

## CHAPTER 4

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# RESOURCES AND TRADE: THE HECKSCHER-OHLIN MODEL

If labor were the only factor of production, as the Ricardian model assumes, comparative advantage could arise only because of international differences in labor productivity. In the real world, however, while trade is partly explained by differences in labor productivity, it also reflects differences in countries' *resources*. Canada exports forest products to the United States not because its lumberjacks are more productive relative to their U.S. counterparts than other Canadians but because sparsely populated Canada has more forested land per capita than the United States. A realistic view of trade must allow for the importance not just of labor, but of other factors of production such as land, capital, and mineral resources.

To explain the role of resource differences in trade, this chapter examines a model in which resource differences are the *only* source of trade. This model shows that comparative advantage is influenced by the interaction between nations' resources (the relative **abundance** of factors of production) and the technology of production (which influences the relative **intensity** with which different factors of production are used in the production of different goods). The same idea was present in the specific factors model of Chapter 3, but the model we study in this chapter puts the interaction between abundance and intensity in sharper relief.

That international trade is largely driven by differences in countries' resources is one of the most influential theories in international economics. Developed by two Swedish economists, Eli Heckscher and Bertil Ohlin (Ohlin received the Nobel Prize in economics in 1977), the theory is often referred to as the **Heckscher-Ohlin theory**. Because the theory emphasizes the interplay between the proportions in which different factors of production are available in different countries and the proportions in which they are used in producing different goods, it is also referred to as the **factor-proportions theory**.

To develop the factor-proportions theory we begin by describing an economy that does not trade, then ask what happens when two such economies trade with each other. Since the factor-proportions theory is both an important theory and a controversial one, the chapter concludes with a discussion of the empirical evidence for and against the theory. ●

## A MODEL OF A TWO-FACTOR ECONOMY

The simplest factor-proportions model is in many ways very similar to the specific factors model developed in Chapter 3. As in that model, it is assumed that each economy is able to produce two goods and that production of each good requires the use of two factors of production. In this case, however, we no longer assume that one of the factors used in each industry is specific to that industry. Instead, the *same* two factors are used in both sectors. This leads to a somewhat more difficult model, but also to some important new insights.

### Assumptions of the Model

The economy we are analyzing can produce two goods: cloth (measured in yards) and food (measured in calories). Production of these goods requires two inputs that are in limited supply: labor, which we measure in hours, and land, which we measure in acres. Let us define the following expressions:

- $a_{TC}$  = acres of land used to produce one yard of cloth
- $a_{LC}$  = hours of labor used to produce one yard of cloth
- $a_{TF}$  = acres of land used to produce one calorie of food
- $a_{LF}$  = hours of labor used to produce one calorie of food
- $L$  = economy's supply of labor
- $T$  = economy's supply of land

Notice that we speak in these definitions of the quantity of land or labor *used* to produce a given amount of food or cloth, rather than the amount *required* to produce that amount. The reason for this change from the Ricardian model is that in a two-factor economy there may be some room for choice in the use of inputs. A farmer, for example, may be able to grow more food per acre if he or she is willing to use more labor input to prepare the soil, weed, and so on. Thus the farmer may be able to choose to use less land and more labor per unit of output. In each sector, then, producers will face not fixed input requirements (as in the Ricardian model) but trade-offs like the one illustrated by curve *II* in Figure 4-1, which shows alternative input combinations that can be used to produce one calorie of food.

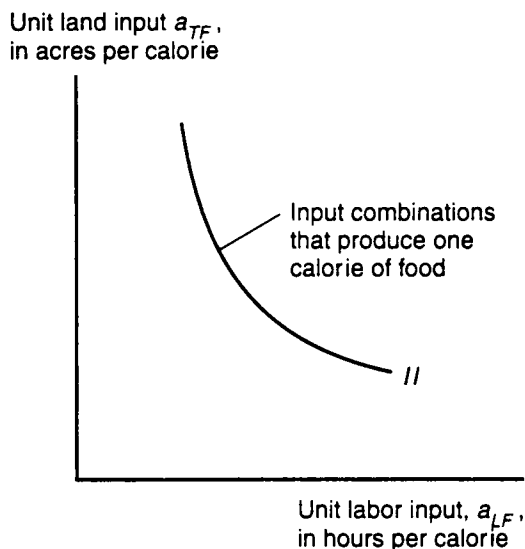
What input choice will producers actually make? It depends on the relative cost of land and labor. If land rents are high and wages low, farmers will choose to produce using relatively little land and a lot of labor; if rents are low and wages high, they will save on labor and use a lot of land. If  $w$  is the wage rate per hour of labor and  $r$  the cost of one acre of land, then the input choice will depend on the ratio of these two **factor prices**,  $w/r$ .<sup>1</sup> The relationship between factor prices and the ratio of land to labor use in production of food is shown in Figure 4-2 as the curve *FF*.

There is a corresponding relationship between  $w/r$  and the land-labor ratio in cloth production. This relationship is shown in Figure 4-2 as the curve *CC*. As drawn, *CC* lies to the left of *FF* indicating that at any given factor prices production of food will always use a higher ratio of land to labor than production of cloth. When this is true, we say that

<sup>1</sup>The optimal choice of the land-labor ratio is explored at greater length in the appendix to this chapter.

**Figure 4-1** Input Possibilities in Food Production

A farmer can produce a calorie of food with less land if he or she uses more labor, and vice versa.



production of food is *land-intensive*, while production of cloth is *labor-intensive*. Notice that the definition of intensity depends on the ratio of land to labor used in production, not the ratio of land or labor to output. Thus a good cannot be both land- and labor-intensive.

## Factor Prices and Goods Prices

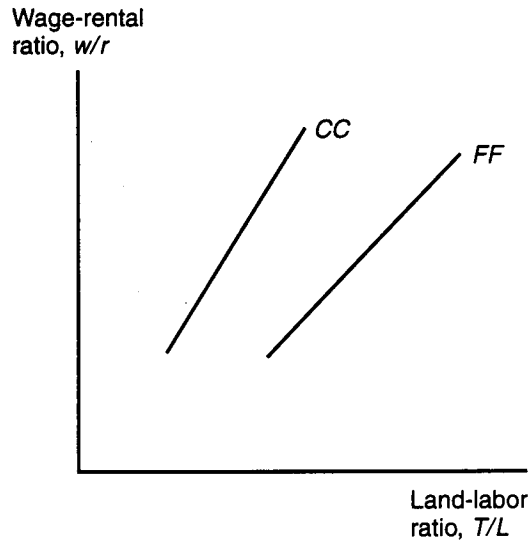
Suppose for a moment that the economy produces both cloth and food. (This need not be the case if the economy engages in international trade, because it might specialize completely in producing one good or the other; but let us temporarily ignore this possibility.) Then competition among producers in each sector will ensure that the price of each good equals its cost of production. The cost of producing a good depends on factor prices: If the rental rate on land is higher, then other things equal the price of any good whose production involves land input will also have to be higher.

The importance of a particular factor price to the cost of producing a good depends, however, on how much of that factor the good's production involves. If cloth production makes use of very little land, then a rise in the price of land will not have much effect on the price of cloth; whereas if food production uses a great deal of land, a rise in land prices will have a large effect on its price. We can therefore conclude that there is a one-to-one relationship between the ratio of the wage rate to the rental rate,  $w/r$ , and the ratio of the price of cloth to that of food,  $P_C/P_F$ . This relationship is illustrated by the upward-sloping curve  $SS$  in Figure 4-3.<sup>2</sup>

<sup>2</sup>The relationship between goods prices and factor prices was clarified in a classic paper by Wolfgang Stolper and Paul Samuelson, "Protection and Real Wages," *Review of Economic Studies* 9 (1941), pp. 58–73, and is therefore known as the *Stolper-Samuelson effect*.

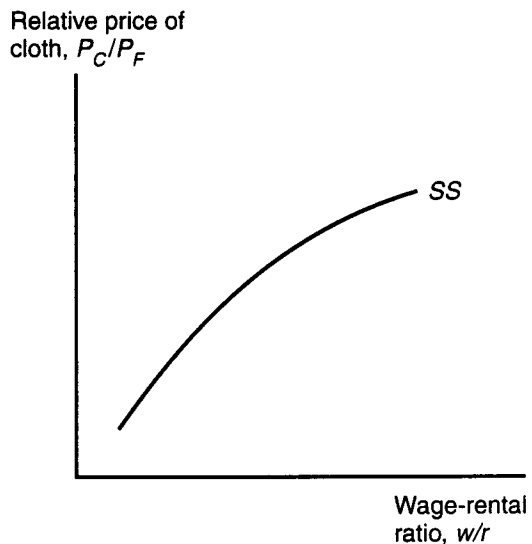
**Figure 4-2** Factor Prices and Input Choices

In each sector, the ratio of land to labor used in production depends on the cost of labor relative to the cost of land,  $w/r$ . The curve  $FF$  shows the land-labor ratio choices in food production, the curve  $CC$  the corresponding choices in cloth production. At any given wage-rental ratio, food production uses a higher land-labor ratio; when this is the case, we say that food production is *land-intensive* and that cloth production is *labor-intensive*.



