of food and clothing that can be produced with fixed inputs of labor and capital, holding technology constant. The frontier in Figure 16.9 is derived from the production contract curve. Each point on both the contract curve and the production possibilities frontier describes an efficiently produced level of both food and clothing.

Point O_F represents one extreme, in which only clothing is produced, and O_C represents the other extreme, in which only food is produced. Points B, C, and D correspond to points at which both food and clothing are efficiently produced.

Recall from §14.4 that a rent-maximizing union attempts to maximize the wages that members earn in excess of their opportunity cost.

Point *A*, representing an inefficient allocation, lies inside the production possibilities frontier. All points within the triangle *ABC* involve the complete utilization of labor and capital in the production process. However, a distortion in the labor market, perhaps due to a rent-maximizing union, has caused the economy as a whole to be productively inefficient.

Where we end up on the production possibilities frontier depends on consumer demand for the two goods. For example, suppose consumers tend to prefer food rather than clothing. A possible competitive equilibrium occurs at *D* in Figure 16.8. On the other hand, if consumers prefer clothing to food, the competitive equilibrium will occur on a point on the production possibilities frontier closer to O_F.

Why is the production possibilities frontier downward sloping? In order to produce more food efficiently, one must switch inputs from the production of clothing, which in turn lowers the clothing production level. Because all points lying within the frontier are inefficient, they are off the production contract curve.

marginal rate of transformation Amount of one good that must be given up to produce one additional unit of a second good.

MARGINAL RATE OF TRANSFORMATION The production possibilities frontier is concave (bowed out)—i.e., its slope increases in magnitude as more food is produced. To describe this, we define the **marginal rate of transformation** of food for clothing (MRT) as the magnitude of the slope of the frontier at each point.

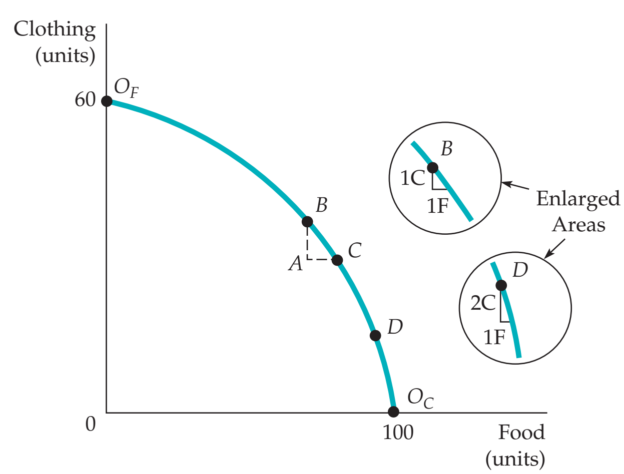


FIGURE 16.9
PRODUCTION POSSIBILITIES FRONTIER

The production possibilities frontier shows all efficient combinations of outputs. The production possibilities frontier is concave because its slope (the marginal rate of transformation) increases as the level of production of food increases.

The MRT measures how much clothing must be given up to produce one additional unit of food. For example, the enlarged areas of Figure 16.9 show that at *B* on the frontier, the MRT is 1 because 1 unit of clothing must be given up to obtain 1 additional unit of food. At *D*, however, the MRT is 2 because 2 units of clothing must be given up to obtain 1 more unit of food.

Note that as we increase the production of food by moving along the production possibilities frontier, the MRT increases.[5] This increase occurs because the productivity of labor and capital differs depending on whether the inputs are used to produce more food or clothing. Suppose we begin at O_F, where only clothing is produced. Now we remove some labor and capital from clothing production, where their marginal products are relatively low, and put them into food production, where their marginal products are high. Under these circumstances, to obtain the first unit of food, very little clothing production is lost. (The MRT is much less than 1.) But as we move along the frontier and produce less clothing, the productivities of labor and capital in clothing production rise and the productivities of labor and capital in food production fall. At *B*, the productivities are equal and the MRT is 1. Continuing along the frontier, we note that because the input productivities in clothing rise more and the productivities in food decrease, the MRT becomes greater than 1.

We can also describe the shape of the production possibilities frontier in terms of the costs of production. At O_F, where very little clothing output is lost to produce additional food, the marginal cost of producing food is very low: A lot of output is produced with very little input. Conversely, the marginal cost of producing clothing is very high: It takes a lot of both inputs to produce another unit of clothing. Thus, when the MRT is low, so is the ratio of the marginal cost of producing food MC_F to the marginal cost of producing clothing MC_C. In fact, *the slope of the production possibilities frontier measures the marginal cost of producing one good relative to the marginal cost of producing the other.* The curvature of the production possibilities frontier follows directly from the fact that the marginal cost of producing food relative to the marginal cost of producing clothing is increasing. At every point along the frontier, the following condition holds:

$$\text{MRT} = \text{MC}_F/\text{MC}_C \qquad \textbf{(16.3)}$$

At *B*, for example, the MRT is equal to 1. Here, when inputs are switched from clothing to food production, 1 unit of output is lost and 1 is gained. If the input cost of producing 1 unit of either good is \$100, the ratio of the marginal costs would be \$100/\$100, or 1. Equation (16.3) also holds at *D* (and at every other point on the frontier). Suppose the inputs needed to produce 1 unit of food cost \$160. The marginal cost of food would be \$160, but the marginal cost of clothing would be only \$80 (\$160/2 units of clothing). As a result, the ratio of the marginal costs, 2, is equal to the MRT.

