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.

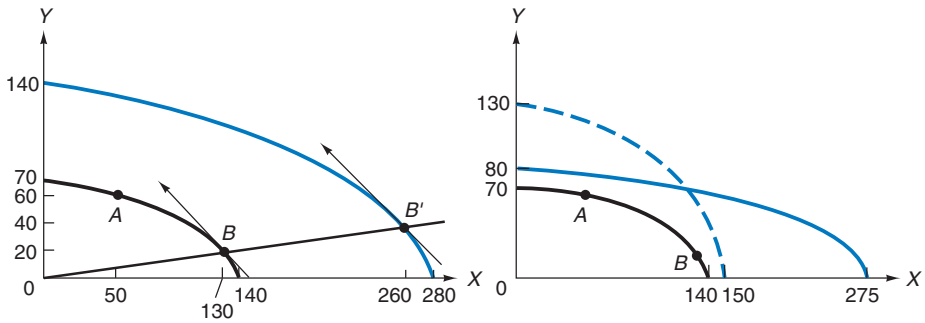

FIGURE 7.1. Growth of Labor and Capital over Time.
The left panel shows the case of balanced growth with *L* and *K* doubling under constant returns to scale. The two production frontiers have identical shapes and the same slope, or P_X/P_Y, along any ray from the origin. The right panel shows the case 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.

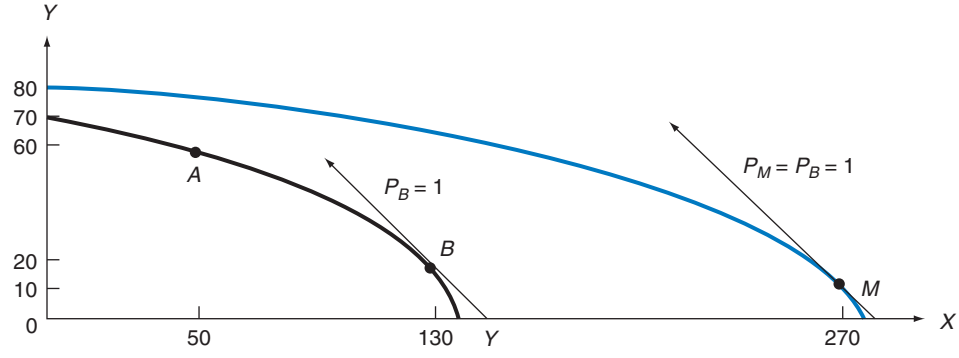

FIGURE 7.2. The Growth of Labor Only and the Rybczynski Theorem.
With trade but before growth, Nation 1 produces at point B (130X and 20Y) at $P_X/P_Y = P_B = 1$, as in previous chapters. After only L doubles and with P_X/P_Y remaining at $P_B = 1$, Nation 1 produces at point M (270X and 10Y) on its 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

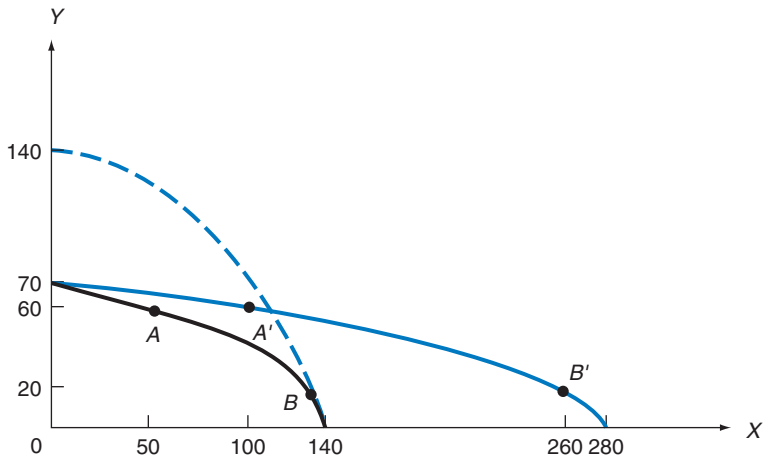

FIGURE 7.3. Neutral Technical Progress.
The figure shows Nation 1's production frontier before technical progress and after the productivity of *L* and *K* doubled in the production of commodity X only, or in the production of commodity Y only (the dashed frontier). Note that if Nation 1 uses all of 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