**Figure 4-3** Factor Prices and Goods Prices

Because cloth production is labor-intensive while food production is land-intensive, there is a one-to-one relationship between the factor price ratio  $w/r$  and the relative price of cloth  $P_C/P_F$ ; the higher the relative cost of labor, the higher must be the relative price of the labor-intensive good. The relationship is illustrated by the curve  $SS$ .



It is possible to put Figures 4-2 and 4-3 together. In Figure 4-4, the left panel is Figure 4-3 (of the  $SS$  curve) turned on its side, while the right panel reproduces Figure 4-2. By putting these two diagrams together, we see what may seem at first to be a surprising linkage of the prices of goods to the ratio of land to labor used in the production of each good. Suppose that the relative price of cloth is  $(P_C/P_F)^1$  (left panel of Figure 4-4); if the economy produces both goods, the ratio of the wage rate to the rental rate on land must

equal  $(w/r)^1$ . This ratio then implies that the ratios of land to labor employed in the production of cloth and food must be  $(T_C/L_C)^1$  and  $(T_F/L_F)^1$ , respectively (right panel). If the relative price of cloth were to rise to the level indicated by  $(P_C/P_F)^2$ , the ratio of the wage rate to the rental rate on land would rise to  $(w/r)^2$ . Because land is now relatively cheaper the ratios of land to labor employed in the production of cloth and food would therefore rise to  $(T_C/L_C)^2$  and  $(T_F/L_F)^2$ .

We can learn one more important lesson from this diagram. The left panel already tells us that an increase in the price of cloth relative to that of food will raise the income of workers relative to that of landowners. But it is possible to make a stronger statement: Such a change in relative prices will unambiguously raise the purchasing power of workers and lower the purchasing power of landowners, by raising real wages and lowering real rents in terms of *both* goods.

How do we know this? When  $P_C/P_F$  increases, the ratio of land to labor rises in both cloth and food production. But as we saw in Chapter 3, in a competitive economy factors of production are paid their marginal product—the real wage of workers in terms of cloth is equal to the marginal productivity of labor in cloth production, and so on. When the ratio of land to labor rises in producing either good, the marginal product of labor in terms of that good increases—so workers find their real wage higher in terms of both goods. On the other hand, the marginal product of land falls in both industries, so landowners find their real income lower in terms of both goods.

In this model, then, as in the specific factors model, changes in relative prices have strong effects on income distribution. Not only does a change in goods prices change the distribution of income; it always changes it so much that owners of one factor of production gain while owners of the other are made worse off.

## Resources and Output

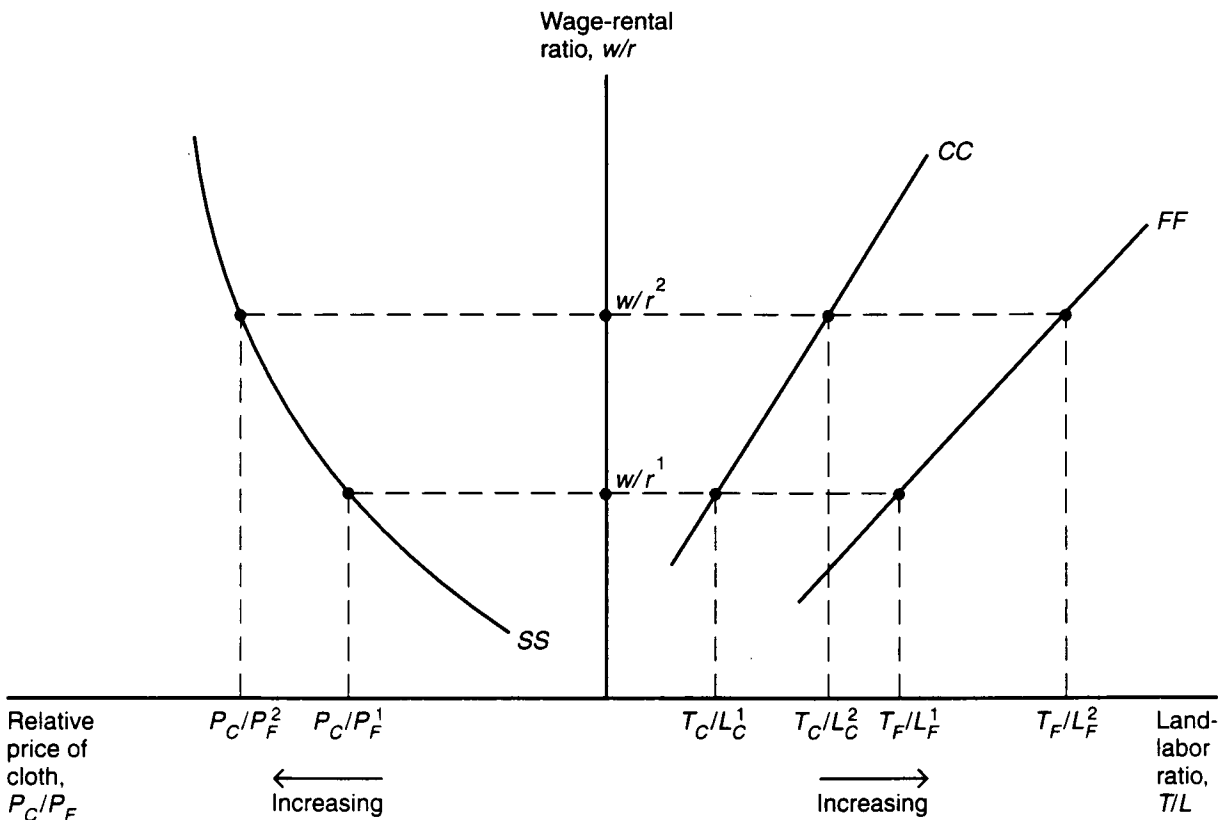
We can now complete the description of a two-factor economy by describing the relationship between goods prices, factor supplies, and output.

Suppose that we take the relative price of cloth as given. We know from Figure 4-4 that this determines the wage-rental ratio  $w/r$ , and thus the ratio of land to labor used in the production of both cloth and food. But the economy must fully employ its supplies of labor and land. It is this last condition that determines the allocation of resources between the two industries and, therefore, the economy's output.

A convenient way to analyze the allocation of resources in a two-factor economy is to use a "box diagram" like Figure 4-5. The width of the box represents the economy's total supply of labor; the height of the box its total supply of land. The allocation of resources between two industries can be represented by a single point within the box, such as point 1. We measure the use of labor and land in the cloth sector as the horizontal and vertical distances of such a point from  $O_C$ ; thus at point 1  $O_C L_C$  is the labor used in cloth production and  $O_C T_C$  is the land used in cloth production. We measure inputs into the food sector starting from the opposite corner:  $O_F L_F$  is the labor,  $O_F T_F$  the land used in food production.

How can we determine the location of this resource allocation point? From Figure 4-4 we know that given goods prices, we can determine the ratio of land to labor in cloth production,  $T_C/L_C$ . Draw a straight line from  $O_C$  whose slope equals that land-labor ratio, such as the line  $O_C C$ ; point 1 must lie on this line. Similarly, the known land-labor ratio in food production determines the slope of another line,  $O_F F$ ; point 1 must also lie on *this* line.

**Figure 4-4** From Goods Prices to Input Choices



Given the relative price of cloth  $(P_C/P_F)^1$ , the ratio of the wage rate to the rental rate on land must equal  $(w/r)^1$ . This wage-rental ratio then implies that the ratios of land to labor employed in the production of cloth and food must be  $(T_C/L_C)^1$  and  $(T_F/L_F)^1$ . If the relative price of cloth rises to  $(P_C/P_F)^2$ , the wage-rental ratio must rise to  $(w/r)^2$ . This will cause the land-labor ratio used in the production of both goods to rise.