Output Efficiency

For an economy to be efficient, goods must not only be produced at minimum cost; *goods must also be produced in combinations that match people's willingness to pay for them.* To understand this principle, recall from Chapter 3 that the

[5]The production possibilities frontier need not have a continually increasing MRT. Suppose, for example, that there are strong diseconomies of scale in the production of food. In that case, as inputs are moved from clothing to food production, the amount of clothing that must be given up to obtain one more unit of food will decline.

marginal rate of substitution of clothing for food (MRS) measures the consumer's willingness to pay for an additional unit of food by consuming less clothing. The marginal rate of transformation measures the cost of an additional unit of food in terms of producing less clothing. An economy produces output efficiently only if, for each consumer,

$$\text{MRS} = \text{MRT} \qquad \textbf{(16.4)}$$

To see why this condition is necessary for efficiency, suppose the MRT equals 1, while the MRS equals 2. In that case, consumers are willing to give up 2 units of clothing to get 1 unit of food, but the cost of getting the additional food is only 1 unit of lost clothing. Clearly, too little food is being produced. To achieve efficiency, food production must be increased until the MRS falls and the MRT increases and the two are equal. The outcome is output efficient only when MRS = MRT for all pairs of goods.

Figure 16.10 shows this important output efficiency condition graphically. Here, we have superimposed one consumer's indifference curve on the production possibilities frontier from Figure 16.9. Note that *C* is the only point on the production possibilities frontier that maximizes the consumer's satisfaction. Although all points on the production frontier are technically efficient, not all involve the most efficient production of goods from the consumer's perspective. At the point of tangency of the indifference curve and the production frontier, the MRS (the slope of the indifference curve) and the MRT (the slope of the production frontier) are equal.

If you were a planner in charge of managing an economy, you would face a difficult problem. To achieve output efficiency, you must equate the marginal rate of transformation with the consumer's marginal rate of substitution. But if different consumers have different preferences for food and clothing, how can you decide what levels of food and clothing to produce and what amount of each to give to every consumer, so that all consumers have the same MRS? The informational and logistical costs are enormous. That is one reason why centrally planned economies, like that of the former Soviet Union, performed so poorly. Fortunately, a well-functioning competitive market system can achieve the same efficient outcome as an ideal managed economy.

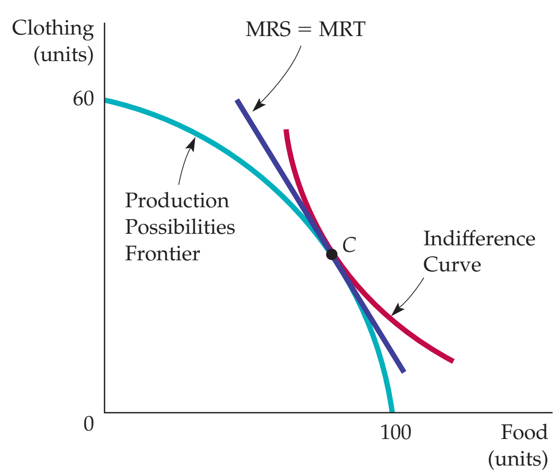


FIGURE 16.10
OUTPUT EFFICIENCY

The efficient combination of outputs is produced when the marginal rate of transformation between the two goods (which measures the cost of producing one good relative to the other) is equal to the consumer's marginal rate of substitution (which measures the marginal benefit of consuming one good relative to the other).

Efficiency in Output Markets

When output markets are perfectly competitive, all consumers allocate their budgets so that their marginal rates of substitution between two goods are equal to the price ratio. For our two goods, food and clothing,

In §3.3, we explain that utility maximization is generally achieved when the marginal rate of substitution of one good for another is equal to the ratio of their two prices.

$$\text{MRS} = P_F/P_C$$

At the same time, each profit-maximizing firm will produce its output up to the point at which price is equal to marginal cost. Again, for our two goods,

$$P_F = \text{MC}_F \quad \text{and} \quad P_C = \text{MC}_C$$

Because the marginal rate of transformation is equal to the ratio of the marginal costs of production, it follows that

$$\text{MRT} = \text{MC}_F/\text{MC}_C = P_F/P_C = \text{MRS} \qquad \textbf{(16.5)}$$

When output and input markets are competitive, production will be output efficient in that the MRT is equal to the MRS. This condition is just another version of the marginal benefit–marginal cost rule discussed in Chapter 4. There we saw that consumers buy additional units of a good up to the point at which the marginal benefit of consumption is equal to the marginal cost. Here we see that the production of food and clothing is chosen so that the marginal benefit of consuming another unit of food is equal to the marginal cost of producing another unit of food; the same is true for the consumption and production of clothing.

In §3.3, we explain that utility maximization is achieved when the marginal benefit of consuming an additional unit of each product is equal to its marginal cost.

Figure 16.11 shows that efficient competitive output markets are achieved when production and consumption choices are separated. Suppose the market generates a price ratio of P_F^1/P_C^1. If producers are using inputs efficiently, they will produce food and clothing at A, where the price ratio is equal to the MRT, the slope of the production possibilities frontier. When faced with this budget constraint, however, consumers would like to consume at B, where they maximize their satisfaction at the higher indifference curve U_2. However, at the price ratio P_F^1/P_C^1, producers will not produce the combination of food and clothing at B. Because the producer wants to produce

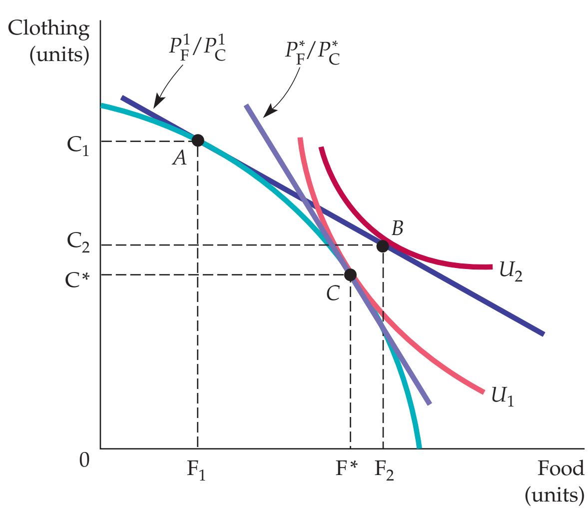


FIGURE 16.11
COMPETITION AND OUTPUT EFFICIENCY

In a competitive output market, people consume to the point where their marginal rate of substitution is equal to the price ratio. Producers choose outputs so that the marginal rate of transformation is equal to the price ratio. Because the MRS equals the MRT, the competitive output market is efficient. Any other price ratio will lead to an excess demand for one good and an excess supply of the other.

