CHAPTER 3

The Standard Theory of International Trade

Learning Goals: After reading this chapter, you should be able to:

- Understand how relative commodity prices and the comparative advantage of nations are determined under increasing costs
- Show the basis and the gains from trade with increasing costs
- Explain the relationship between international trade and deindustrialization in the United States and other advanced nations

3.1 Introduction

This chapter extends our simple trade model to the more realistic case of increasing opportunity costs. Tastes or demand preferences are introduced with community indifference curves. We then see how these forces of supply and demand determine the equilibrium-relative commodity price in each nation in the absence of trade under increasing costs. This will also indicate the commodity of comparative advantage for each nation.

Subsequently, we examine how, with trade, each nation gains by specializing in the production of the commodity of its comparative advantage and exporting some of its output in exchange for the commodity of its comparative disadvantage. The last section of the chapter shows how mutually beneficial trade is possible even when two nations are exactly alike except for tastes under increasing cost conditions.

In this and in the following chapters, it will be convenient to generalize the presentation and deal with Nation 1 and Nation 2 (instead of the United States and United Kingdom) and commodity X and commodity Y (instead of wheat and cloth).

The appendix to this chapter is a review of those aspects of production theory that are essential for understanding the material presented in the appendices of the chapters that follow. This and the subsequent appendices can be omitted without loss of continuity in the text.

3.2 The Production Frontier with Increasing Costs

It is more realistic for a nation to face increasing rather than constant opportunity costs. **Increasing opportunity costs** mean that the nation must give up more and more of one commodity to release just enough resources to produce each additional unit of another commodity. Increasing opportunity costs results in a production frontier that is concave from the origin (rather than a straight line).

3.2A Illustration of Increasing Costs

Figure 3.1 shows the hypothetical production frontier of commodities X and Y for Nation 1 and Nation 2. Both production frontiers are concave from the origin, reflecting the fact that each nation incurs increasing opportunity costs in the production of *both* commodities.

Suppose that Nation 1 wants to produce more of commodity X, starting from point *A* on its production frontier. Since at point *A* the nation is already utilizing all of its resources with the best technology available, the nation can only produce more of X by reducing the output of commodity Y. (In Chapter 2, we saw that this is the reason production frontiers are negatively sloped.)

Figure 3.1 shows that for each additional batch of 20X that Nation 1 produces, it must give up more and more Y. The increasing opportunity costs in terms of Y that Nation 1 faces are reflected in the longer and longer downward arrows in the figure, and result in a production frontier that is concave from the origin.

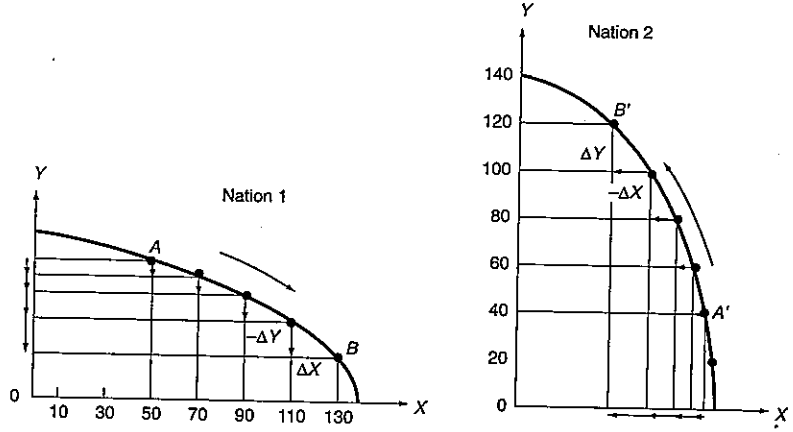

FIGURE 3.1. Production Frontiers of Nation 1 and Nation 2 with Increasing Costs. Concave production frontiers reflect increasing opportunity costs in each nation in the production of *both* commodities. Thus, Nation 1 must give up more and more of Y for each additional batch of 20X that it produces. This is illustrated by downward arrows of increasing length. Similarly, Nation 2 incurs increasing opportunity costs in terms of forgone X (illustrated by the increasing length of the leftward arrows) for each additional batch of 20Y it produces.

Nation 1 also faces increasing opportunity costs in the production of Y. This could be demonstrated graphically by showing that Nation 1 has to give up increasing amounts of X for each additional batch of 20Y that it produces. However, instead of showing this for Nation 1, we demonstrate increasing opportunity costs in the production of Y with the production frontier of Nation 2 in Figure 3.1.

Moving upward from point *A′* along the production frontier of Nation 2, we observe leftward arrows of increasing length, reflecting the increasing amounts of X that Nation 2 must give up to produce each additional batch of 20Y. Thus, concave production frontiers for Nation 1 and Nation 2 reflect increasing opportunity costs in each nation in the production of *both* commodities.

3.2B The Marginal Rate of Transformation

The **marginal rate of transformation (MRT)** of X for Y refers to the amount of Y that a nation must give up to produce each additional unit of X. Thus, MRT is another name for the opportunity cost of X (the commodity measured along the horizontal axis) and is given by the (absolute) *slope* of the production frontier at the point of production.

If in Figure 3.1 the slope of the production frontier (MRT) of Nation 1 at point *A* is ¼, this means that Nation 1 must give up ¼ of a unit of Y to release just enough resources to produce one additional unit of X at this point. Similarly, if the slope, or MRT, equals 1 at point *B*, this means that Nation 1 must give up one unit of Y to produce one additional unit of X at this point.

Thus, a movement from point *A* down to point *B* along the production frontier of Nation 1 involves an increase in the slope (MRT) from ¼ (at point *A*) to 1 (at point *B*) and reflects the increasing opportunity costs in producing more X. This is in contrast to the case of a straight-line production frontier (as in Chapter 2), where the opportunity cost of X is constant regardless of the level of output and is given by the constant value of the slope (MRT) of the production frontier.

3.2c Reasons for Increasing Opportunity Costs and Different Production Frontiers

We have examined the meaning of increasing opportunity costs as reflected in concave production frontiers. But how do increasing opportunity costs arise? And why are they more realistic than constant opportunity costs?

Increasing opportunity costs arise because resources or factors of production (1) are not homogeneous (i.e., all units of the same factor are not identical or of the same quality) and (2) are not used in the *same* fixed proportion or intensity in the production of all commodities. This means that as the nation produces more of a commodity, it must utilize resources that become progressively less efficient or less suited for the production of that commodity. As a result, the nation must give up more and more of the second commodity to release just enough resources to produce each additional unit of the first commodity.

For example, suppose some of a nation's land is flat and suited for growing wheat, and some is hilly and better suited for grazing and milk production. The nation originally specialized in wheat but now wants to concentrate on producing milk. By transferring its hilly areas from wheat growing to grazing, the nation gives up very little wheat and obtains a great deal of milk. Thus, the opportunity cost of milk in terms of the amount of wheat given up is initially small. But if this transfer process continues, eventually flat land, which is better suited for wheat growing, will have to be used for grazing. As a result, the opportunity cost of milk will rise, and the production frontier will be concave from the origin.

The difference in the production frontiers of Nation 1 and Nation 2 in Figure 3.1 is due to the fact that the two nations have different factor endowments or resources at their disposal and/or use different technologies in production. In the real world, the production frontiers of different nations will usually differ, since practically no two nations have indentical factor endowments (even if they could have access to the same technology).

As the supply or availability of factors and/or technology changes over time, a nation's production frontier shifts. The type and extent of these shifts depend on the type and extent of the changes that take place. These changes are examined in detail in Chapter 7, which deals with economic growth and its effect on international trade.

3.3 Community Indifference Curves

So far, we have discussed production, or supply, considerations in a nation, as reflected in its production frontier. We now introduce the tastes, or demand preferences, in a nation. These are given by community (or social) indifference curves.

A **community indifference curve** shows the various combinations of two commodities that yield equal satisfaction to the community or nation. Higher curves refer to greater satisfaction, lower curves to less satisfaction. Community indifference curves are negatively sloped and convex from the origin. To be useful, they must not cross. (Readers familiar with an individual's indifference curves will note that community indifference curves are almost completely analogous.)

3.3A Illustration of Community Indifference Curves

Figure 3.2 shows three hypothetical indifference curves for Nation 1 and Nation 2. They differ on the assumption that tastes, or demand preferences, are different in the two nations.

Points *N* and *A* give equal satisfaction to Nation 1, since they are both on indifference curve I. Points *T* and *H* refer to a higher level of satisfaction, since they are on a higher indifference curve (II). Even though *T* involves more of Y but less of X than *A*, satisfaction is greater at *T* because it is on indifference curve II. Point *E* refers to still greater satisfaction, since it is on indifference curve III. For Nation 2, $A' = R' < H' < E'$.

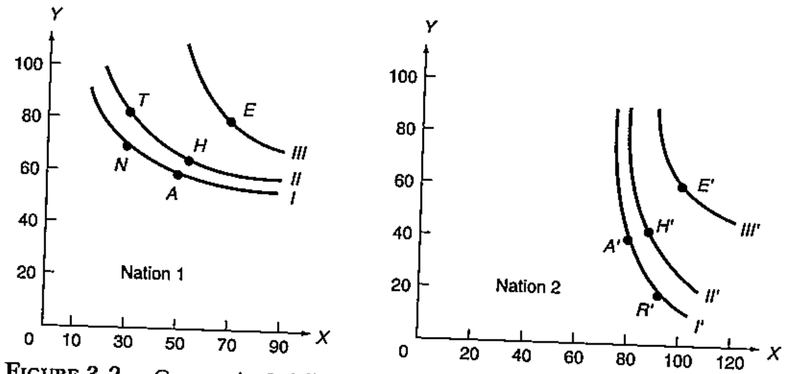

FIGURE 3.2. Community Indifference Curves for Nation 1 and Nation 2. A community indifference curve shows the various combinations of X and Y that yield equal satisfaction to the community or nation. A higher curve refers to a higher level of satisfaction. Community indifference curves are downward, or negatively, sloped and convex from the origin; to be useful, they must not cross. The declining slope of the curve reflects the diminishing marginal rate of substitution (MRS) of X for Y in consumption.

Note that the community indifference curves in Figure 3.2 are negatively sloped. This is always the case because as a nation consumes more of X, it must consume less of Y if the nation is to have the same level of satisfaction (i.e., remain on the same level of satisfaction). Thus, as Nation 1 moves from *N* to *A* on indifference curve I, it consumes more of X but less of Y. Similarly, as Nation 2 moves from *A′* to *R′* on indifference curve I′, it consumes more of X but less of Y. If a nation continued to consume the same amount of Y as it increased its consumption of X, the nation would necessarily move to a higher indifference curve.

3.3B The Marginal Rate of Substitution

The **marginal rate of substitution (MRS)** of X for Y in consumption refers to the amount of Y that a nation could give up for one extra unit of X and *still remain on the same indifference curve.* This is given by the (absolute) slope of the community indifference curve at the point of consumption and declines as the nation moves down the curve. For example, the slope, or MRS, of indifference curve I is greater at point *N* than at point *A* (see Figure 3.2). Similarly, the slope, or MRS, of indifference curve I′ is greater at point *A′* than at *R′*.

The decline in MRS or absolute slope of an indifference curve is a reflection of the fact that the more of X and the less of Y a nation consumes, the more valuable to the nation is a unit of Y at the margin compared with a unit of X. Therefore, the nation can give up less and less of Y for each additional unit of X it wants.

Declining MRS means that community indifference curves are convex from the origin. Thus, while *increasing* opportunity cost in production is reflected in *concave* production frontiers, a *declining* marginal rate of substitution in consumption is reflected in *convex* community indifference curves. In Section 3.4, we will see that this convexity property of indifference curves is necessary to reach a unique (i.e., a single) equilibrium consumption point for the nation.

3.3C Some Difficulties with Community Indifference Curves

As we said earlier, to be useful, community indifference curves must not intersect (cross). A point of intersection would refer to equal satisfaction on two different community indifference curves, which is inconsistent with their definition. Thus, the indifference curves of Nation 1 and Nation 2 in Figure 3.2 are drawn as nonintersecting.

However, a particular set, or map, of community indifference curves refers to a particular *income distribution* within the nation. A different income distribution would result in a completely new set of indifference curves, which might intersect previous indifference curves.

This is precisely what may happen as a nation opens trade or expands its level of trade. Exporters will benefit, while domestic producers competing with imports will suffer. There is also a differential impact on consumers, depending on whether an individual's consumption pattern is oriented more toward the X or the Y good. Thus, trade will change the distribution of real income in the nation and *may* cause indifference curves to intersect. In that case, we could not use community indifference curves to determine whether the opening or the expansion of trade increased the nation's welfare.

One way out of this impasse is through the so-called *compensation principle.* According to this principle, the nation benefits from trade if the gainers would be better off (i.e., retain some of their gain) even after fully compensating the losers for their losses. This is true whether or not compensation actually occurs. (One way that compensation would occur is for the government to tax enough of the gain to fully compensate the losers with subsidies or tax relief.) Alternatively, we could make a number of restrictive assumptions about tastes, incomes, and patterns of consumption that would preclude intersecting community indifference curves.

Although the compensation principle or restrictive assumptions do not completely eliminate all the conceptual difficulties inherent in using community indifference curves, they do allow us to draw them as nonintersecting (so that we can continue to make use of them, even if a bit cautiously).

3.4 Equilibrium in Isolation

In Section 3.2, we discussed production frontiers, which illustrate the production, or supply, conditions in a nation. In Section 3.3, we examined community indifference curves, which reflect the tastes, or demand preferences, in a nation. We will now see how the interaction of these forces of demand and supply determines the equilibrium point, or point of maximum social welfare, in a nation in isolation (i.e., in the absence of trade).

In the absence of trade, a nation is in equilibrium when it reaches the highest indifference curve possible given its production frontier. This occurs at the point where a community indifference curve is tangent to the nation's production frontier. The common slope of the two curves at the tangency point gives the internal equilibrium-relative commodity price in the nation and reflects the nation's comparative advantage. Let us see what all this means.

3.4A Illustration of Equilibrium in Isolation

Figure 3.3. brings together the production frontiers of Figure 3.1 and the community indifference curves of Figure 3.2. We see in Figure 3.3 that indifference curve I is the highest indifference curve that Nation 1 can reach with its production frontier. Thus, Nation 1 is in equilibrium, or maximizes its welfare, when it produces and consumes at point *A* in the absence of trade, or **autarky**. Similarly, Nation 2 is in equilibrium at point *A′*, where its production frontier is tangent to indifference curve I′.

Note that since community indifference curves are convex from the origin and drawn as nonintersecting, there is only one such point of tangency, or

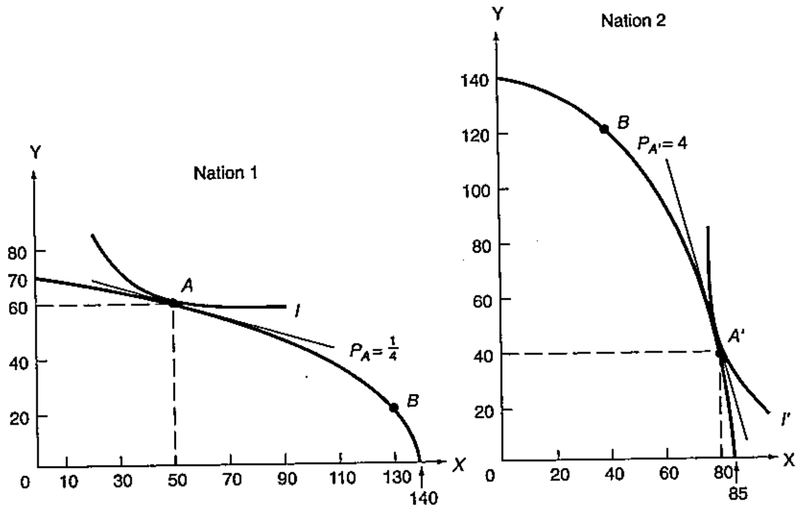

FIGURE 3.3. Equilibrium in Isolation. Nation 1 is in equilibrium, or maximizes its welfare, in isolation by producing and consuming at point A, where its production frontier reaches (is tangent to) indifference curve I (the highest possible). Similarly, Nation 2 is in equilibrium at point A', where its production frontier is tangent to indifference curve I′. The equilibrium relative price of X in Nation 1 is given by the slope of the common tangent to its production frontier and indifference curve I at point A. This is $P_A = 1/4$. For Nation 2, $P_{A'} = 4$. Since the relative price of X is lower in Nation 1 than in Nation 2, Nation 1 has a comparative advantage in commodity X and Nation 2 in commodity Y.

equilibrium. Furthermore, we can be certain that one such equilibrium point exists because there are an infinite number of indifference curves (i.e., the indifference map is dense). Points on lower indifference curves are possible but would not maximize the nation's welfare. On the other hand, the nation cannot reach higher indifference curves with the resources and technology presently available.

3.4B Equilibrium-Relative Commodity Prices and Comparative Advantage

The **equilibrium-relative commodity price in isolation** is given by the slope of the common tangent to the nation's production frontier and indifference curve at the autarky point of production and consumption. Thus, the equilibrium-relative price of X in isolation is $P_A = P_X/P_Y = 1/4$ in Nation 1 and $P_{A'} = P_X/P_Y = 4$ in Nation 2 (see Figure 3.3). Relative prices are different in the two nations because their production frontiers and indifference curves differ in shape and location.

Since in isolation $P_A < P_A'$ Nation 1 has a comparative advantage in commodity X and Nation 2 in commodity Y. It follows that both nations can gain if Nation 1 specializes in the production of and exports X in exchange for Y from Nation 2. How this takes place will be seen in the next section.

Figure 3.3 illustrates that the forces of supply (as given by the nation's production frontier) and the forces of demand (as summarized by the nation's indifference map) *together* determine the equilibrium-relative commodity prices in each nation in autarky. For example, if indifference curve I had been of a different shape, it would have been tangent to the production frontier at a different point and would have determined a different relative price of X in Nation 1. The same would be true for Nation 2. This is in contrast to the constant costs case, where the equilibrium P_X/P_Y is constant in each nation regardless of the level of output and conditions of demand, and is given by the constant slope of the nation's production frontier.

Case Study 3-1 examines the present, real-world or **revealed comparative advantage** of the United States, the European Union, and Japan.

Case Study 3-1 Comparative Advantage of the United States, the European Union, and Japan

The revealed comparative advantage of the United States, the European Union, and Japan can be measured by the excess in the percentage of total exports over the percentage of total imports in each major commodity group for each country or region. The 25-member European Union (EU) refers to Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and Slovak Republic. Although international trade is not balanced for many countries, especially the United States and Japan, and trade restrictions distort comparative advantage, they usually do not completely obscure it.

Table 3-1 shows that the United States has a strong revealed comparative *advantage* in food (since U.S. food exports as a percentage of total overall U.S. exports exceed U.S. food imports as a percentage of total U.S. imports), but a strong revealed comparative *disadvantage* in fuels. In manufactures, the United States has a strong revealed comparative advantage in chemicals and a weak one in office and telecommunications equipment, but a revealed comparative disadvantage in automotive products, and textiles and clothing.

The EU seems to have a comparative advantage in automotive products and chemicals, and a comparative disadvantage in all other commodity groups. Japan seems to have a very strong comparative advantage in manufactures (other than textiles and clothing) and an equally strong comparative disadvantage in primary commodities. Product differentiation is the reason for intra-industry trade (i.e., for the same type of product being both exported and imported by the same nation or region; intra-industry trade is examined in detail in Section 6.4).

(continued)

Case Study 3-1 (continued)

TABLE 3.1. *Composition of Exports and Imports of the United States, the European Union, and Japan in 2004 and Their Revealed Comparative Advantage*

	United States % of Total		European Union % of Total		Japan % of Total	
	Exports	Imports	Exports	Imports	Exports	Imports
Primary commodities	11.9	20.6	14.0	20.0	2.4	39.1
Food	7.3	4.4	7.8	8.1	0.5	11.6
Fuels	4.6	16.2	6.2	11.9	1.9	27.5
Manufactures	81.8	74.3	81.2	74.9	92.7	56.2
Automotive products	9.3	12.9	12.7	10.5	20.5	2.8
Chemicals	13.8	7.6	14.8	12.4	8.5	7.6
Office and telecom. equip.	14.8	14.0	8.5	10.5	18.1	14.1
Textiles and clothing	2.1	6.3	3.9	5.0	1.4	6.0

Source: WTO, *International Trade Statistics* (Geneva, 2005).

3.5 The Basis for and the Gains from Trade with Increasing Costs

A difference in relative commodity prices between two nations is a reflection of their comparative advantage and forms the basis for mutually beneficial trade. The nation with the lower relative price for a commodity has a comparative advantage in that commodity and a comparative disadvantage in the other commodity, with respect to the second nation. Each nation should then specialize in the production of the commodity of its comparative advantage (i.e., produce more of the commodity than it wants to consume domestically) and exchange part of its output with the other nation for the commodity of its comparative disadvantage.

However, as each nation specializes in producing the commodity of its comparative advantage, it incurs increasing opportunity costs. Specialization will continue until relative commodity prices in the two nations become equal at the level at which trade is in equilibrium. By then trading with each other, both nations end up consuming more than in the absence of trade.

3.5A Illustrations of the Basis for and the Gains from Trade with Increasing Costs

We have seen (Figure 3.3) that in the absence of trade the equilibrium-relative price of X is $P_A = 1/4$ in Nation 1 and $P_{A'} = 4$ in Nation 2. Thus, Nation 1 has a comparative advantage in commodity X and Nation 2 in commodity Y.

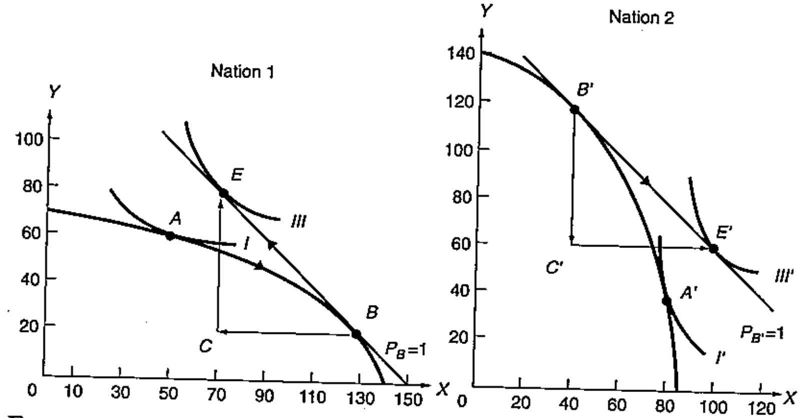

FIGURE 3.4. The Gains from Trade with Increasing Costs. With trade, Nation 1 moves from point *A* to point *B* in production. By then exchanging 60X for 60Y with Nation 2 (see trade triangle *BCE*), Nation 1 ends up consuming at point *E* (on indifference curve III). Thus, Nation 1 gains 20X and 20Y from trade (compare autarky point *A* with point *E*). Similarly, Nation 2 moves from *A'* to *B'* in production. By then exchanging 60Y for 60X with Nation 1 (see trade triangle *B'C'E'*), Nation 2 ends up consuming at point *E'* and also gains 20X and 20Y. $P_B = P_{B'} = 1$ is the equilibrium-relative price—the price at which trade is balanced.

Suppose that trade between the two nations becomes possible (e.g., through the elimination of government obstacles to trade or a drastic reduction in transportation costs). Nation 1 should now specialize in the production and export of commodity X in exchange for commodity Y from Nation 2. How this takes place is illustrated by Figure 3.4.

Starting from point *A* (the equilibrium point in isolation), as Nation 1 specializes in the production of X and moves *down* its production frontier, it incurs increasing opportunity costs in the production of X. This is reflected in the increasing *slope* of its production frontier. Starting from point *A'*, as Nation 2 specializes in the production of Y and moves *upward* along its production frontier, it experiences increasing opportunity costs in the production of Y. This is reflected in the *decline in the slope* of its production frontier (a reduction in the opportunity cost of X, which means a rise in the opportunity cost of Y).

This process of specialization in production continues until relative commodity prices (the slope of the production frontiers) become equal in the two nations. The common relative price (slope) with trade will be somewhere between the pretrade relative prices of 1/4 and 4, at the level at which trade is balanced. In Figure 3.4, this is $P_B = P_{B'} = 1$.

With trade, Nation 1 moves from point *A* down to point *B* in production. By then exchanging 60X for 60Y with Nation 2 (see trade triangle *BCE*), Nation 1 ends up consuming at point *E* (70X and 80Y) on its indifference curve III. This is the highest level of satisfaction that Nation 1 can reach with trade at $P_X/P_Y = 1$. Thus, Nation 1 gains 20X and 20Y from its no-trade equilibrium point. (Compare point E on indifference curve III with point A on indifference curve I.) Line BE is called the *trade possibilities line* or, simply, *trade line* because trade takes place along this line.

Similarly, Nation 2 moves from point A' up to point B' in production, and, by exchanging 60Y for 60X with Nation 1 (see trade triangle $B'C'E'$), it ends up consuming at point E' (100X and 60Y) on its indifference curve III′. Thus, Nation 2 also gains 20X and 20Y from specialization in production and trade.

Note that with specialization in production and trade, each nation can consume outside its production frontier (which also represents its no-trade consumption frontier).

3.5B Equilibrium-Relative Commodity Prices with Trade

The **equilibrium-relative commodity price with trade** is the common relative price in both nations at which trade is balanced. In Figure 3.4, this is $P_B = P_{B'} = 1$. At this relative price, the amount of X that Nation 1 wants to export (60X) equals the amount of X that Nation 2 wants to import (60X). Similarly, the amount of Y that Nation 2 wants to export (60Y) exactly matches the amount of Y that Nation 1 wants to import at this price (60Y).

Any other relative price could not persist because trade would be unbalanced. For example, at $P_X/P_Y = 2$, Nation 1 would want to export more of X than Nation 2 would be willing to import at this high price. As a result, the relative price of X would fall toward the equilibrium level of 1. Similarly, at a relative price of X lower than 1, Nation 2 would want to import more of X than Nation 1 would be willing to export at this low price, and the relative price of X would rise. Thus, the relative price of X would gravitate toward the equilibrium price of 1. (The same conclusion would be reached in terms of Y.)

The equilibrium-relative price in Figure 3.4 was determined by trial and error; that is, various relative prices were tried until the one that balanced trade was found. There is a more rigorous theoretical way to determine the equilibrium-relative price with trade. This makes use of either the total demand and supply curve of each commodity in each nation, or the so-called offer curves, and is discussed in the next chapter.

All we need to say at this point is that the greater is Nation 1's desire for Y (the commodity exported by Nation 2) and the weaker is Nation 2's desire for X (the commodity exported by Nation 1), the closer the equilibrium price with trade will be to ¼ (the pretrade equilibrium price in Nation 1) and the smaller will be Nation 1's share of the gain. Once the equilibrium-relative price with trade is determined, we will know exactly how the gains from trade are divided between the two nations, and our trade model will be complete. In Figure 3.4, the equilibrium-relative price of X with trade ($P_B = P_B' = 1$) results in equal gains (20X and 20Y) for Nation 1 and Nation 2, but this need not be the case.

Of course, if the *pretrade-relative* price had been the same in both nations (an unlikely occurrence), there would be no comparative advantage or disadvantage to speak of in either nation, and no specialization in production or mutually beneficial trade would take place.

3.5C Incomplete Specialization

There is one basic difference between our trade model under increasing costs and the constant opportunity costs case. Under constant costs, both nations specialize completely in production of the commodity of their comparative advantage (i.e., produce only that commodity). For example, in Figures 2.2 and 2.3, the United States specialized completely in wheat production, and the United Kingdom specialized completely in cloth production. Since it paid for the United States to exchange some wheat for British cloth, it paid for the United States to obtain *all* of its cloth from the United Kingdom in exchange for wheat because the opportunity cost of wheat remained constant in the United States. The same was true for the United Kingdom in terms of cloth production.

In contrast, under increasing opportunity costs, there is **incomplete specialization** in production in both nations. For example, while Nation 1 produces more of X (the commodity of its comparative advantage) with trade, it continues to produce some Y (see point B in Figure 3.4). Similarly, Nation 2 continues to produce some X with trade (see point B' in Figure 3.4).

The reason for this is that as Nation 1 specializes in the production of X, it incurs increasing opportunity costs in producing X. Similarly, as Nation 2 produces more Y, it incurs increasing opportunity costs in Y (which means declining opportunity costs of X). Thus, as each nation specializes in producing the commodity of its comparative advantage, relative commodity prices move toward each other (i.e., become less unequal) until they are identical in both nations.

At that point, it does not pay for either nation to continue to expand production of the commodity of its comparative advantage (see Case Study 3-2). This

Case Study 3-2 Specialization and Export Concentration in Selected Countries

Because of increasing costs, no nation specializes completely in the production of only one product in the real world. The closest to complete specialization in production and trade that any nation comes is Kuwait, where petroleum exports represented 92.8 percent of the total value of its exports in 2004. For Argentina, another developing nation with highly specialized natural resources, food exports represent 49.6 percent of its total exports. As Table 3.2 shows, the largest export product for the United States, Japan, and Germany represents less than one quarter of their total exports.

Table 3.2. *Leading Export as a Percentage of Total Exports of Selected Countries in 2004*

United States	Office and telecommunications equipment	14.8
Japan	Automotive products	20.5
Germany	Automotive products	22.1
Korea	Office and telecommunications equipment	32.5
Argentina	Food	49.6
Kuwait	Fuels	92.8

Source: WTO, *International Trade Statistics* (Geneva, 2005).

occurs before either nation has completely specialized in production. In Figure 3.4, $P_B = P'_B = 1$ before Nation 1 or Nation 2 has completely specialized in production.

3.5D Small-Country Case with Increasing Costs

Recall that under constant costs, the only exception to complete specialization in production occurred in the small-country case. There, only the small nation specialized completely in production of the commodity of its comparative advantage. The large nation continued to produce both commodities even with trade (see Figure 2.3) because the small nation could not satisfy all of the demand for imports of the large nation. In the increasing costs case, however, we find incomplete specialization even in the small nation.

We can use Figure 3.4 to illustrate the small-country case with increasing costs. Let us assume that Nation 1 is now a very small country, which is in equilibrium at point A (the same as before) in the absence of trade, and that Nation 2 is a very large country or even the rest of the world. (The diagram for Nation 2 in Figure 3.4 is to be completely disregarded in this case.)

Suppose that the equilibrium-relative price of X on the world market is 1 ($P_W = 1$), and it is not affected by trade with small Nation 1. Since in the absence of trade, the relative price of X in Nation 1 ($P_A = ¼$) is lower than the world market price, Nation 1 has a comparative advantage in X. With the opening of trade, Nation 1 specializes in the production of X until it reaches point B on its production frontier, where $P_B = 1 = P_W$. Even though Nation 1 is now considered to be a small country, it still does not specialize completely in the production of X (as would be the case under constant costs).

By exchanging 60X for 60Y, Nation 1 reaches point E on indifference curve III and gains 20X and 20Y (compared with its autarky point A on indifference curve I). Note that this is exactly what occurred when Nation 1 was *not* considered to be small. The only difference is that now Nation 1 does not affect relative prices in Nation 2 (or the rest of the world), and Nation 1 captures all the benefits from trade (which now amount to only 20X and 20Y).

3.5E The Gains from Exchange and from Specialization

A nation's gains from trade can be broken down into two components: the gains from exchange and the gains from specialization. Figure 3.5 illustrates this breakdown for *small* Nation 1. (For simplicity, the autarky price line, $P_A = ¼$, and indifference curve I are omitted from the figure.)

Suppose that, for whatever reason, Nation 1 could *not* specialize in the production of X with the opening of trade but continued to produce at point A, where MRT = ¼. Starting from point A, Nation 1 could export 20X in exchange for 20Y at the prevailing world relative price of $P_W = 1$ and end up consuming at point T on indifference curve II. Even though Nation 1 consumes less of X and more of Y at point T in relation to point A, it is better off than it was in autarky because T is on higher indifference curve II. The

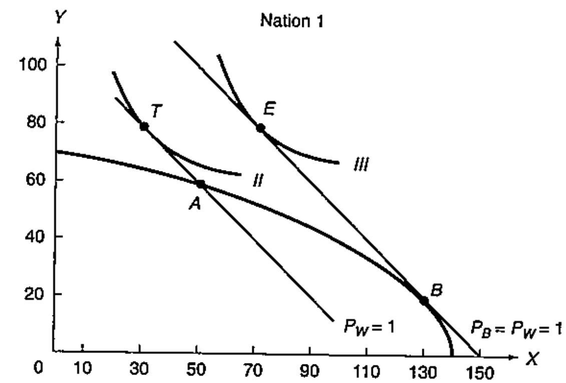

FIGURE 3.5. The Gains from Exchange and from Specialization. If Nation 1 could not specialize in the production of X with the opening of trade but continued to produce at point A, Nation 1 could export 20X in exchange for 20Y at the prevailing world price of $P_W = 1$ and end up consuming at point T on indifference curve II. The increase in consumption from point A (in autarky) to point T represents the gains from exchange alone. If Nation 1 subsequently did specialize in the production of X and produced at point B, it would then consume at point E on indifference curve III. The increase in consumption from T to E would represent the gains from specialization in production.

movement from point A to point T in consumption measures the **gains from exchange**.

If subsequently Nation 1 also specialized in the production of X and produced at point B, it could then exchange 60X for 60Y with the rest of the world and consume at point E on indifference curve III (thereby gaining even more). The movement from T to E in consumption measures the **gains from specialization** in production.

In sum, the movement from A (on indifference curve I) to T (on indifference curve II) is made possible by exchange alone. This takes place even if Nation 1 remains at point A (the autarky point) in production. The movement from point T to point E (on indifference curve III) represents the gains resulting from specialization in production.

Note that Nation 1 is not in equilibrium in production at point A with trade because MRT $< P_W$. To be in equilibrium in production, Nation 1 should expand its production of X until it reaches point B, where $P_B = P_W = 1$. Nation 2's gains from trade can similarly be broken down into gains from exchange and gains from specialization.