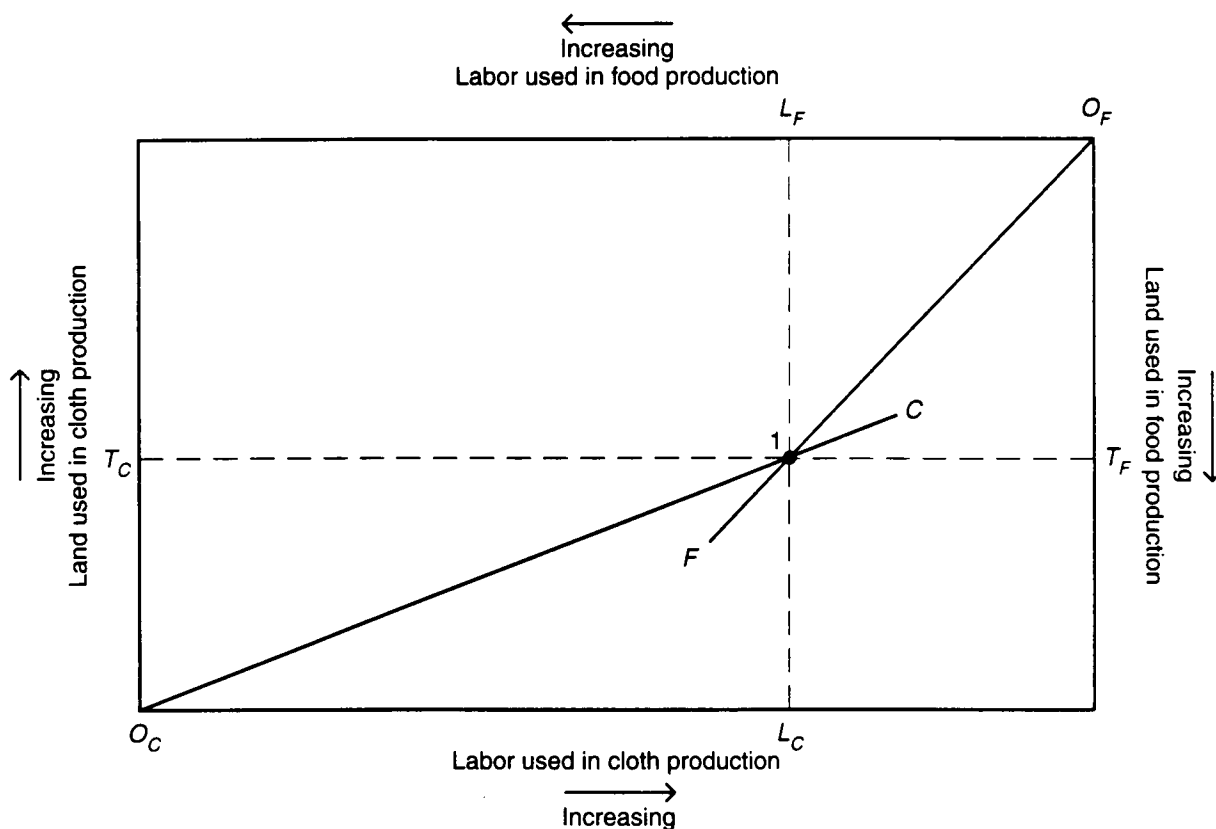
( $O_F F$  is steeper than  $O_C C$ , because, as we saw earlier, the ratio of land to labor is higher in food than in cloth production.) Thus the economy's resource allocation is identified by the point at which the two lines representing land-labor ratios cross—here, at point 1.<sup>3</sup>

Given the prices of cloth and food and the supplies of land and labor, then, it is possible to determine how much of each resource the economy devotes to the production of each good; and thus also to determine the economy's output of each good. The next question is how these outputs change when the economy's resources change.

The initially surprising answer is shown in Figure 4-6, which shows what happens when the economy's supply of land is increased, holding both goods prices and the labor supply

<sup>3</sup>Some readers may notice that  $O_C C$  and  $O_F F$  need not intersect inside the box. What happens then? The answer is that in that case the economy specializes in producing only one good, and uses all its land and labor to produce that good. Remember that the relationship between goods prices and factor prices shown in Figures 4-3 and 4-4 depends on the assumption that the economy is producing both goods.

**Figure 4-5** The Allocation of Resources

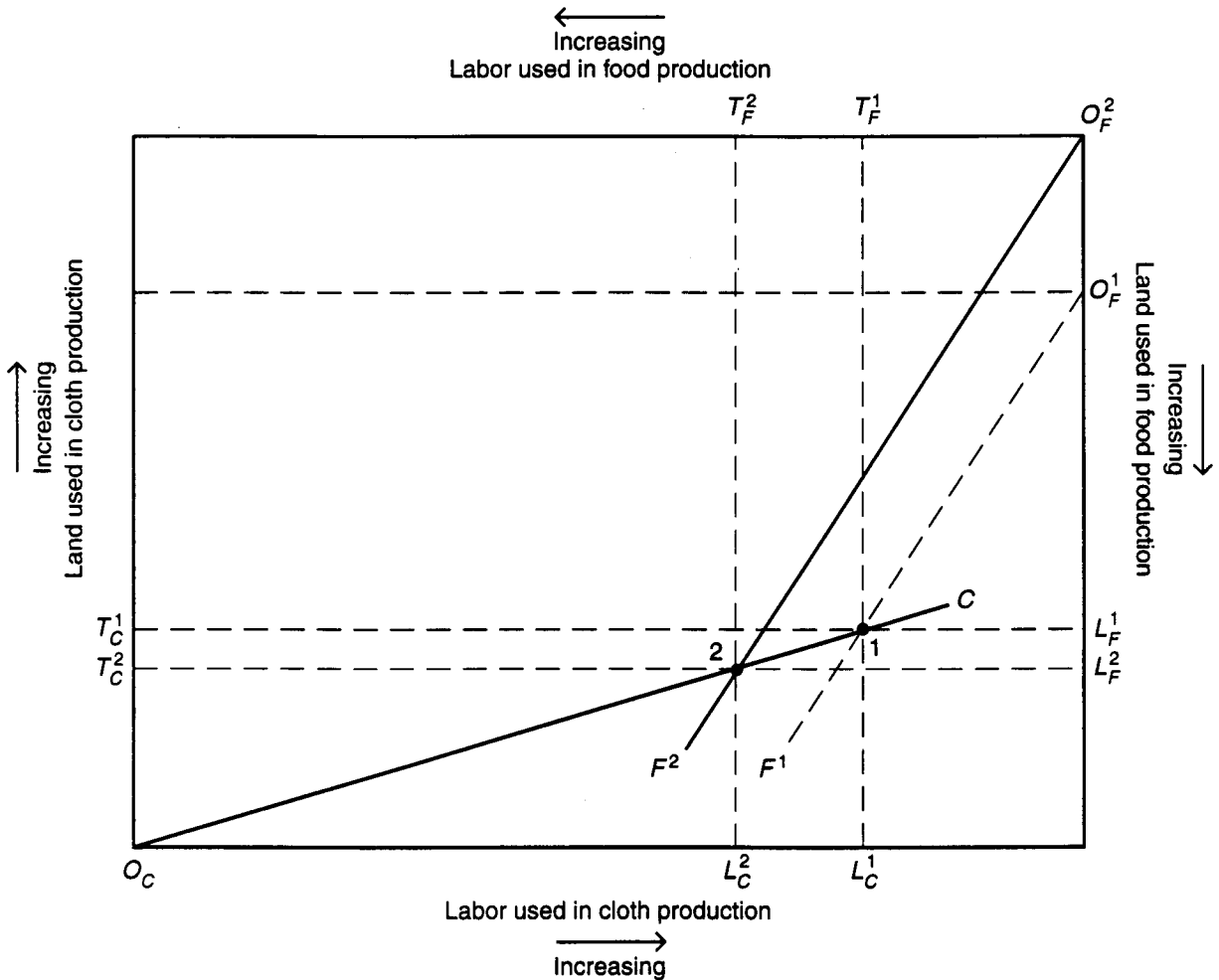


The sides of the box measure the economy's total supplies of labor (horizontal axis) and land (vertical axis). Inputs into cloth production are measured from the lower-left corner; inputs into food production from the upper-right corner. Given the land-labor ratio in cloth production,  $T_C/L_C$ , the cloth industry's employment of resources must lie on the line  $O_C C$ , which is a line drawn from the origin with the slope  $T_C/L_C$ . Similarly, the food industry's employment of resources must lie on the line  $O_F F$ . The allocation of resources can therefore be read off from point 1, where these lines intersect.

fixed. With the increased supply of land the box is taller. This means that inputs into food production can no longer be measured from  $O_F$  (now labeled  $O_F^1$ ), but must be measured from the corner of the new, enlarged box,  $O_F^2$ , and the original line  $O_F^1 F^1$  must be replaced with  $O_F^2 F^2$ . The resource allocation point must therefore move from 1 to 2.

What is surprising about this result? Notice that the quantities of labor and land used in cloth production actually *fall*, from  $L_C^1$  and  $T_C^1$  to  $L_C^2$  and  $T_C^2$ . Thus an increase in the economy's supply of land will, holding prices constant, lead to a fall in the output of the labor-intensive good. What happens to the land and labor no longer used in cloth production? It is now used in the food sector, whose output must have risen more than proportionately to the

**Figure 4-6** An Increase in the Supply of Land



An increased land supply makes the box representing the economy's resources taller; resources allocated to food production must now be measured from  $O_F^2$ . If goods prices remain unchanged, and thus factor prices and land-labor ratios remain the same, resources allocation moves from point 1 to point 2, with more land and less labor devoted to food production. The output of clothing falls, while output of food rises more than proportionately to the increase in land supply.

