CHAPTER 3

Factor Endowments and the Commodity Composition of Trade

"Generally, abundant factors are relatively cheap, scanty factors are relatively dear, in each region. Commodities requiring for their production much of the former and little of the latter are exported in exchange for goods that call for factors in the opposite proportions. Thus indirectly, factors in abundant supply are exported and factors in scanty supply are imported."

Bertil Ohlin

Introduction

So far, we have shown that two countries can benefit from trade if each country specializes in the production of the good it can produce at a lower comparative cost and imports the good that would require a higher comparative cost to produce. In a world with free trade, the activities of businesses and individuals will produce these benefits for the country as a byproduct of their desire to make a profit. International trade will increase until the point that all profitable opportunities for trade are exhausted. The model developed in the previous chapter was able to produce these results.

However, the model left us with some important but unanswered questions. The model developed in this chapter addresses the following questions: What determines a country's comparative advantage? How does international trade affect the size of an economy's various industries? How does international trade affect the payments or returns to the factors of production such as labor and capital? How does international trade affect the distribution of income within a country? In answering these questions, you will learn why international trade is a major public policy issue within a country.[1]

[1] For a more extensive discussion, see Paul Krugman, "What Do Undergrads Need to Know About Trade?" *American Economic Review,* May 1993, 83(2), pp. 23–26.

Further, determining the best location to produce a particular product is one of the more challenging problems in international business. Investment in plant and equipment requires a firm to commit substantial resources over a long period of time. A production facility that is profitable in a country means the managers, who had to decide where to locate it, had an understanding of the determinants of comparative advantage for the good that is produced there. The opposite of comparative advantage is comparative disadvantage. A successful exporter has figured out which goods can be produced domestically and determined which countries have a comparative disadvantage in the production of that good. Knowledge of the basis for international trade can help a businessperson spot opportunities that others might miss. Also, without a good understanding of what determines comparative advantage, any type of long-term corporate strategy is likely to be flawed. Not only is it necessary to understand what causes comparative advantage, it is also necessary to understand how the factors influencing comparative advantage can change over time.

In the next section, the basic theory that explains the causes of comparative advantage is presented. This basic theory is then extended to explain how international trade affects the returns of factors of production and the distribution of income within a country. Once we understand the causes of comparative advantage, we then consider the situation where a factor of production cannot move from one industry to another. The final section of the chapter discusses various empirical tests of the theory. These tests are useful in expanding our understanding of the basic theory of what causes comparative advantage.

The Factor-Proportions Theory

For nearly one hundred years economists could explain trade based on comparative advantage, but they could not explain what caused comparative advantage. In the early part of the 20th century two Swedish economists, Eli Heckscher and Bertil Ohlin, explained the causes of comparative advantage. Paul Samuelson later refined their basic idea, which is referred to as the **factor-proportions theory**. The factor-proportions theory states that a country's comparative advantage is determined by its initial resource endowments.[2]

Factor-proportions theory the theory that a country's comparative advantage is based on its endowment of the factors of production.

We begin our analysis with the simplest version of the factor-proportions theory. From the research on the basic theory, we can extend it to cover many more goods and/or countries without affecting the validity of its results.[3] The next section covers the assumptions of the basic theory. These assumptions are important for two reasons. First, it is necessary to look at the theory in its most basic form in order for it to be easily understood. Second, much of what we do in the next several chapters involves changing one or more of these assumptions. As we will see, the theory is much more realistic than the basic version outlined below.

[2] The factor-proportions theory often is referred to as the factor-endowment model, the Heckscher–Ohlin theory (HO), or the Heckscher–Ohlin–Samuelson model.

[3] Some types of international trade are difficult to explain using the factor-proportions theory. These types of trade are covered in Chapter 4.

Assumptions of the Factor-Proportions Theory

We begin our explanation of the factor-proportions theory by picking up where we left off in Chapter 2. To illustrate the factor-proportions theory of trade, we will assume that:

- As before, the U.S. and India each produce two goods, machines (M) and cloth (C).
- The production and consumption of the goods occur under **perfect competition** both in the product and factor markets. This means that:
  - firms are price takers and their individual actions cannot influence conditions in their respective markets;
  - the prices of the two goods and the prices paid to the factors of production are determined by supply and demand in each market;
  - and in the long run, the prices of the goods are equal to their respective costs of production.
- There are no transportation costs, taxes on trade, or other obstructions to the free flow of goods between the two countries.
- The introduction of international trade does not cause complete specialization in the production of one of the goods in either country. Both countries will continue to produce both goods.
- Consumers in the two countries have equal tastes and preferences. This means that when the price of machines in terms of cloth is the same in the two countries, both countries will consume the same proportion of the two goods.
- Both countries are endowed with two homogeneous **factors of production**, capital (K) and labor (L); and both resources are employed in the production of the two goods.[4]
- The technology available to produce the two goods is the same in both countries, and each good is produced under constant returns to scale. **Constant returns to scale** is a production condition in which proportionate changes in the factors of production lead to proportionate changes in output. In this case, if the amount of labor and capital used to produce cloth doubles, then the output of cloth doubles.
- Labor and capital are mobile domestically. This means that within each country labor and capital can flow freely from one industry to the other. As a result, both industries within a country will pay the same wage rate and the same return to capital.
- Labor and capital cannot move between the two countries. This allows for differences in wage rates and the return to capital between the two countries. It also rules out the possibility of eliminating wage differences between countries through migration.[5]

Perfect competition the market condition where there are many buyers and sellers of a good or factor of production, with each buyer and seller having no control over the price of the good or factor.

Factors of production resource inputs used to produce goods (e.g., labor and capital).

Constant returns to scale the production condition where proportionate changes in factors of production lead to proportionate changes in output.

[4] This is sometimes called the 2-by-2-by-2 model, where each 2 refers to the number of countries, goods, and factors of production. Most conclusions generalize to higher dimensional models such as 3-by-3-by-3.

[5] Exceptions to this are sufficiently important that the implications of internationally mobile factors will be considered in Chapter 5.