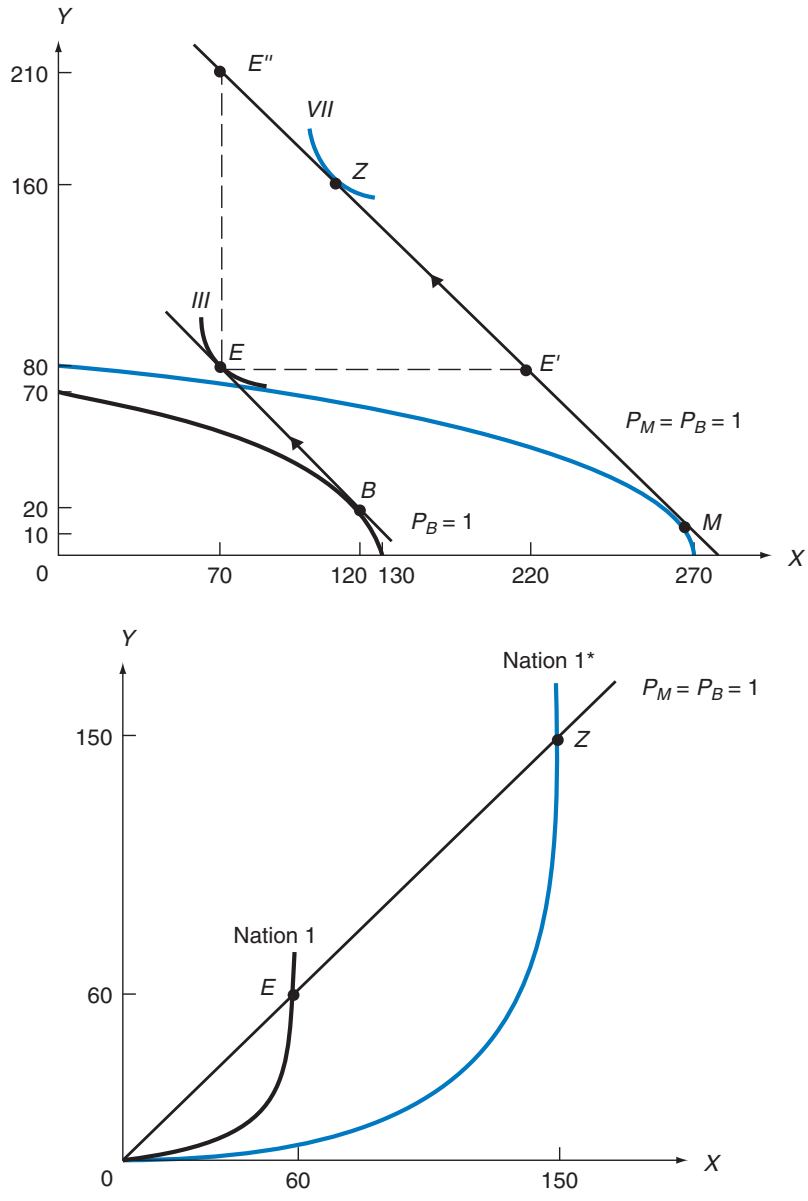

FIGURE 7.4. Factor Growth and Trade: The Small-Country Case.
The top panel shows that after L doubles, Nation 1 exchanges 150X for 150Y at $P_M = P_B = 1$ and reaches indifference curve *VII*. Since the consumption of both X and Y rises with growth, both commodities are normal goods. Since L doubled 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.