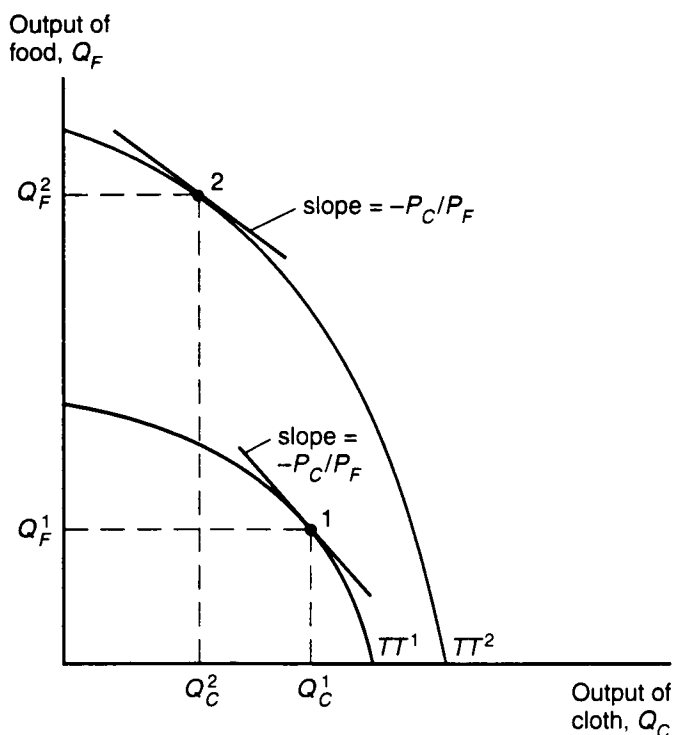
increase in land supply; for example, if land supply were to rise by 10 percent, food output might rise by 15 or 20 percent.

The best way to think about this result is in terms of how resources affect the economy's production possibilities. In Figure 4-7 the curve  $TT^1$  represents the economy's production possibilities before the increase in land supply. Output is at point 1, where the slope of the production possibility frontier equals minus the relative price of cloth,  $-P_C/P_F$ , and the



### Figure 4-7 Resources and Production Possibilities

An increase in the supply of land shifts the economy's production possibility frontier outward from  $TT^1$  to  $TT^2$ , but does so disproportionately in the direction of food production. The result is that at an unchanged relative price of cloth (indicated by the slope  $-P_C/P_F$ ), cloth production actually declines from  $Q_C^1$  to  $Q_C^2$ .



economy produces  $Q_C^1$  and  $Q_F^1$  of cloth and food. The curve  $TT^2$  shows the production possibility frontier after an increase in land supply. The production possibility frontier shifts out to  $TT^2$ , that is, the economy could produce more of both cloth and food than before. The outward shift of the frontier is, however, much larger in the direction of food than of clothing, that is, there is a **biased expansion of production possibilities** which occurs when the production possibility frontier shifts out much more in one direction than in the other. In this case, the expansion is so strongly biased toward food production that at unchanged relative prices production moves from point 1 to point 2, which involves an actual fall in cloth output from  $Q_C^1$  to  $Q_C^2$  and a large increase in food output from  $Q_F^1$  to  $Q_F^2$ .

The biased effect of increases in resources on production possibilities is the key to understanding how differences in resources give rise to international trade.<sup>4</sup> An increase in the supply of land expands production possibilities disproportionately in the direction of food production, while an increase in the supply of labor expands them disproportionately in the direction of cloth production. Thus an economy with a high ratio of land to labor will be relatively better at producing food than an economy with a low ratio of land to labor. *Generally, an economy will tend to be relatively effective at producing goods that are intensive in the factors with which the country is relatively well-endowed.*

<sup>4</sup>The biased effect of resource changes on production was pointed out in a paper by the Polish economist T. M. Rybczynski, "Factor Endowments and Relative Commodity Prices," *Economica* 22 (1955), pp. 336–341. It is therefore known as the *Rybczynski effect*.

## EFFECTS OF INTERNATIONAL TRADE BETWEEN TWO-FACTOR ECONOMIES

Having outlined the production structure of a two-factor economy, we can now look at what happens when two such economies, Home and Foreign, trade. As always, Home and Foreign are similar along many dimensions. They have the same tastes and therefore have identical relative demands for food and cloth when faced with the same relative price of the two goods. They also have the same technology: A given amount of land and labor yields the same output of either cloth or food in the two countries. The only difference between the countries is in their resources: Home has a higher ratio of labor to land than Foreign does.

### Relative Prices and the Pattern of Trade

Since Home has a higher ratio of labor to land than Foreign, Home is *labor-abundant* and Foreign is *land-abundant*. Note that abundance is defined in terms of a ratio and not in absolute quantities. If America has 80 million workers and 200 million acres (a labor-to-land ratio of one-to-two-and-a-half), while Britain has 20 million workers and 20 million acres (a labor-to-land ratio of one-to-one) we consider Britain to be labor-abundant even though it has less total labor than America. “Abundance” is always defined in relative terms, by comparing the ratio of labor to land in the two countries, so that no country is abundant in everything.

Since cloth is the labor-intensive good, Home’s production possibility frontier relative to Foreign’s is shifted out more in the direction of cloth than in the direction of food. Thus, other things equal, Home tends to produce a higher ratio of cloth to food.

Because trade leads to a convergence of relative prices, one of the other things that will be equal is the price of cloth relative to food. Because the countries differ in their factor abundances, however, for any given ratio of the price of cloth to that of food Home will produce a higher ratio of cloth to food than Foreign will: Home will have a larger *relative supply* of cloth. Home’s relative supply curve, then, lies to the right of Foreign’s.

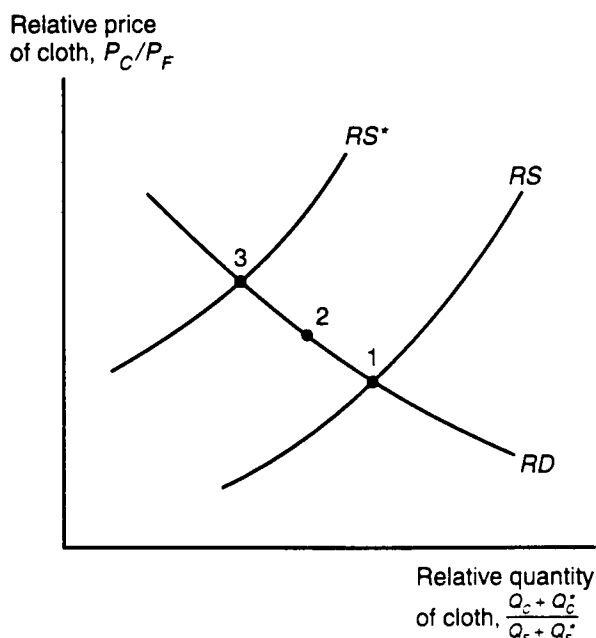
The relative supply schedules of Home ( $RS$ ) and Foreign ( $RS^*$ ) are illustrated in Figure 4-8. The relative demand curve, which we have assumed to be the same for both countries, is shown as  $RD$ . If there were no international trade, the equilibrium for Home would be at point 1, the equilibrium for Foreign at point 3. That is, in the absence of trade the relative price of cloth would be lower in Home than in Foreign.

When Home and Foreign trade with each other, their relative prices converge. The relative price of cloth rises in Home and declines in Foreign, and a new world relative price of cloth is established at a point somewhere between the pretrade relative prices, say at point 2. In Home, the rise in the relative price of cloth leads to a rise in the production of cloth and a decline in relative consumption, so Home becomes an exporter of cloth and an importer of food. Conversely, the decline in the relative price of cloth in Foreign leads it to become an importer of cloth and an exporter of food.

To sum up what we have learned about the pattern of trade: Home has a higher ratio of labor to land than Foreign; that is, Home is abundant in labor and Foreign is abundant in land. Cloth production uses a higher ratio of labor to land in its production than food; that is, cloth is labor-intensive and food is land-intensive. Home, the labor-abundant country, exports cloth, the labor-intensive good; Foreign, the land-abundant country, exports food,

**Figure 4-8** Trade Leads to a Convergence of Relative Prices

In the absence of trade, Home's equilibrium would be at point 1, where domestic relative supply  $RS$  intersects the relative demand curve  $RD$ . Similarly, Foreign's equilibrium would be at point 3. Trade leads to a world relative price that lies between the pretrade prices, e.g., at point 2.



the land-intensive good. The general statement of the result is: *Countries tend to export goods whose production is intensive in factors with which they are abundantly endowed.*

## Trade and the Distribution of Income

Trade produces a convergence of relative prices. Changes in relative prices, in turn, have strong effects on the relative earnings of labor and land. A rise in the price of cloth raises the purchasing power of labor in terms of both goods while lowering the purchasing power of land in terms of both goods. A rise in the price of food has the reverse effect. Thus international trade has a powerful effect on income distribution. In Home, where the relative price of cloth rises, people who get their income from labor gain from trade but those who derive their income from land are made worse off. In Foreign, where the relative price of cloth falls, the opposite happens: Laborers are made worse off and landowners are made better off.

The resource of which a country has a relatively large supply (labor in Home, land in Foreign) is the **abundant factor** in that country, and the resource of which it has a relatively small supply (land in Home, labor in Foreign) is the **scarce factor**. The general conclusion about the income distribution effects of international trade is: *Owners of a country's abundant factors gain from trade, but owners of a country's scarce factors lose.*

This conclusion is similar to the one reached in our analysis of the case of specific factors. There we found that factors of production that are “stuck” in an import-competing industry lose from the opening of trade. Here we find that factors of production that are used intensively by the import-competing industry are hurt by the opening of trade. As a practical matter, however, there is an important difference between these two views. The specificity of factors to particular industries is often only a temporary problem: Garment

makers cannot become computer manufacturers overnight, but given time the U.S. economy can shift its manufacturing employment from declining sectors to expanding ones. Thus income distribution effects that arise because labor and other factors of production are immobile represent a temporary, transitional problem (which is not to say that such effects are not painful to those who lose). In contrast, effects of trade on the distribution of income among land, labor, and capital are more or less permanent.