TABLE 3.1
PRODUCTION CONDITIONS IN THE U.S. AND INDIA

Country	Input Requirements to Produce	
	1 Machine	10 Yards of Cloth
U.S.	10 units of capital +4 days of labor	4 units of capital +8 days of labor
India	10 units of capital +4 days of labor	4 units of capital +8 days of labor

- The production techniques available to produce machines and cloth in both countries are such that the production of machines is everywhere **capital intensive** and the production of cloth is everywhere **labor intensive**. This means the production of machines tends to use a lot of capital relative to labor or the production of machinery requires a high **capital-to-labor ratio (K/L)**. The production of cloth requires a substantial amount of labor relative to capital, or the K/L ratio for cloth is low relative to the production of machines.

  Referring to Table 3.1, the production of machines and cloth occurs using a fixed ratio of the factors of production. Notice that the production of machines in both countries requires more units of capital than units of labor. Further, the capital-to-labor, K/L, ratio for the machine industry is 2.5 (= 10/4). In both countries, the production of cloth requires more inputs of labor than capital and the cloth industry's K/L ratio is 0.5 (= 4/8). Comparing the K/L ratios, the cloth industry's K/L ratio (= 0.5) is low relative to the K/L ratio of the machine industry (= 2.5). This indicates that the production of machines in both the U.S. and India is relatively capital intensive.

- The U.S. is a relatively **capital-abundant** country and India is a relatively **labor-abundant** country. This means that the capital-to-labor ratio in the U.S. is greater than the capital-to-labor ratio in India. The important point here is not whether the U.S. has more units of capital than India, but whether the U.S. has a larger capital-to-labor ratio than India. To illustrate, the capital-to-labor ratio in the U.S. is approximately $35,993 and the capital-to-labor ratio in India is approximately $1,997.[6] In this case, the U.S. is capital abundant relative to India and India is labor abundant relative to the U.S.

Capital intensive the good is produced with a higher capital-to-labor ratio than another good.

Labor intensive the good is produced with a lower capital-to-labor ratio than another good.

Capital-to-labor ratio (K/L) the amount of capital per unit of labor used to produce a good.

Capital abundant the capital-to-labor ratio in one country is greater than the capital-to-labor ratio in another country.

Labor abundant the capital-to-labor ratio in one country is smaller than the capital-to-labor ratio in another country.

In the factor-proportions theory of international trade, the K/L ratio of a country plays an important role in determining the relative abundance of capital and labor in a country. One of the reasons this theory can explain international trade is that the various countries of the world have widely different capital-to-labor ratios. These ratios are presented in Table 3.2. The countries shown on the left side of the table are all high-income countries, and those on the right are middle- and low-income countries. The lowest K/L ratio for the group of high-income countries is over $22,000 for the U.K. On the other

[6] Both capital-to-labor ratios are measured as nonresidential capital stock per worker for 1992 and were obtained from Penn World Tables on the Internet.

TABLE 3.2
CAPITAL STOCK PER WORKER OF SELECTED COUNTRIES IN 1992 (IN 1985 INTERNATIONAL DOLLAR PRICES)

High-Income Country	Capital-to-Labor Ratio	Middle- and Low-Income Country	Capital-to-Labor Ratio
Switzerland	$76,733	Mexico	$13,697
Canada	44,970	Poland	11,811
Japan	41,286	Chile	11,306
Australia	38,729	Turkey	7,626
France	37,460	Thailand	5,853
U.S.	35,993	Philippines	3,598
Netherlands	34,084	India	1,997
Italy	33,775	Kenya	822
Spain	30,888	Nigeria	735
U.K.	22,509		

Source: Penn World Tables, 5.6 (dc2.chass.utoronto.ca/pwt/)

hand, the highest K/L ratio for a middle- to low-income country is a little over $13,000. The K/L ratios for Kenya and Nigeria are less than $1,000. Our point is that some countries are relatively capital abundant or relatively labor abundant. These substantial differences among countries serve to make the theory of comparative advantage much more realistic.

THE FACTOR-PROPORTIONS THEOREM

Given our assumptions, we can explain what determines a country's comparative advantage. We assumed consumers in the U.S. and India have equal demand conditions for machines and cloth. Because of this assumption, the supply of resources, as reflected by each country's resource endowments, will be the sole determinant of factor prices. This means that before the U.S. and India trade with one another, capital would be relatively less expensive in the capital-abundant country, and labor would be relatively less expensive in the labor-abundant country. In the U.S., capital would be relatively cheap and labor would be expensive. The reverse would be true for India, capital would be relatively expensive and labor would be cheap. This would be reflected in the ratio of the payment made to labor—wages—and the payment made to capital—which economists call rent. In this case, the ratio is higher in the U.S. than in India. This can be seen in the following relationship:

$$\left[\frac{\text{Wages in U.S.}}{\text{Rent in U.S.}}\right] > \left[\frac{\text{Wages in India}}{\text{Rent in India}}\right]$$

Because the wage-rent ratios are different, a country will have a lower opportunity cost of production in goods where the production technique requires greater quantities of the abun-

dant factor and smaller quantities of the scarce factor. In our example, the U.S. will have a lower opportunity cost in goods produced using more capital and less labor. India's opportunity cost will be lower in goods produced using more labor and less capital. This leads to the following two important conclusions concerning the U.S. and India.

- The U.S. has a comparative advantage in the production of machines because the production of machines is capital intensive and the U.S. has an abundance of capital.
- India has a comparative advantage in the production of cloth because the production of cloth is labor intensive and India has an abundance of labor.

The abundance of a particular factor of production in a country tends to make that factor less expensive relative to the cost of that same factor in other countries. Given this, a country will tend to produce and export goods that intensively use their less expensive factor of production. The **factor-proportions theorem** can be expressed in the following way.

> A country will have a comparative advantage in goods whose production intensively uses its relatively abundant factor of production. A country will have a comparative disadvantage in goods whose production intensively uses its relatively scarce factor of production.

Factor-proportions theorem the premise that a country will have a comparative advantage and export goods whose production intensively uses its relatively abundant factor of production.

This is one of the most powerful statements in international economics. If you examine the U.S. pattern of trade, much of what the U.S. imports are goods from countries where labor is abundant relative to capital. The reverse also is true. Much of what the U.S. exports are capital-intensive goods. We have reached this conclusion using a simplified model with only two countries, two goods, and two factors of production, but these results can be generalized into many factors and many goods.