Case Study 3-3 illustrates the reallocation of labor in the United States as a real-world example of comparative advantage at work, while Case Study 3-4 shows that **deindustrialization** in the industrial countries as a group, in the United States, the European Union, and Japan was due mainly to increases in labor productivity or internal causes rather than to foreign trade.

Case Study 3-3 Job Losses in High U.S. Import-Competing Industries, 1979–1999

Table 3.3 shows the number of workers who lost their jobs (i.e., were displaced) in various high import-competing industries in the United States between 1979 and 1999. High import-competing industries were broadly defined as those in the top 25 percent in import shares. From the table, we see that almost 6.5 million workers lost their jobs in these industries over the 1979–1999 period, with the electrical machinery and apparel industries leading the list, with 1,181,000 and 1,136,000 jobs lost, respectively. As we will see in Case Study 3-4, however, most of the jobs lost in these industries were not due to imports but to purely internal or domestic causes such as technological change, changes in consumer demand, and restructuring. Highly import competitive industries did, however, experience a higher job loss than other manufacturing industries because of imports. This is evident from the fact that although high import-competing industries accounted for 30 percent of U.S. manufacturing employment, they experienced 38.4 percent of U.S. manufacturing job losses over the 1970–1999 period. *Baily* and *Lawrence* (2004), however, found that of the total of 2.85 million manufacturing jobs lost in the United States from 2000 to 2003 only 315,000 or 11.1 percent were due to net imports or outsourcing. Still, *Samuelson* (2004) believes that trade could hurt the United States and other rich nations today. *Bhagwati, Panagaryia* and *Srinivansan* (2004) disagree.

TABLE 3.3. *Job Losses in High Import-Competing Industries, 1979–1999*

Industry	Job Lost (thousands)	Industry	Job Lost (thousands)
Electrical machinery	1,181	Textiles	159
Apparel	1,136	Toys and sporting goods	156
Motor vehicles	918	Primary metals other than steel	133
Electronic computing equipment	513	Photographic equipment	68
		Leather products	57
Radio and television	395	Office and accounting machines	41
Steel	361		
Construction machinery	351	Pottery and related products	24
Tires and other rubber products	193	Watches and clocks	9
Footwear	184	Leather, tanning and finishing	5
Scientific instruments	164	Other industries	406
		Total	6,454

Source: L. G. Kletzer, *Job Loss from Imports: Measuring the Costs* (Washington, D.C.: Institute for International Economics, 2001), pp. 18–19; and M. N. Baily and R. Z. Lawrence, "What Happened to the Great U.S. Job Machine? The Role of Trade and Electronic Offshoring," *Brookings Papers on Economic Activity*, No. 2, 2004, pp. 211–284.

Case Study 3-4 International Trade and Deindustrialization in the United States, the European Union, and Japan

Since the 1970s, the United States has been concerned with the problem of deindustrialization, as reflected in its declining share of manufacturing employment. But this phenomenon occurred in all industrial countries and was not primarily the result of foreign trade, as it has been sometimes claimed. Table 3.4 shows the relative importance of the different factors accounting for deindustrialization in all industrial countries as a group, in the United States, the European Union, and Japan from 1970 to 1994.

TABLE 3.4. *Factors Responsible for Deindustrialization in Industrial Countries*

	Industrial Countries	United States	European Union	Japan
Share of manufacturing employment (in percent)				
1970	27.6	26.4	30.4	27.0
1994	18.0	16.0	20.2	23.2
Change	−9.6	−10.4	−10.2	−3.8
Percentage of change due to:				
Productivity growth	65.6	65.4	59.8	157.9
Trade	(−)2.1	9.6	(−)2.9	(−)30.0
Investment	18.8	3.8	20.6	71.1
Other	17.7	21.2	22.5	(−)51.7
Total	100.0	100.0	100.0	100.0

Source: International Monetary Fund, *Staff Studies for the World Economic Outlook* (Washington, D.C., December 1997), p. 68.

The table shows that from 1970 to 1994 the average share of manufacturing employment declined by about 10 percentage points in industrial countries as a group, in the United States and in the European Union, and 4 percentage points in Japan. The table also shows that most of this decline resulted from the growth of labor productivity, which made possible higher levels of output with less labor. Growing trade deficits in manufactures were responsible for only 9.6 percent of the loss of manufacturing employment in the United States, while growing trade surpluses in manufactures resulted in a 30-percent *increase* in manufacturing employment in Japan. The trade effect in the European Union and all industrial nations as a group was very small. The decline in the rate of investment also contributed to the reduction in the share of manufacturing employment, as did the changes in other factors (such as shifts in the pattern of consumption away from manufactures to services), except in Japan.

3.6 Trade Based on Differences in Tastes

The difference in *pretrade-relative* commodity prices between Nation 1 and Nation 2 in Figures 3.3 and 3.4 was based on the difference in the production frontiers and indifference curves in the two nations. This determined the comparative advantage of each nation and set the stage for specialization in production and mutually beneficial trade.

With increasing costs, even if two nations have identical production possibility frontiers (which is unlikely), there will still be a basis for mutually beneficial trade if tastes, or demand preferences, in the two nations differ. The nation with the relatively smaller demand or preference for a commodity will have a lower autarky relative price for, and a comparative advantage in, that commodity. The process of specialization in production and trade would then follow, exactly as described in the previous section.

3.6A Illustration of Trade Based on Differences in Tastes

Trade based solely on differences in tastes is illustrated in Figure 3.6. Since the production frontiers of the two nations are now assumed to be identical, they are represented by a single curve. With indifference curve I tangent to the production frontier at point *A* for Nation 1 and indifference curve I′ tangent at point *A*′ for Nation 2, the pretrade-relative price of X is lower in Nation 1. Thus, Nation 1 has a comparative advantage in commodity X and Nation 2 in commodity Y.

With the opening of trade, Nation 1 specializes in the production of X (and moves down its production frontier), while Nation 2 specializes in Y (and moves up its own production frontier). Specialization continues until PX/PY is the same in both nations and trade is balanced. This occurs at point B (which coincides with point B′), where $P_B = P_{B'} = 1$. Nation 1 then exchanges 60X for 60Y with Nation 2 (see trade triangle BCE) and ends up consuming at point E on its indifference curve III. Nation 1 thus gains 20X and 20Y as compared with point A. Similarly, Nation 2 exchanges 60Y for 60X with Nation 1 (see trade triangle B′C′E′) and ends up consuming at point E′ on its indifference curve III′ (also gaining 20X and 20Y from point A¢). Note that when trade is based solely on taste differences, the patterns of production become more similar as both nations depart from autarky.

Thus, mutually beneficial trade can be based exclusively on a difference in tastes between two nations. In Chapter 5, we will examine the opposite case, where trade between the two nations is based exclusively on a difference in factor endowments and production frontiers. (This will be referred to as the Heckscher–Ohlin model.) Only if the production frontier and the indifference curves are identical in both nations (or the difference in production frontiers is exactly neutralized, or offset, by the difference in the indifference curves) will the pretrade-relative commodity prices be equal in both nations, ruling out the possibility of mutually beneficial trade.

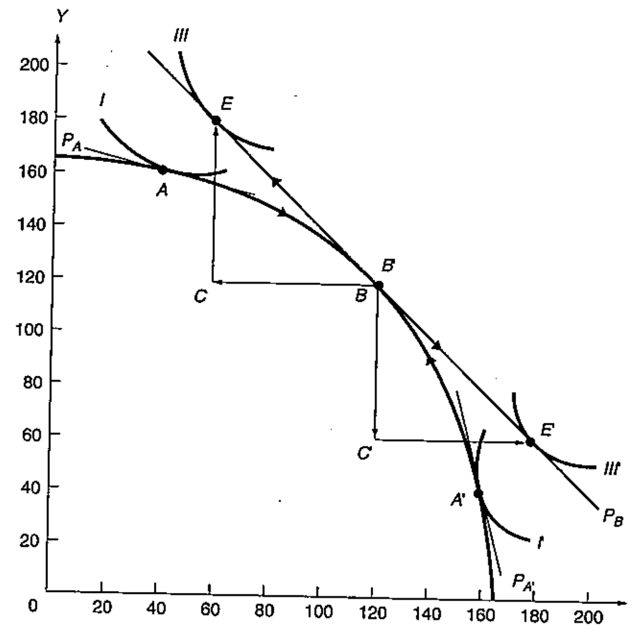

Figure 3.6. Trade Based on Differences in Tastes. Nations 1 and 2 have identical production frontiers (shown by a single curve) but different tastes (indifference curves). In isolation, Nation 1 produces and consumes at point *A* and Nation 2 at point *A*′. Since $P_A < P_{A'}$, Nation 1 has a comparative advantage in X and Nation 2 in Y. With trade, Nation 1 specializes in the production of X and produces at *B*, while Nation 2 specializes in Y and produces at *B*′ (which coincides with *B*). By exchanging 60X for 60Y with each other (see trade triangles *BCE* and *B′C′E′*), Nation 1 ends up consuming at *E* (thereby gaining 20X and 20Y), while Nation 2 consumes at *E*′ (and also gains 20X and 20Y).

Summary

1. This chapter extended our simple trade model to the more realistic case of increasing opportunity costs. It also introduced demand preferences in the form of community indifference curves. We then went on to examine how the interaction of these forces of demand and supply determines each nation's comparative advantage and sets the stage for specialization in production and mutually beneficial trade.
2. Increasing opportunity costs mean that the nation must give up more and more of one commodity to release just enough resources to produce each additional unit of another commodity. This is reflected in a production frontier that is concave from the origin. The slope of the production frontier gives

the marginal rate of transformation (MRT). Increasing opportunity costs arise because resources are not homogeneous and are not used in the same fixed proportion in the production of all commodities. Production frontiers differ because of different factor endowments and/or technology in different nations.

3. A community indifference curve shows the various combinations of two commodities that yield equal satisfaction to the community or nation. Higher curves refer to a greater level of satisfaction. Community indifference curves are negatively sloped and convex from the origin. And to be useful, they must not cross. The slope of an indifference curve gives the marginal rate of substitution (MRS) in consumption, or the amount of commodity Y that a nation could give up for each extra unit of commodity X and still remain on the same indifference curve. Trade affects the income distribution within a nation and can result in intersecting indifference curves. This difficulty can be overcome by the compensation principle, which states that the nation gains from trade if the gainers would retain some of their gain even after fully compensating losers for their losses. Alternatively, some restrictive assumptions could be made.
4. In the absence of trade, a nation is in equilibrium when it reaches the highest indifference curve possible with its production frontier. This occurs at the point where a community indifference curve is tangent to the nation's production frontier. The common slope of the two curves at the tangency point gives the internal equilibrium-relative commodity price in the nation and reflects the nation's comparative advantage.
5. With trade, each nation specializes in producing the commodity of its comparative advantage and faces increasing opportunity costs. Specialization in production proceeds until relative commodity prices in the two nations are equalized at the level at which trade is in equilibrium. By then trading, each nation ends up consuming on a higher indifference curve than in the absence of trade. With increasing costs, specialization in production is incomplete, even in a small nation. The gains from trade can be broken down into gains from exchange and gains from specialization in production.
6. With increasing costs, even if two nations have identical production frontiers, there is still a basis for mutually beneficial trade if tastes, or demand or preferences, differ in the two nations. The nation with the relatively smaller demand or preference for a commodity will have a lower autarky-relative price for, and a comparative advantage in, that commodity. This will set the stage of specialization in production and mutually beneficial trade, as described earlier.

In Chapter 4, we will introduce the demand curve for imports and the supply curve of exports, as well as the offer curve of each nation, in order to examine precisely how the equilibrium-relative commodity price and terms of trade of each nation are determined with trade. We can then determine how the gains from trade are shared by each nation. With this addition, our simple trade model will be complete. In Chapter 5, we will see how this simple trade model was extended by Heckscher and Ohlin.

Key Terms

Increasing opportunity costs
Marginal rate of transformation (MRT)
Community indifference curve
Marginal rate of substitution (MRS)
Autarky
Equilibrium-relative commodity price in isolation
Revealed comparative advantage
Equilibrium-relative commodity price with trade
Incomplete specialization
Gains from exchange
Gains from specialization
Deindustrialization

Questions for Review

1. In what way is the material in this chapter more realistic than that of Chapter 2?
2. How are the tastes, or demand preferences, of a nation introduced in this chapter? Why are they needed?
3. Why does a production frontier that is concave from the origin indicate increasing opportunity costs in both commodities? What does the slope of the production frontier measure? How does the slope change as the nation produces more of the commodity measured along the horizontal axis? more of the commodity measured along the vertical axis?
4. What is the reason for increasing opportunity costs? Why do the production frontiers of different nations have different shapes?
5. What does a community indifference curve measure? What are its characteristics? What does the slope of an indifference curve measure? Why does it decline as the nation consumes more of the commodity measured along the horizontal axis?
6. What difficulties arise in the use of community indifference curves in trade theory? How can these difficulties be overcome?
7. What is meant by the equilibrium-relative commodity price in isolation? How is this price determined in each nation? How does it define the nation's comparative advantage?
8. Why does specialization in production with trade proceed only up to the point where relative commodity prices in the two nations are equalized? How is the equilibrium-relative commodity price with trade determined?
9. Why is there incomplete specialization in production (even in a smaller nation) with increasing opportunity costs? How are the results under increasing costs different from the fixed-costs case?
10. What is meant by gains from exchange? By gains from specialization?
11. Can specialization in production and mutually beneficial trade be based solely on a difference in tastes between two nations? How is this different from the more general case?
12. Can specialization in production and mutually beneficial trade be based exclusively on a difference in factor endowments and/or technology between two nations?

1. On one set of axes, sketch a fairly large production frontier concave from the origin.
   (a) Starting near the midpoint on the production frontier, use arrows to show that the nation incurs increasing opportunity costs in producing more of X (the commodity measured along the horizontal axis) and more of Y.
   (b) How does the slope of the production frontier change as the nation produces more of X? more of Y? What do these changes reflect?

2. On another set of axes, sketch three community indifference curves, making the top two curves cross each other.
   (a) Why have you drawn community indifference curves downward, or negatively, sloped?
   (b) What does the slope of the curves measure? Why is the slope of each curve smaller for lower points?
   (c) Which of the two intersecting indifference curves shows a greater level of satisfaction to the right of the point of intersection? to the left? Why is this inconsistent with the definition of indifference curves? What conclusion can you reach?

*3. On one set of axes, sketch a community indifference curve tangent to the fairly flat section of a concave production frontier. On a second set of axes, sketch another (different) community indifference curve tangent to the fairly steep portion of another (different) concave production frontier.
   (a) Draw in the line showing the equilibrium-relative commodity price in isolation in each nation.
   (b) Which is the commodity of comparative advantage for each nation?
   (c) Under what (unusual) condition would there be no such thing as comparative advantage or disadvantage between the two nations?

*4. (a) On the graphs of Problem 3, show, for each nation with trade, the direction (by an arrow on the production frontier) of specialization in production and the equilibrium point of production and consumption.
   (b) How much does each nation gain in consumption compared with its autarky point? Which of the two nations gains more from trade? Why?

5. On one set of axes, sketch Nation 1's supply of exports of commodity X so that the quantity supplied (QS) of X is $QS_x = 0$ at $P_x/P_y = 1/4$, $QS_x = 40$ at $P_x/P_y = 1/2$, $QS_x = 60$ at $P_x/P_y = 1$, and $QS_x = 70$ at $P_x/P_y = 1\frac{1}{2}$. On the same set of axes, sketch Nation 2's demand for Nation 1's exports of commodity X so that the quantity demanded (QD) of X is $QD_x = 40$ at $P_x/P_y = 1\frac{1}{2}$, $QD_x = 60$ at $P_x/P_y = 1$, and $QD_x = 120$ at $P_x/P_y = 1/2$.
   (a) Determine the equilibrium-relative commodity price of the exports of commodity X with trade.
   (b) What would happen if P_x/P_y were $1\frac{1}{2}$?
   (c) What would happen if $P_x/P_y = 1/2$?

6. What is the relationship between the figure you sketched for Problem 5 and the results you obtained in Problem 5 and Figure 3.4 in the text? Explain.

*7. On one set of axes, sketch a community indifference curve tangent to the fairly flat section of a concave production frontier and show the nation's autarky equilibrium-relative commodity price, labeling it P_A. Assume that this graph refers to a very small nation whose trade does not affect relative prices on the world market, given by P_W. Show on the graph the process of specialization in the production, the amount traded, and the gains from trade.

* = Answer provided at www.wiley.com/college/salvatore.

8. (a) Explain why the small nation of Problem 7 does not specialize completely in the production of the commodity of its comparative advantage.
   (b) How does your answer to part (a) differ from the constant-cost case?

9. On two sets of axes, draw identical concave production frontiers with different community indifference curves tangent to them.
   (a) Indicate the autarky equilibrium-relative commodity price in each nation.
   (b) Show the process of specialization in production and mutually beneficial trade.

10. What would have happened if the two community indifference curves had also been identical in Problem 9? Sketch a graph of this situation.

11. What would happen if the production frontiers are identical and the community indifference curves are different, but we have constant opportunity costs? Draw a graph of this.

12. Draw a figure showing the separation of the gains from exchange from the gains from specialization for Nation 2 in the right panel of Figure 3.4 if Nation 2 were now a small nation.

13. During the negotiations for NAFTA (North American Free Trade Agreement among the United States, Canada, and Mexico) in the early 1990s, opponents argued that the United States would lose many jobs to Mexico because of the much lower wages in Mexico. What was wrong with this line of reasoning?

Appendix

In this appendix, we review those aspects of production theory that are essential for understanding the material presented in subsequent appendices. We begin with a review of production functions, isoquants, isocosts, and equilibrium. We then illustrate these concepts for two nations, two commodities, and two factors. Next, we derive the Edgeworth box diagram and, from it, the production frontier of each nation. Finally, we use the Edgeworth box diagram to show the change in the ratio of resource use as each nation specializes in production with trade.

A3.1 Production Functions, Isoquants, Isocosts, and Equilibrium

A **production function** gives the *maximum* quantities of a commodity that a firm can produce with various amounts of factor inputs. This purely technological relationship is supplied by engineers and is represented by isoquants.

An **isoquant** is a curve that shows the various combinations of two factors, say, capital (K) and labor (L), that a firm can use to produce a specific level of output. Higher isoquants refer to larger outputs and lower ones to smaller outputs. Isoquants have the same general characteristics as indifference curves. They are negatively sloped, convex from the origin, and do not cross. (However, isoquants give a cardinal measure of output, while indifference curves give only an ordinal measure of utility.)

Isoquants are negatively sloped because a firm using less K must use more L to remain on the same isoquant. The (absolute) slope of the isoquant is called the **marginal rate of technical substitution of labor for capital in production (MRTS)** and measures how much K the firm can give up by increasing L by one unit and still remain on the same isoquant. As a firm moves down an isoquant and uses more L and less K, it finds it more and more difficult to replace K with L. That is, the marginal rate of technical substitution of L for K (or slope of the isoquant) diminishes. This makes the isoquant convex from the origin. Finally, isoquants do not cross because an intersection would imply the same level of output on two isoquants, which is inconsistent with their definition.

In Figure 3.7, the curve labeled 1X is the isoquant for one arbitrarily defined unit of commodity X, and curve 2X is the isoquant for two units of X. Note that the isoquants are negatively sloped and convex from the origin and that they do not cross.

An **isocost** is a line that shows the various combinations of K and L that a firm can hire for a given expenditure, or total outlay (*TO*), at given factor prices. For example, suppose that the total outlay of the firm in Figure 3.7 is $TO = \$30$, that the price of a unit of capital is $P_K = \$10$, and that the wage rate is $P_L = \$5$. Under these conditions, the firm can hire either 3K (the vertical intercept) or 6L (the horizontal intercept) or any combination of L and K shown on the straight line (isocost). The (absolute) slope of the isocost of $3/6 = 1/2$ gives the relative price of L (the factor plotted along the horizontal axis). That is, $P_L/P_K = \$5/\$10 = 1/2$. A $TO = \$60$ and unchanged factor prices give a new isocost parallel to the first one and twice as far from the origin (see Figure 3.7).

A **producer** is in **equilibrium** when it maximizes output for a given cost outlay (i.e., when it reaches the highest isoquant possible with a given isocost). This occurs where an isoquant is tangent to an isocost (i.e., MRTS = P_L/P_K). In Figure 3.7, the producer is in equilibrium at point A_1, producing 1X with the lower isocost, and at point A_2, producing 2X with the higher isocost. Note that isoquant 2X involves twice as much output as isoquant 1X, is twice as far from the origin, and requires twice as much outlay as K and L to be reached. The straight line from the origin connecting equilibrium points A_1 and A_2 is called the **expansion path** and shows the constant $K/L = 1/4$ in producing 1X and 2X.

A production function, such as the one above, that has a straight-line expansion path and that shows that increasing inputs in a given proportion results in output increasing in

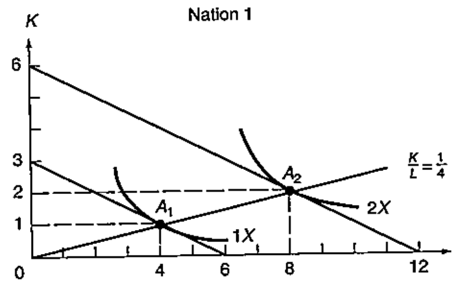

FIGURE 3.7. Isoquants, Isocosts, and Equilibrium. *Isoquants* 1X and 2X give the various combinations of K and L that the firm can use to produce one and two units of X, respectively. Isoquants are negatively sloped, convex, and do not cross. An *isocost* shows the various amounts of K and L that a firm can hire with a given total outlay (*TO*). The lines from 3K to 6L and from 6K to 12L are isocosts. The (absolute) slope of the isocost measures P_L/P_K. Equilibrium is at points A_1 and A_2, where the firm reaches the highest isoquant possible for a given *TO*. At A_2 the firm produces twice as much output and uses twice as much K and L as at A_1. The straight line through the origin joining A_1 and A_2 is the *expansion path* and gives the constant $K/L = 1/4$ ratio in producing 1X and 2X.

the same proportion is a **Cobb–Douglas production function** that is **homogeneous of degree 1** and exhibits **constant returns to scale**. We will make much use of this production function in international economics because of its useful properties. Since the K/L ratio remains the same with this production function (as long as factor prices do not change), the productivity of K and L also remains the same, regardless of the level of output. Furthermore, with this type of production function, all the isoquants that refer to the production of various quantities of a particular commodity look exactly alike or have identical shape (see Figure 3.7). As a result, the elasticity of substitution of labor for capital (which measures the degree by which labor can be substituted for capital in production as the price of labor or the wage rate falls) is equal to 1. (This is examined in detail in Appendix A5.6.)

A3.2 Production Theory with Two Nations, Two Commodities, and Two Factors

Figure 3.8 extends Figure 3.7 to deal with the case of two nations, two commodities, and two factors. Figure 3.8 shows isoquants for commodity X and commodity Y for Nation 1 and Nation 2. Note that commodity Y is produced with a higher K/L ratio in both nations. Thus, we say that Y is K-intensive and X is the L-intensive commodity. Note also that the K/L ratio is lower in Nation 1 than in Nation 2 for both X and Y. The reason for this is that the relative price of labor (i.e., P_L/P_K, or slope of the isocosts) is lower in Nation 1 than in Nation 2.

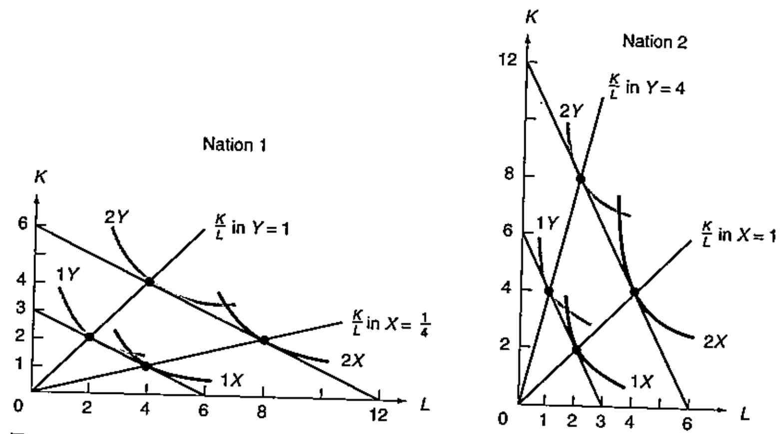

FIGURE 3.8. Production with Two Nations, Two Commodities, and Two Factors. Y is the K-intensive commodity in both nations. The K/L ratio is lower in Nation 1 than in Nation 2 in both X and Y because P_L/P_K is lower in Nation 1. Since Y is always the K-intensive commodity and X is always the L-intensive commodity in both nations, the X and Y isoquants intersect only once in each nation.

If, for whatever reason, the relative price of labor (i.e., P_L/P_K) rose in both nations, each nation would substitute K for L in the production of both commodities to minimize costs. As a result, the K/L ratio would rise in both nations in the production of both commodities.

Even though both X and Y are more K intensive in Nation 2 than in Nation 1, X is always the L-intensive commodity in both nations. This important fact is reflected in the isoquants of X and Y intersecting only once (see Figure 3.8), and it will be of great use in the appendix to Chapter 5, which deals with factor-intensity reversal.

A3.3 Derivation of the Edgeworth Box Diagram and Production Frontiers

We will now use the knowledge gained from Figure 3.8 to derive the **Edgeworth box diagram** and, from it, the production frontier of each nation. This is illustrated in Figure 3.9 for Nation 1 and in Figure 3.10 for Nation 2.

Our discussion will first concentrate on the top panel of Figure 3.9. The dimensions of the box in the top panel reflect the total amount of L (measured by the length of the box) and K (the height of the box) available in Nation 1 at a given time.

The lower left-hand corner of the box (O_X) represents the zero origin for commodity X, and X-isoquants farther from O_X refer to greater outputs of X. On the other hand, the top right-hand corner (O_Y) represents the zero origin for commodity Y, and Y-isoquants farther from O_Y refer to greater outputs of Y.

Any point within the box indicates how much of the *total* amount of labor available (L) and how much of the total amount of capital available (K) is used in the production of X and Y. For example, at point A, L_A and K_A are used to produce 50X, and the remaining quantities, or $L - L_A$ and $K - K_A$, are used in the production of 60Y (see Figure 3.9).

By joining all points in the box where an X-isoquant is tangent to a Y-isoquant, we get the nation's **production contract curve**. Thus, the contract curve of Nation 1 is given by the line joining O_X to O_Y through points A, F, and B. At any point not on the contract curve, production is not efficient because the nation could increase its output of one commodity without reducing its output of the other.

For example, from point Z in the figure, Nation 1 could move to point F and produce more of X (i.e., 95X instead of 50X), and the same amount of Y (both Z and F are on the isoquant for 45Y). Or Nation 1 could move from point Z to point A and produce more Y (i.e., 60Y instead of 45Y) and the same amount of X (both Z and A are on the isoquant for 50X). Or Nation 1 could produce a little more of both X and Y and end up on the contract curve somewhere between A and F. (The isoquants for this are not shown in the figure.) Once on its contract curve, Nation 1 could only expand the output of one commodity by reducing the output of the other. The fact that the contract curve bulges toward the lower right-hand corner indicates that commodity X is the L-intensive commodity in Nation 1.

By transposing the contract curve from the input space in the top panel to the output space in the bottom panel, we derive Nation 1's production frontier, shown in the bottom panel. For example, from point Z, where the isoquant for 50X crosses the straight-line diagonal O_XO_Y in the top panel, we get point A (i.e., 50X) in the bottom

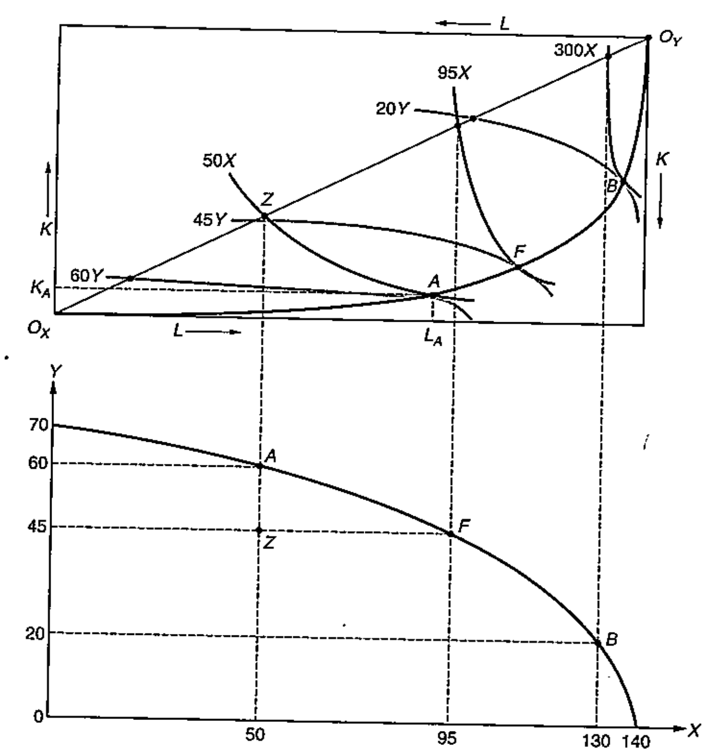

FIGURE 3.9. Derivation of the Edgeworth Box Diagram and Production Frontier for Nation 1. The size of the box in the top panel gives the total amount of L and K available to Nation 1. The bottom left-hand corner is the origin for X, so that higher X outputs are given by X-isoquants farther away from this origin. The top right-hand corner is the origin for Y, and higher Y outputs are given by Y-isoquants farther from this origin. Any point in the box gives how much K and L are used in the production of X and Y, respectively. The line joining points of tangency of X- and Y-isoquants is called the *contract curve*. Any point not on the contract curve is not efficient because the nation could produce more of one commodity without reducing the output of the other. The contract curve is not a straight line because factor prices change to keep K and L fully employed. By mapping the contract curve from input to output space, we derive the production frontier of Nation 1 in the bottom panel.

panel. Note that point A in the bottom panel is directly below point Z in the top panel, rather than directly below point A in the top panel, because output is *measured* at constant K/L (i.e., along the straight-line diagonal). The measurement along the diagonal reflects the fact that inputs are being used to measure outputs (with constant returns to scale).

Even though outputs are measured along the diagonal, efficiency considerations (discussed earlier) require that Nation 1 produce 50X at point A in the top panel, where the X-isoquant for 50X is *tangent* to the Y-isoquant for 60Y. This gives point A in the

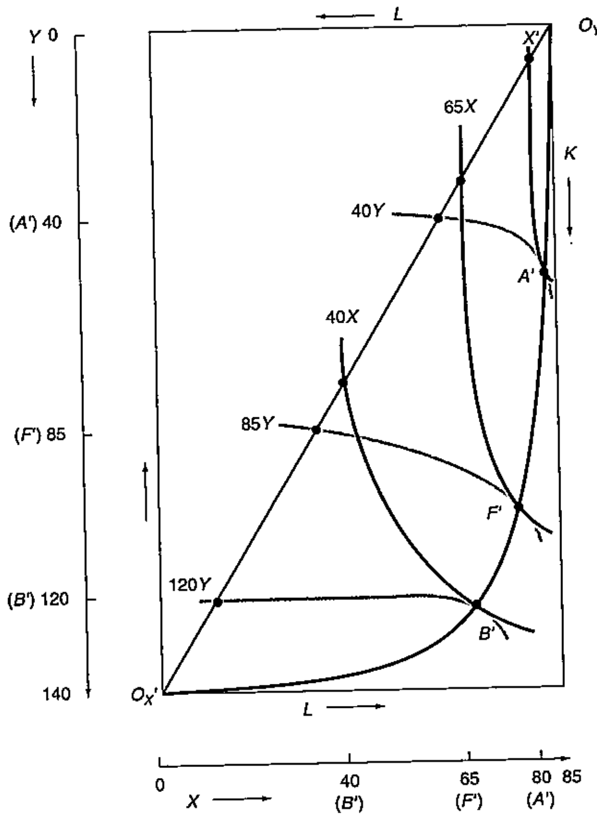

FIGURE 3.10. Derivation of the Edgeworth Box Diagram and Production Frontier for Nation 2. The dimensions of its Edgeworth box indicate that Nation 2 has a relative abundance of K compared with Nation 1. Efficiency considerations require that Nation 2 produce on its contract curve shown by the line joining O_X' to O_Y' through points A', F', and B'. The amount of commodity X produced at points A', F', and B' is given by the points where the X-isoquant through each crosses the diagonal. This output is then projected down to the X-axis at the bottom of the figure. Similarly, the amount of commodity Y produced at points A', F', and B' is given by the points where the Y-isoquant through each (and tangent to an X-isoquant) crosses the diagonal. This output is then projected to the Y-axis at the left of the figure.

bottom panel, referring to the output of 50X and 60Y. If Nation 1 produced at point Z instead of point A in the top panel, Nation 1 would produce 50X but only 45Y, giving point Z *inside* the production frontier in the bottom panel.

Similarly, directly below the point in the top panel where the X-isoquant showing 95X crosses the diagonal, we get point F, referring to 95X and 45Y, on the production frontier in the bottom panel. Finally, point B on the isoquants for 130X and 20Y in the top panel is projected down to point B, referring to 130X and 20Y, on the production frontier in the bottom panel. Thus, there is a one-to-one correspondence between the contract curve and the production frontier, with each point on the contract curve uniquely defining one point on the production frontier.

Note that the output of commodity X is proportional to the distance from origin O_X along the diagonal because of our assumption of constant returns to scale. Similarly, the output of commodity Y is proportional to the distance from origin O_Y along the diagonal. (This is the reason for measuring outputs along the diagonal.) Also note that the X-intercept and the Y-intercept of the production frontier correspond to the length and height of the Edgeworth box.