F_1 units of food, while consumers want to buy F_2, there will be an excess demand for food. Correspondingly, because consumers wish to buy C_2 units of clothing while producers wish to sell C_1, there will be an excess supply of clothing. Prices in the market will then adjust: The price of food will rise and that of clothing will fall. As price ratio P_F/P_C increases, the price line will move along the production frontier.

An equilibrium results when the price ratio is P_F^*/P_C^* at C. In equilibrium, there is no way to make a consumer better off without making another consumer worse off. Hence, this equilibrium is Pareto efficient. Moreover, producers want to sell F* units of food and C* units of clothing; consumers want to buy the same amounts. At this equilibrium, the MRT and the MRS are equal again; therefore, the competitive equilibrium is output efficient.

16.5 The Gains from Free Trade

Clearly there are gains from international trade in an exchange economy. We have seen that two persons or two countries can benefit by trading to reach a point on the contract curve. However, there are additional gains from trade when the economies of two countries differ so that one country has a *comparative advantage* in producing one good while the other has a comparative advantage in producing another.

Comparative Advantage

comparative advantage Situation in which Country 1 has an advantage over Country 2 in producing a good because the cost of producing the good in 1, relative to the cost of producing other goods in 1, is lower than the cost of producing the good in 2, relative to the cost of producing other goods in 2.

absolute advantage Situation in which Country 1 has an advantage over Country 2 in producing a good because the cost of producing the good in 1 is lower than the cost of producing it in 2.

Country 1 has a **comparative advantage** *over Country 2 in producing a good if the cost of producing that good, relative to the cost of producing other goods in 1, is lower than the cost of producing the good in 2, relative to the cost of producing other goods in 2.*[6] Note that comparative advantage is not the same as *absolute* advantage. A country has an **absolute advantage** in producing a good if its cost is lower than the cost in another country. A comparative advantage, on the other hand, implies that a country's cost, *relative to the costs of other goods it produces*, is lower than the other country's.

When each of two countries has a comparative advantage, they are better off producing what they are best at and purchasing the rest. To see this, suppose that the first country, Holland, has an *absolute* advantage in producing both cheese and wine. A worker there can produce a pound of cheese in 1 hour and a gallon of wine in 2 hours. In Italy, on the other hand, it takes a worker 6 hours to produce a pound of cheese and 3 hours to produce a gallon of wine. The production relationships are summarized in Table 16.3.[7]

TABLE 16.3 HOURS OF LABOR REQUIRED TO PRODUCE CHEESE AND WINE

	CHEESE (1 *LB*)	WINE (1 *GAL*)
Holland	1	2
Italy	6	3

[6]Formally, if there are 2 goods, x and y, and 2 countries, i and j, we say that country i has a comparative advantage in the production of good x if $\frac{a_x^i}{a_y^i} < \frac{a_x^j}{a_y^j}$ where a_x^i is the cost of producing good x in country i.

[7]This example is based on "World Trade: Jousting for Advantage," *The Economist* (September 22, 1990): 5–40.

Holland has a *comparative* advantage over Italy in producing cheese. Holland's cost of cheese production (in terms of hours of labor used) is half its cost of producing wine, whereas Italy's cost of producing cheese is twice its cost of producing wine. Likewise, Italy has a comparative advantage in producing wine, which it can produce at half the cost at which it can produce cheese.

WHAT HAPPENS WHEN NATIONS TRADE The comparative advantage of each country determines what happens when they trade. The outcome will depend on the price of each good relative to the other when trade occurs. To see how this might work, suppose that with trade, one gallon of wine sells for the same price as one pound of cheese in both Holland and Italy. Suppose also that because there is full employment in both countries, the only way to increase production of wine is to take labor out of the production of cheese, and vice versa.

Without trade, Holland could, with 24 hours of labor input, produce 24 pounds of cheese, 12 gallons of wine, or a combination of the two, such as 18 pounds of cheese and 3 gallons of wine. But Holland can do better. For every hour of labor, Holland can produce 1 pound of cheese, which it can trade for 1 gallon of wine; if the wine were produced at home, 2 hours of labor would be required. It is, therefore, in Holland's interest to specialize in the production of cheese, which it will export to Italy in exchange for wine. If, for example, Holland produced 24 pounds of cheese and traded 6, it would be able to consume 18 pounds of cheese and 6 gallons of wine—a definite improvement over the 18 pounds of cheese and 3 gallons of wine available in the absence of trade.

Italy is also better off with trade. Note that without trade, Italy can, with the same 24 hours of labor input, produce 4 pounds of cheese, 8 gallons of wine, or a combination of the two, such as 3 pounds of cheese and 2 gallons of wine. On the other hand, with every hour of labor, Italy can produce one-third of a gallon of wine, which it can trade for one-third of a pound of cheese. If it produced cheese at home, twice as much time would be involved. Specialization in wine production, therefore, is advantageous for Italy. Suppose that Italy produced 8 gallons of wine and traded 6; in that case, it would be able to consume 6 pounds of cheese and 2 gallons of wine—likewise an improvement over the 3 pounds of cheese and 2 gallons of wine available without trade.

An Expanded Production Possibilities Frontier

When there is comparative advantage, international trade has the effect of allowing a country to consume outside its production possibilities frontier. This can be seen graphically in Figure 16.12, which shows a production possibilities frontier for Holland. Suppose initially that Holland has been prevented from trading with Italy because of a protectionist trade barrier. What is the outcome of the competitive process in Holland? Production is at point A, on indifference curve U_1, where the MRT and the pre-trade price of wine is twice the price of cheese. If Holland were able to trade, it would want to export 2 pounds of cheese in exchange for 1 gallon of wine.