This theory provides an explanation of what determines a country's comparative advantage, but keep in mind the other side of the coin, comparative disadvantage. A country will have a comparative disadvantage in the production of goods that intensively uses its scarce factor of production. We usually focus on a country's comparative advantage. However, comparative disadvantage is just as important in generating the gains from trade. Remember: the gains from trade are realized when a country exports goods based on its comparative advantage and imports goods based on its comparative disadvantage.[7]

Factor-Price Equalization and the Distribution of Income

The premise of the factor-proportions theory is that comparative advantage and international trade occur because countries are endowed with different factor proportions. Employing the results of the theory, we also can illustrate several other phenomena associated with international trade. For example, what happens to the relative size of industries as an

[7] For a more thorough explanation of the factor-proportions theory and factor-price equalization, see Appendix 3.1.

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U.S.–China Trade If we compare the resource endowments of the U.S. to China, we find that the U.S. possesses abundant skilled labor (human capital) and scarce unskilled labor. China possesses abundant unskilled labor and scarce skilled labor. Thus, the factor-proportions theory would predict that the U.S. has a comparative advantage and should export goods that intensively use skilled labor in its production, and that China has a comparative advantage and should export goods that intensively use unskilled labor in its production.

Table 3.3 shows the results of a recent study that tested this prediction based on U.S.–China trade in 1990. In this study, the authors divided a sample of 131 industries into 10 groups based on their skill intensity. Group 1 industries embodied the most skill intensive, and group 10 industries the least skill intensive. This table provides sample industries for each group and the group's share of U.S. exports to China, and China's exports to the U.S.

Notice that the pattern of U.S.–China trade shown in Table 3.3 fits the prediction of the factor-proportions theory well. U.S. exports to China are concentrated in the high-skilled industries, as industry groups 1 through 3 account for 78 percent of U.S. exports to China. Also, China's exports to the U.S. are concentrated in the least-skilled industries. Industry groups 9 and 10 account for more than 40 percent of China's exports to the U.S.

TABLE 3.3

THE FACTOR-PROPORTIONS THEORY AND U.S.–CHINA TRADE

Skill Group	Industry Examples	Percent of Chinese Exports to the United States	Percent of U.S. Exports to China
Most Skilled			
1	Periodical, office and computing machines	4.8%	7.7%
2	Aircraft and parts, industrial inorganic chemicals	2.6	48.8
3	Engines and turbines, fats and oils	3.9	21.3
4	Concrete, nonelectric plumbing and heating	11.5	4.3
5	Watches, clocks, toys, sporting goods	18.9	6.3
6	Wood buildings, blast furnaces, basic steel	8.2	1.3
7	Ship building and repair, furniture and fixtures	4.1	2.8
8	Cigarettes, motor vehicles, iron and steel foundries	5.2	1.8
9	Weaving, wool, leather tanning and finishing	17.2	0.4
10	Children's outerwear, nonrubber footwear	23.5	5.2
Least Skilled			

Source: Jeffery Sachs and Howard Shatz, "Trade and Jobs in U.S. Manufacturing," *Brookings Papers on Economic Activity,* 1, 1994, pp. 18–53.

economy moves from autarky to free trade? What happens to the payments or returns to factors of production such as labor and capital within an economy? What is the relationship between international trade and the distribution of income within a country?

Factor-Price Equalization

In Chapter 2, we described how free trade equalizes the price of cloth and machines in both countries at the same terms of trade. Within the factor-proportions theory, this adjustment to free trade produces a very interesting result known as the **factor-price equalization theorem**. This theorem states that when international trade occurs between two countries based on different factor proportions, not only will free trade equalize the price of the traded goods but also the relative factor prices in the two countries will tend to converge. The changes in the relative factor prices will occur over a period of years or decades. Such changes have long-run implications for businesses that want to exploit short-run differences in the costs of production between countries.

Factor-price equalization theorem the premise that international trade will reduce or equalize factor prices between countries.

To illustrate the factor-price equalization theorem, we return to our previous example. The U.S. has a comparative advantage in capital-intensive machine production because it is a capital-abundant country, and India has a comparative advantage in labor-intensive cloth production because it is a labor-abundant country. As trade opens up between the U.S. and India, the price of cloth and machines in the U.S. and India equalize as both countries trade at the same terms of trade. Because each country will specialize their production in their comparative advantage good, the size of the machine and cloth industries in each country will change as each country moves along its production possibilities frontier.

For the U.S., machine production expands and cloth production contracts as international trade allows the U.S. to specialize in the production of machines. For India, machine production contracts and cloth production expands as international trade allows India to specialize in the production of cloth. This change in machine and cloth production within each country changes each country's **industrial structure**. Industrial structure refers to the percentage of output accounted for by each industry within a country. Without any trade, both the U.S. and India would have a certain percentage of their total industrial capacity devoted to producing machines and cloth. By allowing international trade, each country specializes its production and changes the percentage of its production that is allocated to produce machines and cloth.

Industrial structure the percentage of output that is accounted for by each industry within a country.

With international trade, the U.S. machine industry experiences an increase in demand for its output as the industry will not only have to supply the U.S. market but also will be supplying—exporting to—India. As a result, the price of machines rises relative to the price of cloth. The U.S. machine industry expands its production to meet this increase in demand. To expand production, the machine industry requires more resources, meaning more capital and more labor. This expansion requires a greater increase in capital relative to the increase in labor because machine production is capital intensive. Assuming the economy is at full employment, the additional resources the machine industry needs will come from the cloth industry.

As trade opens up, the U.S. cloth industry experiences a decrease in demand for its output, and the price of cloth declines relative to the price of machines. The cloth industry produces less cloth as imports from India replace domestic production. As the cloth industry contracts, it uses less capital and less labor. This contraction releases more labor relative to the release of

capital because cloth production is labor intensive. However, this shift of capital and labor from one industry to another is not a perfect fit. The expanding machine industry is capital intensive. To expand, this industry needs a lot of capital and only a little more labor. On the other hand, the contracting cloth industry is releasing a lot of labor and only a little more capital.

Refer to the production conditions shown in Table 3.1. As the cloth industry contracts, it releases 4 units of capital and 8 days of labor. The expanding machine industry requires 10 units of capital and 4 days of labor. In this case, the 4 units of capital supplied is less than the 10 units of capital demanded. The result is a shortage of capital, and the price paid to capital (rent) rises. The opposite occurs in the labor market where the 8 days of labor supplied is greater than the 4 days of labor demanded. The result is a surplus of labor, and the price paid to labor (wages) falls. Given these conditions, the relative price of the factors of production (the ratio of wages to rent) decreases. The introduction of international trade sets in motion market forces that cause a change in the relative price of machines in terms of cloth. The changes in the prices of the two goods cause changes in the industrial structure of the U.S. In turn, this change in the industrial structure causes changes in the prices paid to the factors of production.