Figure 3.10 shows the Edgeworth box for Nation 2. The dimensions of the box indicate that Nation 2 has a relative abundance of K compared with Nation 1. As with Nation 1, the amount of commodity X produced at points A', F', and B' is given by the points where the X-isoquant through each point crosses the diagonal. This output is then projected down to the X-axis at the bottom of the figure. Similarly, the amount of commodity Y produced at points A', F', and B' is given by the points where the Y-isoquant through each point (and tangent to an X-isoquant) crosses the diagonal. This output is then projected to the Y-axis at the left of the figure. For example, the X-isoquant through B' crosses the diagonal at an output of 40X (see the X-axis at the bottom of the figure). Similarly, the Y-isoquant through point B' crosses the diagonal at the output of 120Y (see the Y-axis at the left of the figure). These give the coordinates of point B' as 40X and 120Y on Nation 2's production frontier (not shown). The other points on Nation 2's production frontier are similarly derived. Note that the production frontiers for Nation 1 and Nation 2 that we have just derived are the ones that we used earlier in this chapter. However, we have now derived rather than assumed them.

Problem Derive from Figure 3.10 Nation 2's production frontier. Which commodity is L intensive in Nation 2? Why?

A3.4 Some Important Conclusions

The movement from point A to point B on Nation 1's *contract curve* (see Figure 3.9) refers to an increase in the production of X (the commodity of its comparative advantage) and results in a rise in the K/L ratio. This rise in the K/L ratio is measured by the increase in the slope of a straight line (not drawn) from origin O_X to point B as opposed to point A. The same movement from point A to point B also raises the K/L ratio in the production of Y. This is measured by the increase in the slope of a line from origin O_Y to point B as opposed to point A.

The rise in the K/L ratio in the production of both commodities in Nation 1 can be explained as follows. Since Y is K intensive, as Nation 1 reduces its output of Y, capital and labor are released in a ratio that exceeds the K/L ratio used in expanding the production of X. There would then be a tendency for some of the nation's capital to be unemployed, causing the relative price of K to fall (i.e., P_L/P_K to rise).

As a result, Nation 1 will substitute K for L in the production of both commodities until all available K is once again fully utilized. Thus, the K/L ratio in Nation 1 rises in the production of both commodities. This also explains why the production contract curve is not a straight line but becomes steeper as Nation 1 produces more X (i.e., it moves farther from origin O_X). The *contract curve would be a straight line only if relative factor prices remained unchanged, and here factor prices change.* The rise in P_L/P_K in Nation 1 can be visualized in the top panel of Figure 3.9 by the greater slope of the common tangent to the isoquants at point *B* as opposed to point *A* (to keep the figure simple, such tangents are not actually drawn). We will review and expand these results in the appendix to Chapter 5, where we prove the factor-price equalization theorem of the Heckscher–Ohlin trade model.

Problem Explain why, as Nation 2 moves from point A' to point B' on its contract curve (i.e., specializes in the production of Y, the commodity of its comparative advantage), its K/L ratio *falls* in the production of both X and Y. (If you cannot, reread Section A3.4.)

Bibliography

For a problem-solving approach to the material covered in this chapter, with many examples and solved problems, see:

- D. Salvatore, *Theory and Problems of International Economics,* 4th ed. (New York: McGraw-Hill, 1996), ch. 2 (sects. 2.4 and 2.5) and ch. 3 (sects. 3.1 and 3.2).

For a classic diagrammatic presentation of cost conditions in international trade, see:

- A. P. Lerner, "The Diagrammatic Representation of Cost Conditions in International Trade," *Economica,* August 1932.
- G. Haberler, *The Theory of International Trade* (London: W. Hodge & Co., 1936), ch. 12.

Two excellent classic articles on the use of community indifference curves in international trade are:

- W. W. Leontief, "The Use of Indifference Curves in International Trade," *Quarterly Journal of Economics,* May 1933, pp. 493–503. Reprinted in H. S. Ellis and L. A. Metzler, *Readings in the Theory of International Trade* (Homewood, Ill.: Irwin, 1950), pp. 229–238.
- P. A. Samuelson, "Social Indifference Curves," *Quarterly Journal of Economics,* February 1956, pp. 1–22.

For an exposition of the gains from trade, see:

- P. A. Samuelson, "The Gains from International Trade," *Canadian Journal of Economics and Political Science,* May 1939, pp. 195–205. Reprinted in H. S. Ellis and L. M. Metzler, *Readings in the Theory of International Trade* (Homewood, Ill.: Irwin, 1950), pp. 239–252.
- P. Kenen, "Distribution, Demand and Equilibrium in International Trade: A Diagrammatic Analysis," *Kyklos,* December 1959, pp. 629–658. Reprinted in R. E. Caves and H. G. Johnson, *Readings in International Economics* (Homewood, Ill.: Irwin, 1968), pp. 90–98.
- P. A. Samuelson, "The Gains from International Trade Once Again," *Economic Journal,* December 1962, pp. 820–829. Also reprinted in J. Bhagwati, *International Trade: Selected Readings* (Cambridge, Mass.: MIT Press, 1981), pp. 131–141.
- A. Dixit and V. Norman, *Theory of International Trade* (Cambridge, UK: Cambridge University Press, 1980).

The changing pattern of comparative advantage in the United States and other industrial nations is examined in:

- B. Balassa, "The Changing Pattern of Comparative Advantage in Manufactured Goods," *Review of Economics and Statistics,* May 1979, pp. 259–266.
- R. Z. Lawrence, *Can America Compete?* (Washington, D.C.: Brookings Institution, 1984).
- M. E. Porter, *The Comparative Advantage of Nations* (New York: The Free Press, 1990).
- G. Hacche and F. Ramaswamy, "Deindustrialization: Causes and Implications," *IMF Working Paper WP/97/42,* April 1997.
- M. N. Baily and R. Z. Lawrence, "What Happened to the Great U.S. Job Machine? The Role of Trade and Electronic Offshoring," *Brookings Papers on Economic Activity,* No. 2, 2004, pp. 211–284.
- P. Samuelson, "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economiests Supporting Globalization," *Journal of Economic Perspectives,* Summer 2004. pp. 135–146.
- J. Bhagwati, Arvind Panagariya and T. N. Srinivan, "The Muddles over Outsourcing," *Journal of Economic Perspectives,* Fall 2004, pp. 93–114.

For a review of, or introduction to, production theory, as well as for the derivation of the Edgeworth box diagram and production frontiers, see:

- D. Salvatore, *Microeconomics: Theory and Applications,* 4th ed. (New York: Oxford University, 2003), chs. 7 and 17 (sects. 17.2 and 17.3).
- D. Salvatore, *Microeconomics: Theory,* 4th ed. (New York: McGraw-Hill, 2006), chs. 6 and 14.
- M. E. Porter, *The Comparative Advantage of Nations* (New York: The Free Press, 1990).
- G. Hacche and F. Ramaswamy, "Deindustrialization: Causes and Implications," *IMF Working Paper WP/97/42,* April 1997.
- M. E. Porter, *On Competition* (Cambridge, Mass.: The Harvard Business School Press, 1998).
- G. Hacche and F. Ramaswamy, "Growth, Trade, and Deindustrialization," *IMF Staff Papers,* March 1999.
- R. D. Richardson and C. Zhang, *Revealing Comparative Advantage,* NBER Working Paper No. 7212, July 1999.

Job losses in high import-competing industries are examined in:

- L. G. Kletzer, *Job Loss from Imports: Measuring the Costs,* (Washington, D.C.: Institute for International Economics, 2001).

INTERNet

Information and data on the comparative advantage of nations, specialization and export concentration, and deindustrialization are published by the World Trade Organization (WTO), the United Nations, the International Monetary Fund, and the World Bank and can be found at:

http://www.wto.org

http://unstats.un.org/unsd

http://www.imf.org

http://worldbank.org

For deindustrialization, see the work of G. Hacche and F. Ramaswamy at:

http://www.imf.org/external/pubs/ft/issues10

http://www.imf.org/external/pubs/ft/wp/WP9742.PDF

U.S. trade statistics by region or country see the International Trade Administration, Office of Trade and Economic Analysis of the U.S. Department of Commerce at:

http://www.ita.doc.gov/td/industry/otea

For hourly compensation of U.S. workers and workers in many advanced countries, see the Bureau of Labor Statistics of the U.S. Department of Labor at:

http://www.bls.gov/data/home.htm

For skepticism of free trade, see:

http://www.citizen.org/trade/index.cfm

Chapter 4

Demand and Supply, Offer Curves, and the Terms of Trade

Learning Goals: ***After reading this chapter, you should be able to:***

- Show how the equilibrium price at which takes place is determined by demand and supply
- Show how the equilibrium price at which takes place is determined with offer curves
- Explain the meaning of the terms of trade and how they changed over time for the United States and other countries

4.1 Introduction

We saw in Chapter 3 that a difference in relative commodity prices between two nations in isolation is a reflection of their comparative advantage and forms the basis for mutually beneficial trade. The equilibrium-relative commodity price at which trade takes place was then found by trial and error at the level at which trade was balanced. In this chapter, we present a more rigorous theoretical way of determining the equilibrium-relative commodity price with trade. We will first do this with partial equilibrium analysis (i.e., by utilizing demand and supply curves) and then by the more complex general equilibrium analysis, which makes use of offer curves.

Section 4.2 shows how the equilibrium-relative commodity price with trade is determined with demand and supply curves (i.e., with partial equilibrium analysis). We then go on to general equilibrium analysis and derive the offer curves of Nation 1 and Nation 2 in Section 4.3. In Section 4.4, we will examine how the interaction of the offer curves of the two nations defines the equilibrium-relative commodity price with trade. In Section 4.5, we examine the relationship between general and partial equilibrium analyses. Finally, Section 4.6 examines the meaning, measurement, and importance of the terms of trade. The appendix to this chapter presents the *formal* derivation of offer curves and examines the case of multiple and unstable equilibria.

4.2 The Equilibrium-Relative Commodity Price with Trade—Partial Equilibrium Analysis

Figure 4.1 shows how the equilibrium-relative commodity price with trade is determined by partial equilibrium analysis. Curves D_X and S_X in panels A and C of Figure 4.1 refer to the demand and supply curves for commodity X of Nation 1 and Nation 2, respectively. The vertical axes in all three panels of Figure 4.1 measure the relative price of commodity X (i.e., P_X/P_Y, or the amount of commodity Y that a nation must give up to produce one additional unit of X). The horizontal axes measure the quantities of commodity X.

Panel A of Figure 4.1 shows that in the absence of trade, Nation 1 produces and consumes at point A at the relative price of X of P_1, while Nation 2 produces and consumes at point A' at P_3. With the opening of trade, the relative price of X will be between P_1 and P_3 if both nations are large. At prices above P_1, Nation 1 will supply (produce) more than it will demand (consume) of commodity X and will export the difference or excess supply (see panel A). On the other hand, at prices below P_3, Nation 2 will demand a greater quantity of commodity X than it produces or supplies domestically and will import the difference or excess demand (see panel C).

Specifically, panel A shows that at P_1, the quantity supplied of commodity X (QS_X) equals the quantity demanded of commodity X (QD_X) in Nation 1, and so Nation 1 *exports* nothing of commodity X. This gives point A^* on curve S (Nation 1's supply curve of exports) in panel B. Panel A also shows that at P_2, the excess of BE of QS_X over QD_X represents the quantity of commodity X that Nation 1 would export at P_2. This is equal to B^*E^* in panel B and defines point E^* on Nation 1's S curve of exports of commodity X.

On the other hand, panel C shows that at P_3, $QD_X = QS_X$ (point A'), so Nation 2 does not demand any *imports* of commodity X. This defines point A'' on Nation 2's demand curve for imports of commodity X (D) in panel B. Panel

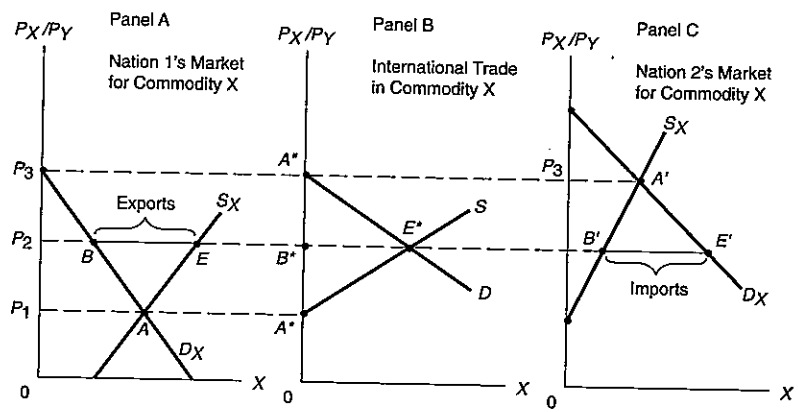

FIGURE 4.1. The Equilibrium-Relative Commodity Price with Trade with Partial Equilibrium Analysis. At P_X/P_Y larger than P_1, Nation 1's excess supply of commodity X in panel A gives rise to Nation 1's supply curve of exports of commodity X (S) in panel B. On the other hand, at P_X/P_Y lower than P_3, Nation 2's excess demand for commodity X in panel C gives rise to Nation 2's demand for imports of commodity X (D) in panel B. Panel B shows that only at P_2 does the quantity of imports of commodity X demanded by Nation 2 equal the quantity of exports supplied by Nation 1. Thus, P_2 is the equilibrium P_X/P_Y with trade. At $P_X/P_Y > P_2$, there will be an excess supply of exports of commodity X, and this will drive P_X/P_Y down to P_2. At $P_X/P_Y < P_2$, there will be an excess demand for imports of X, and this will drive P_X/P_Y up to P_2.

C also shows that at P_2, the excess $B'E'$ of QD_X over QS_X represents the quantity of commodity X that Nation 2 would import at P_2. This is equal to B^*E^* in panel B and defines point E^* on Nation 2's D curve of imports of commodity X.

At P_2, the quantity of imports of commodity X demanded by Nation 2 ($B'E'$ in panel C) equals the quantity of exports of commodity X supplied by Nation 1 (BE in panel A). This is shown by the intersection of the D and S curves for trade in commodity X in panel B. Thus, P_2 is the equilibrium-relative price of commodity X with trade. From panel B we can also see that at $P_X/P_Y > P_2$ the quantity of exports of commodity X supplied exceeds the quantity of imports demanded, and so the relative price of X (P_X/P_Y) will fall to P_2. On the other hand, at $P_X/P_Y < P_2$, the quantity of imports of commodity X demanded exceeds the quantity of exports supplied, and P_X/P_Y will rise to P_2.

The same could be shown with commodity Y. Commodity Y is exported by Nation 2 and imported by Nation 1. At any relative price of Y higher than equilibrium, the quantity of exports of Y supplied by Nation 2 would exceed the quantity of imports of Y demanded by 'Nation 1, and the relative price of Y would fall to the equilibrium level. On the other hand, at any P_Y/P_X below equilibrium, the quantity of imports of Y demanded would exceed the quantity of exports of Y supplied, and P_Y/P_X would rise to the equilibrium level. (You will be asked to show this graphically in Problem 1.) Case Study 4-1 shows the

Case Study 4-1 Demand, Supply, and the International Price of Petroleum

Table 4.1 shows that the price of petroleum fluctuated widely from 1972 to 2005. As a result of supply shocks during the Arab–Israeli War in fall 1973 and the Iranian revolution in 1979–1980, OPEC (the Organization of Petroleum Exporting Countries) was able to increase the price of petroleum from an average of $2.89 per barrel in 1972 to $11.60 in 1974 and to the all-time high of $36.68 per barrel in 1980. This stimulated energy conservation and expanded exploration and petroleum production by non-OPEC countries. In the face of excess supplies during the 1980s and 1990s, OPEC was unable to prevent the price of petroleum from falling to a low of $14.17 in 1986 and $13.07 in 1998. The price of petroleum then rose to $28.24 in 2000 and $55.0 in 2005.

If we consider, however, that all prices have risen over time, we can see from Table 4.1 that the real (i.e., inflation-adjusted) price of petroleum rose from $2.89 per barrel in 1972 to $9.51 in 1974 and to $17.14 in 1980, but it then fell to $4.69 in 1986 and $2.90 in 1988, but then rose to $5.73 in 2000 and $9.12 in 2005. Thus, the real price of petroleum increased by 216 percent (i.e., more than doubled) from 1972 to 2005 ($9.12 compared with $2.89) rather than by 18 times or 1,803 percent (in nominal prices).

TABLE 4.1. *Nominal and Real Petroleum Prices, Selected Years, 1972–2005*

Year	1972	1973	1974	1978	1979	1980
Petroleum Prices ($/barrel)	2.89	3.24	11.60	13.39	30.21	36.68
Real Petroleum Prices ($/barrel)	2.89	3.00	9.51	7.70	15.82	17.14

Year	1985	1986	1990	1998	2000	2005
Petroleum Prices ($/barrel)	27.37	14.17	22.99	13.07	28.23	55.00
Real Petroleum Prices ($/barrel)	9.34	4.69	6.51	2.90	5.73	8.12

Source: Elaborated from data in IMF, *International Financial Statistics* (Washington, D.C., 2006).

Case Study 4-2 The Index of Export to Import Prices for the United States

Figure 4.2 shows the index of U.S. export to import prices or terms of trade from 1972 to 2005. This index declined almost continuously from 1972 to 1980, it rose from 1980 to 1986, and then it remained in the 98–102 range (with 1995 = 100), except in 1998 when it rose to 103.6 and in 2005 when it fell to 92.2 (see the figure). The decline in the index was particularly large during the two "oil shocks"

(continued)

Case Study 4-2 (continued)

of 1973–74 and 1979–80, and in 2005 when the price of petroleum imports also rose sharply. From the figure, we can see that the average relative price of U.S. exports declined from 123 in 1972 to 87 in 1980, and it was 92 in 2005. This means that, on the average, the United States had to export 29 percent more in 1980 and 25 percent more in 2005 to import the same quantity of goods and services that it imported in 1972.

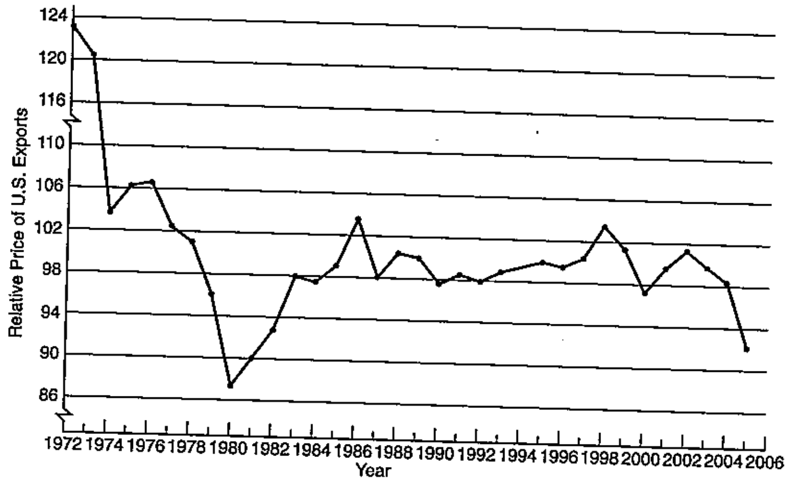

FIGURE 4.2. Index of Relative U.S. Export Prices (1995 = 100). The index of U.S. export to import prices declined from 123.1 in 1972 to 103.8 in 1974 (due to the sharp increase in petroleum prices between 1973 and 1974) and to 87.4 in 1980, as a result of the second "oil shock." The index then rose to 103.7 in 1986 and 103.6 in 1998, but it fell to 92.2 in 2005 as a result of the sharp increase in petroleum prices in 2005.

Source: Elaborated from data in IMF, *International Financial Statistics* (Washington, D.C. 2006).

international price of petroleum in nominal and real (i.e., inflation-adjusted) terms from 1972 to 2005, while Case Study 4-2 shows the index of export to import prices for the United States over the same period.

4.3 Offer Curves

In this section, we define offer curves and note their origin. We then derive the offer curve of the two nations and examine the reasons for their shape.

4.3A Origin and Definition of Offer Curves

Offer curves (sometimes referred to as **reciprocal demand curves**) were devised and introduced into international economics by *Alfred Marshall* and *Ysidro Edgeworth*, two British economists of the turn of the twentieth century. Since then, offer curves have been used extensively in international economics, especially for pedagogical purposes.

The offer curve of a nation shows how much of its import commodity the nation demands for it to be willing to supply various amounts of its export commodity. As the definition indicates, offer curves incorporate elements of both demand and supply. Alternatively, we can say that the offer curve of a nation shows the nation's willingness to import and export at various relative commodity prices.

The offer curve of a nation can be derived rather easily and somewhat informally from the nation's production frontier, its indifference map, and the various hypothetical relative commodity prices at which trade could take place. The formal derivation of offer curves presented in the appendix is based on the work of *James Meade*, another British economist and Nobel Prize winner.

4.3B Derivation and Shape of the Offer Curve of Nation 1

In the left panel of Figure 4.3, Nation 1 starts at the no-trade (or autarky) point A, as in Figure 3.3. If trade takes place at $P_B = P_X/P_Y = 1$, Nation 1 moves to point B in production, trades 60X for 60Y with Nation 2, and reaches point E

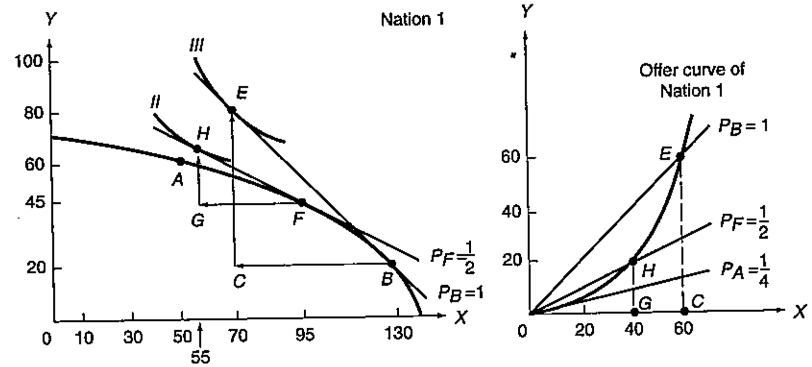

FIGURE 4.3. Derivation of the Offer Curve of Nation 1. In the left panel, Nation 1 starts at pretrade-equilibrium point A. If trade takes place at $P_B = 1$, Nation 1 moves to point B in production, exchanges 60X for 60Y with Nation 2, and reaches point E. This gives point E in the right panel. At $P_F = ½$ in the left panel, Nation 1 would move instead from point A to point F in production, exchange 40X for 20Y with Nation 2, and reach point H. This gives point H in the right panel. Joining the origin with points H and E in the right panel, we generate Nation 1's offer curve. This shows how much imports of commodity Y Nation 1 requires to be willing to export various quantities of commodity X.

on its indifference curve III. (So far this is exactly the same as in Figure 3.4.) This gives point E in the right panel of Figure 4.3.

At $P_F = P_X/P_Y = ½$ (see the left panel of Figure 4.3), Nation 1 would move instead from point A to point F in production, exchange 40X for 20Y with Nation 2, and reach point H on its indifference curve II. This gives point H in the right panel. Joining the origin with points H and E and other points similarly obtained, we generate Nation 1's offer curve in the right panel. The offer curve of Nation 1 shows how much imports of commodity Y Nation 1 requires to be willing to export various quantities of commodity X.

To keep the left panel simple, we omitted the autarky price line $P_A = ¼$ and indifference curve I tangent to the production frontier and P_A at point A. Note that P_A, P_F, and P_B in the right panel refer to the same P_X/P_Y as P_A, P_F, and P_B in the left panel because they refer to the same *absolute* slope.

The offer curve of Nation 1 in the right panel of Figure 4.3 lies above the autarky price line of $P_A = ¼$ and bulges toward the X-axis, which measures the commodity of its comparative advantage and export. To induce Nation 1 to export more of commodity X, P_X/P_Y must rise. Thus, at $P_F = ½$, Nation 1 would export 40X, and at $P_B = 1$, it would export 60X. There are two reasons for this: (1) Nation 1 incurs increasing opportunity costs in producing more of commodity X (for export), and (2) the more of commodity Y and the less of commodity X that Nation 1 consumes with trade, the more valuable to the nation is a unit of X at the margin compared with a unit of Y.

4.3C Derivation and Shape of the Offer Curve of Nation 2

In the left panel of Figure 4.4, Nation 2 starts at the autarky equilibrium point A', as in Figure 3.3. If trade takes place at $P_{B'} = P_X/P_Y = 1$, Nation 2 moves to point B' in production, exchanges 60Y for 60X with Nation 1, and reaches point E' on its indifference curve III'. (So far this is exactly the same as in Figure 3.4.) Trade triangle $B'C'E'$ in the left panel of Figure 4.4 corresponds to trade triangle $O'C'E'$ in the right panel, and we get point E' on Nation 2's offer curve.

At $P_{F'} = P_X/P_Y = 2$ in the left panel, Nation 2 would move instead to point F' in production, exchange 40Y for 20X with Nation 1, and reach point H' on its indifference curve II'. Trade triangle $F'G'H'$ in the left panel corresponds to trade triangle $O'G'H'$ in the right panel, and we get point H' on Nation 2's offer curve. Joining the origin with points H' and E' and other points similarly obtained, we generate Nation 2's offer curve in the right panel. The offer curve of Nation 2 shows how many imports of commodity X Nation 2 demands to be willing to export various quantities of commodity Y.

Once again, we omitted the autarky price line $P_{A'} = 4$ and indifference curve I' tangent to the production frontier and $P_{A'}$ at point A'. Note that $P_{A'}$, $P_{F'}$, and $P_{B'}$ in the right panel refer to the same P_X/P_Y as $P_{A'}$, $P_{F'}$, and $P_{B'}$ in the left panel because they refer to the same *absolute* slope.

The offer curve of Nation 2 in the right panel of Figure 4.4 lies *below* its autarky price line of $P_{A'} = 4$ and bulges toward the Y-axis, which measures the commodity of its comparative advantage and export. To induce Nation 2 to export more of

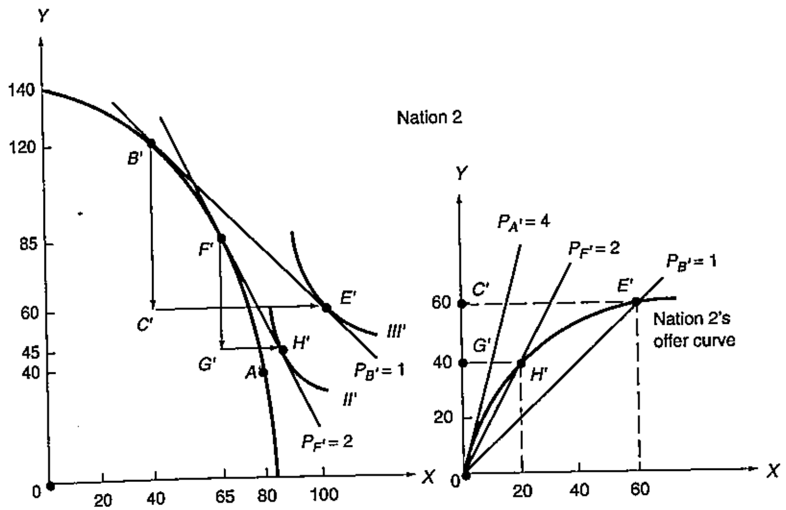

FIGURE 4.4. Derivation of the Offer Curve of Nation 2. In the left panel, Nation 2 starts at pretrade equilibrium point A'. If trade takes place at $P_{B'} = 1$, Nation 2 moves to point B' in production, exchanges 60Y for 60X with Nation 1, and reaches point E'. This gives point E' in the right panel. At $P_{F'} = 2$ in the left panel, Nation 2 would move instead from A' to F' in production, exchange 40Y for 20X with Nation 1, and reach H'. This gives point H' in the right panel. Joining the origin with points H' and E' in the right panel, we generate Nation 2's offer curve. This shows how many imports of commodity X Nation 2 demands to be willing to supply various amounts of commodity Y for export.

commodity Y, the relative price of Y must rise. This means that its reciprocal (i.e., P_X/P_Y) must fall. Thus, at $P_{F'} = 2$, Nation 2 would export 40Y and at $P_{B'} = 1$, it would export 60Y. Nation 2 requires a higher relative price of Y to be induced to export more of Y because (1) Nation 2 incurs increasing opportunity costs in producing more of commodity Y (for export), and (2) the more of commodity X and the less of commodity Y that Nation 2 consumes with trade, the more valuable to the nation is a unit of Y at the margin compared with a unit of X.

4.4 The Equilibrium-Relative Commodity Price with Trade—General Equilibrium Analysis

The intersection of the offer curves of the two nations defines the equilibrium-relative commodity price at which trade takes place between them. Only at this equilibrium price will trade be balanced between the two nations. At any other relative commodity price, the *desired* quantities of imports and exports of the two

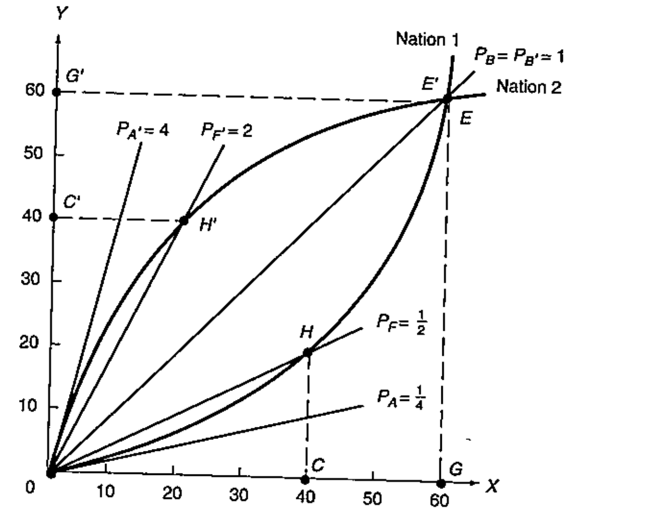

FIGURE 4.5. Equilibrium-Relative Commodity Price with Trade. The offer curves of Nation 1 and Nation 2 are those of Figures 4.3 and 4.4. The offer curves intersect at point E, defining the equilibrium-relative commodity price $P_B = 1$. At P_B, trade is in equilibrium because Nation 1 offers to exchange 60X for 60Y and Nation 2 offers exactly 60Y for 60X. At any $P_X/P_Y < 1$, the quantity of exports of commodity X supplied by Nation 1 would fall short of the quantity of imports of commodity X demanded by Nation 2. This would drive the relative commodity price up to the equilibrium level. The opposite would be true at $P_X/P_Y > 1$.

commodities would not be equal. This would put pressure on the relative commodity price to move toward its equilibrium level. This is shown in Figure 4.5.

The offer curves of Nation 1 and Nation 2 in Figure 4.5 are those derived in Figures 4.3 and 4.4. These two offer curves intersect at point E, defining equilibrium $P_X/P_Y = P_B = P_{B'} = 1$. At P_B, Nation 1 offers 60X for 60Y (point E on Nation 1's offer curve), and Nation 2 offers exactly 60Y for 60X (point E' on Nation 2's offer curve). Thus, trade is in equilibrium at P_B.

At any other P_X/P_Y, trade would not be in equilibrium. For example, at $P_F = ½$, the 40X that Nation 1 would export (see point H in Figure 4.5) would fall short of the imports of commodity X demanded by Nation 2 at this relatively low price of X. (This is given by a point, not shown in Figure 4.5, where the extended price line P_F crosses the extended offer curve of Nation 2.)

The excess import demand for commodity X at $P_F = ½$ by Nation 2 tends to drive P_X/P_Y up. As this occurs, Nation 1 will supply more of commodity X for export (i.e., Nation 1 will move up its offer curve), while Nation 2 will reduce its import demand for commodity X (i.e., Nation 2 will move down its offer curve). This will continue until supply and demand become equal at P_B. The pressure for P_F to move toward P_B could also be explained in terms of commodity Y and arises at any other P_X/P_Y, such as $P_F \neq P_B$.

Note that the equilibrium-relative commodity price of $P_B = 1$ with trade (determined in Figure 4.5 by the intersection of the offer curves of Nation 1 and Nation 2) is identical to that found by trial and error in Figure 3.4. At $P_B = 1$, both nations happen to gain equally from trade (refer to Figure 3.4).

4.5 Relationship between General and Partial Equilibrium Analyses

We can also illustrate equilibrium for our two nations with demand and supply curves and thus show the relationship between the general equilibrium analysis of Section 4.4 and the partial equilibrium analysis of Section 4.2. This is shown with Figure 4.6.

In Figure 4.6, S is Nation 1's supply curve of exports of commodity X and is derived from Nation 1's production frontier and indifference map in the left panel of Figure 4.3 (the same information from which Nation 1's offer curve in the right panel of Figure 4.3 is derived). Specifically, S shows that the quantity supplied of exports of commodity X by Nation 1 is zero (point A) at $P_X/P_Y = 1/4$,

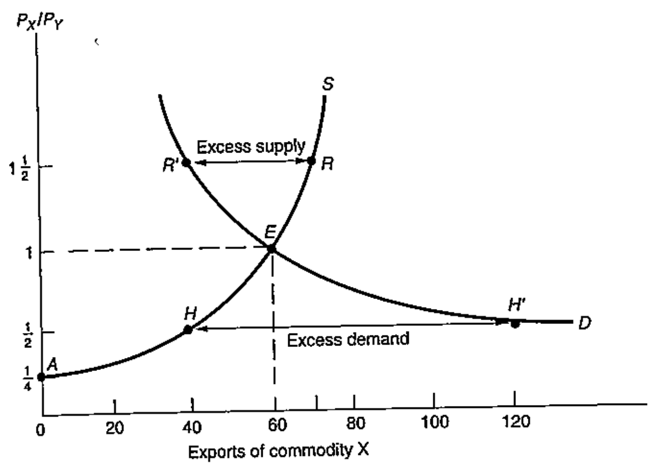

FIGURE 4.6. Equilibrium-Relative Commodity Price with Partial Equilibrium Analysis. S refers to Nation 1's supply curve of exports of commodity X, while D refers to Nation 2's demand curve for Nation 1's exports of commodity X. S and D are derived from the left panel of Figures 4.3 and 4.4, and show the same basic information as Figure 4.5. D and S intersect at point E, determining the equilibrium $P_X/P_Y = 1$ and the equilibrium quantity of exports of 60X. At $P_X/P_Y = 1\frac{1}{2}$ there is an excess supply of exports of $R'R$ = 30X, and P_X/P_Y falls toward equilibrium $P_X/P_Y = 1$. At $P_X/P_Y = 1/2$, there is an excess demand of exports of HH' = 80X, and P_X/P_Y rises toward $P_X/P_Y = 1$.

