chapter

7

Economic Growth and International Trade

LEARNING GOALS:

After reading this chapter, you should be able to:

- Explain how the change in a nation's factor endowments affects its growth, terms of trade, volume of trade, and welfare
- Explain how technological change affects growth, trade, and welfare
- Understand how a change in tastes affects trade, growth, and welfare

7.1 Introduction

Aside from trade based on technological gaps and product cycles (discussed in Section 6.5), which is dynamic in nature, the trade theory discussed thus far is completely static in nature. That is, given the nation's factor endowments, technology, and tastes, we proceeded to determine the nation's comparative advantage and the gains from trade. However, factor endowments change over time; technology usually improves; and tastes may also change. As a result, the nation's comparative advantage also changes over time.

In this chapter, we extend our trade model to incorporate these changes. We show how a change in factor endowments and/or an improvement in technology affect the nation's production frontier. These changes, together with possible changes in tastes, affect the nation's offer curve, the volume and the terms of trade, and the gains from trade.

In Section 7.2, we illustrate the effect of a change in factor endowments on the nation's production frontier and examine the Rybczynski theorem. In Section 7.3, we define the different types of technical progress and illustrate their effect on the nation's production frontier. Section 7.4 deals with and illustrates the effect of growth on trade and welfare in a nation that is too small to affect the terms of trade. Section 7.5 extends the analysis to the more complex case of the large nation. Finally, Section 7.6 examines the effect of growth and changes in tastes in both nations on the volume and terms of trade. The appendix presents the formal proof

of the Rybcynski theorem, examines growth when one factor is not mobile within the nation, and gives a graphical presentation of Hicksian technical progress.

Throughout this chapter and in the appendix, we will have the opportunity to utilize most of the tools of analysis developed in previous chapters and truly see trade theory at work. The type of analysis that we will be performing is known as **comparative statics** (as opposed to **dynamic analysis**). *Comparative statics* analyzes the effect on the equilibrium position resulting from a change in underlying economic conditions and without regard to the transitional period and process of adjustment. *Dynamic analysis*, on the other hand, deals with the time path and the process of adjustment itself. Dynamic trade theory is still in its infancy. However, our comparative statics analysis can carry us a long way in analyzing the effect on international trade resulting from changes in factor endowments, technology, and tastes over time.

7.2 Growth of Factors of Production

Through time, a nation's population usually grows and with it the size of its labor force. Similarly, by utilizing part of its resources to produce capital equipment, the nation increases its stock of capital. *Capital* refers to all the human-made means of production, such as machinery, factories, office buildings, transportation, and communications, as well as to the education and training of the labor force, all of which greatly enhance the nation's ability to produce goods and services.

Although there are many different types of labor and capital, we will assume for simplicity that all units of labor and capital are homogeneous (i.e., identical), as we have done in previous chapters. This will leave us with two factors—labor (L) and capital (K)—so that we can conveniently continue to use plane geometry for our analysis. In the real world, of course, there are also natural resources, and these can be depleted (such as minerals) or new ones found through discoveries or new applications.

We will also continue to assume that the nation experiencing growth is producing two commodities (commodity X, which is L intensive, and commodity Y, which is K intensive) under constant returns to scale.

7.2A Labor Growth and Capital Accumulation over Time

An increase in the endowment of labor and capital over time causes the nation's production frontier to shift outward. The type and degree of the shift depend on the rate at which L and K grow. If L and K grow at the same rate, the nation's production frontier will shift out evenly in all directions at the rate of factor growth. As a result, the slope of the old and new production frontiers (before and after factor growth) will be the same at any point where they are cut by a ray from the origin. This is the case of **balanced growth**.

If only the endowment of L grows, the output of both commodities grows because L is used in the production of both commodities and L can be substituted for K to some extent in the production of both commodities. However, the output of commodity X (the L-intensive commodity) grows faster than the output of commodity Y (the K-intensive commodity). The opposite is true if only the endowment of K grows. If L and K grow at different rates, the outward shift in the nation's production frontier can similarly be determined.

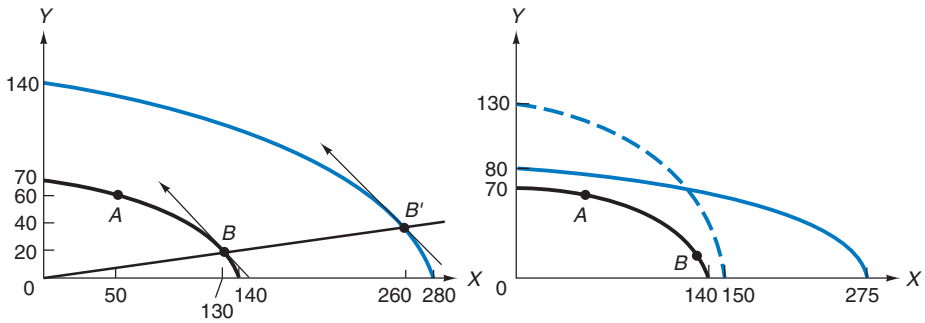

FIGURE 7.1. Growth of Labor and Capital over Time.
The left panel shows the case of balanced growth with *L* and *K* doubling under constant returns to scale. The two production frontiers have identical shapes and the same slope, or P_X/P_Y, along any ray from the origin. The right panel shows the case when only *L* or only *K* doubles. When only *L* doubles, the output of commodity X (the *L*-intensive commodity) grows proportionately more than the output of Y (but less than doubles). Similarly, when only *K* doubles, the output of Y grows proportionately more than that of X but less than doubles (see the dashed production frontier).

Figure 7.1 shows various types of hypothetical factor growth in Nation 1. (The growth of factors and endowments is exaggerated to make the illustrations clearer.) The presentation is completely analogous for Nation 2 and will be left as an end-of-chapter problem.

The left panel of Figure 7.1 shows the case of balanced growth under the assumption that the amounts of *L* and *K* available to Nation 1 double. With constant returns to scale, the maximum amount of each commodity that Nation 1 can produce also doubles, from 140X to 280X or from 70Y to 140Y. Note that the shape of the expanded production frontier is identical to the shape of the production frontier before growth, so that the slope of the two production frontiers, or P_X/P_Y, is the same at such points as *B* and *B′*, where they are cut by a ray from the origin.

The right panel repeats Nation 1's production frontier before growth (with intercepts of 140X and 70Y) and shows two additional production frontiers—one with only *L* doubling (solid line) and the other with only *K* doubling (dashed line). When only *L* doubles, the production frontier shifts more along the X-axis, measuring the *L*-intensive commodity. If only *K* doubles, the production frontier shifts more along the Y-axis, measuring the *K*-intensive commodity. Note that when only *L* doubles, the maximum output of commodity X does not double (i.e., it only rises from 140X to 275X). For X to double, *both* *L* and *K* must double. Similarly, when only *K* doubles, the maximum output of commodity Y less than doubles (from 70Y to 130Y).

When both *L* and *K* grow at the same rate and we have constant returns to scale in the production of both commodities, the productivity, and therefore the returns of *L* and *K*, remain the same after growth as they were before growth took place. If the dependency rate (i.e., the ratio of dependents to the total population) also remains unchanged, real per capita income and the welfare of the nation tend to remain unchanged. If only *L* grows (or *L* grows proportionately more than *K*), *K/L* will fall and so will the productivity of *L*, the returns to *L*, and real per capita income. If, on the other hand, only the endowment of *K* grows (or *K* grows proportionately more than *L*), *K/L* will rise and so will the productivity of *L*, the returns to *L*, and real per capita income.

7.2B The Rybczynski Theorem

The **Rybczynski theorem** postulates that at constant commodity prices, an increase in the endowment of one factor will increase by a greater proportion the output of the commodity intensive in that factor and will reduce the output of the other commodity. For example, if only L grows in Nation 1, then the output of commodity X (the L-intensive commodity) expands more than proportionately, while the output of commodity Y (the K-intensive commodity) declines at constant P_X and P_Y.

Figure 7.2 shows the production frontier of Nation 1 before and after only L doubles (as in the right panel of Figure 7.1). With trade but before growth, Nation 1 produces at point B (i.e., 130X and 20Y) at $P_X/P_Y = P_B = 1$, as in previous chapters. After only L doubles and with P_X/P_Y remaining at $P_B = 1$, Nation 1 would produce at point M on its new and expanded production frontier. At point M, Nation 1 produces 270X but only 10Y. Thus, the output of commodity X more than doubled, while the output of commodity Y declined (as predicted by the Rybczynski theorem). Doubling L and transferring some L and K from the production of commodity Y more than doubles the output of commodity X.

The formal graphical proof of the Rybczynski theorem will be presented in the appendix. Here we will give intuitive but still adequate proof of the theorem. The proof is as follows. For *commodity* prices to remain constant with the growth of one factor, *factor* prices (i.e., w and r) must also remain constant. But factor prices can remain constant only if K/L and the productivity of L and K also remain constant in the production of both commodities. The only way to fully employ all of the increase in L and still leave K/L unchanged in the production of both commodities is for the output of commodity Y (the K-intensive commodity) to fall in order to release enough K (and a little L) to absorb all of the increase in L in the production of commodity X (the L-intensive commodity). Thus, the output of commodity X rises while the output of commodity Y declines at constant commodity prices.

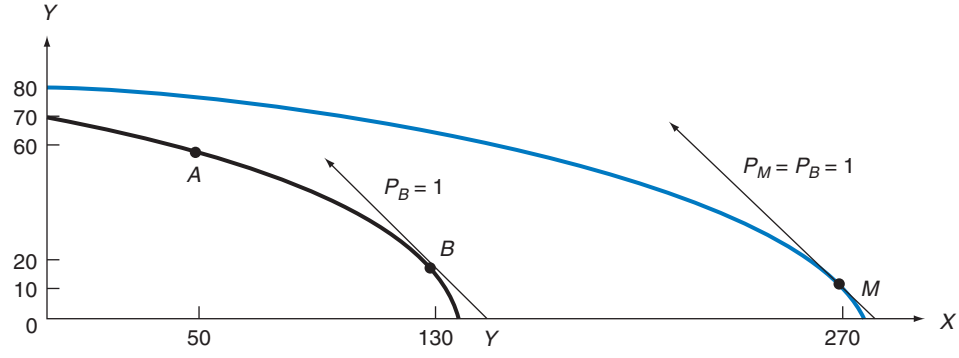

FIGURE 7.2. The Growth of Labor Only and the Rybczynski Theorem.
With trade but before growth, Nation 1 produces at point B (130X and 20Y) at $P_X/P_Y = P_B = 1$, as in previous chapters. After only L doubles and with P_X/P_Y remaining at $P_B = 1$, Nation 1 produces at point M (270X and 10Y) on its new and expanded production frontier. Thus, the output of X (the L-intensive commodity) expanded, and the output of Y (the K-intensive commodity) declined, as postulated by the Rybczynski theorem.