A similar situation occurs in India where the introduction of trade leads to an increase in the price of cloth relative to machines. The change in the price of cloth relative to machines causes changes in India's industrial structure. In India, the production of cloth expands and the production of machines contracts. This change in India's industrial structure causes the price paid to the abundant factor in India (labor) to increase and the price paid to the scarce factor (capital) to decrease. As a result, the relative price of the factors of production (wages/rent) in India increases.

In the U.S., labor becomes less costly and in India, labor becomes more expensive. The difference in the price of labor between the two countries narrows. The same thing is happening with respect to capital. In the U.S., the price paid to capital increases and in India, it decreases. The difference in the price of capital in the two countries also narrows with trade. Would the price of each factor of production in the U.S. ever reach perfect equality with the price of the corresponding factor in India? Under the very strict assumptions of the factor-proportions theorem, the answer is yes. However, under practical conditions, the answer is no. Absolute factor-price equalization may not occur for a variety of reasons. Among these reasons are less than perfectly competitive conditions in the product and factor markets; differences in technology; or the existence of transportation costs or trade barriers. Nevertheless, we can view the factor-price equalization theorem as a consistent tendency. This is true because international trade puts market forces in motion that tend to move relative factor prices in the two countries closer together in the long run. They may never reach perfect equality, but the direction of change in relative factor prices is clear.

The factor-price equalization theorem also has important implications for multinational corporations. Companies located in countries where labor is relatively expensive could profit by importing products from companies located in countries where labor is relatively less expensive. A multinational corporation might also consider building a plant in a relatively low-wage country if profits are potentially higher from products produced in a foreign plant than buying the products from a foreign company. However, investment in plant and equipment is a long-run investment that might last 20 to 30 years. If the multinational corporation assumes that the labor-cost differential between countries that exists today will persist in

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Changes in the K/L Ratio Over Time: South Korea and India A country's K/L ratio can change over time as its factor endowments change. For example, a country that is labor abundant today may not be a labor-abundant country in 20 or 30 years. South Korea is a good example of a country changing its factor endowments. Some basic data on the South Korean economy are given in Table 3.4. In the mid 1960s, the capital stock per worker in South Korea was a bit more than $2,000. By the early 1990s, it was nearly $18,000. Given that Korean-produced goods can be found in almost every U.S. store, this should not be too surprising. Less than 40 years ago, South Korea was a very poor developing country. GDP per capita at the end of the Korean War was less than $800. In less than 40 years, GDP per capita had increased to $7,235. Some of this progress can be attributed to the relative openness of the Korean economy. In the early 1950s, exports plus imports as a percentage of GDP were a little more than 10 percent. By 1990, they were more than 60 percent.

India is a good study in contrast. In the 1950s, India's GDP per capita was only slightly lower than South Korea's. India, like South Korea, was a labor-abundant country with a low capital stock per worker, as evidenced in Table 3.4. The level of openness in the two economies was also similar in the early 1950s. Today, India is still a poor, labor-abundant economy for many reasons. But at least part of the story can be found by contrasting the rates at which the two economies opened themselves up to trade over the last 40 years.

TABLE 3.4

ECONOMIC DATA FOR SOUTH KOREA AND INDIA

	South Korea		India	
Economic Variable	Year	Value	Year	Value
GDP per capita	1953	$796	1953	$641
	1962	928	1962	760
	1972	1,841	1972	786
	1982	3,395	1982	936
	1991	7,251	1991	1,251
Capital/worker	1965	2,093	1965	786
	1975	6,533	1975	1,259
	1985	12,036	1985	1,712
	1992	17,995	1992	1,997
Degree of openness [(Export + Imports)/GDP]	1953	11.8%	1953	10.4%
	1962	22.1	1962	11.2
	1972	44.5	1972	8.8
	1982	71.5	1982	14.5
	1990	62.5	1992	21.4

Source: Penn World Tables, 5.6 (dc2.chass.utoronto.ca/pwt/)

the long run, it might be partially wrong. At minimum, the relative labor-cost differential would tend to narrow over time and affect the potential profitability of the investment. Factor-price equalization is another factor that multinational corporations need to consider when making long-run investment decisions in a global marketplace.

Trade and the Distribution of Income

We have just explained how international trade changes the prices paid to the factors of production in the two trading countries. We showed that the price paid to the abundant factor of production would rise and the price paid to the scarce factor of production would fall within a country. These factor-price results have significant implications regarding the effects of international trade on a country's distribution of income.

In our example, as trade opens up, the price paid to capital (the abundant factor) in the U.S. would rise, and the price paid to labor (the scarce factor) in the U.S. would fall. In India, the price paid to labor (the abundant factor) would rise, and the price paid to capital (the scarce factor) would fall. Carrying this analysis one step further produces an interesting result. Because we assume that labor and capital remain fully employed both before and after trade, the real income of both labor and capital will move in the same direction as the factor-price movements.

In our example, the percentage of national income that capital receives would increase in the U.S., and the percentage of national income that labor receives would decrease. For India, the percentage of national income that capital receives would fall, and the percentage of income that labor receives would increase. The result is that international trade has discernible effects on the distribution of income within a trading country. Specifically, the abundant factor tends to receive a larger share of the income pie, and the scarce factor tends to receive a smaller share of the income pie. This effect is called the **Stolper-Samuelson theorem**.

Stolper-Samuelson theorem the premise that international trade will reduce the income of the scarce factor of production and increase the income of the abundant factor of production within a country.

International trade enhances a country's total welfare, but the gains from trade are not necessarily equally distributed among the factors of production. In many cases, the changes in the distribution of income may be very subtle in the sense that the incomes of the abundant factor may be growing faster over time than the incomes of the scarce factor. The main point is that international trade has the potential to change the distribution of income among the various factors of production in a predictable way. The same type of change would occur in India. As trade opens up, the abundant factor's income would tend to rise and the scarce factor's income would tend to fall. Labor in India would receive a larger percentage of national income and capital would receive a smaller percentage.