40 (point H) at $P_X/P_Y = 1/2$, and 60 (point E) at $P_X/P_Y = 1$ (*as indicated in the left panel of Figure 4.3 and on Nation 1's offer curve in the right panel of Figure 4.3*). The export of 70X by Nation 1 at $P_X/P_Y = 1\frac{1}{2}$ (point R on the S curve in Figure 4.6) can similarly be obtained from the left panel of Figure 4.3 and is shown as point R on Nation 1's offer curve in Figure 4.9 in Appendix A4.3.

On the other hand, D refers to Nation 2's demand for Nation 1's exports of commodity X and is derived from Nation 2's production frontier and indifference map in the left panel of Figure 4.4 (the same information from which Nation 2's offer curve in the right panel of Figure 4.4 is derived). Specifically, D in Figure 4.6 shows that the quantity demanded of Nation 1's exports of commodity X by Nation 2 is 60 (point E) at $P_X/P_Y = 1$ (as in the left panel of Figure 4.4), 120 (point H') at $P_X/P_Y = 1/2$, but 40 (point R') at $P_X/P_Y = 1\frac{1}{2}$.

D and S intersect at point E in Figure 4.6, determining the equilibrium $P_X/P_Y = 1$ and the equilibrium quantity of exports of 60X (as in Figure 4.5). Figure 4.6 shows that at $P_X/P_Y = 1\frac{1}{2}$ there is an excess supply of exports of $R'R$ = 30X, and P_X/P_Y falls toward equilibrium $P_X/P_Y = 1$. On the other hand, at $P_X/P_Y = 1/2$, there is an excess demand of exports of HH' = 80X, and P_X/P_Y rises toward $P_X/P_Y = 1$. Thus, the relative price of X gravitates toward the equilibrium price of $P_X/P_Y = 1$, given by point E in Figure 4.6 (the same as in Figure 4.5). The same conclusion would be reached in terms of Y (see Problem 8, with answer at the end of the book).

If, on the other hand, Nation 2 were small, its demand curve for Nation 1's exports of commodity X would intersect the horizontal portion of Nation 1's supply curve of exports of commodity X (near the vertical axis). In that case, Nation 2 would trade at the pretrade price of $P_X/P_Y = 1/4$ in Nation 1, and Nation 2 would receive all of the gains from trade. (This could also be shown with offer curves; see Problem 10, with the answer at the end of the book.)

Going back to our Figure 4.6, we see that it shows the same basic information as Figure 4.5, and both are derived from the nation's production frontier and indifference map. There is a basic difference, however, between the two figures. Figure 4.5 refers to general equilibrium analysis and considers all markets together, not just the market for commodity X. This is important because changes in the market for commodity X affect other markets, and these may give rise to important repercussions on the market for commodity X itself. On the other hand, the partial equilibrium analysis of Figure 4.6, which utilizes D and S curves, does not consider these repercussions and the connections that exist between the market for commodity X and the market for all other commodities in the economy. Partial equilibrium analysis is often useful as a first approximation, but for the complete and full answer, the more difficult general equilibrium analysis is usually required.

4.6 The Terms of Trade

In this section, we define the terms of trade of each nation and illustrate their measurement. We also discuss the meaning of a change in a nation's terms of trade. Finally, we pause to take stock of what we have accomplished up to this point and examine the usefulness of our trade model.

4.6A Definition and Measurement of the Terms of Trade

The **terms of trade** of a nation are defined as the ratio of the price of its export commodity to the price of its import commodity. Since in a two-nation world, the exports of a nation are the imports of its trade partner, the terms of trade of the latter are equal to the inverse, or reciprocal, of the terms of trade of the former.

In a world of many (rather than just two) traded commodities, the terms of trade of a nation are given by the ratio of the price *index* of its exports to the price *index* of its imports. This ratio is usually multiplied by 100 in order to express the terms of trade in percentages. These terms of trade are often referred to as the **commodity or net barter terms of trade** to distinguish them from other measures of the terms of trade presented in Chapter 11 in connection with trade and development.

As supply and demand considerations change over time, offer curves will shift, changing the volume and the terms of trade. This matter will be examined in Chapter 7, which deals with growth and change, and international trade. An improvement in a nation's terms of trade is usually regarded as beneficial to the nation in the sense that the prices that the nation receives for its exports rise relative to the prices that it pays for imports.

4.6B Illustration of the Terms of Trade

Since Nation 1 exports commodity X and imports commodity Y, the terms of trade of Nation 1 are given by P_X/P_Y. From Figure 4.5, these are $P_X/P_Y = P_B =$ 1 or 100 (in percentages). If Nation 1 exported and imported many commodities, P_X would be the *index* of its export prices, and P_Y would be the *index* of its import prices.

Since Nation 2 exports commodity Y and imports commodity X, the terms of trade of Nation 2 are given by P_Y/P_X. Note that this is the inverse, or reciprocal, of Nation 1's terms of trade and also equals 1 or 100 (in percentages) in this case.

If through time the terms of trade of Nation 1 rose, say, from 100 to 120, this would mean that Nation 1's export prices rose 20 percent in relation to its import prices. This would also mean that Nation 2's terms of trade have deteriorated from 100 to (100/120)100 = 83. Note that we can always set a nation's terms of trade equal to 100 in the base period, so that changes in its terms of trade over time can be measured in percentages.

Even if Nation 1's terms of trade improve over time, we cannot conclude that Nation 1 is *necessarily* better off because of this, or that Nation 2 is necessarily worse off because of the deterioration in its terms of trade. Changes in a nation's terms of trade are the result of many forces at work both in that nation and in the rest of the world, and we cannot determine their net effect on a nation's welfare by simply looking at the change in the nation's terms of trade. To answer this

Case Study 4-3 The Terms of Trade of the G-7 Countries

Table 4.2 gives the terms of trade of the Group of seven largest industrial countries (G-7) for selected years from 1972 to 2004. The terms of trade were measured by dividing the index of export unit value by the index of import unit value, taking 1995 as 100. Table 4.2 shows that the terms of trade of industrial countries declined from 1972 to 1980, improved somewhat by 1986 (except for Canada), and continued to improve until 2004 (except for the United States and Germany); but they were still lower in 2004 than in 1972, except for France and the United Kingdom.

TABLE 4.2. *The Terms of Trade of Industrial Countries, Selected Years, 1972–2004 (Export Unit Value ÷ Import Unit Value; 1995 = 100)*

	1972	1974	1980	1986	1990	1996	2000	2004	% Change 1972–2004
United States	123	104	87	104	98	100	97	98	–20
Canada	115	131	111	95	100	101	103	110	–4
Japan	95	70	52	77	73	92	96	89	–6
Germany	109	97	89	100	102	100	93	100	–8
France	95	84	85	94	94	99	95	102	7
United Kingdom	107	82	91	94	101	101	103	108	1
Italy	110	83	93	97	98	104	100	103	–6

Source: Elaborated from data in IMF, *International Financial Statistics* (Washington, D.C.: 2006).

question, we need more information and analysis, and we will postpone that until Chapter 11. Case Study 4-3 shows the terms of trade of the G-7 countries, and Case Study 4-4 gives the terms of trade of industrial and developing countries for selected years over the 1972–2005 period.

4.6C Usefulness of the Model

The trade model presented thus far summarizes clearly and concisely a remarkable amount of useful information and analysis. It shows the conditions of production, or supply, in the two nations, the tastes, or demand preferences, the autarky point of production and consumption, the equilibrium-relative commodity price in the absence of trade, and the comparative advantage of each nation (refer to Figure 3.3). It also shows the degree of specialization in production with trade, the volume of trade, the terms of trade, the gains from trade, and the share of these gains going to each of the trading nations (see Figures 3.4 and 4.5).

Because it deals with only two nations (Nation 1 and Nation 2), two commodities (X and Y), and two factors (labor and capital), our trade model is a

Case Study 4-4 The Terms of Trade of Industrial and Developing Countries

Table 4.3 gives the terms of trade of industrial countries, developing countries as a whole, as well as for Asian, Middle Eastern, and Western Hemispheric developing countries (data on African countries were not available) for selected years from 1972 to 2005. The terms of trade were measured by dividing the index of export unit value by the index of import unit value, with 1995 as 100.

Table 4.3 shows that the terms of trade of industrial countries declined from 1972 to 1985 but then rose until 1996, and they were 95 in 2005, as compared with 105 in 1972. For developing countries, the terms of trade rose sharply from 1972 to 1980 primarily as a result of the very sharp increase in the terms of trade of Western Hemispheric countries, but they then declined until 1986, and they were 96 in 2005, as compared with 61 in 1972.

Although the terms of trade of industrial and developing countries reflected to a large extent the large fluctuations in the price of petroleum over the period examined, other forces were also clearly at work (note, for example, that the largest fluctuation was in the terms of trade of the Western Hemisphere, whose exports were mostly nonpetroleum and that the terms of trade of the Middle East as a whole declined between 1972 and 1974 and between 1978 and 1980 because many Middle Eastern countries did not export petroleum.) A detailed analysis and data on the forces that determine the terms of trade of developing countries are presented in Chapter 11.

TABLE 4.3. *The Terms of Trade of Industrial and Developing Countries, Selected Years, 1972–2005 (Export Unit Value/Import Unit Value; 1995 = 100)*

	1972	1973	1974	1978	1979	1980
Industrial countries	105	104	92	95	93	86
Developing countries	61	64	85	87	95	105
Asia	100	102	101	100	102	98
Middle East	137	134	109	143	138	131
Western Hemisphere	37	41	103	91	139	181

	1985	1986	1990	1996	2000	2005
Industrial countries	83	93	95	99	95	95
Developing countries	99	90	101	101	99	96
Asia	95	94	100	98	94	91
Middle East	117	120	159	107	130	125
Western Hemisphere	177	99	121	113	101	106

na = not available

Source: Elaborated from data in IMF, *International Financial Statistics* (Washington, D.C.: 2006).

completely **general equilibrium model**. It can be used to examine how a change in demand and/or supply conditions in a nation would affect the terms of trade, the volume of trade, and the share of the gains from trade in each nation. This is done in Chapter 7.

Before doing that, however, our trade model must be extended in two important directions: (1) to identify the *basis* for (i.e., what determines) comparative advantage and (2) to examine the effect of international trade on the returns, or earnings, of resources or factors of production in the two trading nations. This is done in the next chapter.

Summary

1. In this chapter, we derived the demand for imports and the supply of exports of the traded commodity, as well as the offer curves for the two nations, and used them to determine the equilibrium volume of trade and the equilibrium-relative commodity price at which trade takes place between the two nations. The results obtained here confirm those reached in Chapter 3 by a process of trial and error.
2. The excess supply of a commodity above the no-trade equilibrium price gives one nation's export supply of the commodity. On the other hand, the excess demand of a commodity below the no-trade equilibrium price gives the other nation's import demand for the commodity. The intersection of the demand curve for imports and the supply curve for exports of the commodity defines the partial equilibrium-relative price and quantity of the commodity at which trade takes place.
3. The offer curve of a nation shows how much of its import commodity the nation demands to be willing to supply various amounts of its export commodity. The offer curve of a nation can be derived from its production frontier, its indifference map, and the various relative commodity prices at which trade could take place. The offer curve of each nation bends toward the axis measuring the commodity of its comparative advantage. The offer curves of two nations will lie between their pretrade, or autarky, relative commodity prices. To induce a nation to export more of a commodity, the relative price of the commodity must rise.
4. The intersection of the offer curves of two nations defines the equilibrium-relative commodity price at which trade takes place between them. Only at this equilibrium price will trade be balanced. At any other relative commodity price, the desired quantities of imports and exports of the two commodities would not be equal. This would put pressure on the relative commodity price to move toward its equilibrium level.
5. We can also illustrate the equilibrium-relative commodity price and quantity with trade with partial equilibrium analysis. This makes use of the demand and supply curves for the traded commodities. These are derived from the nations' production frontiers and indifference map—the same basic information from

which the nations' offer curves (which are used in general equilibrium analysis) are derived.

6. The terms of trade of a nation are defined as the ratio of the price of its export commodity to the price of its import commodity. The terms of trade of the trade partner are then equal to the inverse, or reciprocal, of the terms of trade of the other nation. With more than two commodities traded, we use the index of export to import prices and multiply by 100 to express the terms of trade in percentages. Our trade model is a general equilibrium model except for the fact that it deals with only two nations, two commodities, and two factors.

In Chapter 5, we will extend our trade model in order to identify one of the most important determinants of the difference in the pretrade-relative commodity prices and the comparative advantage among nations. This will also allow us to examine the effect that international trade has on the relative price and income of the various factors of production. Our trade model so extended is referred to as the Heckscher–Ohlin model. In Chapter 6, we will present other more recent trade models.

Offer curves
Reciprocal demand curves
Terms of trade
Commodity or net barter terms of trade
General equilibrium model

1. How can the supply curve of exports and the demand curve of imports of a commodity be derived from the total demand and supply curves of a commodity in the two nations?
2. How is the equilibrium-relative commodity price with trade determined with demand and supply curves?
3. What is the usefulness of offer curves? How are they related to the trade model of Figure 3.4?
4. What do offer curves show? How are they derived? What is their shape? What explains their shape?
5. How do offer curves define the equilibrium-relative commodity price at which trade takes place?
6. What are the forces that would push any nonequilibrium-relative commodity price toward the equilibrium level?
7. How is a nation's supply curve of its export commodity and demand for its import commodity derived from the nation's production frontier and indifference map?
8. Why does the use of demand and supply curves of the traded commodity refer to partial equilibrium analysis? In what way is partial equilibrium analysis of trade related to general equilibrium analysis?
9. Under what condition will trade take place at the pretrade-relative commodity price in one of the nations?
10. What do the terms of trade measure? What is the relationship between the terms of trade in a world of two trading nations? How are the terms of trade measured in a world of more than two traded commodities?
11. What does an improvement in a nation's terms of trade mean? What effect does this have on the nation's welfare?
12. In what way does our trade model represent a general equilibrium model? In what way does it not? In what ways does our trade model require further extension?

Problems

1. Show graphically how the equilibrium-relative commodity price of commodity Y with trade can be derived from Figure 4.1.
2. Without looking at the text, derive a nation's offer curve from its production frontier, its indifference map, and two relative commodity prices at which trade could take place (i.e., sketch a figure similar to Figure 4.3).
3. Do the same as for Problem 2 for the trade partner (i.e., sketch a figure similar to Figure 4.4).
4. Bring together on another graph the offer curves that you derived in Problems 2 and 3 and determine the equilibrium-relative commodity prices at which trade would take place (i.e., sketch a figure similar to Figure 4.5).
5. In what way is a nation's offer curve similar to:
   (a) a demand curve?
   (b) a supply curve?
   (c) In what way is the offer curve *different* from the usual demand and supply curves?

*6. Sketch a figure similar to Figure 4.5.
   (a) Extend the $P_{F'}$ price line and the offer curve of Nation 1 until they cross. (In extending it, let the offer curve of Nation 1 bend backward.)
   (b) Using the figure you sketched, explain the forces that push $P_{F'}$ toward P_B in terms of commodity Y.
   (c) What does the backward-bending (negatively sloped) segment of Nation 1's offer curve indicate?
7. To show how nations can share unequally in the benefits from trade:
   (a) Sketch a figure showing the offer curve of a nation having a much greater curvature than the offer curve of its trade partner.
   (b) Which nation gains more from trade, the nation with the offer curve of greater or the one with the lesser curvature?
   (c) Can you explain why?

*8. From the left panel of Figure 4.4, derive Nation 2's supply curve of exports of commodity Y. From the left panel of Figure 4.3, derive Nation 1's demand curve for Nation 2's exports of commodity Y. Use the demand and supply curves that you derived to show how the equilibrium-relative commodity price of commodity Y with trade is determined.

9. (a) Why does the analysis in the answer to Problem 8 refer to partial equilibrium analysis?
   (b) Why does the analysis of Figure 4.5 refer to general equilibrium analysis?
   (c) What is the relationship between partial and general equilibrium analysis?

*10. Draw the offer curves for Nation 1 and Nation 2, showing that Nation 2 is a small nation

* = Answer provided at www.wiley.com/college/salvatore.

that trades at the pretrade-relative commodity prices in Nation 1. How are the gains from trade distributed between the two nations? Why?

11. Draw a figure showing the equilibrium point with trade for two nations that face constant opportunity costs.

12. Suppose that the terms of trade of a nation improved from 100 to 110 over a given period of time.

(a) By how much did the terms of trade of its trade partner deteriorate?

(b) In what sense can this be said to be unfavorable to the trade partner? Does this mean that the welfare of the trade partner has definitely declined?

13. It has often been said that OPEC (Organization of Petroleum Exporting Countries) operates as a cartel and is able to set petroleum prices by restricting supplies. Do you agree? Explain.

Appendix

This appendix presents the formal derivation of offer curves, using a technique perfected by James Meade. In Section A4.1, we derive a trade indifference curve for Nation 1, and in Section A4.2, its trade indifference map. In Section A4.3, Nation 1's offer curve is derived from its trade indifference map and various relative commodity prices at which trade could take place. Section A4.4 outlines the derivation of Nation 2's offer curve in relation to Nation 1's offer curve. In Section A4.5, we present the complete general equilibrium model showing production, consumption, and trade in both nations simultaneously. Finally, in Section A4.6, we examine multiple and unstable equilibria.

A4.1 Derivation of a Trade Indifference Curve for Nation 1

The second (upper-left) quadrant of Figure 4.7 shows the familiar production frontier and community indifference curve I for Nation 1. The only difference between this and Figure 3.3 is that now the production frontier and community indifference curve I are in the second rather than the first quadrant, and quantities are measured from right to left instead of from left to right. (The reason for this will become evident in a moment.) As in Figure 3.3, Nation 1 is in equilibrium at point *A* in the absence of trade by producing and consuming 50X and 60Y.

Now let us slide Nation 1's production block, or frontier, along indifference curve I so that the production block remains tangent to indifference curve I and the commodity axes are kept parallel at all times. As we do this, the origin of the production block will trace out curve TI (see Figure 4.7). Point A^* is derived from the tangency at *A*, point B^* from the tangency at *B*, point W^* from the tangency at *W* (not shown to keep the figure simple), and point Z^* from the tangency at *Z*.

Curve TI is Nation 1's trade indifference curve, corresponding to its indifference curve I. TI shows the various trade situations that would keep Nation 1 at the same level of welfare as in the initial no-trade situation. For example, Nation 1 is as well off at point *A* as at point *B*, since both points *A* and *B* are on the same community indifference curve I. However, at point *A*, Nation 1 produces and consumes 50X and 60Y without trade. At point *B*, Nation 1 would produce 130X and 20Y (with reference to the origin at B^*) and consume 30X and 70Y (with reference to the origin at O or A^*) by exporting 100X in exchange for 50Y (see the figure).

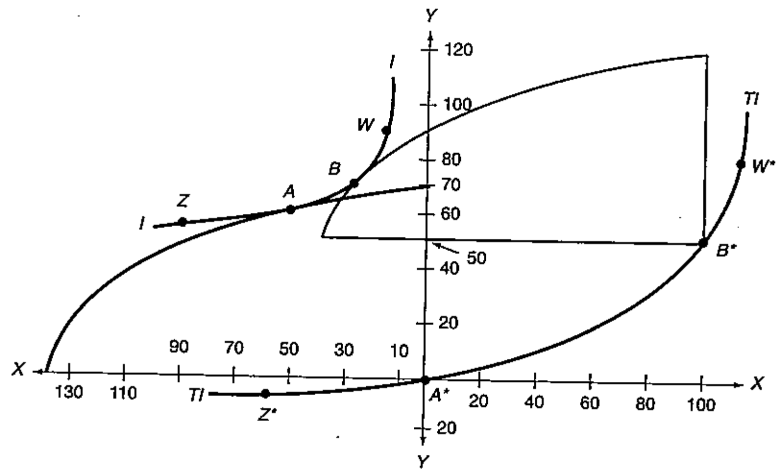

Figure 4.7. Derivation of a Trade Indifference Curve for Nation 1. Trade indifference curve TI is derived by sliding Nation 1's production frontier, or block, along its indifference curve I so that the production block remains tangent to indifference curve I and the commodity axes are kept parallel at all times. As we do this, the *origin* of the production block will trace out TI. This shows the various *trade* situations that would keep Nation 1 at the same level of welfare as in the initial no-trade situation (given by point *A* on indifference curve I).

Thus, a **trade indifference curve** shows the various trade situations that provide a nation equal welfare. The level of welfare shown by a trade indifference curve is given by the community indifference curve, from which the trade indifference curve is derived. Also note that the slope of the trade indifference curve at any point is equal to the slope at the corresponding point on the community indifference curve from which the trade indifference curve is derived.

A4.2 Derivation of Nation 1's Trade Indifference Map

There is one trade indifference curve for each community indifference curve. Higher community indifference curves (reflecting greater national welfare) will give higher trade indifference curves. Thus, a nation's *trade* indifference map can be derived from its *community* indifference curve map.

Figure 4.8 shows the derivation of trade indifference curve TI from community indifference curve I (as in Figure 4.7) and the derivation of trade indifference curve TIII from community indifference curve III for Nation 1. Note that community indifference curve III is the one shown in Figure 3.2. To reach community indifference curve III in Figure 4.8, the production block must be shifted up parallel to the axes until it is tangent to that community indifference curve. Thus, the tangency point *J* gives J^* on TIII. Tangency point *E* would give E^* on TIII, and so on.

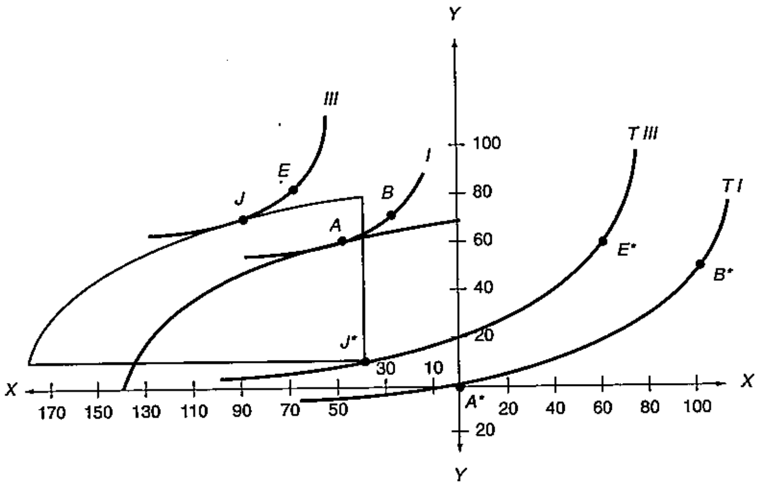

FIGURE 4.8. Derivation of Nation 1's Trade Indifference Map. Trade indifference curve TI is derived from Nation 1's indifference curve I, as shown in Figure 4.7. Trade indifference curve TIII is similarly derived by sliding Nation 1's production block along its indifference curve III while keeping the axes always parallel. Higher community indifference curve III gives higher trade indifference curve TIII. For each indifference curve, we could derive the corresponding trade indifference curve and obtain the entire trade indifference map of Nation 1.

Figure 4.8 shows only the derivation of TI and TIII (to keep the figure simple). However, for each indifference curve for Nation 1, we could derive the corresponding trade indifference curve and obtain the entire trade indifference map of Nation 1.

A4.3 Formal Derivation of Nation 1's Offer Curve

A nation's offer curve is the locus of tangencies of the relative commodity price lines at which trade could take place with the nation's trade indifference curves. The formal derivation of Nation 1's offer curve is shown in Figure 4.9.

In Figure 4.9, TI and TII are Nation 1's trade indifference curves, derived from its production block and community indifference curves, as illustrated in Figure 4.8. Lines P_A, P_F, P_B, P_F', and P_A' from the origin refer to relative prices of commodity X at which trade could take place (as in Figure 4.5).

Joining the origin with tangency points *H*, *E*, *R*, *S*, and *T* gives Nation 1's offer curve. This is the same offer curve that we derived with a simpler technique in Figure 4.3. The only difference is that now we have derived the top and backward-bending portion of Nation 1's offer curve as well. As defined earlier, Nation 1's offer curve shows the amount of imports of commodity Y that Nation 1 demands to be willing to supply various amounts of commodity X for export. Note that the greater Nation 1's terms of trade are, the higher is the trade indifference curve reached and the greater is Nation 1's welfare.

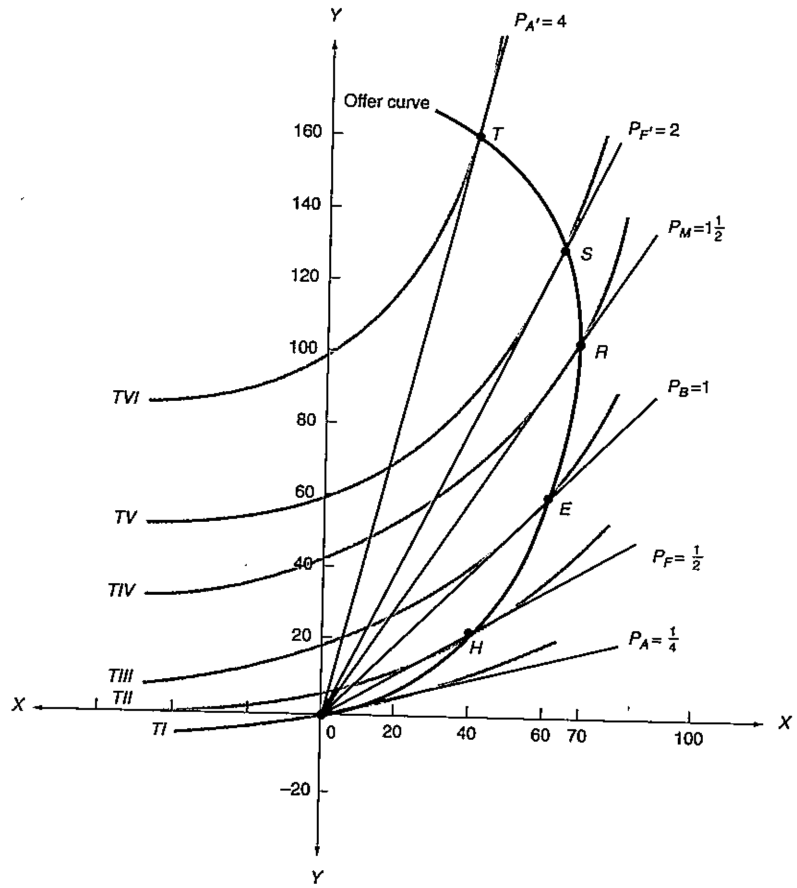

FIGURE 4.9. Formal Derivation of Nation 1's Offer Curve. Curves TI to TIII are Nation 1's trade indifference curves, derived from its production block and community indifference curves, as illustrated in Figure 4.8. Lines P_A, P_F, P_B, P_M', P_F', and P_A' from the origin refer to relative prices of commodity X at which trade could take place. Joining the origin with tangency points of price lines with trade indifference curves gives Nation 1's offer curve. This is elastic up to point *R*, unitary elastic at point *R*, and inelastic over its backward-bending portion.

From Figure 4.9, we can see that as its terms of trade rise from $P_A = 1/4$ to $P_M = 1\frac{1}{2}$, Nation 1 offers more and more exports of commodity X in exchange for more and more imports of commodity Y. At point *R*, Nation 1 offers the maximum amount of 70X for export. Past point *R*, Nation 1 will only export less and less of commodity X in exchange for more and more imports of commodity Y. The reason for the backward bend in Nation 1's offer curve past point *R* is generally the same as the reason (discussed in Section 4.3B) that gives the offer curve its shape and curvature before the bend. Past point *R*, the opportunity cost of X has risen so much and the marginal rate of substitution of X for Y has fallen so much that Nation 1 is only willing to offer less and less of X for more and more of Y.

The shape of Nation 1's offer curve can also be explained in terms of the substitution and income effects on Nation 1's *home demand* for commodity X. As P_X/P_Y rises, Nation 1 tends to produce more of commodity X and demand less of it. As a result, Nation 1 has more of commodity X available for export. At the same time, as P_X/P_Y rises, the income of Nation 1 tends to rise (because it exports commodity X), and when income rises, more of every normal good is demanded in Nation 1, including commodity X. Thus, by itself, the income effect tends to reduce the amount of commodity X available to Nation 1 for export, while the substitution effect tends to increase it. These effects operate simultaneously. Up to $P_X/P_Y = 1\frac{1}{2}$ (i.e., up to point *R*), the substitution effect overwhelms the opposite income effect, and Nation 1 supplies more of commodity X for export. At $P_X/P_Y > 1\frac{1}{2}$, the income effect overwhelms the opposite substitution effect, and Nation 1 supplies less of commodity X for export (i.e., Nation 1's offer curve bends backward).

Note that Nation 1's offer curve also represents its demand for imports of commodity Y, *not in terms of the price of imports (as along a usual demand curve), but in terms of total expenditures in terms of the nation's exports of commodity* X. As Nation 1's terms of trade rise (and P_Y/P_X falls) so that it demands more imported Y, its expenditures in terms of commodity X rise up to point *R*, reach the maximum at point *R*, and fall past *R*. Thus, the nation's offer curve is elastic up to point *R*, unitary elastic at point *R*, and inelastic past point *R*.

We can now understand (at least intuitively) why the nation with the weaker or less intense demand for the other nation's export commodity has an offer curve with a greater curvature (i.e., less elasticity) and gains more from trade than the nation with the stronger or more intense demand (refer to Problem 5).

This is sometimes referred to as the **law of reciprocal demand**, first expounded numerically by *John Stuart Mill* (another British classical economist) and subsequently generalized and visualized with offer curves, or reciprocal demand curves.

Problem Starting with Nation 1's offer curve, the more advanced student should attempt to sketch (a) Nation 1's demand curve for imports of commodity Y (with P_Y/P_X along the vertical axis) and (b) Nation 1's supply curve for exports of commodity X (with P_X/P_Y along the vertical axis).

A4.4 Outline of the Formal Derivation of Nation 2's Offer Curve

Nation 2's offer curve can be formally derived in a completely analogous way from its trade indifference map and the various relative commodity prices at which trade could take place. This is outlined in Figure 4.10 without repeating the entire process.

Quadrant 2 of Figure 4.10 shows Nation 1's production frontier, or block, and indifference curves I and III, while quadrant 4 shows the same things for Nation 2. Nation 2's production frontier and indifference curves are placed in quadrant 4 so that its offer curve will be derived in the proper relationship to Nation 1's offer curve in quadrant 1.

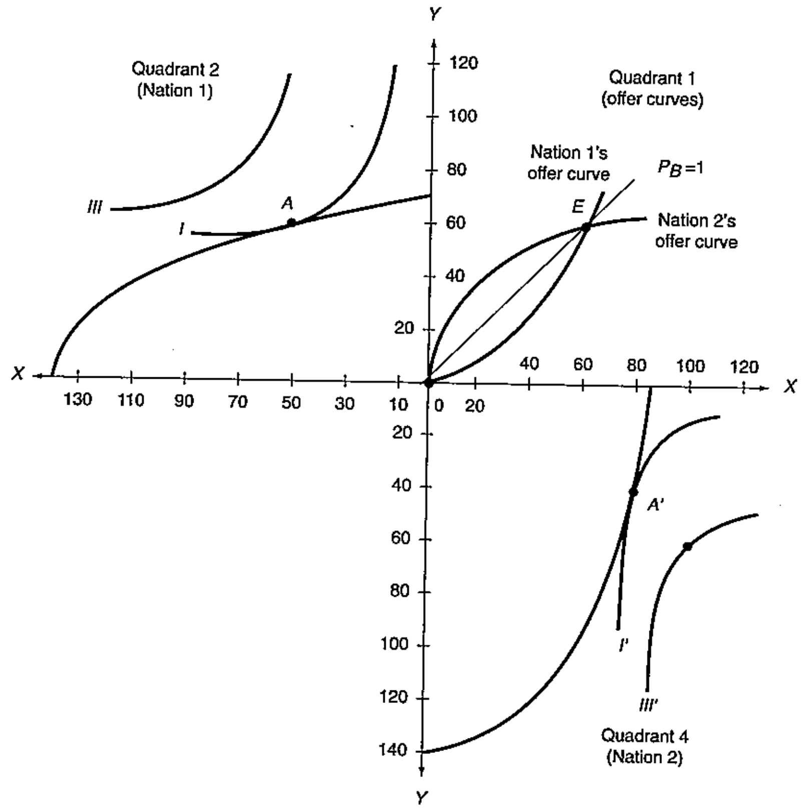

Figure 4.10. Outline of the Formal Derivation of Nation 2's Offer Curve. Nation 2's offer curve can be formally derived from its trade indifference map and the various relative commodity prices at which trade could take place, as was done for Nation 1. This is simply outlined here without repeating the entire process. Thus, Nation 1's offer curve in quadrant 1 is derived from its production block and indifference curves in quadrant 2 and bends in the same direction as its indifference curves. Nation 2's offer curve in quadrant 1 could similarly be derived from its production block and indifference curves in quadrant 4 and bends in the same direction as its indifference curves.

Nation 1's offer curve in quadrant 1 of Figure 4.10 was derived from its trade indifference map in Figure 4.9. Note that Nation 1's offer curve bends in the same direction as its community indifference curves. In a completely analogous way, Nation 2's offer curve in quadrant 1 of Figure 4.10 can be derived from its trade indifference map and bends in the same direction as its community indifference curves in quadrant 4.