We will see shortly that the trade pattern of the United States suggests that compared with the rest of the world the United States is abundantly endowed with highly skilled labor and that low-skilled labor is correspondingly scarce. This means that international trade tends to make low-skilled workers in the United States worse off—not just temporarily, but on a sustained basis. The negative effect of trade on low-skilled workers poses a persistent political problem. Industries that use low-skilled labor intensively, such as apparel and shoes, consistently demand protection from foreign competition, and their demands attract considerable sympathy because low-skilled workers are relatively badly off to begin with.

The distinction between income distribution effects due to immobility and those due to differences in factor intensity also reveals that there is frequently a conflict between short-term and long-term interests in trade. Consider a highly skilled U.S. worker who is employed in an industry that is intensive in low-skilled labor. Her short-term interest is to restrict international trade, because she cannot instantly shift jobs. Over the long term, however, she would be better off with free trade, which will raise the income of skilled workers generally.

## Factor Price Equalization

In the absence of trade, labor would earn less in Home than in Foreign, and land would earn more. Without trade, labor-abundant Home would have a lower relative price of cloth than land-abundant Foreign, and the difference in relative prices of *goods* implies an even larger difference in the relative prices of *factors*.

When Home and Foreign trade, the relative prices of goods converge. This convergence, in turn, causes convergence of the relative prices of land and labor. Thus there is clearly a tendency toward **equalization of factor prices**. How far does this tendency go?

The surprising answer is that in the model the tendency goes all the way. International trade leads to complete equalization of factor prices. Although Home has a higher ratio of labor to land than Foreign, once they trade with each other the wage rate and the rent on land are the same in both countries. To see this, refer back to Figure 4-3, which shows that given the prices of cloth and food we can determine the wage rate and the rental rate without reference to the supplies of land and labor. If Home and Foreign face the same relative prices of cloth and food, they will also have the same factor prices.

To understand how this equalization occurs, we have to realize that when Home and Foreign trade with each other more is happening than a simple exchange of goods. In an indirect way the two countries are in effect trading factors of production. Home lets Foreign have the use of some of its abundant labor, not by selling the labor directly but by trading goods produced with a high ratio of labor to land for goods produced with a low labor-land ratio. The goods that Home sells require more labor to produce than the goods it receives in return; that is, more labor is *embodied* in Home's exports than in its imports. Thus Home exports its labor, embodied in its labor-intensive exports. Conversely, Foreign's exports embody more land than its imports, thus Foreign is indirectly exporting its land. When

**Table 4-1** Comparative International Wage Rates (United States = 100)

Country	Hourly compensation of production workers, 1997
United States	100
Germany	155
Japan	106
Spain	67
South Korea	40
Portugal	29
Mexico	10
Sri Lanka*	3

\*1996

Source: Bureau of Labor Statistics, *Foreign Labor Statistics Home Page*.

viewed this way, it is not surprising that trade leads to equalization of the two countries' factor prices.

Although this view of trade is simple and appealing, there is a major problem: In the real world factor prices are *not* equalized. For example, there is an extremely wide range of wage rates across countries (Table 4-1). While some of these differences may reflect differences in the quality of labor, they are too wide to be explained away on this basis alone.

To understand why the model doesn't give us an accurate prediction, we need to look at its assumptions. Three assumptions crucial to the prediction of factor price equalization are in reality certainly untrue. These are the assumptions that (1) both countries produce both goods; (2) technologies are the same; and (3) trade actually equalizes the prices of goods in the two countries.

1. To derive the wage and rental rates from the prices of cloth and food in Figure 4-3, we assumed that the country produced both goods. This need not, however, be the case. A country with a very high ratio of labor to land might produce only cloth, while a country with a very high ratio of land to labor might produce only food. This implies that factor price equalization occurs only if the countries involved are sufficiently similar in their relative factor endowments. (A more thorough discussion of this point is given in the appendix to this chapter.) Thus, factor prices need not be equalized between countries with radically different ratios of capital to labor or of skilled to unskilled labor.

2. The proposition that trade equalizes factor prices will not hold if countries have different technologies of production. For example, a country with superior technology might have both a higher wage rate and a higher rental rate than a country with an inferior technology. As described later in this chapter, recent work suggests that it is essential to allow for such differences in technology to reconcile the factor proportions model with actual data on world trade.

3. Finally, the proposition of complete factor price equalization depends on complete convergence of the prices of goods. In the real world, prices of goods are not fully equalized by international trade. This lack of convergence is due to both natural barriers

(such as transportation costs) and barriers to trade such as tariffs, import quotas, and other restrictions.

## CASE STUDY

### North-South Trade and Income Inequality

Between the late 1970s and the early 1990s there was a sharp increase in the inequality of wages in the United States. For example, while the real wage of male workers at the 90th percentile (i.e., those earning more than the bottom 90 percent but less than the top 10 percent) rose 15 percent between 1970 and 1989, that of workers at the 10th percentile fell by 25 percent over the same period. The growing inequality of wages in the United States has arguably worsened the country's social problems: Falling wages at the bottom have made it more difficult for families to climb out of poverty, while the contrast between stagnating incomes for many families and rapidly rising incomes at the top may have contributed to a general social and political malaise.

Why has wage inequality increased? Many observers attribute the change to the growth of world trade and in particular to the growing exports of manufactured goods from newly industrializing economies (NIEs), such as South Korea and China. Until the 1970s trade between advanced industrial nations and less-developed economies—often referred to as “North-South” trade because most advanced nations are still in the temperate zone of the Northern Hemisphere—consisted overwhelmingly of an exchange of Northern manufactures for Southern raw materials and agricultural goods, such as oil and coffee. From 1970 onward, however, former raw material exporters increasingly began to sell manufactured goods to high-wage countries like the United States. As Table 4-2 shows, manufactured exports from newly industrializing countries rose from insignificance in 1970 to almost 2 percent of the incomes of advanced nations by the early 1990s. While NIEs also provided a rapidly growing market for exports from the high-wage nations, the exports of the newly industrializing economies obviously differed greatly in factor intensity from their imports. Overwhelmingly, NIE exports to advanced nations consisted of clothing, shoes, and other relatively unsophisticated products whose production is intensive in unskilled labor, while advanced-country exports to the NIEs consisted of capital- or skill-intensive goods such as chemicals and aircraft.

**Table 4-2** Exports of Manufactured Goods from Developing Countries  
(Percent of Income in Destination)

	All Industrial Economies	European Union	United States
1970	0.24	0.22	0.28
1990	1.61	1.30	1.91

**Source:** Exports from UNCTAD, *Handbook of Trade and Development Statistics*; GDP from OECD *National Accounts Statistics*.

To many observers the conclusion seemed straightforward: What was happening was a move toward factor price equalization. Trade between advanced countries that are abundant in capital and skill and NIEs with their abundant supply of unskilled labor was raising the wages of highly skilled workers and lowering the wages of less-skilled workers in the skill- and capital-abundant countries, just as the factor proportions model predicts.

This is an argument with much more than purely academic significance. If one regards the growing inequality of income in advanced nations as a serious problem, as many people do, and if one also believes that growing world trade is the main cause of that problem, it becomes difficult to maintain the traditional support of economists for free trade. (As we pointed out in Chapter 3, in principle taxes and government payments can offset the effect of trade on income distribution, but one may argue that this is unlikely to happen in practice.) Some influential commentators have argued that advanced nations will have to restrict their trade with low-wage countries if they want to remain basically middle-class societies.

While some economists believe that growing trade with low-wage countries has been the main cause of growing inequality of income in the United States, however, most empirical workers believed at the time of writing that international trade has been at most a contributing factor to that growth, and that the main causes lie elsewhere.<sup>5</sup> This skepticism rested on four main observations.

First, although advanced countries were exporting capital-intensive goods and importing labor-intensive goods, as of the early 1990s there had been virtually no change in the distribution of income between capital and labor; the share of compensation (wages plus benefits) in U.S. national income was the same (73 percent) in 1993 as it had been in 1973. So at most the trade story could apply to a shift in the distribution of income between skilled and unskilled workers, rather than between workers and capital.

Second, the factor proportions model says that international trade affects the income distribution via a change in relative goods prices. So if international trade was the main driving force behind growing income inequality, there ought to be clear evidence of a rise in the price of skill-intensive products compared with those of unskilled-labor-intensive goods. Studies of international price data, however, failed to find clear evidence of such a change in relative prices.

Third, the model predicts that relative factor prices should converge: If wages of skilled workers are rising and those of unskilled workers falling in the skill-abundant country, the reverse should be happening in the labor-abundant country. While data on wages and income distribution in the NIEs are poor, casual observation suggested that in many countries, notably in China, the reverse was true: Income inequality was increasing at least as rapidly in the NIEs as in the advanced countries, and skilled workers were doing very well.