Suppose now that the trade barrier is dropped and Holland and Italy are both open to trade. Suppose also that, as a result of differences in demand and costs in the two countries, trade occurs on a one-to-one basis. Holland will find

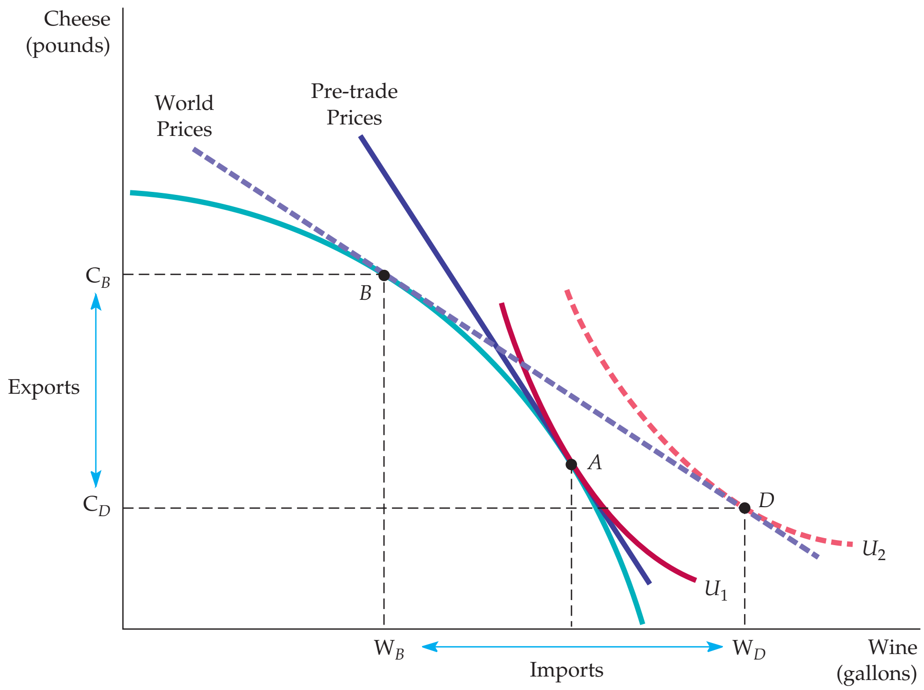


FIGURE 16.12
THE GAINS FROM TRADE

Without trade, production and consumption are at point *A*, where the price of wine is twice the price of cheese. With trade at a relative price of 1 cheese to 1 wine, domestic production is now at *B*, while domestic consumption is at *D*. Free trade has allowed utility to increase from U_1 to U_2.

it advantageous to produce at point *B*, the point of tangency of the 1/1 price line and Holland's production possibilities frontier.

That is not the end of the story, however. Point *B* represents the production decision in Holland. (Once the trade barrier has been removed, Holland will produce less wine and more cheese domestically.) With trade, however, consumption will occur at point *D*, at which the higher indifference curve U_2 is tangent to the trade price line. Thus trade has the effect of expanding Holland's consumption choices beyond its production possibilities frontier. Holland will import $W_D - W_B$ units of wine and export $C_B - C_D$ units of cheese.

With trade, each country will undergo a number of important adjustments. As Holland imports wine, the production of domestic wine will fall, as will employment in the wine industry. Cheese production will increase, however, as will the number of jobs in that industry. Workers with job-specific skills may find it difficult to change employment. Not everyone will, therefore, gain as the result of free trade. Although consumers will clearly be better off, producers of wine and workers in the wine industry are likely to be worse off, at least temporarily.

EXAMPLE 16.3 iPHONE PRODUCTION

Most people think of foreign trade as importing or exporting manufactured products. However, trade often involves many steps that transform raw materials into finished products. At each of these steps, intermediate goods are combined with labor or machines to make part or all of finished products. For instance, workers might assemble a set of chips and other components for a computer. Thus, a typical product embodies a sequence of tasks. Where and how those tasks are performed is an important part of efficient production and trade.

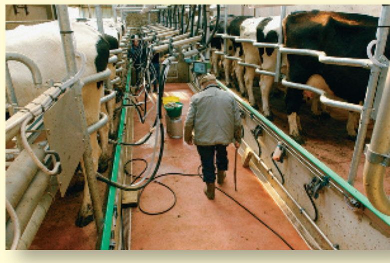
Consider an Apple iPhone 6. On the back it says "Designed in California," but it also says "Assembled in China." But this is only the beginning and end of a long sequence of tasks required to make an iPhone. Two things are of note. First, iPhone manufacturing is truly a global undertaking. Product design takes place in one location, company management somewhere else, and actual assembly in yet a third location. This can be seen most clearly when we examine some of the key components of the phone. The processor chips for the phones are manufactured primarily in Asia. Samsung (South Korea) had been supplying a substantial portion of iPhone chips, but Apple switched to TSMC, a Taiwanese supplier, for the iPhone 6. With respect to the screen, Japan Display (Japan) and Innolux (Taiwan) are the major suppliers. For storage, Toshiba (Japan) and SK Hynix (South Korea) are the leading suppliers. This "unbundling" of production allows firms to use different countries' comparative advantages in different steps of production; it has been made possible by better communications technology and a decline in shipping costs. The designs and the parts are sent to China, which, with its low labor costs and ability to achieve economies of scale, has a comparative advantage in the task of assembly. The assembled iPhones are then shipped back to the United States, where U.S. companies perform distribution and retail tasks.

Second, note that the iPhone's components are semi-finished products rather than raw materials such as plastic or silicon. To make production more efficient, specialized firms design and manufacture most parts. Certainly, Apple could have set up its own factories to make processors, storage, or displays, but it is more efficient to trade and make use of production skills of other firms in other countries. Suppose Apple had brought iPhone manufacturing to the U.S. According to one source (Tim Worstall, *Forbes*), it would cost Apple $4.2 billion to do so. In its current operation, Apple's design and development, sourcing, warehousing, and distribution have generated several hundred thousand jobs in the U.S. At the same time, the iPhone has been a real plus for the economies of South Korea, Taiwan, and Japan.