The offer curves of Nation 1 and Nation 2 in quadrant 1 of Figure 4.10 are the offer curves of Figure 4.5 and define the equilibrium-relative commodity price of $P_B = 1$ at their intersection. As will be seen in the next section, only at point E does general equilibrium exist.

Problem Draw a figure showing Nation 2's trade indifference curves that would give its offer curve, including its backward-bending portion.

A4.5 General Equilibrium of Production, Consumption, and Trade

Figure 4.11 brings together in one diagram all the information about production, consumption, and trade for the two nations in equilibrium. The production blocks of Nation 1 and

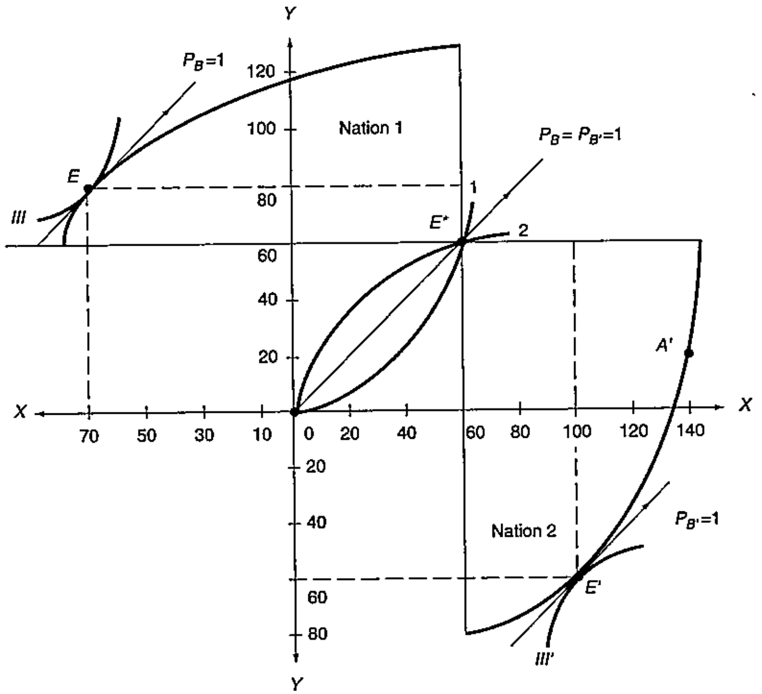

Figure 4.11. Meade's General Equilibrium Trade Model. The production blocks of Nations 1 and 2 are joined at point E^* (the same as point E in Figure 4.10), where the offer curves of the two nations cross. With trade, Nation 1 produces 130X and 20Y (point E with reference to point E^*) and consumes 70X and 80Y (the same point E but with reference to the origin) by exchanging 60X and 60Y with Nation 2. On the other hand, Nation 2 produces 40X and 120Y and consumes 100X and 60Y by exchanging 60Y for 60X with Nation 1. International trade is in equilibrium at point E^*. $P_B = 1$ is the equilibrium-relative commodity price prevailing in international trade and domestically in each nation.

Nation 2 are joined at point E^* (the same as point E in Figure 4.10), where the offer curves of the two nations cross.

With trade, Nation 1 produces 130X and 20Y (point E with reference to point E^*) and consumes 70X and 80Y (the same point E but with reference to the origin, O) by exchanging 60X and 60Y with Nation 2. On the other hand, Nation 2 produces 40X and 120Y (point E' with reference to point E^*) and consumes 100X and 60Y (the same point E' but with reference to the origin) by exchanging 60Y for 60X with Nation 1.

International trade is in equilibrium with 60X exchanged for 60Y at $P_B = 1$. This is shown by the intersection of offer curves 1 and 2 at point E^*. $P_B = 1$ is also the relative commodity price of X prevailing *domestically* in Nations 1 and 2 (see the relative price line tangent to each nation's production blocks at points E and E', respectively). Thus, producers, consumers, and traders in both nations all respond to the same set of equilibrium-relative commodity prices.

Note that point E on Nation 1's indifference curve III measures consumption in relation to the origin, O, while the same point E on Nation 1's production block measures production from point E^*. Finding Nation 1's indifference curve III tangent to its production block at point E seems different but is in fact entirely consistent and confirms the results of Figure 3.4 for Nation 1. The same is true for Nation 2.

Figure 4.11 summarizes and confirms all of our previous results and the conclusions of our trade model (compare, for example, Figure 4.11 with Figure 3.4). Thus, Figure 4.11 is a complete general equilibrium model (except for the fact that it deals with only two nations and two commodities). The figure is admittedly complicated. But this is because it summarizes in a single graph a tremendous amount of very useful information. Figure 4.11 is the pinnacle of the neoclassical trade model. The rewards of mastering it are great indeed in terms of future deeper understanding.

A4.6 Multiple and Unstable Equilibria

In Figure 4.12, offer curve 1 and offer curve 2 intersect at three points (A, B, and C) where at least one of the offer curves is inelastic. Equilibrium points B and C are stable, while equilibrium point A is unstable. The reason is that a small displacement from point A will give rise to economic forces that will automatically shift the equilibrium point farther away from A and toward either B or C.

For example, at P_F, Nation 2 will demand GH more of commodity X than Nation 1 is willing to export at that price. At the same time, Nation 1 will demand FH less of commodity Y than Nation 2 wants to export at P_F. For both reasons, P_X/P_Y will rise until point B is reached. Past point B, Nation 1 will demand more of commodity Y than Nation 2 is willing to offer, and Nation 2 will demand less of commodity X than Nation 1 wants to export, so that P_X/P_Y will fall until the nations have moved back to point B. Thus, point B is a point of stable equilibrium.

On the other hand, if for whatever reason P_X/P_Y falls below P_A (see Figure 4.12), automatic forces will come into play that will push the nations to equilibrium point C, which is also a point of stable equilibrium.

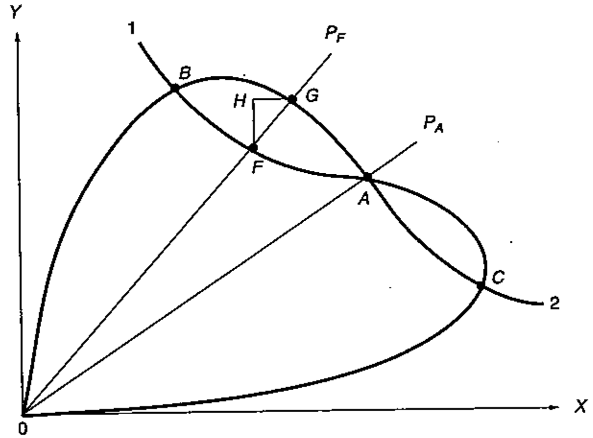

FIGURE 4.12. Stable and Unstable Equilibria. Equilibrium point A is unstable because any displacement from it will give rise to economic forces that will automatically move the nations even farther away from it and toward either point B or point C. For example, at P_F, Nation 2 demands GH more of commodity X than Nation 1 is willing to export at that price. At the same time, Nation 1 demands FH less of commodity Y than Nation 2 wants to export at P_F. For both reasons, P_X/P_Y will rise until point B is reached. Any small displacement away from point B will push the nations back to point B. On the other hand, if P_X/P_Y falls below P_A, the nations will be pushed toward stable equilibrium point C.

Problem Draw two relative commodity price lines on Figure 4.12, one between point A and point C and one intersecting both offer curves to the right of point C. Starting from each of the two price lines that you have drawn, explain the forces that will automatically push the nations toward equilibrium point C.

Bibliography

For a problem-solving approach to the material covered in this chapter, see:

- D. Salvatore, *Theory and Problems of International Economics*, 4th ed. (New York: McGraw-Hill, 1996), ch. 3 (sects. 3.3 to 3.6).

An excellent discussion of offer curves is found in:

- A. P. Lerner, "The Diagrammatic Representation of Demand Conditions in International Trade," *Economica*, 1934, pp. 319–334.
- G. Haberler, *The Theory of International Trade* (London: W. Hodge & Co., 1936), ch. 11.
- J. Viner, *Studies in the Theory of International Trade* (New York: Harper & Brothers, 1937), ch. 9.

For the law of reciprocal demand, see:

- J. S. Mill, *Principles of Political Economy* (New York: Kelly, 1965, a reprint of Mill's 1848 treatise), ch. 18.

For the formal derivation of offer curves perfected by Meade and presented in the appendix to this chapter, see:

- J. E. Meade, *A Geometry of International Trade* (London: George Allen & Unwin, 1952), chs. 1–4.

INTERNet

Online current and historical data on energy prices in general and petroleum prices in particular are available from the Energy Information Administration at: http://www.eia.doe.gov

Historical series on export and import unit values, which are used to determine the terms of trade of 45 countries, as well as other specific commodity prices, are found in *International Financial Statistics*, published monthly and yearly by the International Monetary Fund (IMF). Unfortunately, the IMF does not provide these volumes online, but only information on their content and on how to order. For this information, see: http://www/imf.org.

CHAPTER 5

Factor Endowments and the Heckscher–Ohlin Theory

Learning Goals: After reading this chapter, you should be able to:

- Explain how comparative advantage is based on differences in factor endowments across nations
- Explain how trade affects relative factor prices within and across nations
- Explain why trade is likely to be only a small reason for higher skilled–unskilled wage inequalities

5.1 Introduction

In this chapter, we extend our trade model in two important directions. First, we explain the basis of (i.e., what determines) comparative advantage. We have seen in previous chapters that the difference in relative commodity prices between two nations is evidence of their comparative advantage and forms the basis for mutually beneficial trade. We now go one step further and explain the reason, or cause, for the difference in relative commodity prices and comparative advantage between the two nations. The second way we extend our trade model is to analyze the effect that international trade has on the earnings of factors of production in the two trading nations. That is, we want to examine the effect of international trade on the earnings of labor as well as on international differences in earnings.

These two important questions were left largely unanswered by Smith, Ricardo, and Mill. According to classical economists, comparative advantage was based on the difference in the *productivity of labor* (the only factor of production they explicitly considered) among nations, but they provided no explanation for such a difference in productivity, except for possible differences in climate. The Heckscher–Ohlin theory goes much beyond that by extending the trade model of the previous two chapters to examine the basis for comparative advantage and the effect that trade has on factor earnings in the two nations.

Section 5.2 deals with the assumptions of the theory. Section 5.3 clarifies the meaning of factor intensity and factor abundance, and explains how the latter is related to factor prices and the shape of the production frontier in each nation. Section 5.4 presents the Heckscher–Ohlin model proper and illustrates it graphically. Section 5.5 examines the effect of international trade on factor earnings and income distribution in the two nations. Section 5.6 concludes the chapter by reviewing empirical tests of the Heckscher–Ohlin trade model. The appendix presents the formal derivation of the factor–price equalization theorem and introduces more advanced tools for empirically testing the Heckscher–Ohlin trade model.

5.2 Assumptions of the Theory

The Heckscher–Ohlin theory is based on a number of simplifying assumptions (some made only implicitly by Heckscher and Ohlin). Rather than note these assumptions along the way as they are needed in the analysis, it is both logical and convenient to present them together and explain their meaning at this point. This will not only allow us to view the theory to be presented in a better perspective but will also make the presentation smoother and more direct. To make the theory more realistic, we will relax these assumptions in the next chapter and examine the effect that such relaxation has on the conclusions reached in this chapter.

5.2A The Assumptions

The Heckscher–Ohlin theory is based on the following assumptions:

1. There are two nations (Nation 1 and Nation 2), two commodities (commodity X and commodity Y), and two factors of production (labor and capital).
2. Both nations use the same technology in production.

3. Commodity X is labor intensive, and commodity Y is capital intensive in both nations.
4. Both commodities are produced under constant returns to scale in both nations.
5. There is incomplete specialization in production in both nations.
6. Tastes are equal in both nations.
7. There is perfect competition in both commodities and factor markets in both nations.
8. There is perfect factor mobility within each nation but no international factor mobility.
9. There are no transportation costs, tariffs, or other obstructions to the free flow of international trade.
10. All resources are fully employed in both nations.
11. International trade between the two nations is balanced.

5.2B Meaning of the Assumptions

The meaning of assumption 1 (two nations, two commodities, and two factors) is clear, and it is made in order to be able to illustrate the theory with a two-dimensional figure. This assumption is made with the knowledge (discussed in the next chapter) that its relaxation (so as to deal with the more realistic case of more than two nations, more than two commodities, and more than two factors) will leave the conclusions of the theory basically unchanged.

Assumption 2 (that both nations use the *same technology*) means that both nations have access to and use the same general production techniques. Thus, if factor prices were the same in both nations, producers in both nations would use exactly the same amount of labor and capital in the production of each commodity. Since factor prices usually differ, producers in each nation will use more of the relatively cheaper factor in the nation to minimize their costs of production.

Assumption 3 (that commodity X is **labor intensive** and commodity Y is **capital intensive**) means that commodity X requires relatively more labor to produce than commodity Y in both nations. In a more technical and precise way, this means that the **labor–capital ratio** (L/K) is higher for commodity X than for commodity Y in both nations at the same relative factor prices. This is equivalent to saying that the **capital–labor ratio** (K/L) is *lower for X than for Y*. But it does not mean that the K/L ratio for X is the same in Nation 1 and Nation 2, only that K/L is lower for X than for Y in both nations. This point is so important that we will use Section 5.3A to clarify it.

Assumption 4 (**constant returns to scale** in the production of both commodities in both nations) means that increasing the amount of labor and capital used in the production of any commodity will increase output of that commodity in the same proportion. For example, if Nation 1 increases by 10 percent both the amount of labor and the amount of capital that it uses in the production of commodity X, its output of commodity X will also increase by 10 percent. If it doubles the amount of both labor and capital used, its output of X will also double. The same is true for commodity Y and in Nation 2.

Assumption 5 (incomplete specialization in production in both nations) means that even with free trade both nations continue to produce both commodities. This implies that neither of the two nations is "very small."

Assumption 6 (equal tastes in both nations) means that demand preferences, as reflected in the shape and location of indifference curves, are identical in both nations. Thus, when relative commodity prices are equal in the two nations (as, for example, with free trade), both nations will consume X and Y in the same proportion. This will be illustrated in Section 5.4C.

Assumption 7 (**perfect competition** in both commodities and factor markets) means that producers, consumers, and traders of commodity X and commodity Y in both nations are each too small to affect the price of these commodities. The same is true for each user and supplier of labor time and capital. Perfect competition also means that, in the long run, commodity prices equal their costs of production, leaving no (economic) profit after all costs (including implicit costs) are taken into account. Finally, perfect competition means that all producers, consumers, and owners of factors of production have perfect knowledge of commodity prices and factor earnings in all parts of the nation and in all industries.

Assumption 8 (perfect **internal factor mobility** but no international factor mobility) means that labor and capital are free to move, and indeed do move quickly, from areas and industries of lower earnings to areas and industries of higher earnings until earnings for the same type of labor and capital are the same in all areas, uses, and industries of the nation. On the other hand, there is zero **international factor mobility** (i.e., no mobility of factors among nations), so that international differences in factor earnings would persist indefinitely in the absence of international trade.

Assumption 9 (no transportation costs, tariffs, or other obstructions to the free flow of international trade) means that specialization in production proceeds until relative (and absolute) commodity prices are the same in both nations with trade. If we allowed for transportation costs and tariffs, specialization would proceed only until relative (and absolute) commodity prices differed by no more than the costs of transportation and the tariff on each unit of the commodity traded.

Assumption 10 (all resources are fully employed in both nations) means that there are no unemployed resources or factors of production in either nation.

Assumption 11 (international trade between the two nations is balanced) means that the total value of each nation's exports equals the total value of the nation's imports.

5.3 Factor Intensity, Factor Abundance, and the Shape of the Production Frontier

Since the Heckscher–Ohlin theory to be presented in Section 5.4 is expressed in terms of factor intensity and factor abundance, it is crucial that the meaning of

these terms be very clear and precise. Hence, the meaning of factor intensity is explained and illustrated in Section 5.3A. In Section 5.3B, we examine the meaning of factor abundance and its relationship to factor prices. Finally, in Section 5.3C, we examine the relationship between factor abundance and the shape of the production frontier of each nation.

5.3A Factor Intensity

In a world of two commodities (X and Y) and two factors (labor and capital), we say that commodity Y is *capital intensive* if the capital–labor ratio (K/L) used in the production of Y is greater than K/L used in the production of X.

For example, if two units of capital ($2K$) and two units of labor ($2L$) are required to produce one unit of commodity Y, the capital–labor ratio is one. That is, $2/2$ in the production of Y. If at the same time $1K$ and $4L$ are required to produce one unit of X, $K/L = 1/4$ for commodity X. Since $K/L = 1$ for Y and $K/L = 1/4$ for X, we say that Y is K intensive and X is L intensive.

Note that it is not the *absolute* amount of capital and labor used in the production of commodities X and Y that is important in measuring the capital and labor intensity of the two commodities, but the amount of capital *per unit of labor* (i.e., K/L). For example, suppose that $3K$ and $12L$ (instead of $1K$ and $4L$) are required to produce 1X, while to produce 1Y requires $2K$ and $2L$ (as indicated earlier). Even though to produce 1X requires $3K$, while to produce 1Y requires only $2K$, commodity Y would still be the K-intensive commodity because K/L is higher for Y than for X. That is, $K/L = 2/2$ for Y, but $K/L = 3/12 = 1/4$ for X.

If we plotted capital (K) along the vertical axis of a graph and labor (L) along the horizontal axis, and production took place along a straight-line ray from the origin, the slope of the line would measure the capital–labor ratio (K/L) in the production of the commodity. This is shown in Figure 5.1.

Figure 5.1 shows that Nation 1 can produce 1Y with $2K$ and $2L$. With $4K$ and $4L$, Nation 1 can produce 2Y because of constant returns to scale (assumption 4). Thus, $K/L = 2/2 = 4/4 = 1$ for Y. This is given by the slope of 1 for the ray from the origin for commodity Y in Nation 1 (see the figure). On the other hand, $1K$ and $4L$ are required to produce 1X, and $2K$ and $8L$ to produce 2X, in Nation 1. Thus, $K/L = 1/4$ for X in Nation 1. This is given by the slope of $1/4$ for the ray from the origin for commodity X in Nation 1. Since K/L, or the slope of the ray from the origin, is higher for commodity Y than for commodity X, we say that commodity Y is K intensive and commodity X is L intensive in Nation 1.

In Nation 2, K/L (or the slope of the ray) is 4 for Y and 1 for X (see Figure 5.1). Therefore, Y is the K-intensive commodity, and X is the L-intensive commodity in Nation 2 also. This is illustrated by the fact that the ray from the origin for commodity Y is steeper (i.e., has a greater slope) than the ray for commodity X in both nations.

Even though commodity Y is K intensive in relation to commodity X in both nations, *Nation 2 uses a higher K/L* in producing both Y and X than Nation 1. For Y, $K/L = 4$ in Nation 2 but $K/L = 1$ in Nation 1. For X, $K/L = 1$ in

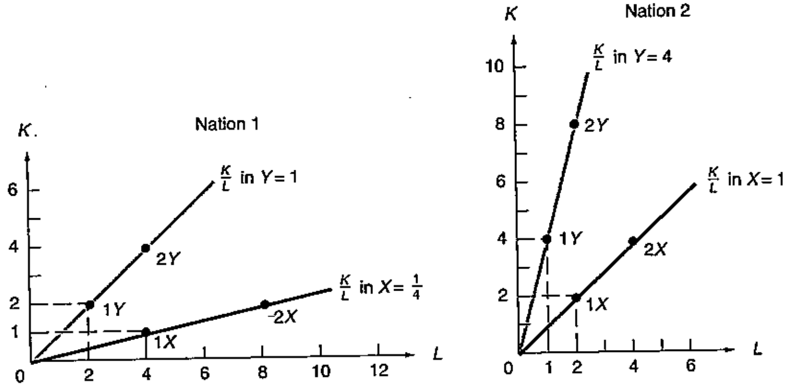

FIGURE 5.1. Factor Intensities for Commodities X and Y in Nations 1 and 2. In Nation 1, the capital–labor ratio (K/L) equals 1 for commodity Y and $K/L = 1/4$ for commodity X. These are given by the slope of the ray from the origin for each commodity in Nation 1. Thus, commodity Y is the K-intensive commodity in Nation 1. In Nation 2, $K/L = 4$ for Y and $K/L = 1$ for X. Thus, commodity Y is the K-intensive commodity, and commodity X is the L-intensive commodity in both nations. Nation 2 uses a higher K/L than Nation 1 in the production of both commodities because the relative price of capital (r/w) is lower in Nation 2. If r/w declined, producers would substitute K for L in the production of both commodities to minimize their costs of production. As a result, K/L would rise for both commodities.

Nation 2 but $K/L = 1/4$ in Nation 1. The obvious question is: Why does Nation 2 use more K-intensive production techniques in both commodities than Nation 1? The answer is that capital must be relatively cheaper in Nation 2 than in Nation 1, so that producers in Nation 2 use relatively more capital in the production of both commodities to minimize their costs of production. But why is capital relatively cheaper in Nation 2? To answer this question, we must define factor abundance and examine its relationship to factor prices.

Before doing this, however, we must settle one other related point of crucial importance. This refers to what happens if, for whatever reason, the relative price of capital falls. Producers would substitute capital for labor in the production of both commodities to minimize their costs of production. As a result, both commodities would become more K intensive. However, only if K/L in the production of commodity Y exceeds K/L in the production of commodity X *at all possible relative factor prices* can we say *unequivocally* that commodity Y is the K-intensive commodity. This is basically an empirical question and will be explored in Section 5.6. For now, we will assume that this is true (i.e., that commodity Y remains the K-intensive commodity at all possible relative factor prices).

To summarize, we say that commodity Y is unequivocally the K-intensive commodity if K/L is higher for commodity Y than for commodity X at all possible relative factor prices. Nation 2 uses a higher K/L in the production of both commodities because the relative price of capital is lower in Nation 2 than in Nation 1. If the relative price of capital declines, producers will substitute K for L in the production of both commodities to minimize their costs of production. Thus, K/L will rise for both commodities, but Y continues to be the K-intensive commodity.

5.3B Factor Abundance

There are two ways to define **factor abundance**. One way is in terms of physical *units* (i.e., in terms of the overall amount of capital and labor available to each nation). Another way to define factor abundance is in terms of **relative factor prices** (i.e., in terms of the rental price of capital and the price of labor time in each nation).

According to the definition in terms of physical units, Nation 2 is capital abundant if the ratio of the total amount of capital to the total amount of labor (TK/TL) available in Nation 2 is *greater* than that in Nation 1 (i.e., if TK/TL for Nation 2 exceeds TK/TL for Nation 1). Note that it is not the absolute amount of capital and labor available in each nation that is important but the *ratio* of the total amount of capital to the total amount of labor. Thus, Nation 2 can have less capital than Nation 1 and still be the capital-abundant nation if TK/TL in Nation 2 exceeds TK/TL in Nation 1.

According to the definition in terms of factor prices, Nation 2 is capital abundant if the ratio of the rental price of capital to the price of labor time (P_K/P_L) is *lower* in Nation 2 than in Nation 1 (i.e., if P_K/P_L in Nation 2 is smaller than P_K/P_L in Nation 1). Since the rental price of capital is usually taken to be the interest rate (r) while the price of labor time is the wage rate (w), $P_K/P_L = r/w$. Once again, it is not the absolute level of r that determines whether or not a nation is the K-abundant nation, but r/w. For example, r may be higher in Nation 2 than in Nation 1, but Nation 2 will still be the K-abundant nation if r/w is lower there than in Nation 1.

The relationship between the two definitions of factor abundance is clear. The definition of factor abundance in terms of physical units considers only the supply of factors. The definition in terms of relative factor prices considers both demand and supply (since we know from principles of economics that the price of a commodity or factor is determined by both demand and supply considerations under perfect competition). Also from principles of economics, we know that the demand for a factor of production is a **derived demand**—derived from the demand for the final commodity that requires the factor in its production.

Since we have assumed that tastes, or demand preferences, are the same in both nations, the two definitions of factor abundance give the same conclusions in our case. That is, with TK/TL larger in Nation 2 than in Nation 1 in the face of equal demand conditions (and technology), P_K/P_L will be smaller in Nation 2. Thus, Nation 2 is the K-abundant nation in terms of both definitions.

This is not always the case. For example, it is conceivable that the demand for commodity Y (the K-intensive commodity), and therefore the demand for capital, could be so much higher in Nation 2 than in Nation 1 that the relative price of capital would be higher in Nation 2 than in Nation 1 (despite the relatively greater supply of capital in Nation 2). In that case, Nation 2 would be considered K abundant according to the definition in physical terms and L abundant according to the definition in terms of relative factor prices.

In such situations, it is the definition in terms of relative factor prices that should be used. That is, a nation is K abundant if the relative price of capital is lower in it than in the other nation. In our case, there is no such contradiction between the two definitions. Nation 2 is K abundant and Nation 1 is L abundant in terms of both definitions. We will assume this to be the case throughout the rest of the chapter, unless otherwise explicitly indicated.

5.3c Factor Abundance and the Shape of the Production Frontier

Since Nation 2 is the K-abundant nation and commodity Y is the K-intensive commodity, Nation 2 can produce *relatively* more of commodity Y than Nation 1. On the other hand, since Nation 1 is the L-abundant nation and commodity X is the L-intensive commodity, Nation 1 can produce relatively more of commodity X than Nation 2. This gives a production frontier for Nation 1 that is relatively flatter and wider than the production frontier of Nation 2 (if we measure X along the horizontal axis).

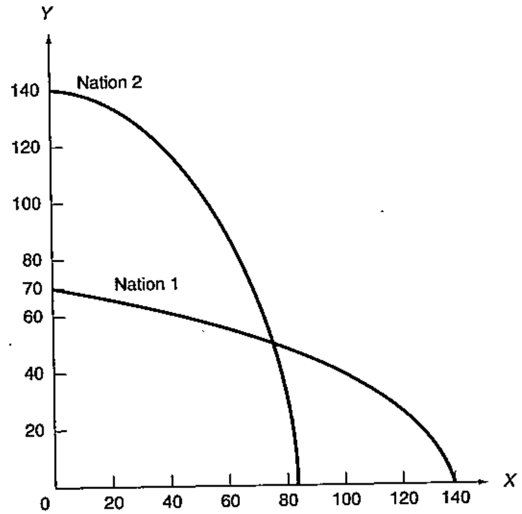

FIGURE 5.2. The Shape of the Production Frontiers of Nation 1 and Nation 2. The production frontier of Nation 1 is flatter and wider than the production frontier of Nation 2. Indicating that Nation 1 can produce relatively more of commodity X than Nation 2. The reason for this is that Nation 1 is the L-abundant nation and commodity X is the L-intensive commodity.

In Figure 5.2, we have plotted the production frontiers of Nation 1 and Nation 2 on the same set of axes. (These are the same production frontiers introduced with Figure 3.1 and used throughout Chapters 3 and 4.) Since Nation 1 is the L-abundant nation and commodity X is the L-intensive commodity, Nation 1's production frontier is skewed toward the horizontal axis, which measures commodity X. On the other hand, since Nation 2 is the K-abundant nation and commodity Y is the K-intensive commodity, Nation 2's production frontier is skewed toward the vertical axis measuring commodity Y. The production frontiers are plotted on the same set of axes so that the difference in their shape is more clearly evident and because this will facilitate the illustration of the Heckscher–Ohlin model in Section 5.4c. Case Study 5-1 presents the relative resource endowments of various countries and regions, while Case Study 5-2 gives the capital stock per worker for a number of leading developed and developing countries.

Having clarified the meaning of factor intensity and factor abundance, we are now ready to present the Heckscher–Ohlin theory.

Case Study 5-1 Relative Resource Endowments of Various Countries and Regions

Table 5.1 gives the share of the world's resource endowments of capital, skilled labor, and unskilled labor of the various nations and regions in 1993. The table shows that the United States has 20.8 percent of the world's capital, 19.4 percent of the skilled labor, and 2.6 percent of the unskilled labor. These amount to 5.6 percent of the world's resources *of these factors*. Since the United States has a greater *relative* share of the world resources of capital and skilled labor (20.8 percent and 19.4 percent, respectively, compared with 5.6 percent of all the world's resources of capital, skilled labor, and unskilled labor combined), we can expect the United States to have a comparative advantage in capital- and skill-intensive commodities and a comparative disadvantage in unskilled-intensive commodities. The situation is similar for other industrialized countries.

For China, India, the rest of Asia, Eastern Europe (including Russia), OPEC, and the rest of the world, the opposite is the case. Mexico and the rest of Latin America seem to have a comparative advantage in capital-intensive commodities, a comparative disadvantage in skill-intensive commodities, and neither a comparative advantage nor a comparative disadvantage in unskilled-intensive commodities for Mexico and a comparative advantage for the rest of Latin America. Hong Kong, South Korea, Taiwan, and Singapore seem to have a comparative advantage in capital-intensive and skill-intensive commodities. As we will see in Case Study 5-3, relative resource endowments seem to be a very good predictor of the revealed comparative advantage of various countries or regions.

(continued)

Case Study 5-1 (continued)

TABLE 5.1. *Factor Endowments of Various Countries and Regions, as a Percentage of the World Total*

Country/Region	Capital	Skilled Labor	Unskilled Labor	All Resources
United States	20.8%	19.4%	2.6%	5.6%
European Union	20.7	13.3	5.3	6.9
Japan	10.5	8.2	1.6	2.9
Canada	2.0	1.7	0.4	0.6
Rest of OECD[a]	5.0	2.6	2.0	2.2
Mexico	2.3	1.2	1.4	1.4
Rest of Latin America	6.4	3.7	5.3	5.1
China	8.3	21.7	30.4	28.4
India	3.0	7.1	15.3	13.7
Hong Kong, South Korea, Taiwan, Singapore	2.8	3.7	0.9	1.4
Rest of Asia	3.4	5.3	9.5	8.7
Eastern Europe (including Russia)	6.2	3.8	8.4	7.6
OPEC[b]	6.2	4.4	7.1	6.7
Rest of the world	2.5	4.0	10.0	8.9
Total	100.0%	100.0%	100.0%	100.0%

[a]OECD = Organization for Economic Cooperation and Development, which includes all the other industrial countries.
[b]OPEC = Organization of Petroleum Exporting Countries.

Source: Elaboration on W. R. Cline, *Trade and Income Distribution* (Washington, D.C.: Institute for International Economics, 1997), pp. 183–185.

Case Study 5-2 Capital–Labor Ratios of Selected Countries

Table 5.2 gives the capital stock per worker of a number of developed and developing countries in 1997. Capital stocks are measured in 1990 international dollar prices to reflect the actual purchasing power of the dollar in each country, thus allowing meaningful international comparisons. The table shows that the United States has a lower capital stock per worker than many other industrial or developed countries (the left-hand part of the table) but a much higher capital stock per worker than developing countries (the right-hand part of the table). From Table 5.2, we can thus infer that the United States has a comparative advantage in capital-intensive commodities with respect to developing countries but not with respect to many other developed or industrial countries. This is broadly consistent with the data presented in Table 5.1.

(continued)

Case Study 5-2 (continued)

TABLE 5.2. *Capital Stock per Worker of Selected Countries in 1997 (in 1990 international dollar prices)*

Developed Country	1997	Developing Country	1997
Japan	77,429	Korea	26,635
Germany	61,673	Chile	17,699
Canada	61,274	Mexico	14,030
France	59,602	Turkey	10,780
United States	50,233	Thailand	8,106
Italy	48,943	Philippines	6,095
Spain	38,897	India	3,094
United Kingdom	30,226	Kenya	1,412

Source: A. Heston, R. Summers, and B. Aten, *Penn World Table Version 6.1*, October 2002. Author's calculations on preliminary results; excludes residential construction captial.

5.4 Factor Endowments and the Heckscher–Ohlin Theory

In 1919 *Eli Heckscher*, a Swedish economist, published an article entitled "The Effect of Foreign Trade on the Distribution of Income," in which he presented the outline of what was to become the "modern theory of international trade." The article went largely unnoticed for over ten years until *Bertil Ohlin*, another Swedish economist and former student of Heckscher, picked it up, built on it, clarified it, and in 1933 published his famous book *Interregional and International Trade*.

We will discuss only Ohlin's work, since it incorporates all that Heckscher had said in his article and much more. However, since the essence of the model was first introduced by Heckscher, due credit is given to him by calling the theory the Heckscher–Ohlin theory. Ohlin, on his part, shared (with James Meade) the 1977 Nobel prize in economics for his work in international trade.

The **Heckscher–Ohlin (H–O) theory** can be presented in a nutshell in the form of two theorems: the so-called *H–O theorem* (which deals with and predicts the pattern of trade) and the *factor-price equalization theorem* (which deals with the effect of international trade on factor prices). The factor-price equalization theorem will be discussed in Section 5.5. In this section, we present and discuss the H–O theorem. We begin with a statement of the theorem and briefly explain its meaning. Then we examine the general equilibrium nature of the H–O theory, and finally we give a geometrical interpretation of the model.

5.4A The Heckscher–Ohlin Theorem

Starting with the assumptions presented in Section 5.2, we can state the **Heckscher–Ohlin theorem** as follows: *A nation will export the commodity whose production requires* *the intensive use of the nation's relatively abundant and cheap factor and import the commodity whose production requires the intensive use of the nation's relatively scarce and expensive factor.* In short, the relatively labor-rich nation exports the relatively labor-intensive commodity and imports the relatively capital-intensive commodity.

In terms of our previous discussion, this means that Nation 1 exports commodity X because commodity X is the *L*-intensive commodity and *L* is the relatively abundant and cheap factor in Nation 1. On the other hand, Nation 2 exports commodity Y because commodity Y is the *K*-intensive commodity and *K* is the relatively abundant and cheap factor in Nation 2 (i.e., r/w is lower in Nation 2 than in Nation 1).

Of all the possible reasons for differences in relative commodity prices and comparative advantage among nations, the H–O theorem isolates the difference in relative factor abundance, or *factor endowments*, among nations as the basic cause or determinant of comparative advantage and international trade. For this reason, the H–O model is often referred to as the **factor-proportions or factor-endowment theory**. That is, each nation specializes in the production of and exports the commodity intensive in its relatively abundant and cheap factor and imports the commodity intensive in its relatively scarce and expensive factor.