Fourth, although trade between advanced countries and NIEs has grown rapidly, it still constitutes only a small percentage of total spending in the advanced nations. As a result, estimates of the “factor content” of this trade—the skilled labor exported, in effect, by advanced countries embodied in skill-intensive exports, and the unskilled labor, in effect,

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<sup>5</sup>Among the important entries in the discussion of the impact of trade on income distribution have been Robert Lawrence and Matthew Slaughter, “Trade and U.S. Wages: Giant Sucking Sound or Small Hiccup?” *Brookings Papers on Economic Activity* 1:1993; Jeffrey Sachs and Howard Shatz, “Trade and Jobs in U.S. Manufacturing,” *Brookings Papers on Economic Activity* 1:1994; and Adrian Wood, *North-South Trade, Employment, and Income Inequality*, Oxford: Clarendon, 1994. For a survey of this debate and related issues, see Robert Lawrence, *Single World, Divided Nations: Globalization and OECD Labor Markets*, Paris: OECD, 1995.

imported in labor-intensive exports—are still only a small fraction of the total supplies of skilled and unskilled labor. This suggests that these trade flows cannot have had a very large impact on income distribution.

What, then, *is* responsible for the growing gap between skilled and unskilled workers in the United States? The view of the majority is that the villain is not trade but technology, which has devalued less-skilled work. The view that trade is in fact the main explanation still has a number of adherents, however.

## EMPIRICAL EVIDENCE ON THE HECKSCHER-OHLIN MODEL

Since the factor-proportions theory of trade is one of the most influential ideas in international economics, it has been the subject of extensive empirical testing.

### Testing the Heckscher-Ohlin Model

**Tests on U.S. Data.** Until recently, and to some extent even now, the United States has been a special case among countries. The United States was until a few years ago much wealthier than other countries, and U.S. workers visibly worked with more capital per person than their counterparts in other countries. Even now, although some Western European countries and Japan have caught up, the United States continues to be high on the scale of countries as ranked by capital-labor ratios.

One would expect, then, that the United States would be an exporter of capital-intensive goods and an importer of labor-intensive goods. Surprisingly, however, this was not the case in the 25 years after World War II. In a famous study published in 1953, the economist Wassily Leontief (winner of the Nobel Prize in 1973) found that U.S. exports were less capital-intensive than U.S. imports.<sup>6</sup> This result is known as the **Leontief paradox**. It is the single biggest piece of evidence against the factor-proportions theory.

Table 4-3 illustrates the Leontief paradox as well as other information about U.S. trade patterns. We compare the factors of production used to produce \$1 million worth of 1962 U.S. exports with those used to produce the same value of 1962 U.S. imports. As the first two lines in the table show, Leontief's paradox was still present in that year: U.S. exports were produced with a lower ratio of capital to labor than U.S. imports. As the rest of the table shows, however, other comparisons of imports and exports are more in line with what one might expect. The U.S. exported products that were more *skilled* labor-intensive than its imports as measured by average years of education. We also tended to export products that were "technology-intensive," requiring more scientists and engineers per unit of sales. These observations are consistent with the position of the United States as a high-skill country, with a comparative advantage in sophisticated products.

<sup>6</sup>See Leontief, "Domestic Production and Foreign Trade: The American Capital Position Re-Examined," *Proceedings of the American Philosophical Society* 97 (1953), pp. 331–349.



**Table 4-3** Factor Content of U.S. Exports and Imports for 1962

	Imports	Exports
Capital per million dollars	\$2,132,000	\$1,876,000
Labor (person-years) per million dollars	119	131
Capital-labor ratio (dollars per worker)	\$17.916	\$14.321
Average years of education per worker	9.9	10.1
Proportion of engineers and scientists in work force	0.0189	0.0255

**Source:** Robert Baldwin, "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review* 61 (March 1971), pp. 126–145.

Why, then, do we observe the Leontief paradox? No one is quite sure. A plausible explanation, however, might be the following: The United States has a special advantage in producing new products or goods made with innovative technologies such as aircraft and sophisticated computer chips. Such products may well be *less* capital-intensive than products whose technology has had time to mature and become suitable for mass production techniques. Thus the United States may be exporting goods that heavily use skilled labor and innovative entrepreneurship, while importing heavy manufactures (such as automobiles) that use large amounts of capital.<sup>7</sup>

**Tests on Global Data.** More recently, economists have attempted to test the Heckscher-Ohlin model using data for a large number of countries. An important study by Harry P. Bowen, Edward E. Leamer, and Leo Sveikauskas<sup>8</sup> was based on the idea, described earlier, that trading goods is actually an indirect way of trading factors of production. Thus if we were to calculate the factors of production embodied in a country's exports and imports, we should find that a country is a net exporter of the factors of production with which it is relatively abundantly endowed, a net importer of those with which it is relatively poorly endowed.

Table 4-4 shows one of the key tests of Bowen et al. For a sample of 27 countries and 12 factors of production, the authors calculated the ratio of each country's endowment of each factor to the world supply. They then compared these ratios with each country's share of world income. If the factor-proportions theory was right, a country would always export factors for which the factor share exceeded the income share, import factors for which it was less. In fact, for two-thirds of the factors of production, trade ran in the predicted direction less than 70 percent of the time. This result confirms the Leontief paradox on a broader level: Trade often does not run in the direction that the Heckscher-Ohlin theory predicts.

<sup>7</sup>Recent studies point to the disappearance of the Leontief paradox by the early 1970s. For example, see Robert M. Stern and Keith E. Maskus, "Determinants of the Structure of U.S. Foreign Trade, 1958–76," *Journal of International Economics* 11 (May 1981), pp. 207–224. These studies show, however, the continuing importance of human capital in explaining U.S. exports.

<sup>8</sup>See Bowen, Leamer, and Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review* 77 (December 1987), pp. 791–809.

**Table 4-4** Testing the Heckscher-Ohlin Model

Factor of Production	Predictive Success*
Capital	0.52
Labor	0.67
Professional workers	0.78
Managerial workers	0.22
Clerical workers	0.59
Sales workers	0.67
Service workers	0.67
Agricultural workers	0.63
Production workers	0.70
Arable land	0.70
Pasture land	0.52
Forest	0.70

\*Fraction of countries for which net exports of factor runs in predicted direction.

**Source:** Harry P. Bowen, Edward E. Leamer, and Leo Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review* 77 (December 1987), pp. 791–809.

**Tests on North-South Trade.** Although the overall pattern of international trade does not seem to be very well accounted for by a pure Heckscher-Ohlin model, North-South trade in manufactures seems to fit the theory much better (as our case study on North-South trade and income distribution already suggested). Consider, for example, Table 4-5, which shows some elements of the trade between the United States and South Korea.

Clearly the goods that the United States exports to South Korea are very different from those it imports in return! And it is also clear that the U.S. exports tend to be sophisticated, skill-intensive products like scientific instruments, while South Korean exports are still largely simple products like shoes. One would therefore expect that the predictions of the Heckscher-Ohlin model might look considerably better when applied to North-South trade than they do for overall international trade. And this turns out to be true in most studies.<sup>9</sup> These findings do not, however, contradict the observation that overall the Heckscher-Ohlin model does not seem to work very well, because North-South trade in manufactures accounts for only about 10 percent of total world trade.

**The Case of the Missing Trade.** In an influential recent paper, Daniel Trefler<sup>10</sup> points out a previously overlooked empirical problem with the Heckscher-Ohlin model. He notes that if one thinks about trade in goods as an indirect way of trading factors of

<sup>9</sup>See Adrian Wood, "Give Heckscher and Ohlin a Chance!" *Weltwirtschaftliches Archiv* 130 (January 1994), pp. 20–49.

<sup>10</sup>Daniel Trefler, "The case of the missing trade and other mysteries," *American Economic Review*, 85 (December 1995), pp. 1029–1046.

**Table 4-5** Trade Between the United States and South Korea, 1992 (million dollars)

Type of Product	U.S. Exports to South Korea	U.S. Imports from South Korea
Chemicals, plastics, pharmaceuticals	1340	105
Power-generating equipment	705	93
Professional and scientific instruments	512	96
Transport equipment other than road vehicles (mainly aircraft)	1531	78
Clothing and shoes	11	4203

Source: Statistical Abstract of the United States, 1994.

production, this predicts not only the direction but the volume of that trade. Factor trade in general turns out to be much smaller than the Heckscher-Ohlin model predicts.

A large part of the reason for this disparity comes from a false prediction of large-scale trade in labor between rich and poor nations. Consider the United States, on one side, and China on the other. The United States has about 25 percent of world income but only about 5 percent of the world’s workers; so a simple factor-proportions story would suggest that U.S. imports of labor embodied in trade should be huge, something like four times as large as the nation’s own labor force. In fact, calculations of the factor content of U.S. trade show only small net imports of labor. Conversely, China has less than 3 percent of world income but approximately 15 percent of the world’s workers; it therefore “should” export most of its labor via trade—but it does not.

Many trade economists now believe that this puzzle can be resolved only by dropping the Heckscher-Ohlin assumption that technologies are the same across countries. The way this resolution works is roughly as follows: if workers in the United States are much more efficient than those in China, then the “effective” labor supply in the United States is much larger compared with that of China than the raw data suggest—and hence the expected volume of trade between labor-abundant China and labor-scarce America is correspondingly less. As we pointed out earlier, technological differences across countries are also one likely explanation for the dramatic failure of factor-price equalization to hold, as documented in Table 4-1.