Third, and finally, the physical components of the iPhone produced outside the U.S. account for less than half of the iPhone 6's retail price.[8] As with most such products, a bundle of different services—design, development, and distribution—is needed to get the final product to the U.S. consumer, and Apple and other firms that perform those services end up with a sizable share of the final selling price.

[8] Jennifer Ribarsky, "Global Manufacturing and Measurement Issues Raised by the iPhone," Bureau of Economic Analysis, U.S. Department of Commerce, May 6, 2011.

EXAMPLE 16.4 THE COSTS AND BENEFITS OF SPECIAL PROTECTION



The demands for protectionist policies increased steadily during the 1980s and into the 1990s. They remain a subject of debate today, whether out of concern for trade with various Asian countries as in the 2016 debate over the Trans-Pacific Partnership (TPP) or in relation to the North American Free Trade Agreement (NAFTA). Protectionism can take many forms, including tariffs and quotas of the kind that we analyzed in Chapter 9, regulatory hurdles, subsidies to domestic producers, and controls on the use of foreign exchange. Table 16.4 highlights the findings of one study of U.S.-imposed trade restrictions.[9]

In §9.1, we explain that consumer surplus is the total benefit or value that consumers receive beyond what they pay for a good; producer surplus is the analogous measure for producers.

Because one of the major purposes of protectionism is to protect jobs in particular industries, it is not surprising that these policies create gains to producers. The costs, however, involve losses to consumers and a substantial reduction in economic efficiency. These efficiency losses are the sum of the loss of producer surplus resulting from inefficient excess domestic production and the loss of consumer surplus resulting from higher domestic prices and lower consumption.

As Table 16.4 shows, the textiles and apparel industry is the largest source of efficiency losses. Although there were substantial gains to producers, consumer

TABLE 16.4 QUANTIFYING THE COSTS OF PROTECTION

INDUSTRY	PRODUCER GAINS[a] ($ MILLIONS)	CONSUMER LOSSES[b] ($ MILLIONS)	EFFICIENCY LOSSES[c] ($ MILLIONS)
Book manufacturing	622	1,020	59
Orange juice	796	1,071	265
Textiles and apparel	44,883	55,084	9,895
Carbon steel	7,753	13,873	673
Color televisions	388	857	14
Dairy products	10,201	11,221	2,795
Meat	3,264	3,672	296
Sugar	1,431	2,882	614

[a]Producer gains in the tariff case are defined as the area of trapezoid A in Figure 9.15.
[b]Consumer losses are the sum of areas A, B, C, and D in Figure 9.15.
[c]These are given by triangles B and C in Figure 9.15.

[9]This example is based on Cletus Coughlin, K. Alec Chrystal, and Geoffrey E. Wood, "Protectionist Trade Policies: A Survey of Theory, Evidence, and Rationale," *Federal Reserve Bank of St. Louis* (January/February 1988): 12–30. The data in the table are taken from Gary Clyde Hufbauer, Diane, T. Berliner, and Kimberly Ann Elliott, "Trade Protection in the United States: 31 Case Studies," *Institute for International Economics* (1986). The dollar amounts have been scaled to 2011 using the CPI. The sugar data are from Figure 9.15.

losses are larger in each case. In addition, efficiency losses from excess (inefficient) domestic production of textiles and reduced domestic consumption of imported textile products were also large—an estimated \$9.89 billion. The second largest source of inefficiency was the dairy industry, where losses amounted to \$2.79 billion.

Finally, note that the efficiency cost of helping domestic producers varies considerably across industries. In textiles the ratio of efficiency costs to producer gains is 22 percent and in dairy products 27 percent; only orange juice is higher (33.3 percent). However, much lower ratios apply to color televisions (3.7 percent), carbon steel (8.7 percent), and book manufacturing (9.5 percent).

16.6 An Overview—The Efficiency of Competitive Markets

Our analysis of general equilibrium and economic efficiency is now complete. In the process, we have obtained two remarkable results. First, we have shown that for any initial allocation of resources, a competitive process of exchange among individuals, whether through exchange, input markets, or output markets, will lead to a Pareto efficient outcome. The first theorem of welfare economics tells us that a competitive system, building on the self-interested goals of consumers and producers and on the ability of market prices to convey information to both parties, will achieve a Pareto efficient allocation of resources.

Second, we have shown that with indifference curves that are convex, any efficient allocation of resources can be achieved by a competitive process with a suitable redistribution of those resources. Of course, there may be many Pareto efficient outcomes. But the second theorem of welfare economics tells us that under certain (admittedly ideal) conditions, issues of equity and efficiency can be treated distinctly from one another. If we are willing to put equity issues aside, then we know that there is a competitive equilibrium that maximizes consumer and producer surplus, i.e., is economically efficient.

Both theorems of welfare economics depend crucially on the assumption that markets are competitive. Unfortunately, neither of these results necessarily holds when, for some reason, markets are no longer competitive. In the next two chapters, we will discuss ways in which markets fail and what government can do about it. Before proceeding, however, it is essential to review our understanding of the workings of the competitive process. We thus list the conditions required for economic efficiency in exchange, in input markets, and in output markets. These conditions are important; in each of these three cases, you should review the explanation of the conditions in this chapter and the underlying building blocks in prior chapters.

Recall from §3.3 that consumer satisfaction is maximized when the marginal rate of substitution of food for clothing is equal to the ratio of the price of food to that of clothing.