In fact, the increase in the output of commodity X expands by a greater proportion than the expansion in the amount of labor because some labor and capital are also transferred from the production of commodity Y to the production of commodity X. This is called the *magnification effect* and is formally proved in Section A7.1 of the appendix.

To summarize, we can say that for P_X and P_Y (and therefore P_X/P_Y) to remain the same, w and r must be constant. But w and r can remain the same only if K/L remains constant in the production of both commodities. The only way for this to occur and also absorb all of the increase in L is to reduce the output of Y so as to release K/L in the greater proportion used in Y, and combine the released K with the additional L at the lower K/L used in the production of X. Thus, the output of X rises and that of Y falls. In fact, the output of X increases by a greater proportion than the increase in L. Similarly, when only K increases, the output of Y rises more than proportionately and that of X falls.

If one of the factors of production is not mobile within the nation, the results differ and depend on whether it is the growing or the nongrowing factor that is immobile. This is examined in Section A7.2 of the appendix using the specific-factors model introduced in the appendix to Chapter 5 (Section A5.4).

7.3 Technical Progress

Several empirical studies have indicated that most of the increase in real per capita income in industrial nations is due to technical progress and much less to capital accumulation. However, the analysis of technical progress is much more complex than the analysis of factor growth because there are several definitions and types of technical progress, and they can take place at different rates in the production of either or both commodities.

For our purposes, the most appropriate definitions of *technical progress* are those advanced by *John Hicks*, the British economist who shared the 1972 Nobel Prize in economics. In Section 7.3A, we define the different types of Hicksian technical progress. In Section 7.3B, we then examine the effect that the different types of Hicksian technical progress have on the nation's production frontier. Throughout our discussion, we will assume that constant returns to scale prevail before and after technical progress takes place and that technical progress occurs in a once-and-for-all fashion.

7.3A Neutral, Labor-Saving, and Capital-Saving Technical Progress

Technical progress is usually classified into neutral, labor saving, or capital saving. All technical progress (regardless of its type) reduces the amount of both labor and capital required to produce any given level of output. The different types of Hicksian technical progress specify how this takes place.

Neutral technical progress increases the productivity of L and K in the same proportion, so that K/L remains the same after the neutral technical progress as it was before *at unchanged relative factor prices (w/r)*. That is, with unchanged w/r, there is no substitution of L for K (or vice versa) in production so that K/L remains unchanged. All that happens is that a given output can now be produced with less L and less K.

Labor-saving technical progress increases the productivity of K proportionately more than the productivity of L. As a result, K is substituted for L in production and K/L rises at unchanged w/r. Since more K is used per unit of L, this type of technical progress is called labor saving. Note that a given output can now be produced with fewer units of L and K but with a higher K/L.

Capital-saving technical progress increases the productivity of L proportionately more than the productivity of K. As a result, L is substituted for K in production and L/K rises (K/L falls) at unchanged w/r. Since more L is used per unit of K, this type of technical progress is called capital saving. Note that a given output can now be produced with fewer units of L and K but with a higher L/K (a lower K/L).

The appendix to this chapter gives a rigorous graphical interpretation of the Hicksian definitions of technical progress, utilizing somewhat more advanced tools of analysis.

7.3B Technical Progress and the Nation's Production Frontier

As in the case of factor growth, all types of technical progress cause the nation's production frontier to shift outward. The type and degree of the shift depend on the type and rate of technical progress in either or both commodities. Here we will deal only with neutral technical progress. Nonneutral technical progress is extremely complex and can only be handled mathematically in the most advanced graduate texts.

With the same rate of neutral technical progress in the production of both commodities, the nation's production frontier will shift out evenly in all directions at the same rate at which technical progress takes place. This has the same effect on the nation's production frontier as balanced factor growth. Thus, the slope of the nation's old and new production frontiers (before and after this type of technical progress) will be the same at any point where they are cut by a ray from the origin.

For example, suppose that the productivity of L and K doubles in the production of commodity X and commodity Y in Nation 1 and constant returns to scale prevail in the production of both commodities. The graph for this type of technical progress is identical to the left panel of Figure 7.1, where the supply of both L and K doubled, and so the graph is not repeated here.

Figure 7.3 shows Nation 1's production frontier before technical progress and after the productivity of L and K doubled in the production of commodity X only, or in the production of commodity Y only (the dashed production frontier).

When the productivity of L and K doubles in the production of commodity X only, the output of X doubles for each output level of commodity Y. For example, at the unchanged output of 60Y, the output of commodity X rises from 50X before technical progress to 100X afterward (points A and A', respectively, in the figure). Similarly, at the unchanged output of 20Y, the output of commodity X increases from 130X to 260X (points B and B'). When all of Nation 1's resources are used in the production of commodity X, the output of X also doubles (from 140X to 280X). Note that the output of commodity Y remains unchanged at 70Y if all of the nation's resources are used in the production of commodity Y and technical progress took place in the production of commodity X only.

Analogous reasoning explains the shift in the production frontier when the productivity of L and K doubles only in the production of commodity Y (the dashed production frontier

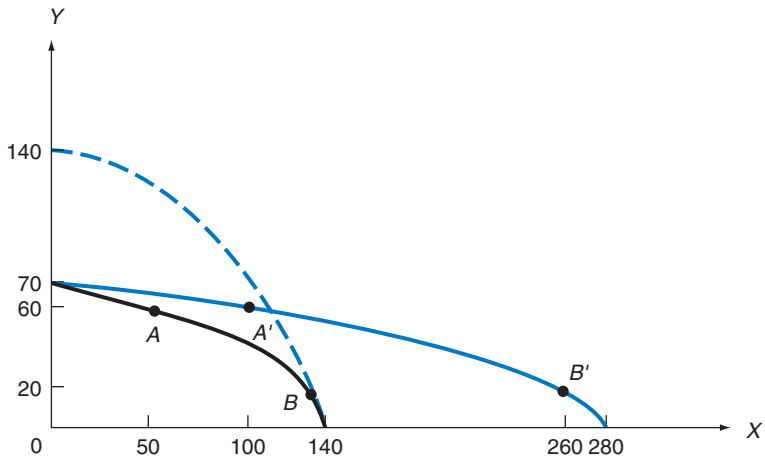

FIGURE 7.3. Neutral Technical Progress.
The figure shows Nation 1's production frontier before technical progress and after the productivity of *L* and *K* doubled in the production of commodity X only, or in the production of commodity Y only (the dashed frontier). Note that if Nation 1 uses all of its resources in the production of the commodity in which the productivity of *L* and *K* doubled, the output of the commodity also doubles. On the other hand, if Nation 1 uses all of its resources in the production of the commodity in which no technical progress occurred, the output of that commodity remains unchanged.

in Figure 7.3). The student should carefully examine the difference between Figure 7.3 and the right panel of Figure 7.1.

Finally, it must be pointed out that, in the absence of trade, all types of technical progress tend to increase the nation's welfare. The reason is that with a higher production frontier and the same *L* and population, each citizen could be made better off after growth than before by an appropriate redistribution policy. The question of the effect of growth on trade and welfare will be explored in the remainder of the chapter. Case Study 7-1 examines the growth over time in the capital stock per worker of selected countries.

CASE STUDY 7-1 Growth in the Capital Stock per Worker of Selected Countries

Table 7.1 gives the growth from 1979 to 1997 and 2006 in the capital stock per worker (measured in terms of 1990 international dollar prices) in the nations included in Table 5.2 in Case Study 5-2. Table 7.1 shows that from 1979 (the first year for which such comparable data are available) to 2006 the stock of capital per worker grew at a faster rate in Canada and the United States than in the other developed countries listed. It grew in China much faster than in the other developing countries listed.

From Table 7.1, we can conclude that from 1979 to 2006 the U.S. *comparative disadvantage* in capital-intensive products increased somewhat with respect to Canada but decreased with respect to the other countries. On the other hand, during the same period the U.S. *comparative advantage* in capital-intensive products decreased sharply with respect to all the developing countries, except Mexico.

(continued)

■ CASE STUDY 7-1 Continued

■ TABLE 7.1. Changes in Capital-Labor Ratios of Selected Countries, 1979, 1997, and 2006 (in 1990 International Dollar Prices)

Country	1979	1997	2006	2006/1979
Japan	$64,218	$77,429	$111,615	1.74
Canada	45,294	61,274	89,652	1.98
Germany	50,487	61,673	87,400	1.73
France	53,901	59,602	85,097	1.58
Italy	43,878	48,943	73,966	1.69
United States	40,366	50,233	73,282	1.82
Spain	29,384	38,897	51,814	1.76
United Kingdom	27,041	30,226	44,545	1.65
Korea	13,002	26,635	45,235	3.48
Mexico	13,681	14,030	23,921	1.75
Turkey	8,976	10,780	20,478	2.28
Brazil	5,807	13,940	16,650	2.87
Russia	5,728	6,246	16,131	2.82
Thailand	3,144	8,106	11,688	3.72
China	1,114	3,219	7,485	6.72
India	2,135	3,094	5,870	2.75

Source: For 1979 and 1997, author's calculation on preliminary results from Penn World Table Version 5.7 (October 2000) and 6.1 (October 2002). For 2006, author's calculations following the Penn World Tables.

7.4 Growth and Trade: The Small-Country Case

We will now build on the discussion of the previous two sections and analyze the effect of growth on production, consumption, trade, and welfare when the nation is too small to affect the relative commodity prices at which it trades (so that the nation's terms of trade remain constant). In Section 7.4A, we discuss growth in general and define protrade, antitrade, and neutral production and consumption. Using these definitions, we illustrate the effect of one type of factor growth in Section 7.4B and analyze the effect of technical progress in Section 7.4C. Section 7.5 then examines the more realistic case where the nation *does* affect relative commodity prices by its trading.

7.4A The Effect of Growth on Trade

We have seen so far that factor growth and technical progress result in an outward shift in the nation's production frontier. What happens to the volume of trade depends on the rates at which the output of the nation's exportable and importable commodities grow and on the consumption pattern of the nation as its national income expands through growth and trade.

If the output of the nation's exportable commodity grows proportionately more than the output of its importable commodity at constant relative commodity prices, then growth tends to lead to greater than proportionate expansion of trade and is said to be **protrade**. Otherwise, it is **antitrade** or **neutral**. The expansion of output has a neutral trade effect if it

leads to the same rate of expansion of trade. On the other hand, if the nation's consumption of its importable commodity increases proportionately more than the nation's consumption of its exportable commodity at constant prices, then the consumption effect tends to lead to a greater than proportionate expansion of trade and is said to be protrade. Otherwise, the expansion in consumption is antitrade or neutral.