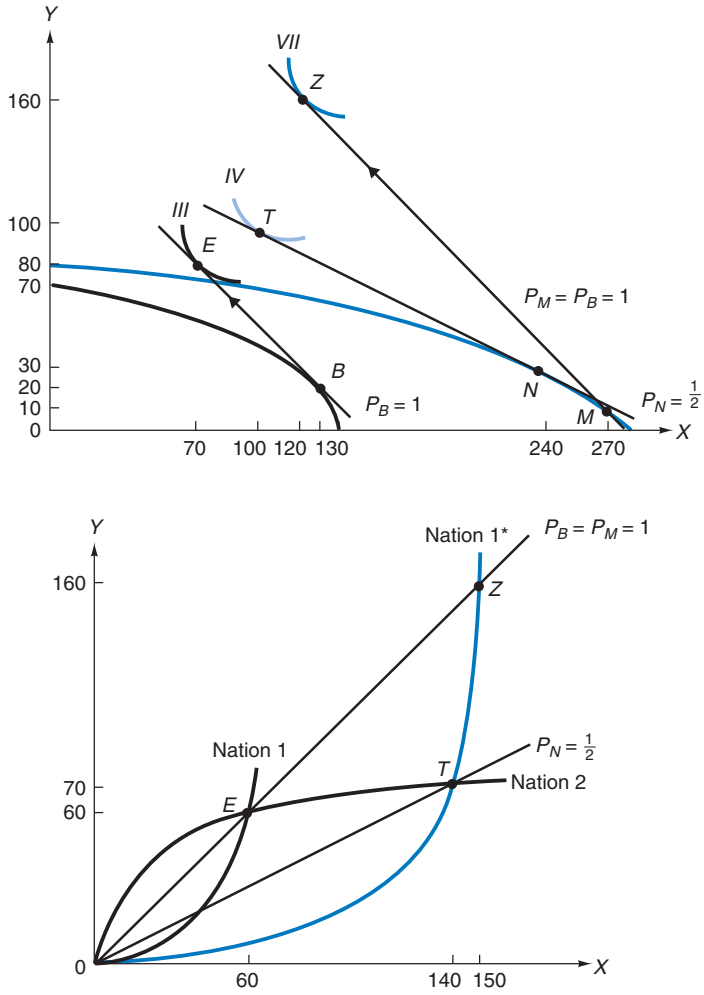

FIGURE 7.5. Growth and Trade: The Large-Country Case.
Figure 7.5 is identical to Figure 7.4, except that now Nation 1 is assumed to be large enough to affect the terms of trade. With the terms of trade deteriorating from $P_M = P_B = 1$ to $P_N = ½$ with growth and trade, Nation 1 produces at point *N*, 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

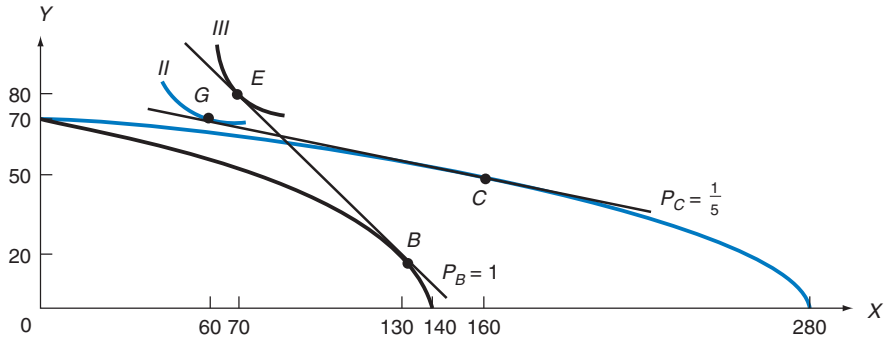

FIGURE 7.6. Immiserizing Growth.
This figure reproduces from Figure 7.3 the production frontier of Nation 1 before and after neutral technical progress increased the productivity of *L* and *K* in the production of commodity X only. With this type of technical progress, the wealth effect, by itself, 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.