Thus, the H–O theorem *explains* comparative advantage rather than assuming it (as was the case for classical economists). That is, the H–O theorem postulates that the difference in relative factor abundance and prices is the *cause* of the pretrade difference in relative commodity prices between two nations. This difference in *relative* factor and *relative* commodity prices is then translated into a difference in *absolute* factor and commodity prices between the two nations (as outlined in Section 2.4D). It is this difference in absolute commodity prices in the two nations that is the *immediate* cause of trade.

5.4B General Equilibrium Framework of the Heckscher–Ohlin Theory

The general equilibrium nature of the H–O theory can be visualized and summarized with the use of Figure 5.3. Starting at the lower right-hand corner of the diagram, we see that tastes and the distribution in the ownership of factors of production (i.e., the distribution of income) together determine the demand for commodities. The demand for commodities determines the derived demand for the factors required to produce them. The demand for factors of production, together with the supply of the factors, determines the price of factors of production under perfect competition. The price of factors of production, together with technology, determines the price of final commodities. The difference in relative commodity prices between nations determines comparative advantage and the pattern of trade (i.e., which nation exports which commodity).

Figure 5.3 shows clearly how all economic forces jointly determine the price of final commodities. This is what is meant when we say that the H–O model is a general equilibrium model.

However, out of all these forces working together, the H–O theorem isolates the difference in the *physical* availability or supply of factors of production among nations (in the face of equal tastes and technology) to explain the difference in relative commodity prices and trade among nations. Specifically, Ohlin assumed equal tastes (and income distribution) among nations. This gave rise to similar demands for final commodities and factors of production in different nations. Thus, it is the difference in the supply of the various factors of production in different nations that is the cause of different relative factor prices in different nations. Finally, the same technology but different factor prices lead to different relative commodity prices and trade among nations. Thus, the difference in the relative supply of factors leading to the difference in relative factor prices and commodity prices is shown by the double lines in Figure 5.3.

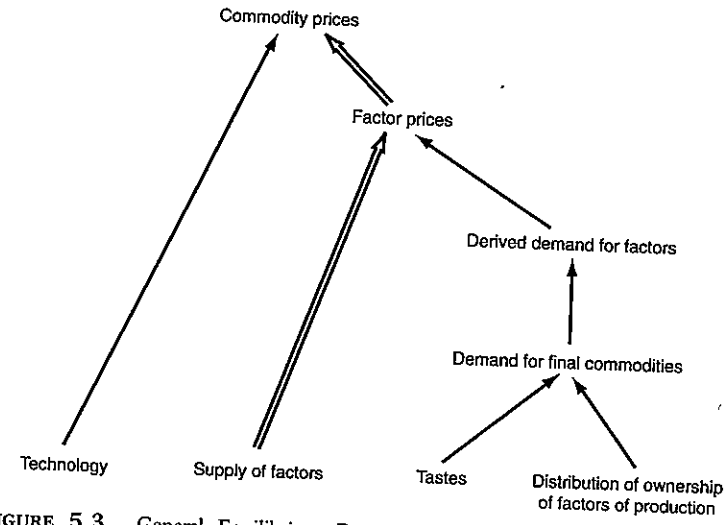

FIGURE 5.3. General Equilibrium Framework of the Heckscher–Ohlin Theory. Beginning at the lower right-hand corner of the diagram, we see that the distribution of ownership of factors of production or income and tastes determines the demand for commodities. The demand for factors of production is then derived from the demand for final commodities. The demand for and supply of factors determine the price of factors. The price of factors and technology determine the price of final commodities. The difference in relative commodity prices among nations then determines comparative advantage and the pattern of trade.

Note that the H–O model does not require that tastes, distribution of income, and technology be exactly the same in the two nations for these results to follow. It only requires that they be broadly similar. The assumptions of equal tastes, distribution of income, and technology do simplify the exposition and graphical illustration of the theory. They will be relaxed in Section 6.2.

5.4C Illustration of the Heckscher–Ohlin Theory

The H–O theory is illustrated in Figure 5.4. The left panel of the figure shows the production frontiers of Nation 1 and Nation 2, as in Figure 5.2. As indicated

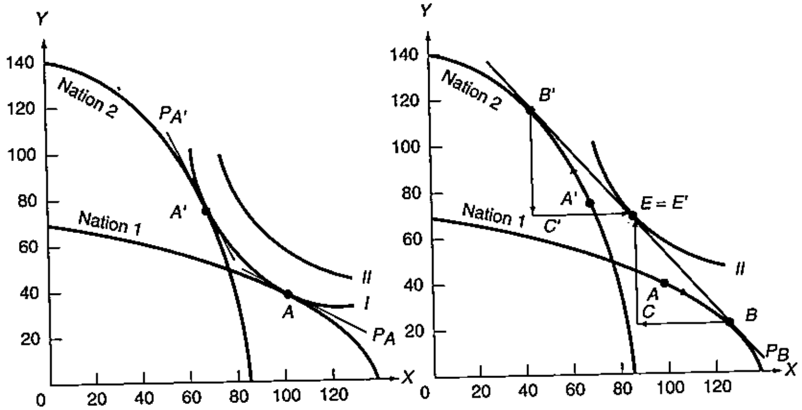

FIGURE 5.4. The Heckscher–Ohlin Model. Indifference curve I is common to both nations because of the assumption of equal tastes. Indifference curve I is tangent to the production frontier of Nation 1 at point A and tangent to the production frontier of Nation 2 at A'. This defines the no-trade equilibrium-relative commodity price of P_A in Nation 1 and $P_{A'}$ in Nation 2 (see the left panel). Since $P_A < P_{A'}$, Nation 1 has a comparative advantage in commodity X and Nation 2 in commodity Y. With trade (see the right panel) Nation 1 produces at point B and by exchanging X for Y reaches point E in consumption (see trade triangle BCE). Nation 2 produces at B' and by exchanging Y for X reaches point E' (which coincides with E). Both nations gain from trade because they consume on higher indifference curve II.

in Section 5.3c, Nation 1's production frontier is skewed along the X-axis because commodity X is the *L*-intensive commodity, Nation 1 is the *L*-abundant nation, and both nations use the same technology. Furthermore, since the two nations have equal tastes, they face the same indifference map. Indifference curve I (which is common for both nations) is tangent to Nation 1's production frontier at point A and to Nation 2's production frontier at A'. Indifference curve I is the highest indifference curve that Nation 1 and Nation 2 can reach in isolation, and points A and A' represent their equilibrium points of production and consumption in the absence of trade. Note that although we assume that the two nations have identical tastes (indifference map), the two nations need not be on the *same* indifference curve in isolation and end up on the same indifference map with trade. We only did so in order to simplify the figure.

The tangency of indifference curve I at points A and A' defines the no-trade, or autarky, equilibrium-relative commodity prices of P_A in Nation 1 and $P_{A'}$ in Nation 2 (see the figure). Since $P_A < P_{A'}$, Nation 1 has a comparative advantage in commodity X, and Nation 2 has a comparative advantage in commodity Y.

The right panel shows that with trade Nation 1 specializes in the production of commodity X, and Nation 2 specializes in the production of commodity Y (see the direction of the arrows on the production frontiers of the two nations). Specialization in production proceeds until Nation 1 has reached point B and Nation 2 has reached point B', where the transformation curves of the two nations are tangent to the common relative price line P_B. Nation 1 will then export commodity X in exchange for commodity Y and consume at point E on indifference curve II (see trade triangle BCE). On the other hand, Nation 2 will export Y for X and consume at point E', which coincides with point E (see trade triangle $B'C'E'$).

Note that Nation 1's exports of commodity X equal Nation 2's imports of commodity X (i.e., $BC = C'E'$). Similarly, Nation 2's exports of commodity Y equal Nation 1's imports of commodity Y (i.e., $B'C' = CE$). At $P_X/P_Y > P_B$, Nation 1 wants to export more of commodity X than Nation 2 wants to import at this high relative price of X, and P_X/P_Y falls toward P_B. On the other hand, at $P_X/P_Y < P_B$, Nation 1 wants to export less of commodity X than Nation 2 wants to import at this low relative price of X, and P_X/P_Y rises toward P_B. This tendency of P_X/P_Y could also be explained in terms of commodity Y.

Also to be noted is that point E involves more of Y but less of X than point A. Nevertheless, Nation 1 gains from trade because point E is on higher indifference curve II. Similarly, even though point E' involves more X but less Y than point A', Nation 2 is also better off because point E' is on higher indifference curve II. This pattern of specialization in production and trade and consumption will remain the same until there is a change in the underlying demand or supply conditions in commodity and factor markets in either or both nations.

It is now instructive briefly to compare Figure 5.4 with Figure 3.4. In Figure 3.4, the difference in the production frontiers of the two nations is reinforced by their difference in tastes, thus making the autarky-relative commodity prices in the two nations differ even more than in Figure 5.4. On the other hand, the tastes of the two nations could be different in such a way as to make mutually beneficial trade impossible. This would occur if the different indifference curves in the two nations were tangent to their respective and different production frontiers in such a way as to result in equal autarky-relative commodity prices in the two nations. This is assigned as end-of-chapter Problem 4, with the answer at the end of the book.

Note also that the H–O theory does not require identical tastes (i.e., equal indifference curves) in the two nations. It only requires that if tastes differ, they do not differ sufficiently to neutralize the tendency of different factor endowments and production possibility curves from leading to different relative commodity prices and comparative advantage in the two nations. Thus, in a sense, Figure 3.4 can be regarded as a more general illustration of the H–O model than Figure 5.4. Case Study 5-3 examines the pattern of revealed comparative advantage and disadvantage of various countries or regions, while Case Study 5-4 identifies the factor intensities and comparative advantage and disadvantage of various U.S. industries.

Case Study 5-3 The Revealed Comparative Advantage of Various Countries and Regions

Table 5.3 gives the revealed comparative advantage or disadvantage in capital-intensive, skill-intensive, and unskilled-intensive manufactured goods of various nations, groups of nations, or regions in 1993. Revealed comparative advantage or disadvantage is measured by exports minus imports in each product category, as a percentage of the total manufactured exports of the nation or region. The estimated coefficients can range from +1 to −1. A positive coefficient indicates a revealed comparative advantage, while a negative coefficient indicates a revealed comparative disadvantage. The absolute value (i.e., the value disregarding the sign) of the estimated coefficient then indicates the degree or strength of comparative advantage or disadvantage.

Table 5.3 shows that the United States, the European Union, and Japan have a comparative advantage in capital-intensive and skill-intensive commodities, but a comparative disadvantage in unskilled-intensive commodities—just as predicted by their relative-factor endowments shown in Table 5.1. Canada has a comparative advantage in capital-intensive commodities but a comparative disadvantage in skilled-intensive and unskilled-intensive commodities. In fact, Canada has a strong comparative advantage in natural-resource commodities (not shown in Table 5.3), which distort the analysis. All other countries or regions have a comparative advantage in unskilled-intensive commodities (which is very high, except for Mexico) and a comparative disadvantage in capital-intensive and skill-intensive commodities (except for Mexico's comparative advantage in skill-intensive commodities). More rigorous tests of the H–O model will be discussed in Section 5.6. Changes in comparative advantage over time are shown in Table 7.3 in Case Study 7-3.

TABLE 5.3. *Revealed Comparative Advantage of Various Countries and Regions*

Country/Region	Capital	Skilled	Unskilled
United States	0.11	0.06	−0.30
European Union	0.03	0.01	−0.06
Japan	0.07	0.15	−0.50
Canada	0.19	−0.25	−0.03
Rest of OECD[a]	0.00	−0.01	0.01
Mexico	−0.05	0.02	0.01
Rest of Latin America	−0.16	−0.23	0.47
China	−0.24	−0.25	0.44
India	−0.04	−0.64	0.37
Hong Kong, South Korea, Taiwan, Singapore	−0.11	−0.03	0.14
Rest of Asia	−0.33	−0.05	0.40
Eastern Europe (including Russia)	−0.08	−0.31	0.36
OPEC[b]	−0.09	−0.29	0.45
Rest of the world	−0.17	−0.18	0.40

[a]OECD = Organization for Economic Cooperation and Development, which includes all the other industrial countries.
[b]OPEC = Organization of Petroleum Exporting Countries.
Source: W. R. Cline, *Trade and Income Distribution*, op. cit., p. 192.

Case Study 5-4 Factor Intensities and Industries of U.S. Comparative Advantage and Disadvantage

Table 5.4 identifies the ten most capital-intensive industries and the 10 most skill-intensive industries in the United States from the 1992 U.S. Census of Manufacturers. These are the industries in which the United States presumably has the strongest comparative advantage. Table 5.4 also indentifies the 10 most *unskilled labor-intensive* industries in which the United States is expected to have the strongest comparative *disadvantage.*

TABLE 5.4. *Factor Intensities of Various U.S. Industries*

Ten Most *Capital-Intensive Industries*	Ten Most *Skill-Intensive Industries*	Ten Most Unskilled *Labor-Intensive Industries*
Cigarettes	Space propulsion units and parts	Gray iron foundries
Flavoring extracts and syrups	Analytical instruments	Industrial patterns
Cereal breakfast foods	Space vehicle equipment	Textile goods
Wet corn milling	Search and navigation equipment	Schiffli machine embroideries
Dog and cat food	Rolling mill machinery	Footwear, except rubber
Agricultural chemicals	Newspapers	Leather gloves and miltens
Roasted coffee	Aircraft	Wood TV and radio cabinets
Distilled liquor, except brandy	Electrical equipment and supplies	Textile bags
Pharmaceutical preparations	Optical instruments and lenses	Special dyes, tools, jigs, and fixtures
Industrial gases	Machine tools, metal cutting types	Ship building and repairing

Source: J. Romalis, "Factor Proportions and the Structure of Commodity Trade," *American Economic Review*, March 2004, pp. 67–97.

5.5 Factor–Price Equalization and Income Distribution

In this section, we examine the *factor–price equalization theorem*, which is really a corollary, since it follows directly from the H–O theorem and holds only if the H–O theorem holds. It was *Paul Samuelson* (1970 Nobel prize in economics) who rigorously proved this factor–price equalization theorem (corollary). For this reason, it is sometimes referred to as the Heckscher–Ohlin–Samuelson theorem (H–O–S theorem, for short).

In Section 5.5A, we state the theorem and explain its meaning. Section 5.5B presents an intuitive proof of the factor–price equalization theorem. In Section 5.5C, we examine the related question of the effect of international trade on the distribution of income within each trading nation. Section 5.5D extends the analysis to the case where one or more factors of production are not mobile but specific to an industry. Finally, in Section 5.5E, we briefly consider the empirical relevance of the factor–price equalization theorem. The rigorous proof of the factor–price equalization theorem and of the specific-factors model are presented in the appendix to this chapter and requires the tools of analysis of intermediate microeconomic theory reviewed in the appendix to Chapter 3.

5.5A The Factor–Price Equalization Theorem

Starting with the assumptions given in Section 5.2A, we can state the **factor–price equalization (H–O–S) theorem** as follows: *International trade will bring about equalization in the relative and absolute returns to homogeneous factors across nations.* As such, international trade is a substitute for the international mobility of factors.

What this means is that international trade will cause the wages of homogeneous labor (i.e., labor with the same level of training, skills, and productivity) to be the same in all trading nations (if all of the assumptions of Section 5.2A hold). Similarly, international trade will cause the return to homogeneous capital (i.e., capital of the same productivity and risk) to be the same in all trading nations. That is, international trade will make w the same in Nation 1 and Nation 2; similarly, it will cause r to be the same in both nations. Both relative and absolute factor prices will be equalized.

From Section 5.4, we know that in the absence of trade the relative price of commodity X is lower in Nation 1 than in Nation 2 because the relative price of labor, or the wage rate, is lower in Nation 1. As Nation 1 specializes in the production of commodity X (the L-intensive commodity) and reduces its production of commodity Y (the K-intensive commodity), the relative demand for labor rises, causing wages (w) to rise, while the relative demand for capital falls, causing the interest rate (r) to fall. The exact opposite occurs in Nation 2. That is, as Nation 2 specializes in the production of Y and reduces its production of X with trade, its demand for L falls, causing w to fall, while its demand for K rises, causing r to rise.

To summarize, international trade causes w to rise in Nation 1 (the low-wage nation) and to fall in Nation 2 (the high-wage nation). Thus, international trade reduces the pretrade difference in w between the two nations. Similarly, international trade causes r to fall in Nation 1 (the K-expensive nation) and to rise in Nation 2 (the K-cheap nation), thus reducing the pretrade difference in r between the two nations. This proves that international trade *tends to reduce* the pretrade difference in w and r between the two nations.

We can go further and demonstrate that international trade not only tends to reduce the international difference in the returns to homogeneous factors, but would in fact bring about complete equalization in relative factor prices when all of the assumptions made hold. This is so because as long as relative factor prices differ, relative commodity prices differ and trade continues to expand. But the expansion of trade reduces the difference in factor prices between nations. Thus, international trade keeps expanding until relative commodity prices are completely equalized, which means that relative factor prices have also become equal in the two nations.

5.5B Relative and Absolute Factor–Price Equalization

We can show graphically that relative factor prices are equalized by trade in the two nations (if all the assumptions of Section 5.2A hold). In Figure 5.5, the

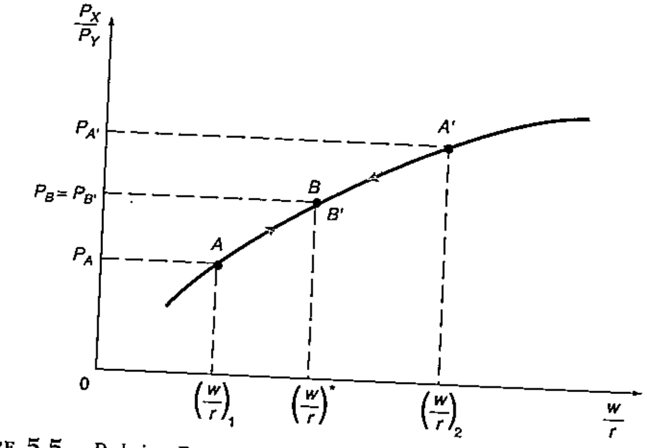

FIGURE 5.5. Relative Factor–Price Equalization. The horizontal axis measures w/r and the vertical axis P_X/P_Y. Before trade, Nation 1 is at point A, with $w/r = (w/r)_1$ and $P_X/P_Y = P_A$ while Nation 2 is at point A', with $w/r = (w/r)_2$ and $P_X/P_Y = P_{A'}$. Since w/r is lower in Nation 1 than in Nation 2, P_A is lower than $P_{A'}$ so that Nation 1 has a comparative advantage in commodity X. As Nation 1 specializes in the production of commodity X with trade and increases the demand for labor relative to capital, w/r rises. As Nation 2 specializes in the production of commodity Y and increases its relative demand for capital, r/w rises (i.e., w/r falls). This will continue until point $B = B'$, at which $P_B = P_{B'}$ and $w/r = (w/r)^*$ in both nations.

relative price of labor (w/r) is measured along the horizontal axis, and the relative price of commodity X (P_X/P_Y) is measured along the vertical axis. Since each nation operates under perfect competition and uses the same technology, there is a one-to-one relationship between w/r and P_X/P_Y. That is, each w/r ratio is associated with a specific P_X/P_Y ratio.

Before trade, Nation 1 is at point A, with $w/r = (w/r)_1$ and $P_X/P_Y = P_A$, while Nation 2 is at point A', with $w/r = (w/r)_2$ and $P_X/P_Y = P_{A'}$. With w/r lower in Nation 1 than in Nation 2 in the absence of trade, P_A is lower than $P_{A'}$ so that Nation 1 has a comparative advantage in commodity X.

As Nation 1 (the relatively L-abundant nation) specializes in the production of commodity X (L-intensive commodity) and reduces the production of commodity Y, the demand for labor increases relative to the demand for capital and w/r rises in Nation 1. This causes P_X/P_Y to rise in Nation 1. On the other hand, as Nation 2 (the K-abundant nation) specializes in the production of commodity Y (the K-intensive commodity), its relative demand for capital increases and r/w rises (i.e., w/r falls). This causes P_Y/P_X to rise (i.e., P_X/P_Y to fall) in Nation 2. The process will continue until point $B = B'$, at which $P_B = P_{B'}$ and $w/r = (w/r)^*$ in both nations (see Figure 5.5). Note that $P_B = P_{B'}$ *only if* w/r is identical in the two nations, since both nations operate under perfect competition and use the same technology (by assumption). Note also that $P_B = P_{B'}$ lies between P_A and $P_{A'}$, and $(w/r)^*$ lies between

$(w/r)_1$ and $(w/r)_2$. To summarize, P_X/P_Y will become equal as a result of trade, and this will occur only when w/r has also become equal in the two nations (as long as both nations continue to produce both commodities). A more rigorous and difficult proof of the relative factor–price equalization theorem is given in the appendix.

The preceding paragraph shows the process by which *relative, not absolute,* factor prices are equalized. Equalization of *absolute* factor prices means that free international trade also equalizes the real wages for the same type of labor in the two nations and the real rate of interest for the same type of capital in the two nations. However, given that trade equalizes relative factor prices, that perfect competition exists in all commodity and factor markets, and that both nations use the same technology and face constant returns to scale in the production of both commodities, it follows that trade also equalizes the absolute returns to homogeneous factors. A rigorous and difficult proof of absolute factor–price equalization is presented in the appendix to this chapter, following the proof of relative factor–price equalization.

Note that trade acts as a substitute for the international mobility of factors of production in its effect on factor prices. With perfect mobility (i.e., with complete information and no legal restrictions or transportation costs), labor would migrate from the low-wage nation to the high-wage nation until wages in the two nations became equal. Similarly, capital would move from the low-interest to the high-interest nation until the rate of interest was equalized in the two nations. *While trade operates on the demand for factors, factor mobility operates on the supply of factors.* In either case, the result is complete equalization in the absolute returns of homogeneous factors. With some (rather than perfect) international mobility of factors, a smaller volume of trade would be required to bring about equality in factor returns between the two nations.

5.5C Effect of Trade on the Distribution of Income

While in the previous section we examined the effect of international trade on the difference in factor prices *between nations,* in this section we analyze the effect of international trade on relative factor prices and income *within each nation.* These two questions are certainly related, but they are not the same.

Specifically, we have seen in Section 5.5A that international trade tends to equalize w in the two nations and also to equalize r in the two nations. We now want to examine how international trade affects real wages and the real income of labor in relation to real interest rates and the real income of owners of capital *within* each nation. Do the real wages and income of labor rise or fall in relation to the real interest rate and earnings of owners of capital in the same nation as a result of international trade?

From our discussion in Section 5.5A, we know that trade increases the price of the nation's abundant and cheap factor and reduces the price of its scarce and expensive factor. In terms of our example, w rises and r falls in Nation 1, while w falls and r rises in Nation 2. Since labor and capital are assumed to remain fully employed before and after trade, the real income of labor and the real income of owners of capital move in the same direction as the movement in factor prices.

Thus, trade causes the real income of labor to rise and the real income of owners of capital to fall in Nation 1 (the nation with cheap labor and expensive capital). On the other hand, international trade causes the real income of labor to fall and the real income of owners of capital to rise in Nation 2 (the nation with expensive labor and cheap capital). This is the conclusion of the *Stolper-Samuelson theorem,* which is examined in detail in Section 8.4C.

Since in developed nations (e.g., the United States, Germany, Japan, France, Britain, Italy, Canada) capital is the relatively abundant factor (as in our Nation 2), international trade tends to reduce the real income of labor and increase the real income of owners of capital. This is why labor unions in developed nations generally favor trade restrictions. On the other hand, in less developed nations (e.g., India, Egypt, Korea, Mexico) labor is the relatively abundant factor, and international trade will increase the real income of labor and reduce the real income of owners of capital.

Since, according to the Heckscher–Ohlin theory, international trade causes real wages and the real income of labor to fall in a capital-abundant and labor-scarce nation such as the United States, shouldn't the U.S. government restrict trade? The answer is almost invariably no. The reason is that the loss that trade causes to labor (particularly unskilled labor; see Case Study 5-5) is less than the gain received by owners of capital. With an appropriate redistribution policy of taxes on owners of capital and subsidies to labor, both broad classes of factors of production can benefit from international trade. Such a redistribution policy can take not only the form of retraining labor displaced by imports but also the form of tax relief for labor and provision of some social services. We will return to this important question in our discussion of trade restrictions in Chapters 8 and 9.

5.5D The Specific-Factors Model

The effect of international trade on the distribution of income discussed in the previous section is based on the assumption that factors are perfectly mobile among the nation's industries or sectors. Although this is likely to be true in the long run, it may not be true in the short run, when some factors, say capital, may be immobile or specific to some industry or sector. In this case, the conclusions of the Heckscher–Ohlin model on the effects of international trade on distribution need to be modified as explained by the **specific-factors model.**

In order to examine the specific-factors model, suppose that a nation that is relatively labor-abundant produces two commodities, commodity X which is L intensive and commodity Y which is K intensive. Both commodities are produced with labor and capital, but labor is mobile between the two industries while capital is specific to each industry. That is, the capital used in the production of X (say, food) cannot be used in the production of Y (say, cloth), and vice versa. This is like having three factors of production: labor (which is used in and is mobile between, the production of X and Y), natural resources (arable land) which are used only in the production of X, and capital which is used only in the production of Y.

With the opening of trade, the nation will specialize in the production of and will export commodity X (the labor-intensive commodity) and import commodity

Case Study 5-5 Has International Trade Increased U.S. Wage Inequalities?

Has international trade increased wage inequalities between skilled and unskilled workers in the United States and other industrial countries during the past two decades? The answer is yes, but it was probably not a major cause. First, some facts. Between 1979 and 1993, average real wages declined by more than 20 percent for U.S. high school graduates but rose by 11 percent for college graduates, resulting in a large increase in skilled-unskilled workers' real wage inequalities. According to another study, the real wage differential between college and high school graduates in the United States increased by 63 percent between 1973 and 1996. The question is how much did international trade contribute to this increase?

Here there are wide disagreements. Some economists, such as *Wood* (1994, 1995, 1998), *Borjas* and *Ramey* (1994), *Sachs* and *Shatz* (1994, 1996, 2001), *Rodrik* (1997), and *Feenstra* and *Hanson* (2001) argue that the growth of manufactured exports from newly industrializing economies (NIEs) was the major cause of the increased wage inequalities in the United States and unemployment in Western Europe during the past two decades. Other economists, such as *Krugman* and *Lawrence* (1994), *Bhagwati* and *Kosters* (1994), *Krugman* (1995, 2000), *Slaughter* and *Wagel* (1997), and OECD (1998), however, point out that industrial countries' nonpetroleum imports from low-wage countries are only about 3 percent of the GDP of industrial countries, and, hence, it could not possibly have been the major cause of the large fall in the real wages of unskilled workers in the United States and large increase in unemployment (because of more rigid wages) in Western Europe during the past two decades. They acknowledge that international trade certainly contributed to the unskilled workers' problems in industrial countries, but that it played only a minor role in (i.e., it may have been responsible for no more than 10 to 15 percent of) the increase in U.S. skilled-unskilled real wage inequalities. Most of the increase in unskilled-skilled real wage inequalities was probably due to technological changes, such as automation and the computerization of many jobs, which sharply reduced the demand for unskilled workers in the United States and Europe.

The weight of evidence seems to be with this latter view: international trade may have speeded up the introduction of labor-saving innovations, but it may have had only a small direct impact on the demand and wages of unskilled labor in industrial nations during the past two decades. Table 5.5 shows that the contribution of the various factors to wage inequality in the United States in 1995 (in percentages) was as follows: technological change 37.7, trade 10.1, stagnant minimum wage 7.2, decline of unions 4.4, immigration 2.9, and unexplained 37.7.

TABLE 5.5. *Sources of Wage Inequalities in the United States*

Source of Wage Inequality	Contribution (in percent)
Technological change	37.7
Trade	10.1
Stagnant minimum wage	7.2
Decline of unions	4.4
Immigration	2.9
Unexplained	37.7

Source: "At the Heart of the Trade Debate: Inequity," *The Wall Street Journal*, October 31, 1997, p. A2.

Y (the specific capital-intensive commodity). This will increase the relative price of X (i.e., Px/Py) and the demand and the nominal wage rate of labor in the nation. Some labor will move from the production of Y to the production of X. Since labor is mobile between the two industries, industry Y will have to pay the higher going nominal wage rate for labor even while facing a reduction in Py/Px and the transfer of some its labor to the production of X.

The effect of this on the *real* wage rate of labor in the nation is ambiguous. The reason is that the increase in Px/Py and in the derived demand for labor will be greater than the increase in the nominal wage rate (since the supply of labor is not vertical—this is explained and shown in Figure 5.9 in the appendix), and so the real wage rate of labor falls in terms of commodity X. On the other hand, since the nominal wage rate increased but the price of commodity Y (the import-competing commodity) declined in the nation, the real wage rate increased in terms of commodity Y. Thus, the real wage rate in the nation falls in terms of X but rises in terms of Y. The effect on the real wage of labor is, therefore ambiguous. The real wage and income will fall for those workers who consume mainly commodity X and will increase for those workers who consume mainly commodity Y.

The result for specific capital is not ambiguous. Since capital is specific to each industry, opening trade does not lead to any transfer of capital from the production of commodity Y to the production of commodity X in the nation. With more labor used with the given specific capital in the production of X (the nation's export commodity), the real return on capital in the production of X rises. On the other hand, with less labor used with the same amount of specific capital in the production of Y (the nation's import-competing commodity), the real return on the specific capital used in the production Y falls.

The conclusion reached by the specific-factors model is that trade will have an ambiguous effect on the nation's mobile factors, benefit the immobile factors specific to the nation's export commodities or sectors, and harm the immobile factors specific to the nation's import-competing commodities or sectors. In the previously mentioned example, the opening of trade will have an ambiguous effect on the real wage and income of labor (the nation's mobile factor), will increase the real return on the specific capital used in the production of X (the nation's export commodity), and will reduce the real return on the other specific factor used in the production of commodity Y (the nation's import-competing commodity). If the specific factor used in the production of X was natural resources, then opening of trade would increase the real return or rent on land, reduce the real return on capital used in the production of Y, and have an ambiguous effect on labor (see Appendix A5.4 for the rigorous proof of this theorem).

5.5E Empirical Relevance

Has international trade equalized the returns to homogeneous factors in different nations in the real world? Even casual observation clearly indicates that it has not. Thus, wages are much higher for doctors, engineers, technicians, mechanics, secretaries, and laborers in the United States and Germany than in Korea and Mexico.

The reason for this is that many of the simplifying assumptions on which the H–O–S theory rests do not hold in the real world. For example, nations do not use exactly the same technology, and transportation costs and trade barriers prevent the equalization of relative commodity prices in different nations. Furthermore, many industries operate under conditions of imperfect competition and nonconstant returns to scale. It should not be surprising, therefore, that international trade has not equalized wages and interest rates for homogeneous factors in different nations.

Under these circumstances, it is more realistic to say that international trade has *reduced*, rather than completely eliminated, the international difference in the returns to homogeneous factors. While international trade seems to have reduced differences in real wages in manufacturing among the leading industrial countries (see Case Study 5-6), this cannot be regarded as "proof" of the theory, and it is even more difficult to give a clear-cut answer for other countries and other factors.

The reason for this is that, even if international trade has operated to reduce absolute differences in factor returns among nations, many other forces were operating at the same time, preventing any such relationship from becoming

Case Study 5-6 Convergence of Real Wages among Industrial Countries

Table 5.6 shows that real hourly wages in manufacturing in the leading industrial countries has converged to U.S. wages over time. Specifically, average wages abroad rose from 27 percent of U.S. wages in 1959 to 43 percent in 1970, 65 percent in 1983, 90 percent in 1990, and 97 percent in 2000. Although the rapid expansion of international trade over this period is likely to have been an important reason for the wage convergence, other important forces were also at work, such as the reduction of the technological gap between the United States and the other leading industrial countries, the smaller growth of the labor force in the latter group of countries than in the United States, and increased international labor mobility.

TABLE 5.6. *Real Hourly Wage in Manufacturing in the Leading Industrial Countries as a Percentage of the U.S. Wage*

Country	1959	1970	1983	1990	2000
Japan	11	24	51	86	111
Italy	23	42	62	79	85
France	27	41	62	102	91
United Kingdom	29	35	53	85	84
Germany	29	56	84	103	121
Canada	42	57	75	84	90
Unweighted average	27	43	65	90	97
United States	100	100	100	100	100

Source: Calculated from indices from: International Monetary Fund, *International Financial Statistics;* Organization for Economic Cooperation and Development, *Economic Outlook;* United Nations, *Monthly Bulletin of Statistics;* and U.S. Bureau of Labor Statistics, *Bulletin.*

clearly evident. For example, while international trade may have tended to reduce the difference in real wages and incomes for the same type of labor between the United States and Egypt, technological advances occurred more rapidly in the United States than in Egypt, so that the difference in earnings has in fact increased. This seems indeed to have been the case between developed nations as a group and most developing nations since World War II.

Once again, this does not disprove the factor–price equalization theorem, since in the absence of trade these international differences might have been much greater than they are now. In any event, the factor–price equalization theorem is useful because it identifies crucial forces affecting factor prices and provides important insights into the general equilibrium nature of our trade model and of economics in general.

One thing the factor–price equalization theorem *does not say* is that international trade will eliminate or reduce international differences in *per capita incomes.* It only predicts that international trade will eliminate or reduce international differences in the returns to *homogeneous factors.* Even if real wages were to be equalized among nations, their per capita incomes could still remain widely different. Per capita income depends on many other forces not directly related to the factor–price equalization theorem. These other forces include the ratio of skilled to unskilled labor, the participation rate in the labor force, the dependency rate, the type of effort made by workers, and so on. For example, Japan has a higher ratio of skilled to unskilled labor than India, a higher participation rate and lower dependency rate, and Japanese workers seem to thrive on work and precision. Thus, even if wages for the same type of labor were exactly the same in Japan and India, Japan would end up with a much higher per capita income than India.