1. ***Efficiency in exchange:*** All allocations must lie on the exchange contract curve so that every consumer's marginal rate of substitution of food for clothing is the same:

$$\mathrm{MRS}^{J}_{\mathrm{FC}} = \mathrm{MRS}^{K}_{\mathrm{FC}}$$

A competitive market achieves this efficient outcome because, for consumers, the tangency of the budget line and the highest attainable indifference curve ensure that:

$$\text{MRS}^J_{\text{FC}} = P_F/P_C = \text{MRS}^K_{\text{FC}}$$

2. ***Efficiency in the use of inputs in production:*** Every producer's marginal rate of technical substitution of labor for capital is equal in the production of both goods:

$$\text{MRTS}^F_{\text{LK}} = \text{MRTS}^C_{\text{LK}}$$

A competitive market achieves this technically efficient outcome because each producer maximizes profit by choosing labor and capital inputs so that the ratio of the input prices is equal to the marginal rate of technical substitution:

Recall from §7.3 that profit maximization requires that the marginal rate of technical substitution of labor for capital be equal to the ratio of the wage rate to the cost of capital.

$$\text{MRTS}^F_{\text{LK}} = w/r = \text{MRTS}^C_{\text{LK}}$$

3. ***Efficiency in the output market:*** The mix of outputs must be chosen so that the marginal rate of transformation between outputs is equal to consumers' marginal rates of substitution:

$$\text{MRT}_{\text{FC}} = \text{MRS}_{\text{FC}}(\text{for all consumers})$$

A competitive market achieves this efficient outcome because profit-maximizing producers increase their output to the point at which marginal cost equals price:

In §8.3, we explain that because a competitive firm faces a horizontal demand curve, choosing its output so that marginal cost is equal to price is profit-maximizing.

$$P_F = \text{MC}_F, \quad P_C = \text{MC}_C$$

As a result,

$$\text{MRT}_{\text{FC}} = \text{MC}_F/\text{MC}_C = P_F/P_C$$

But consumers maximize their satisfaction in competitive markets only if

$$P_F/P_C = \text{MRS}_{\text{FC}}(\text{for all consumers})$$

Therefore,

$$\text{MRS}_{\text{FC}} = \text{MRT}_{\text{FC}}$$

and the output efficiency conditions are satisfied. Thus efficiency requires that goods be produced in combinations and at costs that match people's willingness to pay for them.

16.7 Why Markets Fail

We can give two different interpretations of the conditions required for efficiency. The first stresses that competitive markets work. It also tells us that we ought to ensure that the prerequisites for competition hold, so that resources can be efficiently allocated. The second stresses that the prerequisites for competition are unlikely to hold. It tells us that we ought to concentrate on ways of dealing with market failures. Thus far we have focused on the first interpretation. For the remainder of the book, we concentrate on the second.

Competitive markets fail for four basic reasons: *market power, incomplete information, externalities*, and *public goods.* We will discuss each in turn.

Market Power

In §10.2, we explain that a seller of a product has monopoly power if it can profitably charge a price greater than marginal cost; similarly, §10.5 explains that a buyer has monopsony power when its purchasing decision can affect the price of a good.

We have seen that inefficiency arises when a producer or supplier of a factor input has market power. Suppose, for example, that the producer of food in our Edgeworth box diagram has monopoly power. It therefore chooses the output quantity at which marginal revenue (rather than price) is equal to marginal cost and sells less output at a price higher than it would charge in a competitive market. The lower output will mean a lower marginal cost of food production. Meanwhile, the freed-up production inputs will be allocated to produce clothing, whose marginal cost will increase. As a result, the marginal rate of transformation will decrease because $\text{MRT}_{\text{FC}} = \text{MC}_F/\text{MC}_C$. We might end up, for example, at *A* on the production possibilities frontier in Figure 16.9. Producing too little food and too much clothing is an output inefficiency because firms with market power use different prices in their output decisions than consumers use in their consumption decisions.

A similar argument would apply to market power in an input market. Suppose that unions gave workers market power over the supply of their labor in the production of food. Too little labor would then be supplied to the food industry at too high a wage (w_F) and too much labor to the clothing industry at too low a wage (w_C). In the clothing industry, the input efficiency conditions would be satisfied because $\text{MRTS}^C_{\text{LK}} = w_C/r$. But in the food industry, the wage paid would be greater than the wage paid in the clothing industry. Therefore, $\text{MRTS}^F_{\text{LK}} = w_F/r > w_C/r = \text{MRTS}^C_{\text{LK}}$. The result is input inefficiency because efficiency requires that the marginal rates of technical substitution be equal in the production of all goods.

Incomplete Information

If consumers do not have accurate information about market prices or product quality, the market system will not operate efficiently. This lack of information may give producers an incentive to supply too much of some products and too little of others. In other cases, while some consumers may not buy a product even though they would benefit from doing so, others buy products that leave them worse off. For example, consumers may buy pills that guarantee weight loss, only to find that they have no medical value. Finally, a lack of information may prevent some markets from ever developing. It may, for example, be impossible to purchase certain kinds of insurance because suppliers of insurance lack adequate information about consumers likely to be at risk.

Each of these informational problems can lead to competitive market inefficiency. We will describe informational inefficiencies in detail in Chapter 17 and see whether government intervention might help to reduce them.

Externalities

The price system works efficiently because market prices convey information to both producers and consumers. Sometimes, however, market prices do not reflect the activities of either producers or consumers. There is an *externality* when a consumption or production activity has an indirect effect on other consumption or production activities that is not reflected directly in market prices. As we explained in Section 9.2 (page 333), the word *externality* is used because the effects on others (whether benefits or costs) are external to the market.

Suppose, for example, that a steel plant dumps effluent in a river, thus making a recreation site downstream unsuitable for swimming or fishing. There is an externality because the steel producer does not bear the true cost of wastewater and so uses too much wastewater to produce its steel. This externality causes an input inefficiency. If this externality prevails throughout the industry, the price of steel (which is equal to the marginal cost of production) will be lower than if the cost of production reflected the effluent cost. As a result, too much steel will be produced, and there will be an output inefficiency.

We will discuss externalities and ways to deal with them in Chapter 18.