Thus, production and consumption can be protrade (if they lead to a greater than proportionate increase in trade at constant relative commodity prices), antitrade, or neutral. *Production is protrade* if the output of the nation's *exportable commodity increases proportionately more* than the output of its importable commodity. *Consumption is protrade* if the nation's consumption of its *importable commodity increases proportionately more* than consumption of its exportable commodity.

What in fact happens to the volume of trade in the process of growth depends on the net result of these production and consumption effects. If both production and consumption are protrade, the volume of trade expands proportionately faster than output. If production and consumption are both antitrade, the volume of trade expands proportionately less than output and may even decline absolutely. If production is protrade and consumption antitrade or vice versa, what happens to the volume of trade depends on the net effect of these two opposing forces. In the unlikely event that both production and consumption are neutral, trade expands at the same rate as output.

Since growth can result from different types and rates of factor growth and technical progress, and production and consumption can be protrade, antitrade, or neutral, the effect of growth on trade and welfare will vary from case to case. Thus, the approach must necessarily be taxonomic (i.e., in the form of "if this is the case, then this is the outcome"). As a result, all we can do is give some examples and indicate the forces that must be analyzed to determine what is likely to happen in any particular situation.

7.4B Illustration of Factor Growth, Trade, and Welfare

The top panel of Figure 7.4 reproduces Figure 7.2, which shows that L doubles in Nation 1 and that Nation 1's terms of trade do not change with growth and trade. That is, before growth, Nation 1 produced at point B, traded 60X for 60Y at $P_B = 1$, and reached indifference curve *III* (as in previous chapters). When L doubles in Nation 1, its production frontier shifts outward as explained in Section 7.2A. If Nation 1 is too small to affect relative commodity prices, it will produce at point M, where the new expanded production frontier is tangent to $P_M = P_B = 1$. At point M, Nation 1 produces more than twice as much of commodity X than at point B but less of commodity Y, as postulated by the Rybczynski theorem. At $P_M = P_B = 1$, Nation 1 exchanges 150X for 150Y and consumes at point Z on its community indifference curve VII.

Since the output of commodity X (Nation 1's exportable commodity) increased while the output of commodity Y declined, the growth of output is protrade. Similarly, since the consumption of commodity Y (Nation 1's importable commodity) increased proportionately more than the consumption of commodity X (i.e., point Z is to the left of a ray from the origin through point E), the growth of consumption is also protrade. With both production and consumption protrade, the volume of trade expanded proportionately more than the output of commodity X.

Note that with growth and trade, Nation 1's *consumption* frontier is given by straight line P_M tangent to the new expanded production frontier at point M. The fact that consumption of both commodities increased with growth and trade means that both commodities are

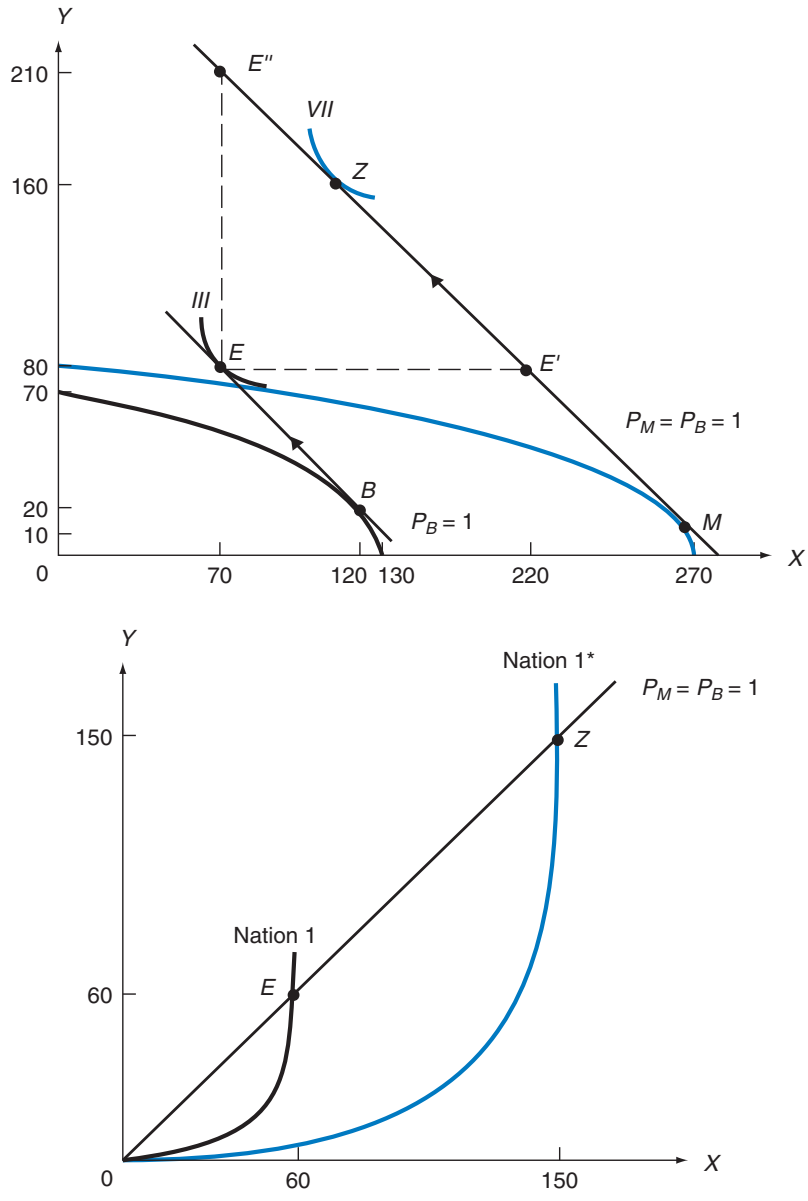

FIGURE 7.4. Factor Growth and Trade: The Small-Country Case.
The top panel shows that after L doubles, Nation 1 exchanges 150X for 150Y at $P_M = P_B = 1$ and reaches indifference curve *VII*. Since the consumption of both X and Y rises with growth, both commodities are normal goods. Since L doubled but consumption less than doubled (compare point Z to point E), the social welfare of Nation 1 declined. The bottom panel shows that with free trade before growth, Nation 1 exchanged 60X for 60Y at $P_X/P_Y = P_B = 1$. With free trade after growth, Nation 1 exchange 150X for 150Y at $P_X/P_Y = P_B = 1$.

normal goods. Only if commodity Y had been an **inferior good** would Nation 1 have consumed a smaller absolute amount of Y (i.e., to the right and below point E' on line P_M). Similarly, Nation 1 would have consumed a smaller absolute amount of commodity X (i.e., to the left and above point E'') only if commodity X had been an inferior good.

The bottom panel of Figure 7.4 utilizes offer curves to show the same growth of trade for Nation 1 at constant terms of trade. That is, with free trade before growth, Nation 1 exchanged 60X for 60Y at $P_X/P_Y = P_B = 1$. With free trade after growth, Nation 1 exchanged 150X for 150Y at $P_X/P_Y = P_M = P_B = 1$. The straight line showing the constant terms of trade also represents the straight-line segment of Nation 2's (or the rest of the world's) offer curve. It is because Nation 1 is very small that its offer curve before and after growth intersects the straight-line segment of Nation 2's (the large nation's) offer curve and the terms of trade remain constant.

Note that Nation 1 is worse off after growth because its labor force (and population) doubled while its total consumption less than doubled (compare point Z with 120X and 160Y after growth to point E with 70X and 80Y before growth). Thus, the consumption and welfare of Nation 1's "representative" citizen decline as a result of this type of growth. A representative citizen is one with the identical tastes and consumption pattern of the nation as a whole but with quantities scaled down by the total number of citizens in the nation.

7.4C Technical Progress, Trade, and Welfare

We have seen in Section 7.3B that *neutral technical progress at the same rate in the production of both commodities* leads to a proportionate expansion in the output of both commodities at constant relative commodity prices. If consumption of each commodity also increases proportionately in the nation, the volume of trade will increase at the same rate at constant terms of trade. That is, the neutral expansion of production and consumption leads to the same rate of expansion of trade. With neutral production and protrade consumption, the volume of trade would expand proportionately more than production. With neutral production and antitrade consumption, the volume of trade would expand proportionately less than production. However, regardless of what happens to the volume of trade, the welfare of the representative citizen will increase with constant L and population and constant terms of trade.

Neutral technical progress in the production of the exportable commodity only is protrade. For example, if neutral technical progress takes place only in the production of commodity X in Nation 1, then Nation 1's production frontier expands only along the X-axis, as indicated in Figure 7.3. At constant terms of trade, Nation 1's output of commodity X will increase even more than in Figure 7.4, while the output of commodity Y declines (as in Figure 7.4). Nation 1 will reach an indifference curve higher than *VII*, and the volume of trade will expand even more than in Figure 7.4. What is even more important is that with a constant population and labor force, the welfare of the representative citizen now rises (as opposed to the case where only L grows in Figure 7.4).

On the other hand, *neutral technical progress only in the production of commodity Y* (the importable commodity) *is antitrade*, and Nation 1's production frontier will expand only along the Y-axis (the dashed production frontier in Figure 7.3). If the terms of trade, tastes, and population also remain unchanged, the volume of trade tends to decline, but national welfare increases. This is similar to the growth of K only in Nation 1 and will

be examined in Section 7.5c. The case where neutral technical change occurs at different rates in the two commodities may lead to a rise or fall in the volume of trade but always increases welfare. The same is generally true for nonneutral technical progress. Thus, technical progress, depending on the type, may increase or decrease trade, but it will always increase social welfare in a small nation. Case Study 7-2 examines the growth of labor

■ CASE STUDY 7-2 Growth in Output per Worker from Capital Deepening, Technological Change, and Improvements in Efficiency

Table 7.2 gives the growth of output per worker from 1965 to 1990 and the contribution to that growth made by capital deepening (i.e., the increase in capital per worker) and improvements in technology and efficiency (catching-up), for a selected group of developed and developing countries, arranged according to the size of their economy. The table shows that the growth of output per worker grew most rapidly in Korea (425 percent), followed by Japan (209 percent), and Thailand (195 percent). The United States experienced the lowest growth (31 percent) among the nations included in Table 7.2. The table also shows that most of the growth in output per worker came from capital deepening. Technology made the largest contribution to growth in France, followed by India, Japan, Germany, and Thailand. The largest contribution from improvements in efficiency occurred in Korea, Italy, and Thailand. Argentina, Chile, Mexico, Spain, and the United Kingdom actually suffered a reduction in efficiency.