These effects of international trade on factor prices have implications for the world economy. In developed countries, the relatively abundant factor of production is capital and the scarce factor is unskilled labor. As a result, the potential gainers from free trade are the owners of capital with above average incomes, and the losers are unskilled labor with the lowest incomes. For the developing countries, international trade tends to increase the incomes of the relatively abundant factor, labor. In this case, trade has the prospect of reducing the poverty prevalent in many of these countries by increasing wages. We will return to these issues in later chapters. For now, keep in mind that although international trade improves the welfare of the trading countries, the benefits are not necessarily distributed evenly and may lead to absolute or relative losses for some segments of society.

These results are based on the assumption that the factors of production are mobile between industries within a country. Although a factor may be mobile in the long run, in the short run, factors may not be able to move from one industry to another within a country. If factors of production are not mobile, then our analysis needs to be modified. Because this situation is not uncommon, the next section of the chapter considers how the immobility of factors of production affects our results.

PASSPORT

Trade Adjustment Assistance If the U.S. has a comparative disadvantage in the production of products that intensively use (unskilled or semiskilled) labor, then imports of labor-intensive products will cause labor in the U.S. to suffer losses of income even though the economy as a whole gains from trade. The abundant factor gains and the scarce factor loses. Paul Samuelson developed one possible solution to this income-redistribution effect in the 1960s. He concluded that the U.S. gains from trade were large enough that society could "bribe" the losers into accepting their losses and still have money left over.[8]

In the U.S., such a system known as Trade Adjustment Assistance (TAA) is actually in place. TAA was created under the Trade Act of 1962. Under this legislation, workers who lost jobs caused by trade liberalization were entitled to compensation. The Trade Act of 1974 greatly liberalized the program. Under this act's new rules, displaced workers could qualify for compensation if import competition caused the job loss. Under the liberalized rules, it was easier to be certified as a worker who was displaced by import competition. Certified displaced workers were then entitled to receive extended unemployment compensation and special training benefits. During 2003, the U.S. government spent $570 million on this program. Given the benefits of imports and the modest cost, the program seemed a bargain.

However, recent research casts some doubt on the program's economic necessity.[9] TAA is by nature discriminatory—workers who lose their jobs due to import competition become eligible for benefits in excess of what is available to other workers who lose their jobs due to other economic conditions. For example, if your firm closes due to competition from a more efficient domestic competitor, you are out of luck! Similarly, if the industry you work in is in long-run decline, then TAA becomes available only if increased imports also are associated with this decline. Indeed, Robert Lawrence has found that is often the case.[10] It is not surprising that Clark, et al. found that there are no significant differences in employment outcomes between workers in manufacturing industries who lost their jobs due to import competition or workers who lost their jobs for other reasons. TAA may be a political necessity, but it does not appear to be an economic necessity.

[8] See Paul Samuelson, "The Gains from International Trade Once Again," *Economic Journal,* 1962, 72, pp. 820–29.

[9] See Don P. Clark, Henry W. Herzog Jr., and Alan M. Schlottmann, "Import Competition, Employment Risk, and the Job-Search Outcomes of Trade-Displaced Manufacturing Workers," *Industrial Relations,* April 1998, 37(2), pp. 182–205.

[10] See Robert Z. Lawrence, *Can America Compete?,* Washington, D.C.: The Brookings Institution, 1984.

The Specific-Factors Model

The factor-proportions theory assumes that labor and capital can move from one industry to another industry in the same economy. In our example, if the machine industry expanded in the U.S., the capital and labor needed for this expansion would come from the cloth industry. This movement of resources is a realistic assumption in the long run, as labor and capital used in the cloth industry could move to the machine industry.

However, in the short run, moving labor between industries may require some length of time as workers might need to acquire new or different skills. In a large country such as the U.S., this movement of labor may also require workers to relocate to another part of the country. Although not impossible, these work force adjustments take time. Moving capital from one industry in the economy to another industry also may be even more difficult. For example, capital equipment designed to produce machines may not be easily adapted to produce cloth. In the long run, reallocating capital from the cloth industry to the

machine industry may mean expanding capital in the machine industry only as existing capital in the cloth industry wears out. In this way, new capital investment over time would eventually reallocate the capital between the two industries. Factor mobility between industries is realistic in the long run, but in the short run, factors of production may be somewhat immobile.

With imperfect factor mobility between industries, the gains and losses resulting from trade to the factors of production need to be modified. To examine why the payments received by the factors of production depend on the mobility of the factors of production, we return to our example. Assume that there are three factors of production: capital used to produce machines, capital used to produce cloth, and labor that can be used to produce both machines and cloth. Capital in this case is called a **specific factor** because its use is specific to either the production of machines or the production of cloth and cannot move between industries. Labor is called a variable or **mobile factor** because over time it can move between machine production and cloth production.

Specific factor a factor of production that is specific to an industry or is immobile between industries.

Mobile factor a factor of production that can move between industries or is mobile between industries.

Remember, when trade opens up between the U.S. and India, the machine industry expands and the cloth industry contracts in the U.S. Initially, if all factors of production are immobile, as the cloth industry contracts, both capital and labor in this industry suffer losses as employment contracts and factories are shut down. In the expanding machine industry, both labor and capital benefit as employment and profits increase. In fact, these initial industry-specific effects often dominate the political debate over trade policy within a country.

Now, suppose that labor can move between industries and capital is immobile between industries. Point E in Figure 3.1 illustrates the before-trade equilibrium for the U.S. In the figure, the total supply of labor in the U.S. is shown along the horizontal axis. The amount of labor employed in the machine industry is measured from O rightward along the axis, and the amount of labor employed in the cloth industry is measured from O′