Public Goods

public good Nonexclusive, nonrival good that can be made available cheaply but which, once available, is difficult to prevent others from consuming.

The last source of market failure arises when the market fails to supply goods that many consumers value. A **public good** can be made available cheaply to many consumers, but once it is provided to some consumers, it is very difficult to prevent others from consuming it. For example, suppose a firm is considering whether to undertake research on a new technology for which it cannot obtain a patent. Once the invention is made public, others can duplicate it. As long as it is difficult to exclude other firms from selling the product, the research will be unprofitable.

Markets therefore undersupply public goods. We will see in Chapter 18 that government can sometimes resolve this problem either by supplying a good itself or by altering the incentives for private firms to produce it.

EXAMPLE 16.5 INEFFICIENCY IN THE HEALTH CARE SYSTEM

The United States spends a larger fraction of its GDP on health care than do most other countries. Does this mean that the U.S. health care system is less "efficient" than other health care systems? This is an important public policy question that we can clarify by taking advantage of the analysis presented in this chapter. There are two distinct efficiency issues here. First, is the U.S. health care system *technically efficient* in production, in the sense of utilizing the best combination of such inputs as hospital beds, physicians, nurses, and drugs to obtain better health outcomes? Second, is the United States *output efficient* in the provision of health care; that is, are the health benefits from the marginal dollar spent on health care greater than the opportunity cost of other goods and services that might be provided instead?

We discussed the question of *technical efficiency* in Chapter 6. As we saw in Example 6.1, as more and more health care is produced, there are diminishing returns, so that even if we are on the production frontier, it will take more and more resources to eke out small gains in health outcomes (e.g., increases in life expectancy). But we saw that there is reason to believe that the health care industry is operating below the frontier, so that if inputs were used more efficiently, better health outcomes could be achieved with little or no increase in resources. For example, for every office-based physician in the United States there are 2.2 administrative workers. This is 25 percent higher than the equivalent number in the United Kingdom, 165 percent more than the Netherlands, and 215 percent more than Germany. It appears that substantially more time and expense is devoted to navigating the complex credentialing, claim reporting, verification, and billing requirements of various insurers in the U.S. relative to other developed countries. In addition, a number of low cost, highly effective treatments seem to be under-prescribed in the United States. Beta blockers, for example, cost just a few cents per dose and are believed to reduce heart attack mortality by 25 percent, yet in some parts of the country they are rarely prescribed.

What about *output efficiency*? It has been suggested that the increasing fraction of income being devoted to health expenditures in the United States is evidence of inefficiency. But, as we saw in Example 3.4, this could simply reflect a strong preference for health care on the part of the U.S. population, whose incomes have generally been increasing. The study underlying that example calculated the marginal rate of substitution between health related and non-health related goods and found that as consumption increases, the marginal utility of consumption for non-health related goods falls quickly. As we explained, this should not be surprising; as individuals age and their incomes increase, an extra year of life expectancy becomes much more valuable than a new car or a second home. Thus an increasing share of income devoted to health is entirely consistent with output efficiency.

SUMMARY

1. Partial equilibrium analyses of markets assume that related markets are unaffected. General equilibrium analyses examine all markets simultaneously, taking into account feedback effects of other markets on the market being studied.
2. An allocation is efficient when no consumer can be made better off by trade without making someone else worse off. When consumers make all mutually advantageous trades, the outcome is Pareto efficient and lies on the contract curve.
3. A competitive equilibrium describes a set of prices and quantities. When each consumer chooses her most preferred allocation, the quantity demanded is equal to the quantity supplied in every market. All competitive equilibrium allocations lie on the exchange contract curve and are Pareto efficient.
4. The utility possibilities frontier measures all efficient allocations in terms of the levels of utility that each of two people achieves. Although both individuals prefer some allocations to an inefficient allocation, not *every* efficient allocation must be so preferred. Thus an inefficient allocation can be more equitable than an efficient one.
5. Because a competitive equilibrium need not be equitable, the government may wish to help redistribute wealth from rich to poor. Because such redistribution is costly, there is some conflict between equity and efficiency.
6. An allocation of production inputs is technically efficient if the output of one good cannot be increased without decreasing the output of another.
7. A competitive equilibrium in input markets occurs when the marginal rate of technical substitution between pairs of inputs is equal to the ratio of the prices of the inputs.
8. The production possibilities frontier measures all efficient allocations in terms of the levels of output that can be produced with a given combination of inputs. The marginal rate of transformation of good 1 for good 2 increases as more of good 1 and less of good 2 are produced. The marginal rate of transformation is equal to the ratio of the marginal cost of producing good 1 to the marginal cost of producing good 2.
9. Efficiency in the allocation of goods to consumers is achieved only when the marginal rate of substitution of one good for another in consumption (which is the same for all consumers) is equal to the marginal rate of transformation of one good for another in production.
10. When input and output markets are perfectly competitive, the marginal rate of substitution (which equals the ratio of the prices of the goods) will equal the marginal rate of transformation (which equals the ratio of the marginal costs of producing the goods).
11. Free international trade expands a country's production possibilities frontier. As a result, consumers are better off.
12. Competitive markets may be inefficient for four reasons. First, firms or consumers may have market power in input or output markets. Second, consumers or producers may have incomplete information and may therefore err in their consumption and production decisions. Third, externalities may be present. Fourth, some socially desirable public goods may not be produced.

QUESTIONS FOR REVIEW

1. Why can feedback effects make a general equilibrium analysis substantially different from a partial equilibrium analysis?
2. In the Edgeworth box diagram, explain how one point can simultaneously represent the market baskets owned by two consumers.
3. In the analysis of exchange using the Edgeworth box diagram, explain why both consumers' marginal rates of substitution are equal at every point on the contract curve.
4. "Because all points on a contract curve are efficient, they are all equally desirable from a social point of view." Do you agree with this statement? Explain.
5. How does the utility possibilities frontier relate to the contract curve?
6. In the Edgeworth production box diagram, what conditions must hold for an allocation to be on the production contract curve? Why is a competitive equilibrium on the contract curve?