■ TABLE 7.2. Growth in Output per Worker from Capital Deepening, Technological Change, and Improvements in Efficiency, 1965–1990

Country	Percentage Change in Output per Worker	Contribution to Percentage Change in Output per Worker of		
		Capital Deepening	Change in Technology	Change in Efficiency
United States	31.1	19.3	9.9	0.0
Japan	208.5	159.9	15.2	3.1
Germany	70.7	31.8	14.4	13.3
France	78.3	47.2	16.3	4.1
United Kingdom	60.7	64.9	1.4	−3.8
Italy	117.4	45.5	13.3	31.9
Canada	54.6	18.6	11.7	16.7
Spain	111.7	125.5	7.1	−12.3
Mexico	47.5	66.7	2.1	−13.3
India	80.5	38.9	15.7	12.4
Korea, Republic of	424.5	259.7	2.9	41.7
Argentina	4.6	59.3	1.8	−35.5
Turkey	129.3	95.6	6.6	9.9
Thailand	194.7	104.1	12.6	28.3
Philippines	43.8	20.9	7.9	10.3
Chile	16.6	50.2	1.9	−23.9

Source: S. Kumar and R. R. Russell, "Technological Change, Technological Catch-up, and Capital Deepening: Relative Contributions to Growth and Convergence," *American Economic Review*, June 2002, pp. 527–548.

productivity attributable to capital accumulation and technological change in a selected group of developed and developing countries over time.

7.5 Growth and Trade: The Large-Country Case

We will now build on our presentation of Section 7.4 to analyze the effect of growth on production, consumption, trade, and welfare when the nation is sufficiently large to affect the relative commodity prices at which it trades (so that the nation's terms of trade change). In Section 7.5A, we examine the effect of growth on the nation's terms of trade and welfare. In Section 7.5B, we deal with the case where growth, by itself, might improve the nation's welfare but its terms of trade deteriorate so much as to make the nation worse off after growth than before. Finally, in Section 7.5C, we examine the case where growth leads to improvement in the country's terms of trade and welfare.

7.5A Growth and the Nation's Terms of Trade and Welfare

If growth, regardless of its source or type, expands the nation's volume of trade at constant prices, then the nation's terms of trade tend to deteriorate. Conversely, if growth reduces the nation's volume of trade at constant prices, the nation's terms of trade tend to improve. This is referred to as the **terms-of-trade effect** of growth.

The effect of growth on the nation's welfare depends on the net result of the terms-of-trade effect and a wealth effect. The **wealth effect** refers to the change in the output per worker or per person as a result of growth. A positive wealth effect, by itself, tends to increase the nation's welfare. Otherwise, the nation's welfare tends to decline or remain unchanged. If the wealth effect is positive and the nation's terms of trade improve as a result of growth and trade, the nation's welfare will definitely increase. If they are both unfavorable, the nation's welfare will definitely decline. If the wealth effect and the terms-of-trade effect move in opposite directions, the nation's welfare may deteriorate, improve, or remain unchanged depending on the relative strength of these two opposing forces.

For example, if only L doubles in Nation 1, the wealth effect, by itself, tends to reduce Nation 1's welfare. This was the case shown in Figure 7.4. Furthermore, since this type of growth tends to expand the volume of trade of Nation 1 at $P_M = P_B = 1$, Nation 1's terms of trade also tend to decline. Thus, the welfare of Nation 1 will decline for both reasons. This case is illustrated in Figure 7.5.

Figure 7.5 is identical to Figure 7.4, except that now Nation 1 is assumed to be large enough to affect relative commodity prices. With the terms of trade deteriorating from $P_M = P_B = 1$ to $P_N = \frac{1}{2}$ with growth and trade, Nation 1 produces at point N, exchanges 140X for 70Y with Nation 2, and consumes at point T on indifference curve IV (see the top panel). Since the welfare of Nation 1 declined (i.e., the wealth effect was negative) even when it was too small to affect its terms of trade, and now its terms of trade have also deteriorated, the welfare of Nation 1 declines even more. This is reflected in indifference curve IV being lower than indifference curve VII.

The bottom panel of Figure 7.5 shows with offer curves the effect of this type of growth on the volume and the terms of trade when Nation 1 does not affect its terms of trade (as in the bottom panel of Figure 7.4) and when it does.

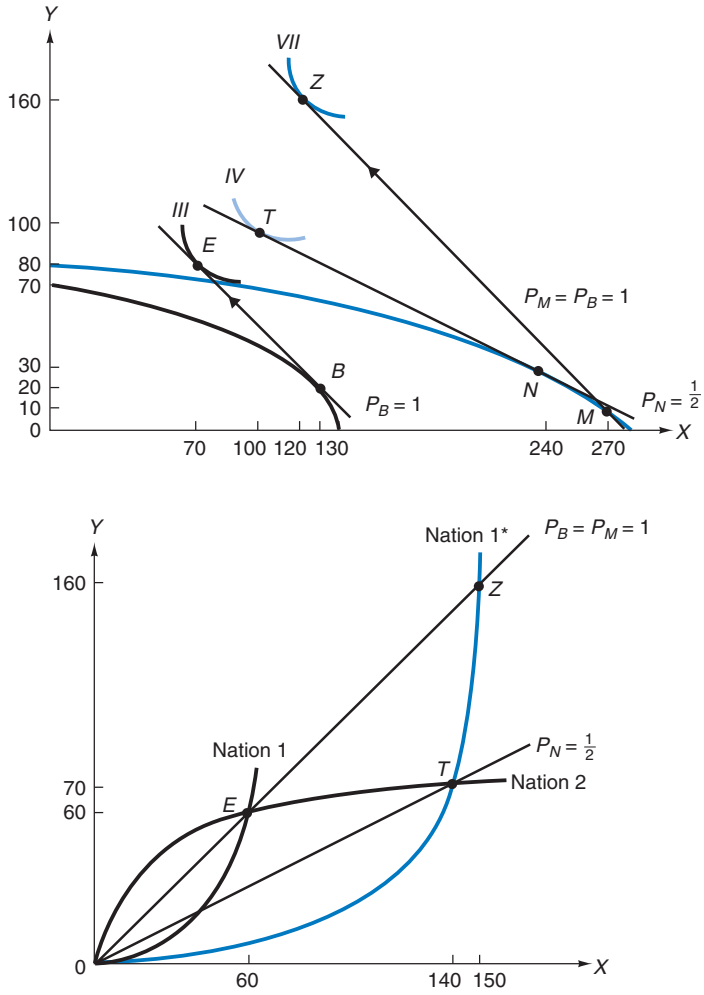

FIGURE 7.5. Growth and Trade: The Large-Country Case.
Figure 7.5 is identical to Figure 7.4, except that now Nation 1 is assumed to be large enough to affect the terms of trade. With the terms of trade deteriorating from $P_M = P_B = 1$ to $P_N = ½$ with growth and trade, Nation 1 produces at point *N*, exchanges 140X for 70Y with Nation 2, and consumes at point *T* on indifference curve *IV* (see the top panel). Since indifference curve *IV* is lower than VII, the nation's welfare will decline even more now. The bottom panel shows with offer curves the effect of this type of growth on the volume and the terms of trade when Nation 1 affects its terms of trade and when it does not.

7.5B Immiserizing Growth

Even if the wealth effect, by itself, tends to increase the nation's welfare, the terms of trade may deteriorate so much as to lead to a net decline in the nation's welfare. This case was termed **immiserizing growth** by *Jagdish Bhagwati* and is illustrated in Figure 7.6.

Figure 7.6 reproduces from Figure 7.3 the production frontier of Nation 1 before and after neutral technical progress doubled the productivity of *L* and *K* in the production

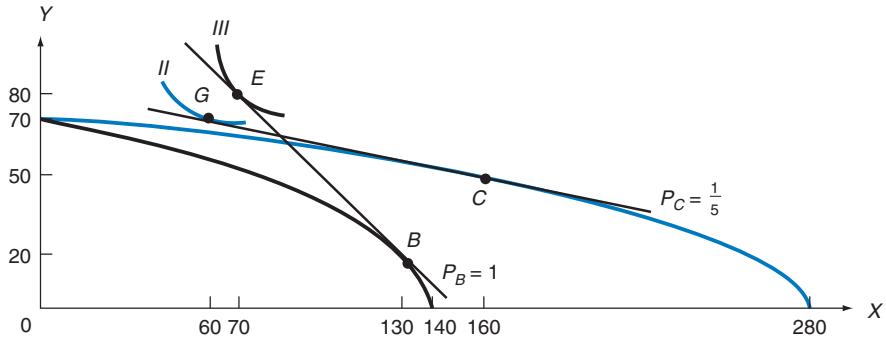

FIGURE 7.6. Immiserizing Growth.
This figure reproduces from Figure 7.3 the production frontier of Nation 1 before and after neutral technical progress increased the productivity of *L* and *K* in the production of commodity X only. With this type of technical progress, the wealth effect, by itself, would increase the welfare of Nation 1. However, Nation 1's terms of trade deteriorate drastically from $P_B = 1$ to $P_C = \frac{1}{5}$, so that Nation 1 produces at point *C*, exports 100X for only 20Y, and consumes at point *G* on indifference curve *II* (which is lower than indifference curve *III*, which Nation 1 reached with free trade *before* growth).

of commodity X only. The wealth effect, by itself, would increase Nation 1's welfare at constant prices because Nation 1's output increases while its labor force (*L*) and population remain constant. However, since this type of technical progress tends to increase the volume of trade, Nation 1's terms of trade tend to deteriorate. With a drastic deterioration in its terms of trade, for example, from $P_B = 1$ to $P_C = \frac{1}{5}$, Nation 1 would produce at point *C*, export 100X for only 20Y, and consume at point *G* on indifference curve *II* (which is lower than indifference curve *III*, which Nation 1 reached with free trade *before* growth).

Immiserizing growth is more likely to occur in Nation 1 when (a) growth tends to increase substantially Nation 1's exports at constant terms of trade; (b) Nation 1 is so large that the attempt to expand its exports substantially will cause a deterioration in its terms of trade; (c) the income elasticity of Nation 2's (or the rest of the world's) demand for Nation 1's exports is very low, so that Nation 1's terms of trade will deteriorate substantially; and (d) Nation 1 is so heavily dependent on trade that a substantial deterioration in its terms of trade will lead to a reduction in national welfare.

Immiserizing growth does not seem very prevalent in the real world. When it does take place, it is more likely to occur in developing than in developed nations. Even though the terms of trade of developing nations seem to have deteriorated somewhat over time, increases in production have more than made up for this, and their real per capita incomes and welfare have generally increased. Real per capita incomes would have increased much faster if the population of developing nations had not grown so rapidly in recent decades. These questions and many others will be fully analyzed in Chapter 11, which deals with international trade and economic development.

7.5c Illustration of Beneficial Growth and Trade

We now examine the case where only *K* (Nation 1's scarce factor) doubles in Nation 1, so that the wealth effect, by itself, tends to increase the nation's welfare. The results would be very similar with neutral technical progress in the production of only commodity Y

(the K-intensive commodity) in Nation 1. Since this type of growth tends to reduce the volume of trade at constant prices, Nation 1's terms of trade tend to improve. With both the wealth and terms-of-trade effects favorable, Nation 1's welfare definitely improves. This is illustrated in Figure 7.7.