5.6 Empirical Tests of the Heckscher–Ohlin Model

This section presents and evaluates the results of empirical tests of the Heckscher–Ohlin model. A model must be successfully tested empirically before it is accepted as a theory. If a model is contradicted by empirical evidence, it must be rejected and an alternative model drawn up.

In Section 5.6A, we present the results of the original empirical test of the Heckscher–Ohlin model, conducted by *Wassily Leontief.* Since these results seemed to conflict with the model, many attempts were made to reconcile them with the model; in the process numerous other empirical tests were undertaken. These are discussed in Section 5.6B. In Section 5.6C, we discuss the situation called factor-intensity reversal, which, if very prevalent, would also lead to rejection of the H–O model. Empirical tests, however, indicate that this is not a very frequent occurrence in the real world.

5.6A Empirical Results—The Leontief Paradox

The first empirical test of the Heckscher–Ohlin model was conducted by *Wassily Leontief* in 1951 using U.S. data for the year 1947. Since the United States was the most K-abundant nation in the world, Leontief expected to find that it exported K-intensive commodities and imported L-intensive commodities.

For this test, Leontief utilized the input–output table of the U.S. economy to calculate the amount of labor and capital in a "representative bundle" of $1 million worth of U.S. exports and import substitutes for the year 1947. (The **input–output table** is a table showing the origin and destination of each product in the economy. Leontief himself had contributed importantly to the development of this new technique of analysis and received the Nobel prize in 1973 for his contributions.)

To be noted is that Leontief estimated K/L for U.S. import substitutes rather than for imports. **Import substitutes** are commodities, such as automobiles, that the United States produces at home but also imports from abroad (because of incomplete specialization in production). Leontief was forced to use U.S. data on import substitutes because *foreign* production data on actual U.S. imports were not available. However, Leontief correctly reasoned that even though U.S. import substitutes would be more K intensive than actual imports (because K was relatively cheaper in the United States than abroad), they should still be less K intensive than U.S. exports if the H–O model held true. Of course, the use of U.S. data on import substitutes, instead of foreign data on actual U.S. imports, also eliminated from the calculations commodities, such as coffee and bananas, not produced at all in the United States.

The results of Leontief's test were startling. U.S. import substitutes were about 30 percent more K intensive than U.S. exports. That is, the United States seemed to export L-intensive commodities and import K-intensive commodities. This was the opposite of what the H–O model predicted, and it became known as the **Leontief paradox** (see Case Study 5-7).

In the same study, Leontief tried to rationalize his results rather than reject the H–O model. He argued that what we had here was an optical illusion: Since in 1947 U.S. labor was about three times as productive as foreign labor, the United States was really an L-abundant nation if we multiplied the U.S. labor force by three and compared this figure to the availability of capital in the nation. Therefore, it was only appropriate that U.S. exports should be L intensive in relation to U.S. import substitutes. This explanation is not acceptable, and Leontief himself subsequently withdrew it. The reason is that while U.S. labor was definitely more productive than foreign labor (though the multiple of three used by Leontief was largely arbitrary), so was U.S. capital. Therefore, both U.S. labor *and* U.S. capital should be multiplied by about the same multiple, leaving the relative abundance of capital in the United States more or less unaffected.

Similarly invalid is another explanation that postulated that U.S. tastes were biased so strongly in favor of K-intensive commodities as to result in higher relative prices for these commodities in the United States. Therefore, the United States would export relatively L-intensive commodities. The reason this explanation is not acceptable is that tastes are known to be similar across nations. A study by *Houthakker* in 1957 on household consumption patterns in many countries found that the income elasticity of demand for food, clothing, housing, and other classes of goods was remarkably similar across nations. As a result, this explanation of the Leontief paradox based on a difference in tastes is also unacceptable.

Case Study 5-7 Capital and Labor Requirements in U.S. Trade

Table 5.7 gives the capital and labor requirements per million dollars of U.S. exports and import substitutes, as well as the capital/worker-year for imports relative to exports. For example, dividing the Leontief's capital/worker-year of $18,180 for U.S. import substitutes by the capital/worker-year of $14,010 for exports using 1947 data (see the third row of the table), Leontief obtained the capital/worker-year for imports relative to exports of 1.30. Since the United States is a relatively capital-abundant nation and U.S. import substitutes are more capital intensive than U.S. exports, we have a paradox. Using 1951 trade data, the K/L ratio for imports/exports fell to 1.06, and, excluding natural resource industries, the ratio fell to 0.88 (thus eliminating the paradox). Using 1958 input requirements and 1962 trade data, Baldwin obtained the K/L ratio for imports/exports of 1.27. When natural resource industries were excluded, the ratio fell to 1.04, and when human capital was included, it fell to 0.92 (once again, eliminating the paradox).

TABLE 5.7. *Capital and Labor Requirements per Million Dollars of U.S. Exports and Import Substitutes*

	Exports	Import Substitutes	Imports/Exports
Leontief			
(1947 input requirements, 1947 trade):			
Capital	$2,550,780	$3,091,339	
Labor (worker-years)	182	170	
Capital/worker-year	$14,010	$18,180	1.30
Leontief			
(1947 input requirements, 1951 trade):			
Capital	$2,256,800	$2,303,400	
Labor (worker-years)	174	168	
Capital/worker-year	$12,977	$13,726	1.06
Capital/worker-year, excluding natural resources			0.88
Baldwin			
(1958 input requirements, 1962 trade):			
Capital	$1,876,000	$2,132,000	
Labor (worker-years)	131	119	
Capital/worker-year	$14,200	$18,000	1.27
Capital/worker-year, excluding natural resources			1.04
Capital/worker-year, excluding natural resources and including human capital			0.92

Sources: Leontief (1951, 1956) and Baldwin (1971). See the Selected Bibliography at the end of the chapter.

5.6B Explanations of the Leontief Paradox and Other Empirical Tests of the H-O Model

One possible explanation of the paradox is that the year 1947, which Leontief used for the test, was too close to World War II to be representative. Leontief himself answered this criticism by repeating his study in 1956 using the 1947 input–output table of the U.S. economy but 1951 trade data. (The year 1951 is usually taken to mark the completion of postwar reconstruction.) This analysis showed that U.S. exports were only 6 percent more *L* intensive than U.S. import substitutes. Leontief had reduced the paradox but had not eliminated it (see Case Study 5-6).

A more general source of bias is that Leontief used a two-factor model (*L* and *K*), thus abstracting from other factors such as natural resources (soil, climate, mineral deposits, forests, etc.). However, a commodity might be intensive in natural resources so that classifying it as either *K* or *L* intensive (with a two-factor model) would clearly be inappropriate. Furthermore, many production processes using natural resources—such as coal mining, steel production, and farming—also require large amounts of physical capital. The U.S. dependence on imports of many natural resources, therefore, might help explain the large capital intensity of U.S. import-competing industries.

U.S. tariff policy was another source of bias in the Leontief study. A tariff is nothing else than a tax on imports. As such, it reduces imports and stimulates the domestic production of import substitutes. In a 1956 study, *Kravis* found that the most heavily protected industries in the United States were the *L*-intensive industries. This biased the pattern of trade and reduced the labor intensity of U.S. import substitutes, thus contributing to the existence of the Leontief paradox.

Perhaps the most important source of bias was the fact that Leontief included in his measure of capital only physical capital (such as machinery, other equipment, buildings, and so on) and completely ignored human capital. **Human capital** refers to the education, job training, and health embodied in workers, which increase their productivity. The implication is that since U.S. labor embodies more human capital than foreign labor, adding the human capital component to physical capital would make U.S. exports more *K* intensive relative to U.S. import substitutes. (In fairness to Leontief, it must be said that the analysis of human capital became fully developed and fashionable only following the work of *Schultz* in 1961 and *Becker* in 1964.)

Somewhat related to human capital is the influence of research and development (R&D) on U.S. exports. The "knowledge" capital resulting from R&D leads to an increase in the value of output derived from a given stock of material and human resources. Even casual observation shows that most U.S. exports are R&D and skill intensive. Thus, human and knowledge capital are important considerations in determining the pattern of U.S. trade. These were not considered by Leontief in his study.

The most important of the numerous empirical studies following a human capital approach were undertaken by Kravis, Keesing, Kenen, and Baldwin. In two studies published in 1956, *Kravis* found that wages in U.S. exports industries in both 1947 and 1951 were about 15 percent higher than wages in U.S. import-competing industries. Kravis correctly argued that the higher wages in U.S. exports industries were a reflection of the greater productivity and human capital embodied in U.S. exports than in U.S. import substitutes.

In a 1966 study, *Keesing* found that U.S. exports were more skill intensive than the exports of nine other industrial nations for the year 1957. This reflected the fact that the United States had the most highly trained labor force, embodying more human capital than other nations.

It remained for *Kenen*, in a 1965 study, to actually estimate the human capital embodied in U.S. exports and import-competing goods, add these estimates to the physical capital requirements, and then recompute *K*/*L* for U.S. exports and U.S. import substitutes. Using 1947 data and without excluding products with an important natural resource content (as in the original Leontief study), Kenen succeeded in eliminating the Leontief paradox.

In a 1971 study, *Baldwin* updated Leontief's study by using the 1958 U.S. input–output table and U.S. trade data for 1962. Baldwin found that excluding natural resource industries was not sufficient to eliminate the paradox unless human capital was included (see Case Study 5-7). The paradox remained, however, for developing nations and for Canada. Similar paradoxical results arose by using other countries' data. A 1977 study by *Branson* and *Monoyios* also raised some questions on the appropriateness of combining human and physical capital into a single measure for the purpose of testing the H–O trade model.

In 1980 and 1984 publications, *Leamer* argued that in a multifactor world we should compare the *K*/*L* ratio in production versus consumption rather than in exports versus imports. Taking this approach to Leontief's 1947 data, *Leamer* (1984) found that the *K*/*L* ratio embodied in U.S. production was indeed greater than that embodied in U.S. consumption, so that the paradox disappeared. This was confirmed in a 1981 study by *Stern* and *Maskus* for the year 1972 and in a 1990 study by *Salvatore* and *Barazesh* for each year from 1958 to 1981 when natural resource industries were excluded.

In a 1987 study, however, *Bowen*, *Leamer*, and *Sveikauskas*, using more complete 1967 cross-sectional data on trade, factor input requirements, and factor endowments for 27 countries, 12 factors (resources), and many commodities, found that the H–O trade model was supported only about half of the time. This seemed to inflict a devastating blow on the validity of the H–O model. Subsequent research, however, does provide support for some restricted form of the H–O trade model. In a 1993 study, *Brecher* and *Choudhri* found production evidence in support of the H–O model for U.S.–Canadian trade; a 1994 study by *Wood* provided support for the H–O model for trade between developed and developing countries based on differences in their relative availability of skills and land, and so did a 1995 study by the World Bank (see Case Study 5-8). Additional evidence in support of the H–O model for trade in manufactured goods among the largest industrial countries was also provided in 1996 by *James and Elmslie*, and more broadly, but still qualified, by *Leamer* (1993, 1995), and *Wood* (1997).

More convincing evidence validating a qualified or restricted form of the H–O theory comes from more recent research. Using data on a large sample of developed and developing countries over the 1970–1992 period and allowing for differences in technology among nations. *Harrigan* and *Zakrajsek* (2000) show that factor endowments do explain comparative advantage. *Schott* (2001, p. 686) provides

Case Study 5-8 The H–O Model with Skills and Land

Figure 5.6 shows that Africa (1) with relatively more abundant land and less skilled workers exports more primary commodities while industrial market economies (5) with relatively more skilled workers export more manufactured goods. Between Africa and industrial countries lie Latin America (2), South Asia (3), and East Asia (4), which have relatively less land and more skilled workers than Africa and export relatively more manufactured goods than Africa but less than industrial countries. The straight line in the figure is the regression line showing the general relationship between relative factor endowments and type of exports. It was estimated for the year 1985 from 126 data points (not shown in the figure), each referring to a country, and it shows a clear positive relationship between skill availability and exports of manufactures. The numbered circles in the figure show regional averages.

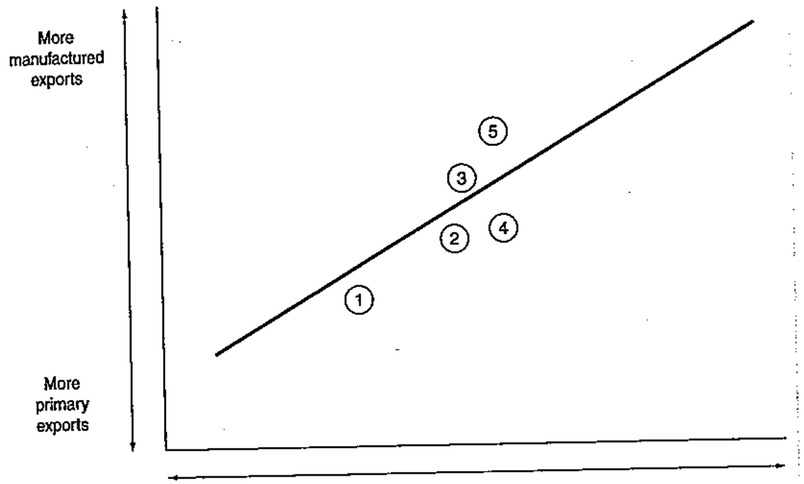

FIGURE 5.6. Comparative Advantage with Skills and Land. The regression line shows that Africa with relatively more land and less skilled workers than other regions exports more primary commodities and less manufactured goods than other regions.

Source: World Bank, *World Development Report* (Washington, D.C., 1995), p. 59.

"strong support for H–O specialization" by utilizing more disaggregated data which shows that countries specialize in the particular subset of goods most suited to their specific factor endowments (showing, for example, that considering all electrical machinery as hi-tech, as done in previous studies, was wrong because electrical machinery also includes portable radios assembled by hand).

Additional evidence is provided by *Davis* and *Weinstein* (2001). Utilizing the trade data of ten countries (the United States, Japan, Germany, France, the United Kingdom, Italy, Canada, Australia, Denmark, and the Netherlands) with the rest of the world, for 34 sectors, over the 1970–1995 period, and allowing for different technologies and factor prices across countries, the existence of non-traded goods, and transportation costs, *Davis* and *Weinstein* show that countries export commodities intensive in their relatively abundant and cheap factors of production and they do so in the predited magnitudes.

More evidence is provided by *Romalis* (2004). By using a many-country version of the Heckscher-Ohlin model with differentiated products and transportation costs, and detailed bilateral trade data, *Romalis* (p. 67) concludes that "Countries capture larger shares of world production and trade in commodities that more intensively use their abundant factor. Countries that rapidly accumulate a factor see their production and export structures systematically shift towards industries that intensively use that factor". *Trefler* and *Zhu* (2005) also provide empirical evidence for the "role of endowments as a source of comparative advantage" using input-output tables for 41 developed and developing countries.

Thus, it seems that we can retain the traditional Heckhser–Olhin model for explaining trade between developed and developing countries (often referred to as North-South trade) and a qualified or restricted version of the H–O model for the much larger trade among developed countries (i.e., North–North trade) if the model is extended to allow for different technologies and factor prices across countries, the existence of non traded goods, economies of scale, product differentiation, and transportation costs. But then some would argue that not much is left from the original H–O model and that all we have is a general factor-endowments trade model. The next chapter will examine economies of scale, product differentiation, and technological differences as additional or complementary factors determining comparative advantage and international trade.

5.6C Factor-Intensity Reversal

Factor-intensity reversal refers to the situation where a given commodity is the *L*-intensive commodity in the *L*-abundant nation and the *K*-intensive commodity in the *K*-abundant nation. For example, factor-intensity reversal is present if commodity X is the *L*-intensive commodity in Nation 1 (the low-wage nation), and, at the same time, it is the *K*-intensive commodity in Nation 2 (the high-wage nation).

To determine when and why factor-intensity reversal occurs, we use the concept of the elasticity of substitution of factors in production. The **elasticity of substitution** measures the degree or ease with which one factor can be substituted for another in production as the relative price of the factor declines. For example, suppose that the elasticity of substitution of L for K is much greater in the production of commodity X than in production of commodity Y. This means that it is much easier to substitute L for K (or vice versa) in the production of commodity X than in the production of commodity Y.

Factor-intensity reversal is more likely to occur the greater is the *difference* in the elasticity of substitution of L for K in the production of the two commodities. With a large elasticity of substitution of L for K in the production of commodity X, Nation 1 will produce commodity X with L-intensive techniques because its wages are low. On the other hand, Nation 2 will produce commodity X with K-intensive techniques because its wages are high. If at the same time the elasticity of substitution of L for K is very low in the production of commodity Y, the two nations will be forced to use similar techniques in producing commodity Y even though their relative factor prices may differ greatly. As a result, commodity X will be the L-intensive commodity in Nation 1 and the K-intensive commodity in Nation 2, and we have a case of factor-intensity reversal.

When factor-intensity reversal is present, neither the H–O theorem nor the factor–price equalization theorem holds. The H–O model fails because it would predict that Nation 1 (the L-abundant nation) would export commodity X (its L-intensive commodity) and that Nation 2 (the K-abundant nation) would also export commodity X (its K-intensive commodity). Since the two nations cannot possibly export the same *homogeneous* commodity to each other, the H–O model no longer predicts the pattern of trade.

With factor-intensity reversal, the factor–price equalization theorem also fails to hold. The reason for this is that as Nation 1 specializes in the production of commodity X and demands more L, the relative and the absolute wage rate will rise in Nation 1 (the low-wage nation). On the other hand, since Nation 2 cannot export commodity X to Nation 1, it will have to specialize in the production of and export commodity Y. Since commodity Y is the L-intensive commodity in Nation 2, the demand for L and thus wages will also rise in Nation 2. What happens to the *difference* in relative and absolute wages between Nation 1 and Nation 2 depends on how fast wages rise in each nation. The difference in relative and absolute wages between the two nations could decline, increase, or remain unchanged as a result of international trade, so that the factor–price equalization theorem no longer holds.

That factor-intensity reversal does occur in the real world is beyond doubt. The question is how prevalent it is. If factor reversal is very prevalent, the entire H–O theory must be rejected. If it occurs but rarely, we can retain the H–O model and treat factor reversal as an exception. The frequency of factor reversal in the real world is an empirical question.

The first empirical research on this topic was a study conducted by *Minhas* in 1962, in which he found factor reversal to be fairly prevalent, occurring in about one-third of the cases that he studied. However, by correcting an important source of bias in the Minhas study, Leontief showed in 1964 that factor reversal occurred in only about 8 percent of the cases studied, and that if two industries with an important natural resource content were excluded, factor reversal occurred in only 1 percent of the cases.

A study by *Ball*, published in 1966 and testing another aspect of Minhas's results, confirmed Leontief's conclusion that factor-intensity reversal seems to be

a rather rare occurrence in the real world. As a result, the assumption that one commodity is L intensive and the other commodity is K intensive (assumption 3 in Section 5.2) at all *relevant* relative factor prices generally holds, so that the H–O model can be retained.

Summary

1. The Heckscher–Ohlin theory presented in this chapter extends our trade model of previous chapters to explain the basis of (i.e., what determines) comparative advantage and to examine the effect of international trade on the earnings of factors of production. These two important questions were left largely unanswered by classical economists.
2. The Heckscher–Ohlin theory is based on a number of simplifying assumptions (some made only implicitly by Heckscher and Ohlin). These are (1) two nations, two commodities, and two factors of production; (2) both nations use the same technology; (3) the same commodity is labor intensive in both nations; (4) constant returns to scale; (5) incomplete specialization in production; (6) equal tastes in both nations; (7) perfect competition in both commodities and factor markets; (8) perfect internal but no international mobility of factors; (9) no transportation costs, tariffs, or other obstructions to the free flow of international trade; (10) all resources are fully employed; (11) trade is balanced. These assumptions will be relaxed in Chapter 6.
3. In a world of two nations (Nation 1 and Nation 2), two commodities (X and Y), and two factors (labor and capital), we say that commodity Y is capital intensive if the capital–labor ratio (K/L) used in the production of Y is greater than K/L for X in both nations. We also say that Nation 2 is the K-abundant nation if the relative price of capital (r/w) is *lower* there than in Nation 1. Thus, Nation 2's production frontier is skewed toward the Y-axis and Nation 1's is skewed toward the X-axis. Since the relative price of capital is lower in Nation 2, producers there will use more K-intensive techniques in the production of both commodities in relation to Nation 1. Producers would also substitute K for L (causing K/L to rise) in the production of both commodities if the relative price of capital declined. Commodity Y is *unequivocally* the K-intensive commodity if K/L remains higher for Y than for X in both nations at all relative factor prices.
4. The Heckscher–Ohlin, or factor-endowment, theory can be expressed in terms of two theorems. According to the Heckscher–Ohlin (H–O) theorem, a nation will export the commodity intensive in its relatively abundant and cheap factor and import the commodity intensive in its relatively scarce and expensive factor. According to the factor–price equalization (H–O–S) theorem, international trade will bring about equalization of relative and absolute returns to homogeneous factors across nations. If some factors are specific (i.e., can only be used in some industries), the specific-factors model postulates that trade will have an ambiguous effect on the nation's mobile factors: It will benefit the immobile factors that are specific to the nation's export commodities or sectors,

and harm the immobile factors that are specific to the nation's import-competing commodities or sectors.

5. Out of all the possible forces that could cause a difference in pretrade-relative commodity prices between nations, Heckscher and Ohlin isolate the difference in factor endowments (in the face of equal technology and tastes) as the basic determinant or cause of comparative advantage. International trade can also be a substitute for the international mobility of factors in equalizing relative and absolute returns to homogeneous factors across nations. The general equilibrium nature of the H–O theory arises from the fact that all commodity and factor markets are components of an overall unified system so that a change in any part affects every other part.
6. The first empirical test of the H–O model was conducted by Leontief using 1947 U.S. data. Leontief found that U.S. import substitutes were about 30 percent more K intensive than U.S. exports. Since the United States is the most K-abundant nation, this result was the opposite of what the H–O model predicted and became known as the Leontief paradox. This paradox could be explained by (1) 1947 being a nonrepresentative year, (2) the use of a two-factor (L and K) model, (3) the fact that U.S. tariffs gave more protection to L-intensive industries, and (4) the exclusion of human capital from the calculations. Some empirical studies, however, give conflicting results.
7. Factor-intensity reversal refers to the situation where a commodity is L intensive in the L-abundant nation and K intensive in the K-abundant nation. This may occur when the elasticity of substitution of factors in production varies greatly for the two commodities. With factor reversal, both the H–O theorem and the factor–price equalization theorem fail. Minhas conducted a test in 1962 that showed that factor reversal was fairly prevalent. Leontief and Ball demonstrated, however, that Minhas's results were biased and that factor reversal was a rather rare occurrence. More recent research provides strong support for a qualified or restricted form of the H–O model of trade based on country differences in factor endowments, broadly defined.

In Chapter 6, we relax the assumptions of the Heckscher–Ohlin model and examine new trade theories that base international trade on economies of scale and imperfect competition, and we evaluate their relative importance as explanations of international trade today. We will also examine the effect of transportation costs and environmental standards on international trade and the relationship between transportation costs and environmental standards on the location of industry.

Same technology	Labor–capital ratio (L/K)
Labor-intensive commodity	Capital–labor ratio (K/L)
Capital-intensive commodity	Constant returns to scale

Perfect competition	Factor–price equalization (H–O–S) theorem
Internal factor mobility	Specific-factors model
International factor mobility	Input–output table
Factor abundance	Import substitutes
Relative factor prices	Leontief paradox
Derived demand	Human capital
Heckscher–Ohlin (H–O) theory	Factor-intensity reversal
Heckscher–Ohlin (H–O) theorem	Elasticity of substitution
Factor-proportions or factor-endowment theory	

Questions for Review

1. In what ways does the Heckscher–Ohlin theory represent an extension of the trade model presented in the previous chapters? What did classical economists say on these matters?
2. State the assumptions of the Heckscher–Ohlin theory. What is the meaning and importance of each of these assumptions?
3. What is meant by labor-intensive commodity? capital-intensive commodity? capital–labor ratio?
4. What is meant by capital-abundant nation? What determines the shape of the production frontier of each nation?
5. What determines the capital–labor ratio in the production of each commodity in both nations? Which of the two nations would you expect to use a higher capital–labor ratio in the production of both commodities? Why? Under what circumstance would the capital–labor ratio be the same in the production of both commodities in each nation?
6. If labor and capital can be substituted for each other in the production of both commodities, when can we say that one commodity is capital intensive and the other labor intensive?
7. What does the Heckscher–Ohlin theory postulate? Which force do Heckscher and Ohlin identify as the basic determinant of comparative advantage and trade?
8. What does the factor–price equalization theorem postulate? What is its relationship to the international mobility of factors of production?
9. Explain why the Heckscher–Ohlin theory is a general equilibrium model.
10. What is meant by the Leontief paradox? What are some possible explanations of the paradox? How can human capital contribute to the explanation of the paradox?
11. What were the results of empirical tests on the relationship between human capital and international trade? natural resources and international trade? What is the status of the H–O theory today?
12. What is meant by factor-intensity reversal? How is this related to the elasticity of substitution of factors in production? Why would the prevalence of factor reversal lead to rejection of the H–O theorem and the factor–price equalization theorem? What were the results of empirical tests on the prevalence of factor reversal in the real world?
13. Did more recent research confirm or reject the H–O model?

Problems

1. Draw two sets of axes, one for Nation 1 and the other for Nation 2, measuring labor along the horizontal axis and capital along the vertical axis.

(a) Show by straight lines through the origin that K/L is higher for commodity Y than for commodity X in both nations in the absence of trade and that K/L is higher in Nation 2 than in Nation 1 for both commodities.

(b) What happens to the slope of the lines measuring K/L of each commodity in Nation 2 if r/w rises in Nation 2 as a result of international trade?

(c) What happens to the slope of the lines measuring K/L in Nation 1 if r/w falls in Nation 1 as a result of international trade?

(d) Given the results of parts b and c, does international trade increase or reduce the difference in the K/L in the production of each commodity in the two nations as compared with the pretrade situation?

2. Without looking at the text,

(a) Sketch a figure similar to Figure 5.4 showing the autarky equilibrium point in each nation and the point of production and consumption in each nation with trade.

(b) With reference to your figure in part a, explain what determines the comparative advantage of each nation.

(c) Why do the two nations consume different amounts of the two commodities in the absence of trade but the same amount with trade?

3. Starting with the production frontiers for Nation 1 and Nation 2 shown in Figure 5.4, show graphically that even with a small difference in tastes in the two nations, Nation 1 would continue to have a comparative advantage in commodity X.

***4.** Starting with the production frontiers for Nation 1 and Nation 2 shown in Figure 5.4, show graphically that sufficiently different tastes in the two nations could conceivably neutralize the difference in their factor endowments and lead to equal relative commodity prices in the two nations in the absence of trade.

5. Starting with the production frontiers for Nation 1 and Nation 2 shown in Figure 5.4, show that with an even greater difference in tastes in the two nations, Nation 1 could end up exporting the capital-intensive commodity.

6. A difference in factor endowments will cause the production frontiers of two nations to be shaped differently.

(a) What else could cause their production frontiers to have different shapes?

(b) What assumption made by Heckscher and Ohlin prevented this in the Heckscher–Ohlin model?

(c) What are other possible causes of a difference in relative commodity prices between the two nations in the absence of trade?

***7.** Draw a figure similar to Figure 5.4 but showing that the Heckscher–Ohlin model holds, even with some difference in tastes between Nation 1 and Nation 2.

8. If you have traveled to poor developing countries, you will have noticed that people there consume very different goods and services than U.S. consumers. Does this mean that tastes in developing countries are very different from U.S. tastes? Explain.

9. Starting from the pretrade equilibrium point in Figure 5.4, assume that tastes in Nation 1 change in favor of the commodity of its comparative *disadvantage* (i.e., in favor of commodity Y).

(a) What is the effect of this change in tastes on P_X/P_Y in Nation 1? How did you reach such a conclusion?

(b) What is the effect of this change in tastes on r/w in Nation 1?

(c) What is the effect of this on the volume of trade and on the trade partner?

10. Comment on the following quotation: "The assumptions necessary to bring about complete equality in the returns to homogeneous factors among nations are so restrictive and unrepresentative of actual reality that the theory can be said to prove the opposite of what it seems to say—namely, that there is no chance whatsoever that factor prices will ever be equalized by free commodity trade."

11. In what way can international trade be said to have contributed to increased wage inequalities in the United States during the past 20 years?

12. (a) Discuss the meaning and importance of the Leontief paradox.

(b) Summarize the empirical results of Kravis, Keesing, Kenen, and Baldwin on the importance of human capital in helping to resolve the paradox.

(c) How was the paradox seemingly resolved by Leamer, Stern, and Maskus, and Salvatore and Barazesh?

(d) What is the status of the controversy today?

***13.** (a) Draw a figure similar to Figure 5.1 showing factor-intensity reversal.

(b) With reference to your figure, explain how factor reversal could take place.

(c) Summarize the empirical results of Minhas, Leontief, and Ball on the prevalence of factor reversal in the real world.

14. Explain why, with factor-intensity reversal, international differences in the price of capital can decrease, increase, or remain unchanged with international trade.

15. (a) Explain how more recent research tried to verify the H–O model.

(b) Explain the results of these more recent empirical tests.

(c) What general conclusion can be reached with respect to the utility and acceptance of the H–O model?

* = Answer provided at www.wiley.com/college/salvatore.

Appendix

This appendix presents the formal proof of the factor–price equalization theorem and examines factor-intensity reversal. Section A5.1 repeats (with some modifications to fit our present aim) the Edgeworth box diagrams of Nation 1 and Nation 2 from Figures 3.9 and 3.10. Section A5.2 then examines how international trade brings about equality in *relative* factor prices in the two nations. Section A5.3 shows that *absolute* factor prices are also equalized across nations as a result of international trade. Section A5.4 examines the effect of trade on the short-run distribution of income with the specific-factors model.

Sections A5.5 to A5.7 then examine factor-intensity reversal, utilizing the more advanced analytical tools reviewed in the appendix to Chapter 3. Section A5.5 gives a diagrammatic presentation of factor-intensity reversal. Section A5.6 presents the formula to measure the elasticity of substitution of L for K in production and examines its relationship to factor-intensity reversal. Section A5.7 discusses the method used to conduct empirical tests to determine the prevalence of factor-intensity reversal in the real world.

A5.1 The Edgeworth Box Diagram for Nation 1 and Nation 2

Figure 5.7 shows the Edgeworth box diagram of Nation 2 superimposed on the box diagram of Nation 1 in such a way that their origins for commodity X coincide. The origins for commodity Y differ because Nation 1 has a relative abundance of labor, whereas Nation 2 has a relative abundance of capital. The box diagrams are superimposed on each other to facilitate the analysis to follow.

Because both nations use the same *technology*, the isoquants for commodity X in the two nations are identical (and are measured from the common origin O_X). Similarly, the

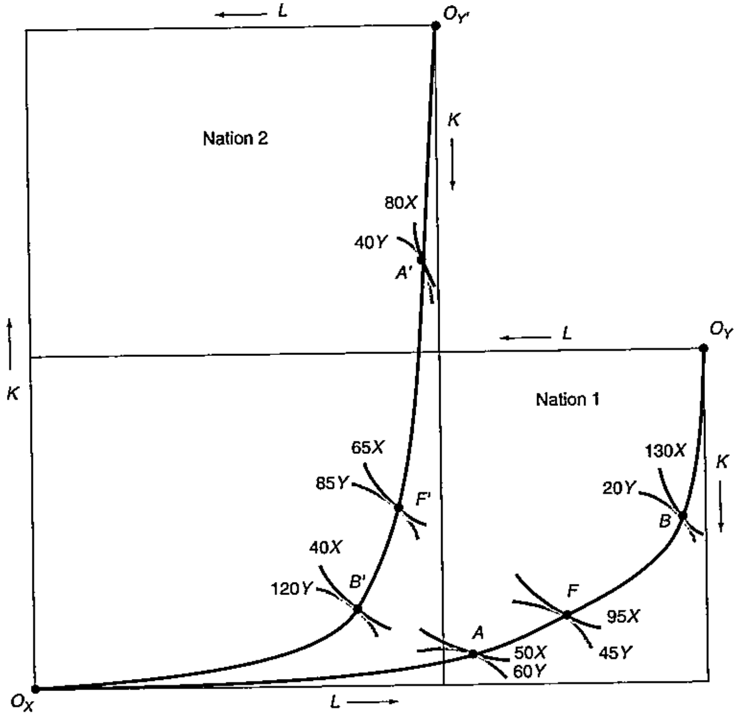

FIGURE 5.7. The Edgeworth Box Diagram for Nation 1 and Nation 2—Once Again. The Edgeworth box diagram of Nation 2 from Figure 3.10 is superimposed on the box diagram for Nation 1 from Figure 3.9 in such a way that their origins for commodity X coincide. Because both nations use the same technology, the isoquants of commodity X are identical in the two nations. The same is true for the Y-isoquants. The points on each nation's production contract curve refer to corresponding points on the nation's production frontier. The contract curves of both nations bulge toward the lower right-hand corner because commodity X is the *L*-intensive commodity in both nations.

isoquants for commodity Y in the two nations are also identical (but are measured from origin O_Y for Nation 1 and from origin $O_{Y'}$ for Nation 2). X-isoquants farther from O_X refer to progressively higher outputs of X, while Y-isoquants farther from O_Y or $O_{Y'}$ refer to greater outputs of Y.

By joining all points where an X-isoquant is tangent to a Y-isoquant in each nation, we obtain the nation's production contract curve. Points *A*, *F*, and *B* on Nation 1's production contract curve in Figure 5.7 refer to corresponding points on Nation 1's production frontier (see Figure 3.9). Similarly, points *A'*, *F'*, and *B'* on Nation 2's production contract curve refer to corresponding points on Nation 2's production frontier. Note that the contract curves of both nations bulge toward the lower right-hand corner because commodity X is the *L*-intensive commodity in both nations.