7. How is the production possibilities frontier related to the production contract curve?
8. What is the marginal rate of transformation (MRT)? Explain why the MRT of one good for another is equal to the ratio of the marginal costs of producing the two goods.
9. Explain why goods will not be distributed efficiently among consumers if the MRT is not equal to the consumers' marginal rate of substitution.
10. Why can free trade between two countries make consumers of both countries better off?
11. If Country *A* has an absolute advantage in the production of two goods compared to Country *B*, then it is not in Country *A*'s best interest to trade with Country *B*. True or false? Explain.
12. Do you agree or disagree with each of the following statements? Explain.
    a. If it is possible to exchange 3 pounds of cheese for 2 bottles of wine, then the price of cheese is 2/3 the price of wine.
    b. A country can only gain from trade if it can produce a good at a lower absolute cost than its trading partner.
    c. If there are constant marginal and average costs of production, then it is in a country's best interest to specialize completely in the production of some goods but to import others.
    d. Assuming that labor is the only input, if the opportunity cost of producing a yard of cloth is 3 bushels of wheat per yard, then wheat must require 3 times as much labor per unit produced as cloth.
13. What are the four major sources of market failure? Explain briefly why each prevents the competitive market from operating efficiently.

EXERCISES

1. Suppose gold (*G*) and silver (*S*) are substitutes for each other because both serve as hedges against inflation. Suppose also that the supplies of both are fixed in the short run ($Q_G = 75$ and $Q_S = 300$) and that the demands for gold and silver are given by the following equations:

$$P_G = 975 - Q_G + 0.5P_S \text{ and } P_S = 600 - Q_S + 0.5P_G.$$

    a. What are the equilibrium prices of gold and silver?
    b. What if a new discovery of gold doubles the quantity supplied to 150? How will this discovery affect the prices of both gold and silver?
2. Using general equilibrium analysis, and taking into account feedback effects, analyze the following:
    a. The likely effects of outbreaks of disease on chicken farms on the markets for chicken and pork.
    b. The effects of increased taxes on airline tickets on travel to major tourist destinations such as Florida and California and on the hotel rooms in those destinations.
3. Jane has 3 liters of soft drinks and 9 sandwiches. Bob, on the other hand, has 8 liters of soft drinks and 4 sandwiches. With these endowments, Jane's marginal rate of substitution (MRS) of soft drinks for sandwiches is 4 and Bob's MRS is equal to 2. Draw an Edgeworth box diagram to show whether this allocation of resources is efficient. If it is, explain why. If it is not, what exchanges will make both parties better off?
4. Jennifer and Drew consume orange juice and coffee. Jennifer's MRS of orange juice for coffee is 1 and Drew's MRS of orange juice for coffee is 3. If the price of orange juice is $2 and the price of coffee is $3, which market is in excess demand? What do you expect to happen to the prices of the two goods?
5. Fill in the missing information in the following tables. For each table, use the information provided to identify a possible trade. Then identify the final allocation and a possible value for the MRS at the efficient solution. (*Note:* There is more than one correct answer.) Illustrate your results using Edgeworth box diagrams.
    a. Norman's MRS of food for clothing is 1 and Gina's MRS of food for clothing is 4:

INDIVIDUAL	INITIAL ALLOCATION	TRADE	FINAL ALLOCATION
Norman	6F, 2C		
Gina	1F, 8C		

    b. Michael's MRS of food for clothing is 1/2 and Kelly's MRS of food for clothing is 3.

INDIVIDUAL	INITIAL ALLOCATION	TRADE	FINAL ALLOCATION
Michael	10F, 3C		
Kelly	5F, 15C		

6. In the analysis of an exchange between two people, suppose both people have identical preferences. Will the contract curve be a straight line? Explain. Can you think of a counterexample?
7. Give an example of conditions when the production possibilities frontier might not be concave.
8. A monopsonist buys labor for less than the competitive wage. What type of inefficiency will this use of monopsony power cause? How would your answer change if the monopsonist in the labor market were also a monopolist in the output market?

9. The Acme Corporation produces x and y units of goods Alpha and Beta, respectively.

a. Use a production possibility frontier to explain how the willingness to produce more or less Alpha depends on the marginal rate of transformation of Alpha or Beta.

b. Consider two cases of production extremes:
(i) Acme produces zero units of Alpha initially, or
(ii) Acme produces zero units of Beta initially. If Acme always tries to stay on its production possibility frontier, describe the initial positions of cases (i) and (ii). What happens as the Acme Corporation begins to produce *both* goods?

10. In the context of our analysis of the Edgeworth production box, suppose that a new invention changes a constant-returns-to-scale food production process into one that exhibits sharply increasing returns. How does this change affect the production contract curve?

11. Suppose that country *A* and country *B* both produce wine and cheese. Country *A* has 800 units of available labor, while country *B* has 600 units. Prior to trade, country *A* consumes 40 pounds of cheese and 8 bottles of wine, and country *B* consumes 30 pounds of cheese and 10 bottles of wine.

	COUNTRY A	COUNTRY B
Labor per pound cheese	10	10
Labor per bottle wine	50	30

a. Which country has a comparative advantage in the production of each good? Explain.

b. Determine the production possibilities curve for each country, both graphically and algebraically. (Label the pretrade production point *PT* and the post-trade point *P*.)

c. Given that 36 pounds of cheese and 9 bottles of wine are traded, label the post-trade consumption point *C*.

d. Prove that both countries have gained from trade.

e. What is the slope of the price line at which trade occurs?

12. Suppose a bakery has 16 employees to be designated as bread bakers (B) and cake bakers (C), so that B + C = 16. Draw the production possibilities frontier for bread (y) and cakes (x) for the following production functions:

a. $y = 2B^{.5}$ and $x = C^{.5}$

b. $y = B$ and $x = 2C^{.5}$