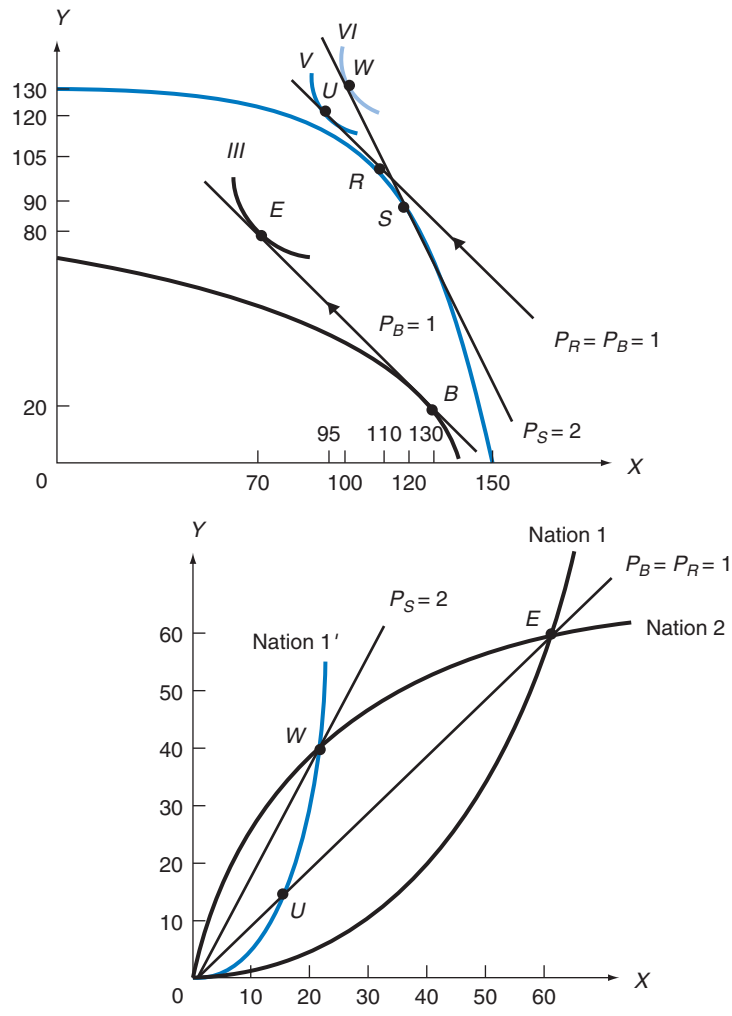

FIGURE 7.7. Growth That Improves Nation 1's Terms of Trade and Welfare.
If K (Nation 1's scarce factor) doubled in Nation 1, production would take place at point R at the unchanged terms of trade of $P_R = P_B = 1$ (see the top panel). Nation 1 would exchange 15X for 15Y with Nation 2 and consume at point U on indifference curve V. However, if Nation 1 is large, its terms of trade will improve because it is willing to export less of X at $P_R = P_B = 1$. At $P_S = 2$, Nation 1 produces at point S, exchanges 20X for 40Y with Nation 2, and consumes at point W on indifference curve VI. Nation 1's welfare increases because of both favorable wealth and terms-of-trade effects. The bottom panel shows with offer curves the effect of this type of growth on the volume and the terms of trade when Nation 1 does not and when it does affect its terms of trade. Compare this to Figure 7.5.

The top panel of the figure shows Nation 1's production frontier before growth and after only K doubles (the dashed production frontier from the right panel of Figure 7.1). At the constant relative commodity price of $P_B = 1$, Nation 1 would produce 110X and 105Y (point R in the top panel), exchange 15X for 15Y with Nation 2, and consume at point U on indifference curve V. With L and population unchanged, this type of growth would increase Nation 1's welfare.

Furthermore, since Nation 1's trade volume declines at constant prices (from the free trade but pregrowth situation at point E), Nation 1's terms of trade also improve, from $P_R = P_B = 1$ to $P_S = 2$. At $P_S = 2$, Nation 1 produces 120X and 90Y at point S, exchanges 20X for 40Y, and consumes at point W on indifference curve VI. Thus, Nation 1's welfare increases because of both wealth and terms-of-trade effects.

The bottom panel of Figure 7.7 shows with offer curves the effect of this type of growth on the volume and the terms of trade when Nation 1 does not and when it does affect its terms of trade. The reader should carefully compare Figure 7.7, where both wealth and terms-of-trade effects are favorable (so that Nation 1's welfare increases for both reasons), with Figure 7.5, where both effects are unfavorable and Nation 1's welfare declines for both reasons. Case Study 7-3 examines growth and the emergence of new economic giants.

■ CASE STUDY 7-3 Growth and the Emergence of New Economic Giants

New economic giants are emerging among developing countries: Brazil, Russia, India, China, and South Africa (BRICS). China is already an economic giant, India is on the way, and Brazil and Russia are following. South Africa, which was sponsored by China to join in 2011, is much smaller. Table 7.3 provides data on the size and economic importance of the new economic giants in relation to the traditional ones: the United States, the European Union, and Japan.

The most important measure of the economic size of a nation is its gross national income (GNI) at purchasing power parity or PPP. This takes into consideration all the reasons (such undervalued exchange rates and nonmarket production—to be discussed in Section 15.2) which lead to serious underestimation of the true GNI of developing nations with respect to that of developed nations.

Table 7.3 shows that the largest economies in terms of PPP are the 27-member European Union (EU-27, examined in Chapter 10) and the United States, followed by China, Japan, and India. Russia and Brazil are smaller, and South Africa much smaller. In terms of per capita income (per capita GNI at PPP—as a measure of the standard of living), the United States is clearly first, followed by Japan, and EU-27. Russia, Brazil, South Africa, China, and India follow with much lower per capita incomes—especially India. Growth of GNI, however, is much faster in China and India, and faster in Russia, South Africa, and Brazil than in the traditional ones, and the size of their economies (total GNIs at PPP), except South Africa, are expected to surpass those of the United States and the EU-27 in 30–40 years *if current growth differentials persist*. In terms of per capita incomes, it would take much longer.

Even more important than economic size and growth rates, however, is the rising competitive challenge that the new giants are providing to the traditional giants, on both world markets and in their own domestic market, in a widening range of increasingly sophisticated products (especially China) and services (especially India).

(continued)

■ CASE STUDY 7-3 Continued

■ TABLE 7.3. Relative Economic Size of the New and Traditional Economic Giants in 2010

	Population (million)	Land Area (sq. km.)	GNI* (billion $)	Per Capita GNI($)*	Average Growth Rate of GNI (%) (2000–2010)
China	1,338	9,598	10,132	7,570	10.8
India	1,171	3,287	4,171	3,560	8.0
Brazil	195	8,515	2,129	10,920	3.7
Russia	142	17,098	2,721	19,190	5.4
S. Africa	50	1,219	514	10,280	3.9
USA	310	9,632	14,562	47,020	1.9
EU 27	501	4,308	15,870	31,677	2.1
Japan	127	378	4,432	34,790	0.9

*Purchasing Power Parity (PPP).
Source: World Bank, *World Development Report*, 2012.

7.6 Growth, Change in Tastes, and Trade in Both Nations

Until now, we have assumed that growth took place only in Nation 1. As a result, only Nation 1's production frontier and offer curve shifted. We now extend our analysis to incorporate growth in both nations. When this occurs, the production frontiers and offer curves of both nations shift. We will now use offer curves to analyze the effect of growth and change in tastes in both nations.

7.6A Growth and Trade in Both Nations

Figure 7.8 shows the effect on the volume and terms of trade of various types of growth in either or both nations. We assume that both nations are large. The offer curves labeled "1" and "2" are the original (pregrowth) offer curves of Nation 1 and Nation 2, respectively. Offer curves "1*" and "2*" and offer curves "1′" and "2′" are the offer curves of Nation 1 and Nation 2, respectively, with various types of growth. A relative commodity price line is not drawn through each equilibrium point in order not to clutter the figure. However, Nation 1's terms of trade (i.e., P_X/P_Y) at each equilibrium point are obtained by dividing the *quantity of commodity Y by the quantity of commodity X* traded at that point. Nation 2's terms of trade at the same equilibrium point are then simply the inverse, or reciprocal, of Nation 1's terms of trade.

With the original pregrowth offer curves 1 and 2, Nation 1 exchanges 60X for 60Y with Nation 2 at $P_B = 1$ (see equilibrium point E_1). If L doubles in Nation 1 (as in Figure 7.5), its offer curve rotates clockwise from 1 to 1* and Nation 1 exports 140X for 70Y (point E_2). In this case, Nation 1's terms of trade deteriorate to $P_X/P_Y = 70Y/140X = ½$, and Nation 2's terms of trade improve to $P_Y/P_X = 2$.

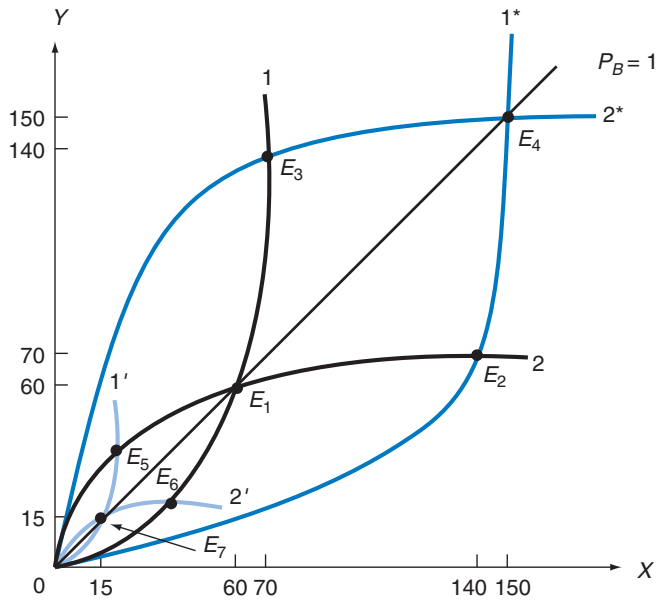

FIGURE 7.8. Growth and Trade in Both Nations.
If L (Nation 1's abundant factor) doubles in Nation 1, its offer curve rotates from 1 to 1^*, giving equilibrium E_2, with a larger volume but lower terms of trade for Nation 1. If K (Nation 2's abundant factor) increases in Nation 2 and its offer curve rotates from 2 to 2^*, equilibrium occurs at E_3, with a larger volume but lower terms of trade for Nation 2. If instead K doubles in Nation 1, its offer curve rotates to $1'$, with a reduction in volume but an increase in Nation 1's terms of trade. If L increases in Nation 2 and its offer curve rotates to $2'$, equilibrium occurs at E_6, with a reduction in volume but an improvement in Nation 2's terms of trade. If both offer curves shift to $1'$ and $2'$, the volume of trade declines even more (see E_7), and the terms of trade of both nations remain unchanged.