A5.2 Relative Factor–Price Equalization

Figure 5.8 repeats Figure 5.7 but omits (to keep the figure simple) all isoquants as well as points *F* and *F'* (which are not needed in the subsequent analysis). The no-trade equilibrium point is *A* in Nation 1 and *A'* in Nation 2 (as in Figures 3.3 and 3.4). The *K/L* ratio in the production of commodity X is smaller in Nation 1 than in Nation 2. This is given by the lesser slope of the line (not shown) from origin O_X to point *A* as opposed to point *A'*. Similarly, the *K/L* ratio in the production of commodity Y is also smaller in Nation 1 than in Nation 2. This is given by the smaller slope of the line (not shown) from O_Y to point *A* as opposed to the slope of the line (also not shown) from $O_{Y'}$ to point *A'*.

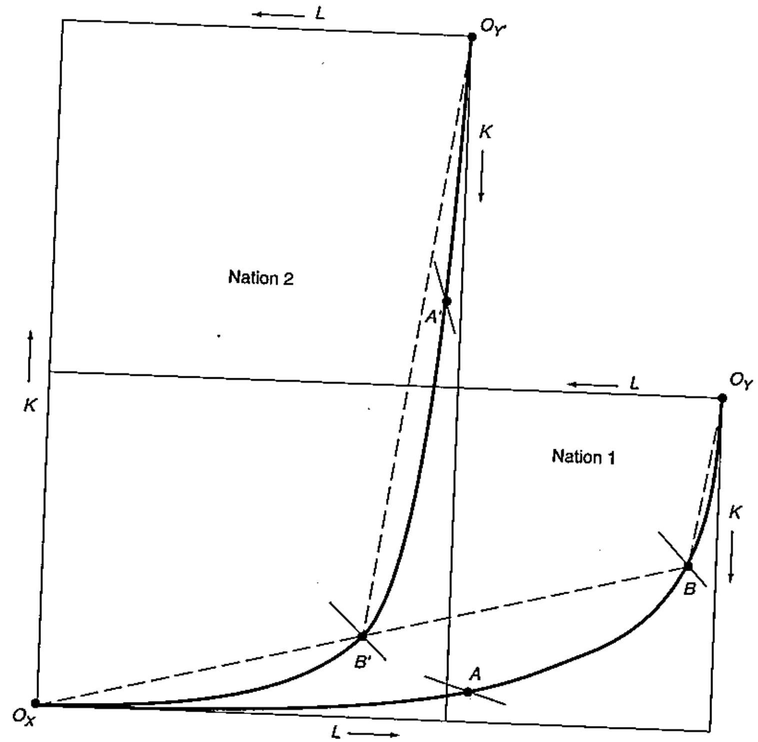

FIGURE 5.8. Formal Proof of the Factor–Price Equalization Theorem. At the no-trade equilibrium point *A* in Nation 1 and *A'* in Nation 2, *K/L* is lower in the production of both commodities in Nation 1 than in Nation 2. These are given by the lower slopes of straight lines (not shown) from O_X and O_Y or $O_{Y'}$ to points *A* and *A'*. Since *w/r* (the absolute slope of the solid line through point *A*) is lower in Nation 1 and commodity X is *L* intensive, Nation 1 specializes in the production of commodity X until it reaches point *B*. Nation 2 specializes in Y until it reaches point *B'*. At *B* and *B'*, *K/L* and therefore *w/r* are the same in both nations.

Since Nation 1 uses a smaller amount of capital per unit of labor (K/L) in the production of both commodities with respect to Nation 2, the productivity of labor and therefore the wage rate (w) are lower, while the productivity of capital and therefore the rate of interest (r) are higher, in Nation 1 than in Nation 2. This is always the case when both nations use a production function that is homogeneous of degree one, showing constant returns to scale (as assumed throughout).

With a lower w and a higher r, w/r is lower in Nation 1 than in Nation 2. This is consistent with the relative physical abundance of labor in Nation 1 and capital in Nation 2. The lower w/r in Nation 1 at autarky point A is reflected in the smaller (absolute) slope of the (short and solid) straight line through point A as opposed to the corresponding line at point A'. (The straight lines are the common tangents to the X- and Y-isoquants—not shown in Figure 5.8—at point A and point A'.)

To summarize, we can say that at the no-trade equilibrium point A, Nation 1 uses a smaller K/L ratio in the production of both commodities with respect to Nation 2. This results in lower productivity of labor and higher productivity of capital in Nation 1 than in Nation 2. As a result, w/r is lower in Nation 1 (the L-abundant nation) than in Nation 2.

Since Nation 1 is the L-abundant nation and commodity X is the L-intensive commodity, with the opening of trade Nation 1 will specialize in the production of commodity X (i.e., will move from point A toward O_Y along its production contract curve). Similarly, Nation 2 will specialize in the production of commodity Y and move from point A' toward O_X. Specialization in production continues until Nation 1 reaches point B and Nation 2 reaches point B', where K/L is the same in each commodity in both nations. This is given by the slope of the dashed line from O_X through points B' and B for commodity X, and by the parallel dashed lines from O_Y and $O_{Y'}$ to points B and B' for commodity Y, for Nation 1 and Nation 2, respectively.

Note that as Nation 1 moves from point A to point B, K/L rises in the production of both commodities. This is reflected by the steeper slope of the dashed lines from O_X and O_Y to point B as opposed to point A. As a result of this increase in K/L, the productivity and therefore the wage of labor rise in Nation 1 (the low-wage nation). On the other hand, as Nation 2 moves from point A' to B', K/L falls in the production of both commodities. This is reflected by the smaller slope of the dashed lines from $O_{Y'}$ and O_X to point B' as opposed to point A'. As a result of this decline in K/L, the productivity and therefore the wage of labor falls in Nation 2 (the high-wage nation). The exact opposite is true for capital.

In the absence of trade, w/r was lower in Nation 1 than in Nation 2 (see the absolute slopes of the solid straight lines through points A and A'). As Nation 1 (the low-wage nation) specializes in the production of commodity X, K/L and w/r rise in the production of both commodities in Nation 1. As Nation 2 (the high-wage nation) specializes in the production of commodity Y, K/L and w/r fall in the production of both commodities. Specialization in production continues until K/L and w/r have become equal in the two nations. This occurs when Nation 1 produces at point B and Nation 2 produces at point B' with trade. This concludes our formal proof that international trade equalizes relative factor prices in the two nations when all the assumptions listed in Section 5.2A hold.

Problem Show graphically that with sufficiently less capital available, Nation 1 would have become completely specialized in the production of commodity X before relative factor prices became equal in the two nations.

A5.3 Absolute Factor–Price Equalization

This proof of absolute factor–price equalization is more difficult than the proof of relative factor–price equalization and is seldom if ever covered in undergraduate courses, even when all students in the course have had intermediate microeconomics and macroeconomics. The proof is included here only for the sake of completeness and for more advanced undergraduate students and first-year graduate students.

The proof makes use of **Euler's theorem**. According to Euler's theorem, if constant returns to scale prevail in production and if each factor is rewarded (paid) according to its productivity, the output produced is exhausted and just exhausted. Specifically, the marginal physical product of labor (MPL) times the amount of labor used in production (L) plus the marginal physical product of capital (MPK) times the amount of capital used in production (K) exactly equals the output produced. The same is true for commodity Y. In equation form, Euler's theorem in the production of commodity X can be expressed as

$$(MPL)(L) + (MPK)(K) = X \qquad (5A\text{-}1)$$

Dividing both sides by L and rearranging:

$$X/L = MPL + (MPK)(K)/L \qquad (5A\text{-}2)$$

Factoring out MPL:

$$X/L = MPL[(1 + K/L)(MPK/MPL)] \qquad (5A\text{-}3)$$

With trade, Nation 1 produces at point B and Nation 2 produces at point B' in Figure 5.8. Since at points B and B', w/r is the same in both nations, MPK/MPL is also the same in both nations. We also know that at points B and B', K/L in the production of commodity X is the same in both nations. Finally, X/L is the average product of labor in the production of commodity X—and this is also the same in the two nations because of the assumptions of constant returns to scale and the same technology. As a result, the last remaining component (MPL) in Equation 5A-3 must also be the same in the production of commodity X *in both nations* if Equation 5A-3 is to hold.

Since the real wage is equal to MPL, the equality of MPL in the two nations means that real wages are the same in the two nations in the production of commodity X. With perfect competition and perfect internal factor mobility, real wages in the production of commodity Y are equal to real wages in the production of commodity X in each nation as well. In a completely analogous way, we can prove that the rate of interest is the same in the two nations in the production of both commodities. This concludes our proof that international trade equalizes absolute factor prices in the production of both commodities in both nations (under highly restrictive assumptions). That is, we have proved that real wages (w) are the same in both nations in the production of both commodities. Similarly, the real rate of interest (r) is also the same in both nations in the production of both commodities.

A5.4 Effect of Trade on the Short-Run Distribution of Income: The Specific-Factors Model

Suppose that in Nation 1 (the L-abundant nation) labor is mobile between industries but capital is not. Since labor is mobile, the wage of labor will be the same in the production of commodities X and Y in Nation 1. The equilibrium wage and the amount of labor employed in the production of X and Y in Nation 1 are given by the intersection of the value of the marginal product of labor curve in the production of X and Y. From microeconomic theory, we know that the value of the marginal product of labor in the production of X is equal to the price of commodity X times the marginal physical product of labor in the production of X. That is, $VMPL_X = (P_X)(MPL_X)$. Similarly, $VMPL_Y = (P_Y)(MPL_Y)$. We also know that if a firm employs more labor with a given amount of capital, *VMPL* declines because of the law of diminishing returns. Finally, to maximize profits, firms will employ labor until the wage they must pay equals the value of the marginal product of labor (i.e., until $w = VMPL$).

We can show the no-trade equilibrium wage and employment of labor in the production of commodities X and Y in Nation 1 with the aid of Figure 5.9. In the figure, the horizontal axis measures the total supply of labor available to Nation 1, and the vertical axis measures the wage rate. To begin with, concentrate on the $VMPL_X$ curve (which is read from left to right, as usual) and on the $VMPL_Y$ curve (which is read from right to left). The equilibrium wage rate is *ED* and is determined at the intersection of the $VMPL_X$ and $VMPL_Y$ curves. The wage rate is identical in the production of X and Y because of perfect labor mobility in the nation between the two industries. The amount

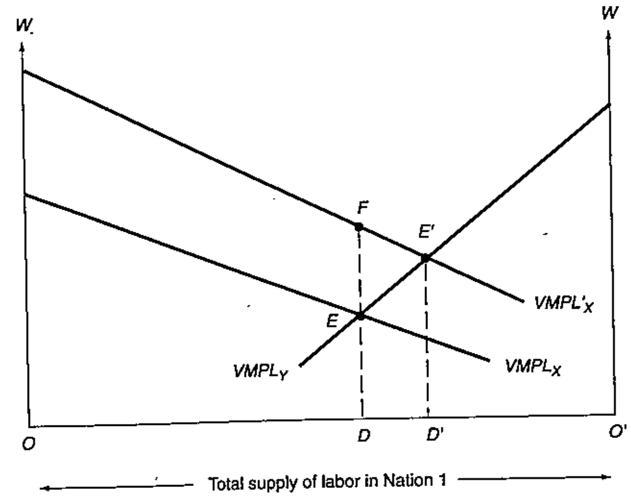

FIGURE 5.9. Specific-Factors Model. Labor is mobile between industries, but capital is not. The horizontal axis measures the total supply of *L* available to Nation 1, and the vertical axis the wage rate (w). Before trade, the intersection of the $VMPL_X$ and $VMPL_Y$ curves determines $w = ED$ in the two industries. *OD* of *L* is used in the production of X and *DO'* in Y. With trade, P_X/P_Y increases and shifts $VMPL_X$ up to $VMPL_X'$, w rises from *ED* to *E'D'*, and *DD'* of *L* shifts from Y to X. Since w rises less than P_X, w falls in terms of X but rises in terms of Y (since P_Y is unchanged). With more *L* used with fixed *K* in the production of X, $VMPK_X$ and r increase in terms of both X and Y. With less *L* used with fixed *K* in Y, $VMPK_Y$ and r fall in terms of both commodities.

OD of labor is used in the production of X, and the remainder, or *DO'*, is used in the production of Y.

Since Nation 1 (the *L*-abundant nation) has a comparative advantage in commodity X (the *L*-intensive commodity), the opening of trade increases P_X/P_Y. Since $VMPL_X = (P_X)(MPL_X)$, the increase in P_X shifts the $VMPL_X$ curve upward proportionately, by *EF*, to $VMPL_X'$. The wage rate increases less than proportionately, from *ED* to *E'D'*, and *DD'* units of labor shift from the production of Y to the production of X. Since w increases by less than the increase in P_X, w falls in terms of X but rises in terms of Y (since P_Y is unchanged). Thus, the effect of the increase in P_X on the real income of labor is ambiguous and depends on spending patterns. Workers who consume mainly commodity X will be worse off, while those who consume mainly commodity Y will be better off.

The rewards (r) to the specific factor (capital) change unambiguously, however. Since the specific capital in the production of commodity X has more labor to work with, $VMPK_X$ and r increase in terms of both commodities X and Y. On the other hand, since less labor is used with the fixed capital in the production of commodity Y, $VMPK_Y$ and r fall in terms of commodity X, and therefore in terms of commodity Y as well.

Thus, with the opening of trade, the real income of the immobile capital (the nation's scarce factor) rises in the production of X and falls in the production of Y, while real wages (which are equal in the production of both commodities) fall in terms of commodity X and rise in terms of commodity Y. This is the result we obtain in the short run with the specific-factors model when capital is specific to or immobile between the two industries of the nation.

Generalizing the specific-factors model, we can say that *trade will have an ambiguous effect on each nation's mobile factors, benefit the immobile factors specific to the nation's export sectors, and harm the immobile factors specific to the nation's import-competing sectors*. This is what we can expect in the short run when some factors are specific or immobile (i.e., can only be used in some industries). In the long run, of course, when all input are mobile among all industries of a nation, the Heckscher–Ohlin model postulates that the opening of trade will lead to an increase in the real income or return of the inputs used intensively in the nation's export sectors and to a reduction in the real income or return of the inputs used intensively in the production of the nation's import-competing sectors.

Problem What effect will the opening of trade have on the real income of labor and capital in Nation 2 (the K-abundant nation) if L is mobile between the two industries in Nation 2 but K is not?

A5.5 Illustration of Factor-Intensity Reversal

Figure 5.10 shows a single isoquant for commodity X and a single isoquant for commodity Y. From Section A3.1, we know that with a homogeneous production function of degree one, a single isoquant completely describes the entire production function of each commodity. Furthermore, since both nations are assumed to use the same technology, we can use the single X- and Y-isoquants to refer to both nations.

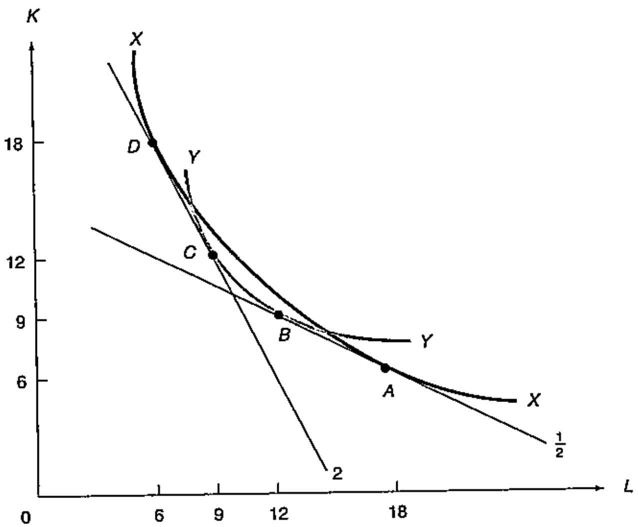

FIGURE 5.10. Factor-Intensity Reversal At $w/r = 1/2$, commodity X is produced at point A with $K/L = 6/18 = 1/3$, while commodity Y is produced at point B with $K/L = 9/12 = 3/4$. Thus, commodity X is the L-intensive commodity. On the other hand, at $w/r = 2$, commodity Y is produced at point C with $K/L = 12/9 = 4/3$, while commodity X is produced at point D with $K/L = 18/6 = 1/3 = 3$. Thus, commodity X is L intensive at $w/r = 1/2$ and K intensive at $w/r = 2$ in relation to commodity Y, and factor-intensity reversal is present.

Figure 5.10 shows that at $w/r = 1/2$, commodity X is produced at point A, where the X-isoquant is tangent to the isocost line with slope (w/r) equal to $1/2$ and $K/L = 6/18 = 1/3$. Commodity Y is produced at point B, where the Y-isoquant is tangent to the same isocost line with slope (w/r) equal to $1/2$ and $K/L = 9/12 = 3/4$. Thus, at $w/r = 1/2$, K/L is higher for commodity Y, so that commodity X is the relatively L-intensive commodity.

On the other hand, at $w/r = 2$, commodity Y is produced at point C, where the Y-isoquant is tangent to the isocost line with slope (w/r) equal to 2 and $K/L = 12/9 = 4/3$. Commodity X is produced at point D, where the X-isoquant is tangent to the same isocost line with slope (w/r) equal to 2 and $K/L = 18/6 = 3$. Thus, at $w/r = 2$, commodity X is the relatively K-intensive commodity.

As a result, commodity X is L intensive at $w/r = 1/2$ and K intensive at $w/r = 2$ with respect to commodity Y, and we say that factor-intensity reversal is present.

With factor-intensity reversal, both the H–O theorem and the factor–price equalization theorem must be rejected. To see this, suppose that Nation 1 is the relatively L-abundant nation with $w/r = 1/2$, while Nation 2 is the relatively K-abundant nation with $w/r = 2$. With $w/r = 1/2$, Nation 1 should specialize in the production of and export commodity X because Nation 1 is the L-abundant nation and commodity X is the L-intensive commodity there. With $w/r = 2$, Nation 2 should specialize in the production of and export commodity X because Nation 2 is the K-abundant nation and commodity X is the K-intensive commodity there. Since both nations cannot export to each other the same *homogeneous* commodity (i.e., commodity X), the H–O theorem no longer predicts the pattern of trade.

When the H–O model does not hold, the factor–price equalization theorem also fails. To see this, note that as Nation 1 (the low-wage nation) specializes in the production of commodity X (the L-intensive commodity), the demand for labor rises, and w/r and w rise in Nation 1. With Nation 1 specializing in and exporting commodity X to Nation 2, Nation 2 must specialize in and export commodity Y to Nation 1 (since the two nations could not possibly export the same homogeneous commodity to each other). However, since commodity Y is the L-intensive commodity in Nation 2, the demand for labor rises, and w/r and w rise in Nation 2 (the high-wage nation) also. Thus, wages rise both in Nation 1 (the low-wage nation) and in Nation 2 (the high-wage nation).

If wages rise faster in Nation 1 than in Nation 2, the difference in wages between the two nations declines, as predicted by the factor–price equalization theorem. If wages rise more slowly in Nation 1 than in Nation 2, the wage difference increases. If wages rise by the same amount in both nations, the wage difference remains unchanged. Since there is no a priori way to determine the effect of international trade on the difference in factor prices in each case, we must reject the factor–price equalization theorem.

From Figure 5.10, we can see that factor-intensity reversal arises because the X-isoquant has a much smaller curvature than the Y-isoquant and the X- and Y-isoquants *cross twice within the two relative factor price lines.* When the two isoquants have similar curvature, they will only cross once and there is no factor-intensity reversal.

Problem Draw a figure similar to Figure 5.10 with the X-isoquant and the Y-isoquant crossing only once within the relative factor price lines of the two nations and show that in that case there is no factor-intensity reversal.

A5.6 The Elasticity of Substitution and Factor-Intensity Reversal

We said above that for factor-intensity reversal to occur, the X-isoquant and the Y-isoquant must have sufficiently *different* curvatures to cross twice within the relative factor price lines prevailing in the two nations. The curvature of an isoquant measures the ease with which L can be substituted for K in production as the relative price of labor (i.e., w/r) declines. When w/r falls, producers will want to substitute L for K in the production of both commodities to minimize their costs of production.

The flatter (i.e., the smaller the curvature of) an isoquant, the easier it is to substitute L for K (and vice versa) in production. A measure of the curvature of an isoquant and the ease with which one factor can be substituted for another in production is given by the elasticity of substitution. The **elasticity of substitution** of L for K in production (e) is measured by the following formula:

$$e = \frac{\Delta(K/L)/(K/L)}{\Delta(\text{slope})/(\text{slope})}$$

For example, the elasticity of substitution of L for K for commodity X between point D and point A is calculated as follows. $K/L = 3$ at point D and $K/L = 1/3$ at point A in Figure 5.10. Therefore, the change in K/L for a movement from point D to point A along the

X-isoquant is $3 - \frac{1}{3} = 2\frac{2}{3} = \frac{8}{3}$. Thus, $\Delta(K/L)/(K/L) = (\frac{8}{3})/3 = \frac{8}{9}$. The absolute slope of the X-isoquant is 2 at point D and ½ at point A. Therefore, $\Delta(\text{slope}) = 2 - \frac{1}{2} = 1\frac{1}{2} = \frac{3}{2}$. Thus, $\Delta(\text{slope})/(\text{slope}) = (\frac{3}{2})/2 = \frac{3}{4}$. Substituting these values into the formula, we get

$$e = \frac{\Delta(K/L)/(K/L)}{\Delta(\text{slope})/(\text{slope})} = \frac{8/9}{3/4} = 32/27 = 1.19$$

Similarly, the elasticity of substitution of L and K between point C and point B along the Y-isoquant is

$$e = \frac{\Delta(K/L)/(K/L)}{\Delta(\text{slope})/(\text{slope})} = \frac{[(4/3) - 3/4)]/(4/3)}{(2 - \frac{1}{2})/(2)}$$
$$= \frac{(7/12)/(4/3)}{(1\frac{1}{2})/2} = \frac{21/48}{3/4} = 84/144 = 0.58$$

Thus, the X-isoquant has a much smaller curvature and a much greater elasticity of substitution than the Y-isoquant. It is this difference in curvature and elasticity of substitution between the X-isoquant and the Y-isoquant that results in their crossing twice within the relative factor price lines, giving factor-intensity reversal. Note that a difference in the curvature of the isoquants and in the elasticity of substitution is a necessary but not sufficient condition for factor-intensity reversal. For factor-intensity reversal to occur, the elasticity of substitution must be sufficiently different so that the isoquants of the two commodities cross *within* the relative factor price lines of the two nations.

Problem Calculate the elasticity of substitution of L and K for your X-isoquant and Y-isoquant of the previous problem (where there is no factor-intensity reversal), and verify that the elasticity of substitution for the two isoquants does not differ much because of their similar curvature. Assume that the coordinates are A (4,2), B (3,3), C (3,2.5), D (2,4), and that the absolute slope of the isoquants is 1 at points A and C and 2 at B and D.

A5.7 Empirical Tests of Factor-Intensity Reversal

Until 1961, economists used almost exclusively the **Cobb–Douglas production function** in their work. This implied that the elasticity of substitution of L for K was equal to 1 in the production of all commodities. As a result, this production function was not at all useful to measure the prevalence of factor-intensity reversal in the real world.

Partially in response to the need to measure factor-intensity reversal in international trade, a new production function was developed in 1961 by *Arrow, Chenery, Minhas,* and *Solow*, called the **constant elasticity of substitution (CES) production function.** As its name implies, the CES production function kept the elasticity of substitution of L for K constant for each industry but allowed the elasticity of substitution to vary from industry to industry.

It was this CES production function that Minhas used to measure factor-intensity reversal. That is, Minhas found that the elasticity of substitution of L and K differed widely in the six industries that he studied and that factor-intensity reversal occurred in one-third of the cases. This rate of occurrence is too frequent for factor reversal to be treated as an exception; if true, it would have seriously damaged the H–O model.

However, *Leontief* calculated the elasticity of substitution of all 21 industries used to derive the CES production function (rather than just the six selected by Minhas) and found that factor reversal occurred in only 8 percent of the cases. Furthermore, when he removed two industries intensive in natural resources, factor reversal fell to about 1 percent of the cases. Thus, Leontief concluded that factor-intensity reversal is a rather rare occurrence and that the H–O model should not be rejected on account of these exceptions.

Minhas also conducted another test in his study. He calculated K/L for the same 20 industries in the United States and Japan, ranked these industries according to the K/L in each nation, and then found the coefficient of rank correlation between the industry rankings in the two nations. Since the United States was the relatively K-abundant nation, all industries could be expected to be more K intensive in the United States than in Japan. However, the K-intensity *ranking* of the industries would have to be very similar in the United States and Japan in order for factor-intensity reversal to be rare. That is, the most K-intensive industries in the United States should also be the most K-intensive industries in Japan. Minhas found that the rank correlation was only 0.34 and concluded that factor reversal was fairly common.

However, *Ball* found that when agriculture and two industries intensive in natural resources were removed from the list, the rank correlation rose to 0.77, so that, once again, the conclusion could be reached that factor-intensity reversal is not a common occurrence.

Selected Bibliography

For a problem-solving approach to the material covered in this chapter, see:

- D. Salvatore, *Theory and Problems of International Economics*, 4th ed. (New York: McGraw-Hill, 1996), ch. 4 (sects. 4.1 and 4.2).

The original sources for the Heckscher–Ohlin theory are:

- E. F. Heckscher, "The Effect of Foreign Trade on the Distribution of Income," *Ekonomisk Tidskrift*, 1919, pp. 497–512. Reprinted in H. S. Ellis and L. A. Metzler, *Readings in the Theory of International Trade* (Homewood, Ill.: Irwin, 1950), pp. 272–300.
- B. Ohlin, *Interregional and International Trade* (Cambridge, Mass.: Harvard University Press, 1983).

The original proof of the factor–price equalization theorem is found in:

- P. A. Samuelson, "International Trade and the Equalization of Factor Prices," *Economic Journal*, June 1948, pp. 165–184.
- P. A. Samuelson, "International Factor–Price Equalization Once again," *Economic Journal*, June 1949, pp. 181–197. Reprinted in J. N. Bhagwati, *International Trade: Selected Readings* (Cambridge, Mass.: MIT Press, 1981), pp. 3–16.

For the effect of international trade on the distribution of income, see:

- W. F. Stolper and P. A. Samuelson, "Protection and Real Wages," *Review of Economic Studies*, November 1941, pp. 58–73. Reprinted in

H. S. Ellis and L. M. Metzler, *Readings in the Theory of International Trade* (Homewood, Ill.: Irwin, 1950), pp. 333–357.

Excellent syntheses of the Heckscher–Ohlin theory are found in:

- R. W. Jones, "Factor Proportions and the Heckscher–Ohlin Theorem," *Review of Economic Studies*, January 1956, pp. 1–10.
- H. G. Johnson, "Factor Endowments, International Trade and Factor Prices," *Manchester School of Economics and Social Studies*, September 1957, pp. 270–283. Reprinted in R. E. Caves and H. G. Johnson, *Readings in International Economics* (Homewood, Ill.: Irwin, 1968), pp. 78–89.
- K. Lancaster, "The Heckscher–Ohlin Trade Model: A Geometric Treatment," *Economica*, February 1957, pp. 19–39. Reprinted in J. N. Bhagwati, *International Trade: Selected Readings* (Baltimore, Md.: Penguin, 1969), pp. 49–76.

For excellent surveys of the Heckscher–Ohlin theory, see:

- J. N. Bhagwati, "The Pure Theory of International Trade: A Survey," *Economic Journal*, 1964, pp. 1–84.
- J. S. Chipman, "A Survey of the Theory of International Trade," *Econometrica*, 1965; Part I, pp. 477–519, Part II, pp. 685–760.
- J. N. Bhagwati, A. Panagariya, and T. N. Srinivasan, *Lectures on International Trade* (Cambridge, Mass.: MIT Press, 1998), Part I (Chaps. 1–11).

For the specific-factors model, see:

- R. W. Jones, "A Three-Factor Model in Theory, Trade, and History," in J. N. Bhagwati et al., eds, *Trade, Balance of Payments, and Growth: Essays in Honor of Charles P. Kindleberger* (Amsterdam: North-Holland, 1971), pp. 3–22.
- M. Mussa, "Tariffs and the Distribution of Income: The Importance of Factor Specificity, Substitutability, and Intensity in the Short and Long Run," *Journal of Political Economy*, November 1974, pp. 1191–1203.
- M. Wolfgang, "Short-Run and Long-Run Equilibrium for a Small Open Economy," *Journal of Political Economy*, September/October 1974, pp. 955–968.
- J. P. Neary, "Short-Run Capital Specificity and the Pure Theory of International Trade," *Economic Journal*, September 1978, pp. 488–510.

For the study on the similarity of consumers' tastes in many nations, see:

- H. Houthakker, "An International Comparison of Household Expenditure Patterns," *Econometrica*, October 1957, pp. 532–551.
- For the specific-factors model, see: D. Salvatore, *Microeconomic Theory and Applications*, 4th ed. (New York: Oxford University Press, 2001), ch. 3 (sect. 3.3).

A survey of the empirical evidence on trade theories is found in:

- A. Deardorff, "Testing Trade Theories and Predicting Trade Flows," in R. W. Jones and P. B. Kenen, eds., *Handbook of International Economics*, Vol. 1, *International Trade* (Amsterdam: North-Holland, 1984), pp. 467–517.

The first empirical test of the H–O model, which gave rise to the so-called Leontief paradox, is:

- W. Leontief, "Domestic Production and Foreign Trade: The American Capital Position Re-examined," *Economia Internazionale*, February 1951, pp. 3–32. Reprinted in R. E. Caves and H. G. Johnson, *Readings in International Economics* (Homewood, Ill.: Irwin, 1968), pp. 503–527.

Attempts to explain the Leontief paradox are found in:

- W. Leontief, "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis," *Review of Economics and Statistics*, November 1956, pp. 386–407.
- I. B. Kravis, "Wages and Foreign Trade," *Review of Economics and Statistics*, February 1956, pp. 14–30.
- I. B. Kravis, "Availability and Other Influences on the Commodity Composition of Trade," *Journal of Political Economy*, April 1956, pp. 143–155.
- P. Kenen, "Nature, Capital and Trade," *Journal of Political Economy*, October 1965, pp. 437–460.

- D. P. Ball, "Factor Intensity Reversals in International Comparison of Factor Cost and Factor Use," *Journal of Political Economy*, February 1966, pp. 710–720.
- D. B. Keesing, "Labor Skills and Comparative Advantage," *American Economic Review*, May 1966, pp. 249–258.
- R. E. Baldwin, "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review*, March 1971, pp. 126–146.
- W. H. Branson and N. Monoyios, "Factor Inputs in U.S. Trade," *Journal of International Economics*, May 1977, pp. 111–131.
- E. E. Leamer, "The Leontief Paradox Reconsidered," *Journal of Political Economy*, June 1980, pp. 495–503.
- R. M. Stern and K. E. Maskus, "Determinants of the Structure of U.S. Foreign Trade," *Journal of International Economics*, May 1981, pp. 207–224.
- E. E. Leamer, *Sources of International Comparative Advantage* (Cambridge, Mass.: MIT Press, 1984).
- H. P. Bowen, E. E. Leamer, and L. Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review*, December 1987, pp. 791–809.
- D. Salvatore and R. Barazesh, "The Factor Content of U.S. Foreign Trade and the Heckscher–Ohlin Theory," *International Trade Journal*, Winter 1990, pp. 149–181.
- E. E. Leamer, "Factor-Supply Differences as a Source of Comparative Advantage," *American Economic Review*, May 1993, pp. 436–439.
- R. A. Brecher and E. U. Choudhri, "Some Empirical Support for the Heckscher–Ohlin Model of Production," *Canadian Journal of Economics*, May 1993, pp. 272–285.
- A. Wood, "Give Heckscher and Ohlin a Chance!" *Weltwirtsschaftliches Archiv*, No. 1, 1994, pp. 20–49.
- E. E. Leamer and J. Levinsohn, "International Trade Theory: The Evidence," in G. M. Grossman and K. Rogoff, eds., *Handbook of International Economics*, Vol. 3 (Amsterdam: North-Holland, 1995), pp. 1339–1394.
- A. M. James and B. T. Elmslie, "Testing Heckscher–Ohlin–Vanek in the G-7," *Weltwirtschaftliches Archiv*, No. 1, 1996, pp. 139–159.
- A. Wood, "Exporting Manufactures: Human Resources, Natural Resources, and Trade Policy," *Journal of Development Studies*, October 1997, pp. 35–59.

More recent empirical tests on an extended version of the Heckscher–Ohlin theory are provided by:

- J. Harrigan and E. Zakrajsek, "Factor Supplies and Specialization in the World Economy," *NBER Working Paper No. 7848*, August 2000.
- P. K. Schott, "One Size Fit All? Heckscher–Ohlin Specialization in Global Production," *American Economic Review*, March 2003, pp. 686–708.
- D. R. Davis and D. E. Weinstein, "An Account of Global Factor Trade" *American Economic Review*, December 2001, pp. 1423–1453.
- John Romalis, "Factor proportions and the Structure of Commodity Trade," *American Economic Review*, March 2004, pp. 67–97.
- R. C. Feenstra, *Advanced Trade Theory* (Princeton, NJ.: Princeton University Press, 2004), Chs. 2–4.
- D. Trefler and S. C. Zhu, "The Structure of Factor Content Predictions," NBER Working Paper No. 11221, March 2005.

On the effect of international trade on U.S. skilled–unskilled workers' wage inequalities in the United States, see:

- A. Wood, *Trade and Wages: Leveling Wages Down?* (New York: Oxford University Press, 1994).
- G. Borjas and V. Ramey, "Time Series Evidence on the Sources of Trends in Wage Inequality," *American Economic Review*, May 1994, pp. 10–16.
- P. R. Krugman and R. Z. Lawrence, "Trade, Jobs and Wages," *Scientific American*, April 1994, pp. 44–49.
- J. Bhagwati and M. H. Kosters, *Trade and Wages: Leveling Wages Down?* (Washington, D.C.: AEI Press, 1994).