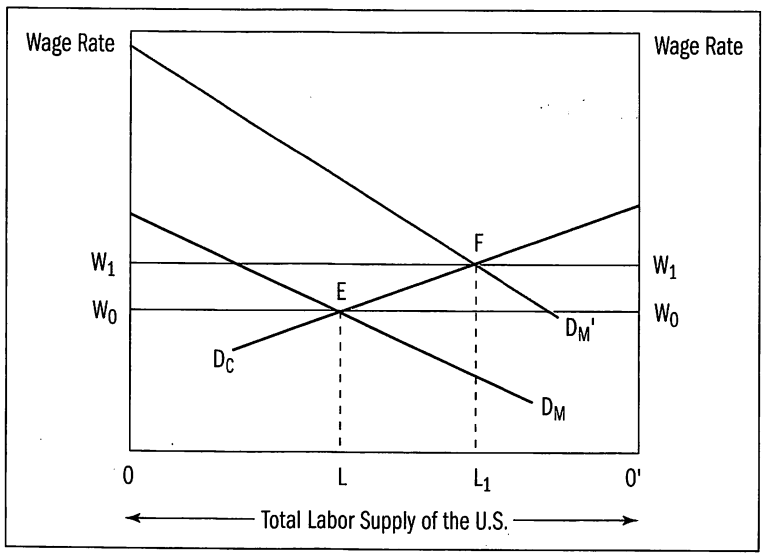

Figure 3.1
Specific Factors Model
With the specific-factors model, as the demand for labor in the machine industry increases, the wage rate rises and workers move from the cloth industry to the machine industry.

leftward along the axis. In each industry, labor is combined with a fixed amount of specific capital to produce either cloth or machines. Under these conditions, labor is subject to diminishing returns in each industry. This means that the demand for labor in each industry is downward sloping and is equal to the value of the marginal product of labor.[11] The machine industry's demand for labor is represented by D_M, and the cloth industry's demand for labor is represented by D_C. (The cloth industry's demand for labor is measured leftward from O'.) By assuming that labor is mobile between industries, both the machine industry and the cloth industry will pay the same wage rate, W_0. This equilibrium occurs at the intersection of the two demand curves at point E. At this point, OL workers are employed in the machine industry and O'L workers are employed in the cloth industry.

When trade opens up between the U.S. and India, machine prices increase in the U.S., causing the demand for labor in the machine industry to increase to D_M'.[12] As a result, the new equilibrium is at point F. Employment in the machine industry increases to OL_1 as machine production expands, and employment decreases in the cloth industry to $O'L_1$ as cloth production declines. In addition, the wage rate paid in both industries increases from W_0 to W_1.

The owners of the specific capital used to produce machines continue to benefit as the industry expands production. The owners of the specific capital used to produce cloth lose as production contracts. The effect on the mobile factor, labor, is indeterminate as the price of machines has increased by more than the increase in wages. Because of trade, U.S. labor faces higher machine prices and lower cloth prices. Whether workers are better or worse off depends on their consumption pattern. If labor consumes more machines than cloth, labor will be worse off as their real wage has decreased. If the reverse is true, labor will be better off. The mobile factor, in this case labor, may gain or lose depending on its consumption pattern.

The results arising from the existence of specific factors are short-run effects. These short-run effects will diminish over time as factors of production move into the industry that has a comparative advantage. In the long run, the abundant factor of production (capital in the U.S.) gains, and the scarce factor of production (labor in the U.S.) loses. The difference is that some owners of sector-specific factors experience gains (owners of capital used to produce machines) or losses (owners of capital used to produce cloth) in the short run. Even with the existence of specific factors, the economy as a whole still gains from trade.

The existence of specific factors can help explain why some groups resist free trade. In general, owners of the abundant factor of production in a country should be in favor of freer international trade, whereas owners of the scarce factor of production would favor trade restrictions. With specific factors of production, both capital and labor in the industry with a comparative disadvantage suffer losses and may well resist free trade.

[11] The value of the marginal product of labor is equal to the price of the product times the marginal product of labor.

[12] We illustrate the impact of trade on the labor market within the U.S. by allowing the price of machines to increase while the price of cloth has remained constant.

PASSPORT

Patterns in U.S. Trade Each month the U.S. Department of Commerce publishes data on the value of U.S. exports and imports in a number of broad categories. In addition, these government statistics record the distribution of U.S. trade among trading partners. Here we summarize the trade of the U.S. in 2002 in terms of types and goods and destinations and sources of exports and imports.

Figure 3.2 depicts U.S. export and import shares by destination for 2002. In addition, the top data in Table 3.5 shows U.S. exports by destination and commodity group. In 2002, the majority of U.S. exports went to Western Europe, Canada, Asia (excluding Japan), Latin America, and Mexico. Overall, this data suggest that the U.S. exports mainly to other developed countries. In addition, U.S. exports are concentrated in capital goods, such as office and telecommunications equipment (excluding automotive). Other major export categories include industrial supplies and materials, automotive vehicles, parts, and engines, and consumer goods.

The bottom data in Table 3.5 depicts U.S. imports by source and commodity group. The major trading partners as defined by imports are the same as for exports. Partners are mainly developed economies and include the two NAFTA partners, Canada and Mexico. U.S. imports are divided fairly equally among capital goods, industrial supplies and materials, consumer goods, and automotive vehicles, parts, and engines.

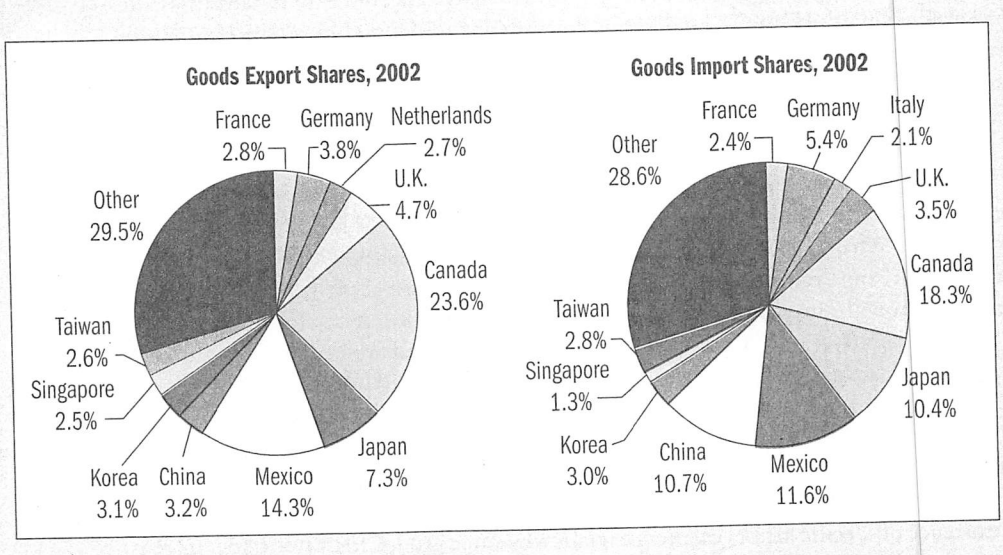

Figure 3.2
U.S. Export and Import Shares

TABLE 3.5

U.S. TRADE IN GOODS BY MAJOR END-USE CATEGORY FOR SELECTED AREAS AND COUNTRIES, 2002 (IN MILLIONS OF DOLLARS)