If growth occurs only in Nation 2 and its offer curve rotates counterclockwise from 2 to 2^*, we get equilibrium point E_3. This might result, for example, from a doubling of K (the abundant factor) in Nation 2. At E_3, Nation 2 exchanges 140Y for 70X with Nation 1; thus, Nation 2's terms of trade deteriorate to $P_Y/P_X = \frac{1}{2}$, and Nation 1's terms of trade improve to $P_X/P_Y = 2$. With growth in both nations and offer curves 1^* and 2^*, we get equilibrium point E_4. The volume of trade expands to 140X for 140Y, but the terms of trade remain at 1 in both nations.

On the other hand, if K doubled in Nation 1 (as in Figure 7.7), its offer curve would rotate counterclockwise from 1 to $1'$ and give equilibrium point E_5. Nation 1 would then exchange 20X for 40Y with Nation 2 so that Nation 1's terms of trade would improve to 2 and Nation 2's terms of trade would deteriorate to $\frac{1}{2}$. If instead Nation 2's labor only grows in such a manner that its offer curve rotates clockwise to $2'$, we get equilibrium point E_6. This might result, for example, from a doubling of L (the scarce factor) in Nation 2. Nation 2 would then exchange 20Y for 40X with Nation 1, and Nation 2's terms of trade would increase to 2 while Nation 1's terms of trade would decline to $\frac{1}{2}$. If growth occurred in both nations in such a way that offer curve 1 rotated to $1'$ and offer curve 2 rotated to $2'$, then the volume of trade would be only 15X for 15Y, and both nations' terms of trade would remain unchanged at the level of 1 (see equilibrium point E_7).

With balanced growth or neutral technical progress in the production of both commodities in both nations, both nations' offer curves will shift outward and move closer to the axis measuring each nation's exportable commodity. In that case, the volume of trade will expand and the terms of trade can remain unchanged or improve for one nation and deteriorate for the other, depending on the shape (i.e., the curvature) of each nation's offer curve and on the degree by which each offer curve rotates.

7.6B Change in Tastes and Trade in Both Nations

Through time not only do economies grow, but national tastes are also likely to change. As we have seen, growth affects a nation's offer curve through the effect that growth has on the nation's production frontier. Similarly, a change in tastes affects a nation's offer curve through the effect that the change in tastes has on the nation's indifference map.

If Nation 1's desire for commodity Y (Nation 2's exportable commodity) increases, Nation 1 will be willing to offer more of commodity X (its exportable commodity) for each unit of commodity Y imported. Another way of stating this is that Nation 1 will be willing to accept less of commodity Y for a given amount of commodity X that it exports. This will cause Nation 1's offer curve to rotate clockwise, say from 1 to 1^* in Figure 7.8, causing an increase in the volume of trade but a decline in Nation 1's terms of trade.

On the other hand, if Nation 2's tastes for commodity X increase, its offer curve will rotate counterclockwise, say from 2 to 2^*, increasing the volume of trade but reducing Nation 2's terms of trade. If tastes change in the opposite direction, the offer curves will rotate in the opposite direction. If tastes change in both nations, both offer curves will rotate. What happens to the volume of trade and the terms of trade then depends on the type and degree of the change in tastes taking place in each nation, just as in the case of growth.

Summarizing, we can say that with growth and/or a change in tastes in both nations, both nations' offer curves will shift, changing the volume and/or the terms of trade. Regardless of its source, a shift in a nation's offer curve toward the axis measuring its exportable commodity tends to expand trade at constant prices and reduce the nation's terms of trade. Opposite shifts in the nation's offer curve tend to reduce the volume of trade at constant prices and improve the nation's terms of trade. For a given shift in its offer curve, the nation's terms of trade will change more, the greater is the curvature of the trade partner's offer curve.

Case Study 7-4 examines the growth of output, trade, and welfare in the G-7 group of industrial countries. (Growth and trade in developing countries are examined in Chapter 11.)

CASE STUDY 7-4 Growth, Trade, and Welfare in the Leading Industrial Countries

Table 7.4 presents data on the average annual rate of growth of real gross domestic product (GDP), exports, terms of trade, and per capita income for the G-7 (leading industrial) countries from 1990 to 2010. The table shows that the average annual rate of growth of real GDP ranged from 2.8 in the United States to 0.9 percent in Italy, for an unweighted average of 1.8 percent for all G-7 countries. The average rate of growth of the volume of exports ranged from 6.1 percent for Germany to 2.7 for Japan, for an average of 4.5 percent for all 7 countries. Thus, exports grew 2.5 times as rapidly as GDP.

(continued)

CASE STUDY 7-4 Continued

The change in the terms of trade ranged from an average yearly decline of 1.1 percent in Japan to an improvement of 1.1 percent for Canada (due primarily to the sharp increase in the price of its fuels and mineral exports), for a zero unweighted average change for all seven countries. The last column of Table 7.4 shows that the annual growth of real per capita GDP (as a rough measure of the average increase in standards of living) ranged from 1.8 percent in the United States to 0.3 percent for Italy, for an unweighted average increase of 1.6 percent per year for all seven countries. Although many factors contributed to the growth of real per capita GDP, the growth of exports was certainly one of them.

TABLE 7.4. Growth of GDP and Exports, and the Terms of Trade, 1990–2010

	Average Annual Percentage Change			
	Real GDP	Volume of Exports	Terms of Trade	Per Capita GDP
United States	2.8	5.4	−0.2	1.8
Japan	1.0	2.5	−1.1	0.9
Germany	1.4	6.1	−0.3	1.4
United Kingdom	2.2	3.8	0.1	1.7
France	1.6	6.7	0.0	1.0
Italy	0.9	2.7	0.2	0.3
Canada	2.6	4.5	1.1	1.6
Unweighted average	1.8	4.5	0.0	1.2

Source: International Monetary Fund, *International Financial Statistics* (Washington, D.C., various issues); Organization for Economic Cooperation and Development, *Economic Outlook* (Paris, various issues); and World Bank, *World Development Indicators* (Washington, D.C., various issues).

SUMMARY

1. The trade theory discussed in previous chapters was for the most part static in nature. That is, given the nation's factor endowments, technology, and tastes, we proceeded to determine its comparative advantage and the gains from trade. However, factor endowments change through time; technology usually improves; and tastes may also change. In this chapter, we examined the effect of these changes on the equilibrium position. This is known as comparative static analysis.

2. With constant returns to scale and constant prices, if L and K grow at the same rate (balanced growth), the nation's production frontier will shift out evenly in all directions at the rate of factor growth, and output per worker will remain constant. If L grows faster than K, the nation's production frontier will shift proportionately more in the direction of the L-intensive commodity, and output per worker will decline. The opposite is true if K grows faster than L. The Rybczynski theorem postulates that at constant commodity prices, an increase in the endowment of one factor will increase by a greater proportion the output of the commodity intensive in that factor and will reduce the output of the other commodity.

3. All technical progress reduces the amount of L and K required to produce any given output, shifts the

production frontier outward, and tends to increase the nation's welfare. Hicksian neutral technical progress increases the productivity of L and K in the same proportion and has the same effect on the nation's production frontier as balanced factor growth. As a result, K/L remains unchanged at constant relative factor prices (w/r). L-saving technical progress increases the productivity of K proportionately more than the productivity of L. As a result, K is substituted for L in production so that K/L rises at unchanged w/r. K-saving technical progress is the opposite of L-saving technical progress.

4. Production and consumption can be protrade (if they lead to a greater-than-proportionate increase in trade at constant prices), antitrade, or neutral. Production is protrade if the output of the nation's exportable commodity increases proportionately more than the output of its importable commodity. Consumption is protrade if the nation's consumption of its importable commodity increases proportionately more than consumption of its exportable commodity. What happens to the volume of trade in the process of growth depends on the net result of the production and consumption effects.

5. If growth, regardless of its source and type, increases the nation's volume of trade at constant prices, the nation's terms of trade tend to deteriorate. Otherwise, the nation's terms of trade tend to remain unchanged or improve. The effect of growth on the nation's welfare also depends on a wealth effect. This refers to the change in output per worker or per person as a result of growth. If both the terms-of-trade and wealth effects of growth are favorable, the nation's welfare will definitely improve. Otherwise, it will remain the same or decline, depending on the net result of these two effects. The case where an unfavorable terms-of-trade effect overwhelms even a favorable wealth effect and leads to a decline in the nation's welfare is known as "immiserizing growth."

6. With growth and/or a change in tastes in both nations, both nations' offer curves will shift, changing the volume and/or the terms of trade. Regardless of its source, a shift in a nation's offer curve toward the axis measuring its exportable commodity tends to expand trade at constant prices and reduce the nation's terms of trade. Opposite shifts in the nation's offer curve tend to reduce the volume of trade at constant prices and improve the nation's terms of trade. For a given shift in its offer curve, the nation's terms of trade will change more the greater the curvature is of its trade partner's offer curve.

A LOOK AHEAD

This chapter concludes our presentation of international trade theory. We now go on to Part Two, which deals with trade policies. We begin with a discussion of tariffs in Chapter 8. We will be primarily concerned with the welfare effects of tariffs on the nation imposing them and on the rest of the world. The welfare effects of tariffs will be analyzed first from a partial equilibrium and then from a general equilibrium point of view, utilizing the tools of analysis and figures developed in Part One.