If one makes the working assumption that technological differences between countries take a simple multiplicative form—that is, that a given set of inputs produces only  $\delta$  times as much in China as it does in the United States, where  $\delta$  is some number less than 1—it is possible to use data on factor trade to estimate the relative efficiency of production in different countries. Table 4-6 shows Trefler’s estimates for a sample of countries; they suggest that technological differences are in fact very large.

But in any case, once we conclude that technology varies across countries, why should we assume that it is the same across all industries? Why not suppose instead that different countries have specific areas of expertise: the British are good at software, the Italians at furniture, the Americans at action movies, and so on? In that case the pattern of international trade might be determined as much by these differing technological capacities as by factor endowments.

**Table 4-6** Estimated Technological Efficiency,  
1983 (United States = 1)

Country	
Bangladesh	0.03
Thailand	0.17
Hong Kong	0.40
Japan	0.70
West Germany	0.78

Source: Trefler, *American Economic Review*, (December 1995), p. 1037.

## Implications of the Tests

The mixed results of tests of the factor-proportions theory place international economists in a difficult position. We saw in Chapter 2 that empirical evidence broadly supports the Ricardian model's prediction that countries will export goods in which their labor is especially productive. Most international economists, however, regard the Ricardian model as too limited to serve as their basic model of international trade. By contrast, the Heckscher-Ohlin model has long occupied a central place in trade theory, because it allows a simultaneous treatment of issues of income distribution and the pattern of trade. So the model that predicts trade best is too limiting for other purposes, while there is by now strong evidence against the pure Heckscher-Ohlin model.

While the Heckscher-Ohlin model has been less successful at explaining the actual patterns of international trade than one might hope, it remains vital for understanding the *effects* of trade, especially its effects on the distribution of income. Indeed, the growth of North-South trade in manufactures—a trade in which the factor intensity of the North's imports is very different from that of its exports—has brought the factor proportions approach into the center of practical debates over international trade policy.



## Summary

1. To understand the role of resources in trade we develop a model in which two goods are produced using two factors of production. The two goods differ in their *factor intensity*, that is, at any given wage-rental ratio, production of one of the goods will use a higher ratio of land to labor than production of the other.
2. As long as a country produces both goods, there is a one-to-one relationship between the relative prices of *goods* and the relative prices of *factors* used to produce the goods. A rise in the relative price of the labor-intensive good will shift the distribution of income in favor of labor, and will do so very strongly: The real wage of labor will rise in terms of both goods, while the real income of landowners will fall in terms of both goods.
3. An increase in the supply of one factor of production expands production possibilities, but in a strongly *biased* way: At unchanged relative goods prices, the output of the good intensive in that factor rises while the output of the other good actually falls.

4. A country that has a large supply of one resource relative to its supply of other resources is *abundant* in that resource. A country will tend to produce relatively more of goods that use its abundant resources intensively. The result is the basic Heckscher-Ohlin theory of trade: Countries tend to export goods that are intensive in the factors with which they are abundantly supplied.
5. Because changes in relative prices of goods have very strong effects on the relative earnings of resources, and because trade changes relative prices, international trade has strong income distribution effects. The owners of a country's abundant factors gain from trade, but the owners of scarce factors lose.
6. In an idealized model international trade would actually lead to equalization of the prices of factors such as labor and capital between countries. In reality, complete *factor price equalization* is not observed because of wide differences in resources, barriers to trade, and international differences in technology.
7. Empirical evidence is mixed on the Heckscher-Ohlin model, but most researchers do not believe that differences in resources alone can explain the pattern of world trade or world factor prices. Instead, it seems to be necessary to allow for substantial international differences in technology. Nonetheless, the Heckscher-Ohlin model is extremely useful, especially as a way to analyze the effects of trade on income distribution.

## Key Terms

abundant factor, p. 76

biased expansion of production

possibilities, p. 74

equalization of factor prices, p. 77

factor abundance, p. 66

factor intensity, p. 66

factor prices, p. 67

factor proportions theory, p. 66

Heckscher-Ohlin theory, p. 66

Leontief paradox, p. 81

scarce factor, p. 76

## Problems

1. In the United States where land is cheap, the ratio of land to labor used in cattle raising is higher than that of land used in wheat growing. But in more crowded countries, where land is expensive and labor is cheap, it is common to raise cows by using less land and more labor than Americans use to grow wheat. Can we still say that raising cattle is land intensive compared with farming wheat? Why or why not?
2. Suppose that at current factor prices cloth is produced using 20 hours of labor for each acre of land, and food is produced using only 5 hours of labor per acre of land.
  - a. Suppose that the economy's total resources are 600 hours of labor and 60 acres of land. Using a diagram determine the allocation of resources.
  - b. Now suppose that the labor supply increases first to 800, then 1000, then 1200 hours. Using a diagram like Figure 4-6, trace out the changing allocation of resources.
  - c. What would happen if the labor supply were to increase even further?
3. "The world's poorest countries cannot find anything to export. There is no resource that is abundant—certainly not capital nor land, and in small poor nations not even labor is abundant." Discuss.

4. The U.S. labor movement—which mostly represents blue-collar workers rather than professionals and highly educated workers—has traditionally favored limits on imports from less-affluent countries. Is this a shortsighted policy or a rational one in view of the interests of union members? How does the answer depend on the model of trade?
5. There is substantial inequality of wage levels between regions within the United States. For example, wages of manufacturing workers in equivalent jobs are about 20 percent lower in the Southeast than they are in the Far West. Which of the explanations of failure of factor price equalization might account for this? How is this case different from the divergence of wages between the United States and Mexico (which is geographically closer to both the U.S. Southeast and the Far West than the Southeast and Far West are to each other)?
6. Explain why the Leontief paradox and the more recent Bowen, Leamer, and Sveikauskas results reported in the text contradict the factor-proportions theory.
7. In the discussion of empirical results on the Heckscher-Ohlin model, we noted that recent work suggests that the efficiency of factors of production seems to differ internationally. Explain how this would affect the concept of factor price equalization.

## Further Reading

- Alan Deardorff. "Testing Trade Theories and Predicting Trade Flows," in Ronald W. Jones and Peter B. Kenen, eds. *Handbook of International Economics*. Vol. 1. Amsterdam: North-Holland, 1984. A survey of empirical evidence on trade theories, especially the factor-proportions theory.
- Ronald W. Jones. "Factor Proportions and the Heckscher-Ohlin Theorem." *Review of Economic Studies* 24 (1956), pp. 1–10. Extends Samuelson's 1948–1949 analysis (cited below), which focuses primarily on the relationship between trade and income distribution, into an overall model of international trade.
- Ronald W. Jones. "The Structure of Simple General Equilibrium Models." *Journal of Political Economy* 73 (1965), pp. 557–572. A restatement of the Heckscher-Ohlin-Samuelson model in terms of elegant algebra.
- Ronald W. Jones and J. Peter Neary. "The Positive Theory of International Trade," in Ronald W. Jones and Peter B. Kenen, eds. *Handbook of International Economics*. Vol. 1. Amsterdam: North-Holland, 1984. An up-to-date survey of many trade theories, including the factor-proportions theory.
- Bertil Ohlin. *Interregional and International Trade*. Cambridge: Harvard University Press, 1933. The original Ohlin book presenting the factor-proportions view of trade remains interesting—its complex and rich view of trade contrasts with the more rigorous and simplified mathematical models that followed.
- Robert Reich. *The Work of Nations*. New York: Basic Books, 1991. An influential tract that argues that the increasing integration of the United States in the world economy is widening the gap between skilled and unskilled workers.
- Paul Samuelson. "International Trade and the Equalisation of Factor Prices." *Economic Journal* 58 (1948), pp. 163–184, and "International Factor Price Equalisation Once Again." *Economic Journal* 59 (1949), pp. 181–196. The most influential formalizer of Ohlin's ideas is Paul Samuelson (again!), whose two *Economic Journal* papers on the subject are classics.



## APPENDIX TO CHAPTER 4

# FACTOR PRICES, GOODS PRICES, AND INPUT CHOICES

In the main body of this chapter we made two assertions that were true but not carefully derived. First was the assertion, embodied in Figure 4-2, that the ratio of land to labor employed in each industry depended on the wage-rental ratio  $w/r$ . Second was the assertion, embodied in Figure 4-3, that there is a one-to-one relationship between relative goods prices  $P_C/P_F$  and the wage-rental ratio. This appendix briefly demonstrates both propositions.

### Choice of Technique

Figure 4A-1 illustrates again the trade-off between labor and land input in producing one unit of food—the *unit isoquant* for food production shown in curve *II*. It also, however, illustrates a number of *isocost lines*: combinations of land and labor input that cost the same amount.