	Canada	Western Europe	U.K.	Germany	Japan	Latin America	Mexico	Asia, excluding Japan	Hong Kong, Korea, Singapore, Taiwan	China
Exports	**$160,879**	**$153,573**	**$32,139**	**$26,038**	**$49,682**	**$137,275**	**$97,361**	**$140,929**	**$68,265**	**$21,980**
Foods, feeds, and beverages	9,707	6,014	1,008	859	9,055	9,101	6,469	10,701	5,149	1,508
Industrial supplies and materials	37,137	32,919	6,001	4,267	9,974	40,079	28,317	29,245	14,599	6,738
Capital goods (except automotive)	45,886	73,863	15,576	13,998	20,322	50,698	33,761	81,600	40,476	12,151
Automotive vehicles, parts, and engines	44,039	9,017	1,750	3,760	2,784	16,873	15,264	3,712	826	414
Consumer goods (nonfood)	18,958	26,243	6,448	2,390	6,335	15,296	9,859	11,919	5,156	1,014
Other exports	5,152	5,517	1,356	764	1,202	5,228	3,691	3,752	2,059	155
Imports	**213,151**	**246,194**	**40,640**	**62,492**	**121,477**	**196,159**	**135,632**	**337,018**	**91,901**	**125,215**
Foods, feeds, and beverages	11,914	10,689	1,257	683	410	13,689	6,179	8,928	668	1,605
Industrial supplies and materials	78,889	47,947	9,461	8,857	10,828	52,633	21,391	47,325	9,564	9,068
Capital goods (except automotive)	29,180	69,595	11,820	19,800	39,315	37,254	32,752	104,429	41,524	30,204
Automotive vehicles, parts, and engines	59,773	35,358	5,277	22,314	49,265	43,981	41,521	13,860	9,785	2,197
Consumer goods (nonfood)	15,966	68,993	9,212	7,739	17,942	40,318	27,346	155,236	27,004	80,769
Other Imports	17,429	13,612	3,613	3,099	3,617	8,284	6,443	7,240	3,356	1,372

Source: U.S. Department of Commerce, *Survey of Current Business,* April 2003, p. 31.

Empirical Evidence on the Factor-Proportions Theory

The factor-proportions theory provides a logical and obvious explanation of international trade. Unfortunately, economists have learned from experience that a "logical and obvious" explanation of an economic phenomenon can be misleading or wrong. It is not enough for a theory to make sense. It also needs to pass enough empirical tests so that we can be confident that what we think is true is actually the case. The empirical testing of the factor-proportions theory of international trade provides an excellent example. Empirical testing of theory is designed to check the validity of the theory. In some cases, the empirical testing leads to a better understanding or extensions of the basic theory. As we will show, this has been the case with the factor-proportions theory.

When the factor-proportions theory of international trade was developed in the early 20th century, lack of economic data made empirical testing of economic theory nearly impossible. Economic data that are routinely reported from news outlets such as radio, TV, newspapers, magazines, and now the Internet did not become available until after 1945. Similarly, the statistical tools used to test economic theory and the means to process the data (computers) were not available until the 1950s and 1960s. Because the factor-proportions theory seemed so logical, most economists accepted it as true before it was empirically tested.

The Leontief Paradox

Wassily Leontief conducted the first and most famous empirical test of the factor-proportions theory in 1954.[13] What Leontief found was surprising. Leontief reasoned that compared to its trading partners, the U.S. was a capital-abundant country. Given the factor-proportions theory, the U.S. should export goods that are capital intensive and import goods that are labor intensive. To test this hypothesis, he calculated how much capital and labor—the K/L ratio—various U.S. industries used in their production. He then compared the K/L ratios of the industries that had a net trade surplus—the net exporters—to the K/L ratios of the industries having a net trade deficit—the net importers. He expected that U.S. industries with a trade surplus would have a high K/L ratio (capital intensive) relative to U.S. industries with a trade deficit (labor intensive).

Leontief's empirical estimation of the capital-to-labor ratio in U.S. industries that had a trade surplus was $14,010, and the capital-to-labor ratio in U.S. industries that had a trade deficit was $18,180. This means that his empirical result was the reverse of what he expected. Net export industries of the U.S. were more labor intensive than net import industries. This result has been called the **Leontief paradox**. This paradox is not some peculiarity of 1947, the year that he studied. Subsequent empirical studies on the factor-proportions theory, some very recent, still obtain this perverse result. Leontief's findings caused considerable dismay among economists. They concluded that something was wrong with either the empirical test or the basic theory. It turned out to be both, as we will show in the next section. In determining that it was both, economists have gained a better understanding of how factor abundance influences international trade.

Leontief paradox the empirical finding that U.S. industries with trade surpluses were more labor intensive than U.S. industries with a trade deficit. This is contrary to the factor-proportions theory.

[13] See Wassily Leontief, "Domestic Production and Foreign Trade: The American Capital Position Reexamined," *Economia Internazionale*, February 1954, 7(1), pp. 3–32.

Explanations of the Leontief Paradox

There are a number of possible explanations for Leontief's results. One is that some imports are not based on an abundance of labor or capital, but depend on the foreign country's possession of natural resources, such as oil, diamonds, bauxite, or copper. Many of these natural-resource industries use highly capital-intensive production techniques to extract the product.[14] Because Leontief used only a two-factor model (labor and capital), his results may be biased. Because the U.S. imports many natural resources, this would help to explain why U.S. imports are capital intensive.