KEY TERMS

Antitrade production and consumption, p. 196
Balanced growth, p. 190
Capital-saving technical progress, p. 194
Comparative statics, p. 190
Dynamic analysis, p. 190
Immiserizing growth, p. 202
Inferior good, p. 199
Labor-saving technical progress, p. 194
Neutral production and consumption, p. 196
Neutral technical progress, p. 193
Normal goods, p. 199
Protrade production and consumption, p. 196
Rybczynski theorem, p. 192
Terms-of-trade effect, p. 201
Wealth effect, p. 201

QUESTIONS FOR REVIEW

1. What is meant when we say that the trade theory discussed in previous chapters is static in nature? What is meant by comparative statics?
2. How can our trade theory of previous chapters be extended to incorporate changes in the nation's factor endowments, technology, and tastes? Is the resulting trade theory a dynamic theory of international trade? Why?
3. What effect do the various types of factor growth have on the growing nation's production frontier? What is meant by balanced growth?
4. What does the Rybczynski theorem postulate?
5. Explain neutral, labor-saving, and capital-saving technical progress.
6. How does neutral technical progress in the production of either or both commodities affect the nation's production frontier? Which type of technical progress corresponds to balanced factor growth as far as its effect on the growing nation's production frontier is concerned?
7. What is meant by production and/or consumption being protrade, antitrade, or neutral?
8. Which sources of growth are most likely to be protrade? Which sources of growth are most likely to be antitrade? Which types of commodities are most likely to result in protrade consumption? antitrade consumption?
9. What is the terms-of-trade effect of growth? What is the wealth effect of growth? How can we measure the change in the welfare of the nation as a result of growth and trade when the nation is too small to affect relative commodity prices? when the nation is large enough to affect relative commodity prices?
10. Which type of growth will most likely lead to a decline in the nation's welfare? What is meant by immiserizing growth? Which type of growth will most likely lead to an increase in the nation's welfare?
11. What is the effect on the volume and terms of trade if a nation's offer curve shifts or rotates toward the axis measuring its exportable commodity? What type of growth and/or change in tastes in the nation will cause its offer curve to shift or rotate this way?
12. How does the shape of the trade partner's offer curve affect the change in the terms of trade resulting from a given shift in a nation's offer curve?

PROBLEMS

1. Starting with Nation 2's pregrowth production frontier of previous chapters, draw a new production frontier for Nation 2 showing that:

   (a) The amount of both capital and labor available to Nation 2 doubled.

   (b) Only the amount of capital doubled.

   (c) Only the amount of labor doubled.

2. Starting with Nation 2's pregrowth production frontier of previous chapters, draw a new production frontier for Nation 2 showing the Rybczynski theorem for the doubling of the amount of capital only.
3. Starting with Nation 2's pregrowth production frontier, draw a production frontier for Nation 2 showing neutral technical progress that doubles the productivity of labor and capital in the production of:

   (a) Both commodity X and commodity Y.

   (b) Commodity X only.

   (c) Commodity Y only.

4. Compare the graphs in Problem 3 with those in Problems 1 and 2.

*5. Draw for Nation 2 a figure analogous to the top panel of Figure 7.4 under the following assumptions:

   (a) Only the amount of capital doubles in Nation 2.

   (b) The free trade equilibrium-relative commodity price is $P_X/P_Y = 1$.

(c) Nation 2 is too small to affect the relative commodity prices at which it trades before and after growth.

(d) Nation 2 exports 150Y after growth.

***6.** Draw for Nation 2 a figure analogous to the bottom panel of Figure 7.4 under the same assumptions as in Problem 5.

7. Draw for Nation 2 a figure analogous to the top panel of Figure 7.5 under the following assumptions:

(a) Nation 2 is now large enough to affect the relative commodity prices at which it trades.

(b) The terms of trade of Nation 2 deteriorate from $P_Y/P_X = 1$ with free trade before growth to $P_Y/P_X = \frac{1}{2}$ with growth and free trade.

(c) Nation 2 exports 140Y with growth and free trade.

8. Draw for Nation 2 a figure analogous to the bottom panel of Figure 7.5 under the same assumptions as in Problem 7.

***9.** Draw a figure analogous to Figure 7.6 showing immiserizing growth for Nation 2 when the productivity of capital and labor doubled only in the production of commodity Y in Nation 2.

10. Draw a figure similar to Figure 7.6 but showing immiserizing growth for an increase in the population and labor force of a nation.

11. Draw for Nation 2 a figure analogous to the top panel of Figure 7.7 under the following assumptions:

(a) Only the amount of labor doubles in Nation 2.

(b) The terms of trade of Nation 2 improve from $P_Y/P_X = 1$ with free trade before growth to $P_Y/P_X = 2$ with growth and free trade.

(c) Nation 2 exports 20Y with growth and free trade.

12. Draw for Nation 2 a figure analogous to the bottom panel of Figure 7.7 under the same assumptions as in Problem 11.

13. The data in Table 7.2 indicate that the United States has the smallest increase in output per worker, no improvements in efficiency, and a small improvement in technology in relation to other developed countries in the table. This seems to contradict the information in Table 6.5. How can this seeming contradiction be resolved?

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

APPENDIX

This appendix presents the formal proof of the Rybczynski theorem in Section A7.1; it examines growth when one factor is not mobile within the nation in Section A7.2; and it gives a graphical interpretation of Hicksian neutral, labor-saving, and capital-saving technical progress in Section A7.3.

A7.1 Formal Proof of the Rybczynski Theorem

As discussed in Section 7.2B, the Rybczynski theorem postulates that at constant commodity prices, an increase in the endowment of one factor will increase by a greater proportion the output of the commodity intensive in that factor and will reduce the output of the other commodity.

The formal proof of the Rybczynski theorem presented here closely follows the analysis for the derivation of a nation's offer curve from its Edgeworth box diagram presented in Section A3.3. Starting from Figure 3.10, we formally prove the Rybczynski theorem for the case where only the amount of labor doubles in Nation 1.

The theorem could be proved either by starting from the free trade production point B (as in Figure 7.2) or by starting from the autarky, or no-trade, production and consumption equilibrium point A (from previous chapters). The starting point is immaterial as long as the new production point after growth is compared with the particular initial point chosen and commodity prices are kept at the same level as at the initial equilibrium point. We will start from point A because that will also allow us to examine the implications of the Rybczynski theorem for relative commodity prices in the absence of trade.

Figure 7.9 shows the proof. Point A on Nation 1's production frontier (in the bottom part of Figure 7.9) is derived from point A in Nation 1's Edgeworth box diagram (in the top of the figure) before the amount of labor doubles. This is exactly as in Figure 3.9. After the amount of labor doubles, Nation 1's Edgeworth box doubles in length but remains the same height (because the amount of capital is kept constant).

For commodity prices to remain constant, factor prices must remain constant. But relative factor prices can remain constant only if K/L and the productivity of L and K remain constant in the production of both commodities. The only way for K/L to remain constant, and for all of L and K to remain fully employed after L doubles, is for production in Nation 1 to move from point A to point A^*, in the Edgeworth box in the top part of the figure. At points A and A^*, K/L in the production of commodity X is the same because point A^* lies on the same ray from origin O_X as point A. Similarly, K/L in the production of commodity Y at point A^* is the same as at point A because the dashed ray from origin O_Y^* to point A^* has the same

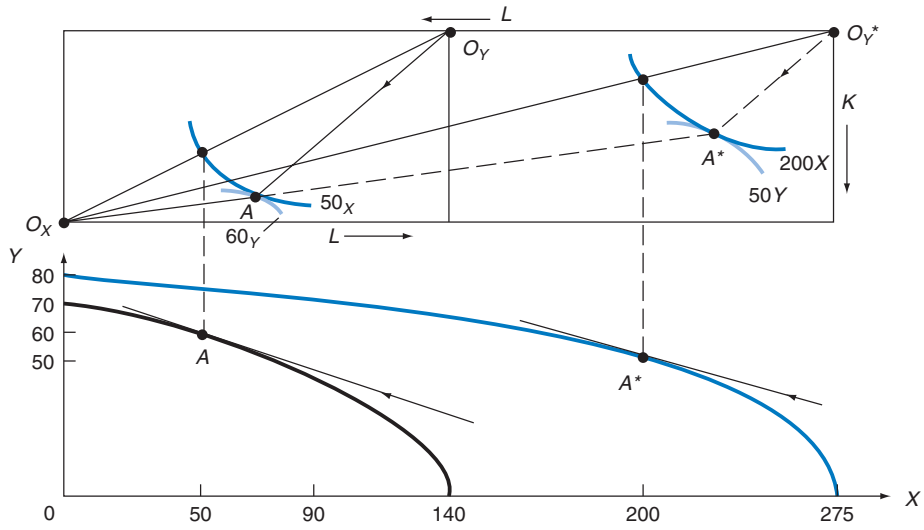

FIGURE 7.9. Graphical Proof of the Rybczynski Theorem.
Point A on Nation 1's production frontier (in the bottom part of the figure) is derived from point A in Nation 1's Edgeworth box (in the top part of the figure). This is exactly as in Figure 3.9. Doubling L doubles the size of the box. For P_X and P_Y to remain the same, w and r must remain constant. But w and r can remain constant only if K/L remains constant in the production of both commodities. Point A^* in the top and bottom parts of the figure is the only point where this is possible and all of the increase in L is fully absorbed. At point A^*, K/L in the production of both commodities is the same as at point A. At A^*, the output of commodity X (the L-intensive commodity) more than doubles, while the output of commodity Y declines, as postulated by the Rybczynski theorem.

slope as the ray from origin O_Y to point A. Point A^* is the only point in the Edgeworth box consistent with full employment of all resources after L has doubled and with K/L constant in the production of both commodities. Note that isoquants have the same slope at points A and A^*, indicating that w/r is the same at both points.

Since point A^* is much farther from origin O_X than point A in the Edgeworth box, Nation 1's output of commodity X has increased. On the other hand, since point A^* is closer to origin O_Y^* than point A is to origin O_Y, Nation 1's output of commodity Y has declined. These events are reflected in the movement from point A on Nation 1's production frontier before L doubled to point A^* on its production frontier after L doubled. That is, at point A on its production frontier before growth, Nation 1 produced 50X and 60Y, whereas at point A^* on its production frontier after growth, Nation 1 produced 200X but only 50Y at $P_A/P_A^* = \frac{1}{4}$. Doubling L more than doubles (in this case, it quadruples) the output of commodity X. That is, the growth of L has a magnified effect on the growth of the output of commodity X (the L-intensive commodity). This completes our proof of the Rybczynski theorem.

After proving that the output of commodity Y falls at constant P_X/P_Y, we must immediately add that P_X/P_Y cannot remain constant unless commodity Y is an inferior good. Only then would the consumption of commodity Y decline absolutely in Nation 1 with the growth of its real *national* income and no trade. Barring inferior goods, P_X/P_Y must fall (P_Y/P_X rises) so that absolutely more of commodity Y is also produced and consumed after growth and with no trade. Thus, keeping relative commodity prices constant is only a way of analyzing what would happen to the output of each commodity *if relative commodity prices remained constant*. However, relative commodity prices cannot remain constant unless commodity Y is inferior or there is free trade and Nation 1 is assumed to be too small to affect the relative commodity prices at which it trades. In that case, Nation 1 can consume more of both commodities after growth even with constant relative commodity prices and without commodity Y having to be an inferior good. This is exactly what Figure 7.4 shows.

Problem (a) Starting from pretrade, or autarky, equilibrium point A^* in Nation 2, prove graphically the Rybczynski theorem for a doubling in the amount of K in Nation 2. (b) What restrictive assumption is required for production and consumption actually to occur at the new equilibrium point after the doubling of K in Nation 2? (c) How are relative commodity prices likely to change as a result of growth only? as a result of both growth and free trade?