An isocost line may be constructed as follows: The cost of purchasing a given amount of labor  $L$  is  $wL$ ; the cost of renting a given amount of land  $T$  is  $rT$ . So if one is able to produce a unit of food using  $a_{LF}$  units of labor and  $a_{TF}$  units of land, the total cost of producing that unit,  $K$ , is

$$K = wa_{LF} + ra_{TF}.$$

A line showing all combinations of  $a_{LF}$  and  $a_{TF}$  with the same cost has the equation

$$a_{TF} = \frac{K}{r} - (w/r)a_{LF}.$$

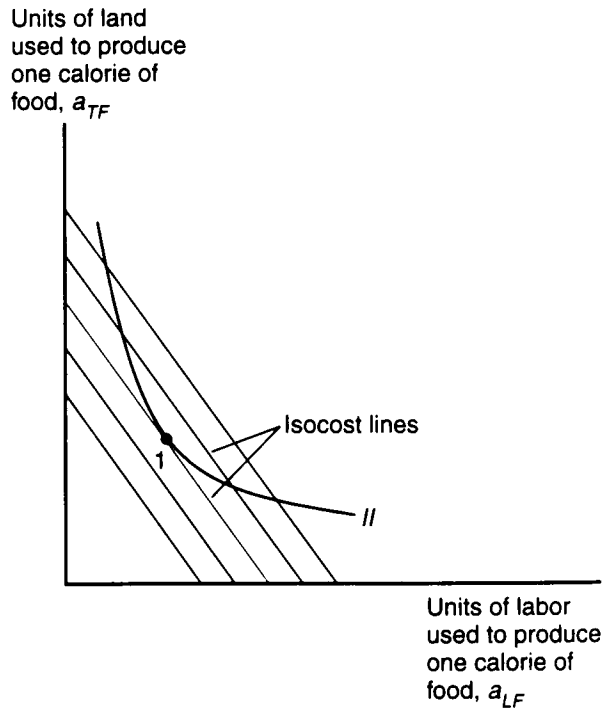
That is, it is a straight line with a slope of  $-w/r$ .

The figure shows a family of such lines, each corresponding to a different level of costs; lines further from the origin indicate higher total costs. A producer will choose the lowest possible cost given the technological trade-off outlined by curve *II*. Here, this occurs at point 1, where *II* is *tangent* to the isocost line and the slope of *II* equals  $-w/r$ . (If these results seem reminiscent of the proposition in Figure 3-5, that the economy produces at a point on the production possibility frontier whose slope equals minus  $P_C/P_F$ , you are right: The same principle is involved.)

Now compare the choice of land-labor ratio for two different factor price ratios. In Figure 4A-2 we show input choice given a low relative price of labor,  $(w/r)^1$ , and a high relative price of labor,  $(w/r)^2$ . In the former case the input choice is at 1; in the latter case at 2.

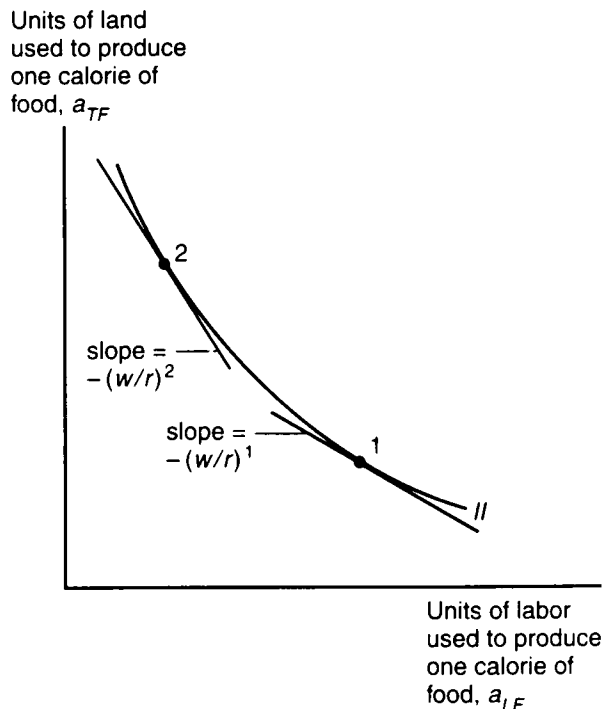
**Figure 4A-1** Choosing the Optimal Land-Labor Ratio

To minimize costs, a producer must get to the lowest possible isocost line; this means choosing the point on the unit isoquant (the curve  $II$ ) where the slope is equal to minus the wage-rental ratio  $w/r$ .



**Figure 4A-2** Changing the Wage-Rental Ratio

A rise in  $w/r$  shifts the lowest-cost input choice from point 1 to point 2, that is, it leads to the choice of a higher land-labor ratio.





That is, the higher relative price of labor leads to the choice of a higher land-labor ratio, as assumed in Figure 4-2.

## Goods Prices and Factor Prices

We now turn to the relationship between goods prices and factor prices. There are several equivalent ways of approaching this problem; here we follow the analysis introduced by Abba Lerner in the 1930s.

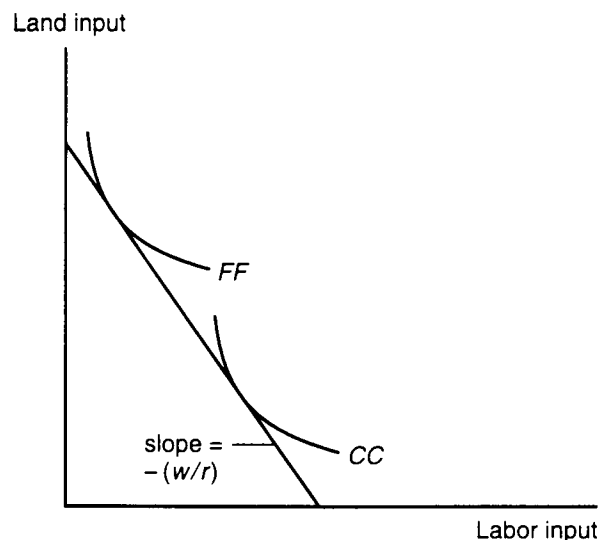
Figure 4A-3 shows land and labor inputs into both cloth and food production. In previous figures we have shown the inputs required to produce one unit of a good. In this figure, however, we show the inputs required to produce *one dollar's worth* of each good. (Actually, any dollar amount will do, as long as it is the same for both goods.) Thus the isoquant for cloth,  $CC$ , shows the possible input combinations for producing  $1/P_C$  units of cloth; the isoquant for food,  $FF$ , shows the possible combinations for producing  $1/P_F$  units of food. Notice that as drawn, food production is land-intensive: For any given  $w/r$ , food production will always use a higher land-labor ratio than cloth production.

If the economy produces both goods, then it must be the case that the cost of producing one dollar's worth of each good is, in fact, one dollar. In particular, the cost of producing one dollar's worth of both goods must be the same. This outcome is only possible, however, if the minimum-cost point of production for both goods lie on the *same* isocost line. Thus the wage-rental ratio  $w/r$  must be the slope of the line shown, which is just tangent to both isoquants.

Finally, now, consider the effects of a rise in the price of cloth on the wage-rental ratio. If the price of cloth rises, it is necessary to produce fewer yards of cloth in order to have one

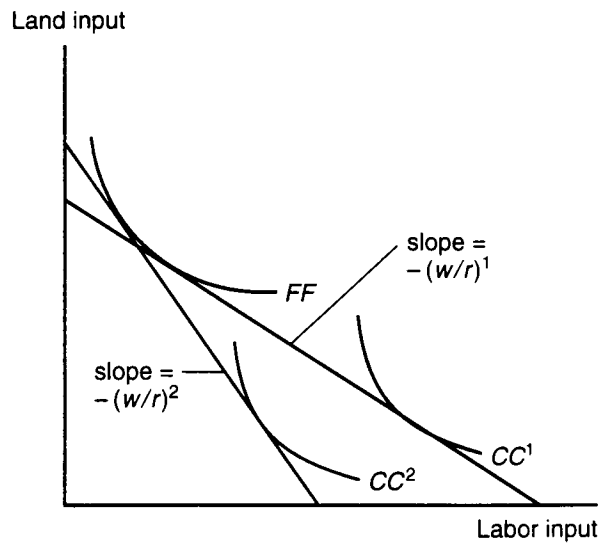
**Figure 4A-3** Determining the Wage-Rental Ratio

The two isoquants  $CC$  and  $FF$  show the inputs necessary to produce *one dollar's worth* of cloth and food, respectively. Since price must equal the cost of production, the inputs into each good must also cost one dollar; this means that the wage-rental ratio must equal minus the slope of a line tangent to both isoquants.



**Figure 4A-4** A Rise in the Price of Cloth

If the price of cloth rises, a smaller output is now worth one dollar; so  $CC^1$  is replaced by  $CC^2$ . The implied wage-rental ratio must therefore rise from  $(w/r)^1$  to  $(w/r)^2$ .



dollar's worth. Thus the isoquant corresponding to a dollar's worth of cloth shift inward. In Figure 4A-4, the original isoquant is shown as  $CC^1$ , the new isoquant as  $CC^2$ .

Once again we must draw a line that is just tangent to both isoquants; the slope of that line is minus the wage-rental ratio. It is immediately apparent from the increased steepness of the isocost line (slope =  $-(w/r)^2$ ) that the new  $w/r$  is higher than the previous one: A higher relative price of cloth implies a higher wage-rental ratio.