Another explanation of the paradox is that U.S. trade policy may have biased the results. Many of the most heavily protected industries in the U.S. are labor intensive (e.g., textiles and apparel). In our earlier discussion of trade and the distribution of income, we showed that the scarce factor of production (labor for the U.S.) generally favors trade restrictions. The effect of imposing trade restrictions on certain labor-intensive goods would be to diminish U.S. imports of labor-intensive products and reduce the overall labor intensity of U.S. imports.[15]

The most important explanations of the Leontief paradox, however, have to do with the skill level of the U.S. workforce and high technology. Leontief's test found that U.S. exports were labor intensive. This conclusion was based on the simple two-factor version of the factor-proportions model. This simple model assumes that labor is homogeneous or that one unit of labor is like any other unit of labor. In many cases, assumptions like this do not alter the predictions of economic models. However, in this case it does affect the model's results. Much of the U.S. labor force is highly skilled or possesses **human capital** (knowledge and skills). A simple way of examining the human capital that is embodied in labor is to consider a worker's wage in relation to the minimum wage. Most U.S. workers earn wages above the minimum wage. To the extent that any employer pays more than the absolute minimum wage means that workers must have something, such as skills, education, or training, that reflects their value in the labor market. Any payment to labor above the minimum wage can be viewed as a return to some form of human capital. In attempting to explain U.S. exports, it is necessary to take account of the human capital embodied in exports. When human capital is taken into account, U.S. exports do not appear to be labor intensive, but appear to be human-capital intensive.[16] In addition, U.S. exports also appear to be intensive in technology, which is somewhat different from capital, labor, or human capital. U.S. exports have been shown to be intensive in research and development (R&D). The level of R&D in an industry is a coarse measure of the level of technology.[17]

Human capital the education, training, and job skills embodied in labor that increase its productivity.

[14] James Hartigan has found that the paradox disappears if natural resources are excluded from consideration. See James C. Hartigan, "The U.S. Tariff and Comparative Advantage: A Survey of Method," *Weltwirtschaftliches Archiv,* 1981, 117(1), pp. 61–109. More specifically, Niroomand has found that the source of this effect may be Canada. See Farhang Niroomand, "Factor Inputs and U.S. Manufacturing Trade Structure: 1963–1980," *Weltwirtschaftliches Archiv,* 1991, 127(4), pp. 744–63.

[15] Empirical evidence supporting this proposition can be found in Robert E. Baldwin, "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review,* March 1971, 61(1), pp. 126–46.

[16] On this point, see Donald B. Keesing, "Labor Skills and Comparative Advantage," *American Economic Review,* May 1966, 56(2), pp. 249–58. In addition, Trefler argues that the U.S. was relatively abundant in land and relatively scarce in both labor and capital. By adjusting for productivity differences across countries, the U.S. would have been classified as a labor-abundant country and expected to export labor-abundant goods. For more information, see Daniel Trefler, "International Factor Price Differences: Leontief Was Right!," *Journal of Political Economy,* December 1993, 101(6), pp. 961–87.

[17] See William Gruber, Dileep Mehta, and Raymond Vernon, "The R&D Factor in International Trade and International Investment of United States Industries," *Journal of Political Economy,* February 1967, 75(1), pp. 20–37.

PASSPORT

Relative Factor Endowments for Selected Countries One of the primary assumptions of the factor-proportions theory is that countries are endowed with different factor endowments. Table 3.6 provides some information on the abundance of capital and two different types of labor on a global basis. The table decomposes labor into two broad classes: skilled and unskilled. Notice that the OECD countries possess more than half of the world's capital and nearly half the world's skilled labor. The developing countries have a relatively small proportion of the world's capital and skilled labor but a large majority of unskilled labor. Notice how the different factor endowments illustrated in the table support the premise that underlying factor supplies vary from country to country, as the factor-proportions theory predicts.

TABLE 3.6

FACTOR ENDOWMENTS OF COUNTRIES AND REGIONS, 1993
(AS A PERCENT OF WORLD TOTAL)

Country/Region	Capital	Skilled Labor	Unskilled Labor	All Resources
U.S.	20.8%	19.4%	2.6%	5.6%
EU	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 OCED	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, 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
Organization of Petroleum Exporting Countries (OPEC)	6.2	4.4	7.1	6.7
Rest of World	2.5	4.0	10.0	8.9
Total	100.0	100.0	100.0	100.0

Source: Adapted from William Cline, *Trade and Income Distribution,* Washington D.C.: Institute for International Economics, 1997, pp. 183–185.

As a result of this research, we can use the factor-proportions theory with some confidence. Most empirical evidence indicates that the basic reasoning embodied in the theory is correct.[18] Countries tend to have a comparative advantage in and export goods whose pro-

[18] In general, the evidence seems to support the factor-proportions theory. For an example of a recent test of the theory, see John Romalis, "Factor Proportions and the Structure of Commodity Trade," *American Economic Review,* March 2004, 94(1), pp. 67–97.

4. The factor-proportions theory suggests that differences in relative factor endowments between countries determine the basis for trade. The theory states that a country has a comparative advantage in, and exports, the good that intensively uses the country's abundant factor of production. Conversely, a country has a comparative disadvantage in, and imports, the good that intensively uses the country's relatively scarce factor of production.
5. The factor-price equalization theorem states that international trade would equalize factor prices between countries. As such, in the long run, there is a tendency toward factor-price equalization.
6. The Stolper-Samuelson theorem states that an increase in the relative price of a commodity raises the real price of the factor used intensively in the commodity's production and reduces the real price of the other factor. These changes in factor prices tend to increase the percentage of national income the abundant factor receives. The reverse is true for the scarce factor.
7. The specific-factors model shows that owners of capital specific to export- or import-competing industries tend to experience gains or losses from international trade. Workers find that their welfare may rise, fall, or remain the same, depending on their consumption of the various goods.
8. Leontief, using 1947 data, conducted the first empirical test of the factor-proportions model. He found that the production of U.S. goods, which were substitutes for imports, were more capital intensive than U.S. exports. His findings became known as the Leontief paradox. A number of possible explanations for the perverse result have been given over the years. The paradox tends to be resolved by considering human capital and technology as separate factors of production.

Key Concepts and Terms

factor-proportions theory p. 61
perfect competition p. 62
factors of production p. 62
constant returns to scale p. 62
capital intensive p. 63
labor intensive p. 63
capital-to-labor ratio (K/L) p. 63
capital abundant p. 63
labor abundant p. 63
factor-proportions theorem p. 65
factor-price equalization theorem p. 67
industrial structure p. 67
Stolper-Samuelson theorem p. 70
specific factor p. 72
mobile factor p. 72
Leontief paradox p. 76
human capital p. 77

Problems and Questions for Review

1. In what ways does the factor-proportions theory represent an extension of the trade model presented in Chapter 2?
2. State the assumptions of the factor-proportions theory. What is the meaning and importance of each assumption?