A7.2 Growth with Factor Immobility

We know from the Rybczynski theorem that at constant commodity prices, an increase in the endowment of one factor will increase by a greater proportion the output of the commodity intensive in that factor and will reduce the output of the other commodity. We also know that factor prices are constant at constant commodity prices.

We now want to analyze the effect of factor growth when one of the factors is not mobile between the nation's industries and commodity prices are constant. We can analyze this case by using the specific-factors model developed in Section A5.4 of the appendix to Chapter 5. We will see that the results differ from those predicted by the Rybczynski theorem and depend on whether it is the growing or the nongrowing factor that is immobile within the nation.

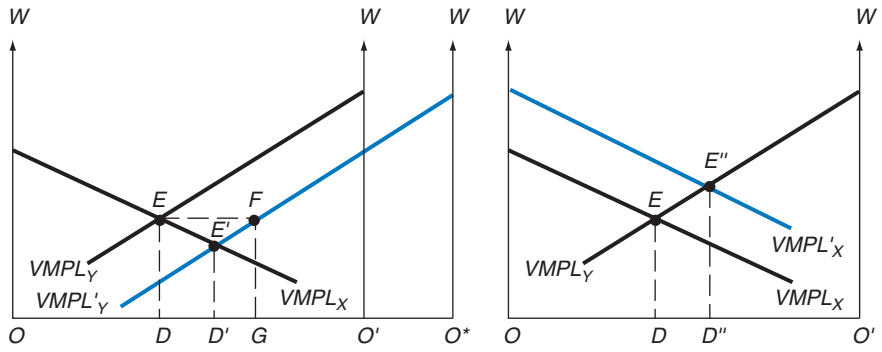

FIGURE 7.10. Growth with the Specific-Factors Model.
Before growth and with L mobile and K immobile in the nation, $w = ED$, and OD of L is used to produce X and DO' to produce Y in both panels. In the left panel, an increase in L of $O'O^* = EF = DG$ results in a fall in wages to $E'D'$, and DD' more L used in the production of X and $D'G$ in Y. The output of X and Y increases, and r rises in both industries. In the right panel, K increases in the production of X only. This causes the $VMPL_X$ curve to shift up to $VMPL'_X$. The wage rate rises to $w = E''D''$, and DD'' of L is transferred from Y to X. The output of X rises and that of Y falls, and r falls in both industries with unchanged commodity prices.

The left panel of Figure 7.10 refers to an increase in the supply of labor (the relatively abundant and mobile factor in Nation 1), and the right panel refers to an increase in the supply of capital (the scarce and immobile factor in Nation 1). In both panels, we begin (as in Figure 5.8) with a total supply of labor in the nation equal to OO'. The equilibrium wage in both industries is ED and is determined by the intersection of the $VMPL_X$ and $VMPL_Y$ curve. OD of labor is used in the production of commodity X and DO' in the production of commodity Y.

Let us now concentrate on the left panel of Figure 7.10, where the supply of labor increases and labor is mobile, while capital is not. If the supply of labor increases by $O'O^* = EF = DG$ from OO' to OO^*, the new equilibrium wage in both industries is $E'D'$ and is determined at the intersection of the $VMPL_X$ and $VMPL'_Y$ curves. Of the DG increase in the supply of labor, DD' is employed in the production of commodity X and $D'G$ in the production of commodity Y. Since the amount of capital used in each industry does not change but the amount of labor increases, the output of both commodities increases. However, the output of commodity X increases by more than the output of commodity Y because commodity X is L intensive and more of the increase in labor is employed in the production of commodity X. Furthermore, since more labor is used in each industry with unchanged amounts of capital, the $VMPK$ and the return on capital (r) rise in both industries.

Thus, when the supply of labor increases and labor is mobile but capital is not, the output of both commodities increases, and w falls and r rises in both industries, at constant commodity prices. In the long run (when both labor and capital are mobile within the nation), an increase in the supply of labor increases the output of commodity X by a greater proportion, reduces the output of commodity Y, and leaves w and r unchanged at constant commodity prices (the Rybczynski theorem).

Let us turn to the right panel of Figure 7.10, where the supply of capital (Nation 1's scarce and immobile factor) increases in the production of commodity X only. Since each unit of labor in the production of commodity X will have more capital to work with, the $VMPL_X$ curve shifts up to $VMPL'_X$. The intersection of the $VMPL'_X$ and $VMPL_Y$ curves now

determines the new and higher equilibrium wage of $E''D''$ in both industries, and DD'' of labor is transferred from the production of commodity Y to the production of commodity X. Since w rises in both industries, r must fall in both in order for commodity prices to remain constant (as assumed). Furthermore, since both more capital and more labor are used in the production of commodity X, the output of commodity X rises. On the other hand, since the same amount of capital but less labor is used in the production of commodity Y, the output of commodity Y declines. Thus, in this case, the changes in outputs are similar to those postulated by the Rybczynski theorem.

All of the above results, however, are based on the assumption that commodity prices do not change. Since the output of commodity X increases while that of Y falls (or increases by less than the increase in the output of X), P_X/P_Y is likely to fall, and this lowers the terms of trade of the nation (unless Nation 1 is small) and modifies the effects of growth on factor prices derived above (on the basis of unchanged commodity prices).

Problem What happens if the supply of capital increases in Nation 1 in the production of commodity Y only?

A7.3 Graphical Analysis of Hicksian Technical Progress

In this section we give a graphical interpretation of the Hicksian classification of neutral, *L*-saving, and *K*-saving technical progress using isoquants (reviewed in Sections A3.1 and A3.2). We also examine the effect of the various types of technical progress on relative factor prices.

All innovations, regardless of their type, can be represented by a shift toward the origin of the isoquant referring to any given level of output. This indicates that fewer inputs or factors are required to produce any level of output after technical progress has occurred. The distinction between various types of technical progress is based on the effect that each has on *K/L* at constant relative factor prices *(w/r)*.

Hicksian technical progress is *neutral* if it leaves *K/L* unchanged. Technical progress is *labor saving* if it tends to increase *K/L* and *capital saving* if it tends to reduce *K/L*. These are shown in Figure 7.11.

In all three panels of the figure, we begin at point A_1, where 100X is produced with $4L$ and $4K$ before technical progress occurs. After neutral technical progress, the same 100X can be produced with $2L$ and $2K$ (point A_2 in the left panel), leaving $K/L = 1$ at unchanged $w/r = 1$ (the absolute slope of the isocosts). With *L*-saving technical progress, the same 100X can be produced with $3K$ and $1L$ (point A_3 in the middle panel) and $K/L = 3$ at unchanged $w/r = 1$. Finally, with *K*-saving technical progress, the same 100X can be produced with $1K$ and $3L$ (point A_3 in the right panel) and $K/L = \frac{1}{3}$ at unchanged $w/r = 1$.

At point A_2 in the middle panel, the ratio of the marginal productivity of K to the interest rate (i.e., *MPK/r*) exceeds *MPL/w*, and so K is substituted for L in the production of commodity X. As K is substituted for L, *r/w* will tend to rise, thus moderating the tendency of *K/L* to rise. In any event, r is likely to rise in relation to w as a result of the *L*-saving innovation.

On the other hand, at point A_2 in the right panel, *MPL/w* exceeds *MPK/r*, and so L is substituted for K in the production of commodity X. As L is substituted for K, *w/r* will

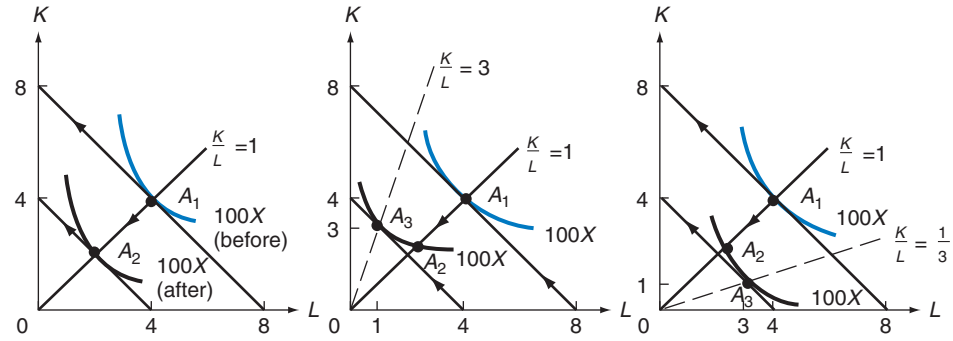

FIGURE 7.11. Hicksian Neutral, L-Saving, and K-Saving Technical Progress.
In all three panels of the figure, we begin at point A_1, where 100X is produced with $4L$ and $4K$ before technical progress occurs. After neutral technical progress, the same 100X can be produced with $2L$ and $2K$ (point A_2 in the left panel), leaving $K/L = 1$ at unchanged $w/r = 1$ (the absolute slope of the isocosts). With L-saving technical progress, the same 100X can be produced with $3K$ and $1L$ (point A_3 in the middle panel) and $K/L = 3$ at unchanged $w/r = 1$. Finally, with K-saving technical progress, the same 100X can be produced with $1K$ and $3L$ (point A_3 in the right panel) and $K/L = \frac{1}{3}$ at unchanged $w/r = 1$.

tend to rise, thus moderating the tendency of K/L to fall (i.e., L/K to rise). In any event, w is likely to rise in relation to r as a result of the K-saving innovation.

Thus, a greater proportionate increase in the amount of L- and/or a K-saving innovation tends to reduce K/L and w/r. This tendency will be greater if the K-saving innovation takes place in the production of the L-intensive commodity. This is the case because then the demand for labor grows the most. To these effects on w/r resulting purely from internal growth would have to be added the effects resulting from international trade in order to determine the net effect on w/r resulting from both growth and trade. These were discussed in the chapter itself.

Problem Using the tools of analysis developed in this chapter, comment in detail on the following statement: Capital investments tend to increase real wages while technical progress, depending on its type, may increase or reduce real wages.

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http://www.bized.ac.uk/dataserv/penndata/penn.htm

For information and data on growth of output and international trade and their effect on the terms of trade, see the Internet site addresses for the International Monetary Fund (IMF), World Trade Organization (WTO), Organization for Economic Cooperation and Development (OECD), World Bank, and United Nations, respectively, at:

http://www.imf.org

http://www.wto.org

http://www.oecd.org

http://worldbank.org

http://www.un.org/depts/unsd/sd

part

2

International Trade Policy

Part Two (Chapters 8–12) deals with international trade or commercial policies. Chapter 8 examines tariffs, the most important of the trade restrictions historically. Chapter 9 extends the discussion to other trade restrictions, evaluates the justification usually given for trade restrictions, and summarizes their history. Chapter 10 deals with economic integration, Chapter 11 focuses on the effect of international trade on economic development, and Chapter 12 looks at international resource movements and multinational corporations.