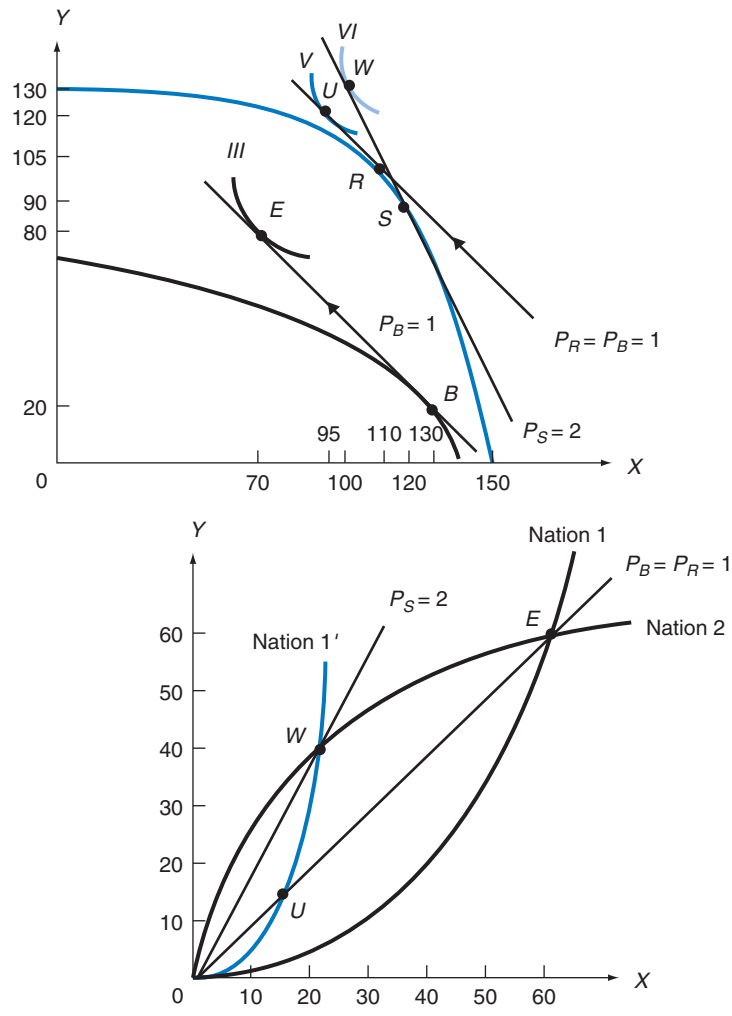

FIGURE 7.7. Growth That Improves Nation 1's Terms of Trade and Welfare.
If K (Nation 1's scarce factor) doubled in Nation 1, production would take place at point R at the unchanged terms of trade of $P_R = P_B = 1$ (see the top panel). Nation 1 would exchange 15X for 15Y with Nation 2 and consume at 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 $P_Y/P_X = 2$.

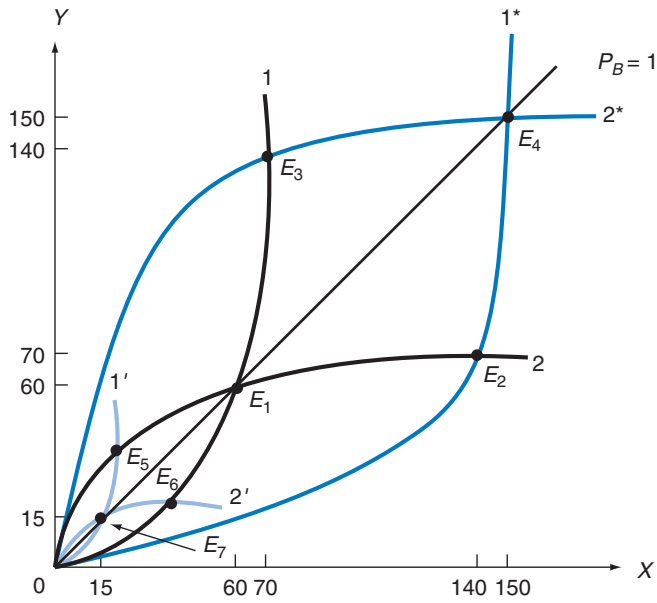

FIGURE 7.8. Growth and Trade in Both Nations.
If L (Nation 1's abundant factor) doubles in Nation 1, its offer curve rotates from 1 to 1^*, giving equilibrium E_2, with a larger volume but lower terms of trade for Nation 1. If K (Nation 2's abundant factor) increases in Nation 2 and its offer curve rotates 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)