PART II

Globalization: Trade Patterns and Income Distribution

CHAPTER 4

Technology and International Income Distribution: The Ricardian Model

What characteristics of production help explain patterns of world trade? What are the repercussions of trade both on the international distribution of income among countries and the intranational distribution of income among workers, land, and capital? Do the forces promoting and reflecting greater globalization tend to help all trading countries? Is there a tendency for labor to be left behind as world income levels rise? Are less developed countries particularly at risk in the globalization process?

Countries, commodities, and productive factors each exhibit striking differences: Countries differ from each other in technology, climate, the skill levels of factors of production, the composition of the factor endowment base, and size. Commodities differ from each other, both in the techniques used to produce them and in their quality and appeal to consumers. Factors differ from each other in the ease with which they can leave one occupation and move to a more promising sector of the economy, or, indeed, can move from one country to another. Some countries are abundant in natural resources and land, whereas others possess relatively plentiful supplies of labor but are poorly endowed with accumulated capital. International trade can have a profound effect in realigning the functional distribution of income within as well as between countries. The models presented in Part II help reveal why various groups within a nation hold such strong views about trade policy.

The role of technology in explaining trade patterns and productivities is the focus of this chapter. Technology is constantly in the news these days, especially with concerns about wage rates for the unskilled. It is perhaps ironic that the earliest model of trade, that associated with the name of David Ricardo (1817), can be used to discuss technology as a source of trade.[1] Chapter 2 has already demonstrated the basic result concerning gains from trade: Countries can mutually benefit from trade if the relative prices of commodities differ between countries in the absence of trade. Ricardo is credited with establishing this result in a simple model in which a country's prices must reflect the relative ratio of labor costs of production. Thus, the trade pattern in a Ricardian world is determined by differences in labor productivity among countries.

[1]A recent edition is David Ricardo, *The Principles of Political Economy and Taxation* (Cambridge, UK: Cambridge University Press, 1981), Chapter 7.

4.1 The Ricardian Setting

The tradition in the theory of international trade of exploring issues by using models of the economy that are frugal in limiting complexity is exemplified in the Ricardian setting: Only a single productive factor (labor) is required to produce commodities, so we postpone questions of internal income distribution until the next pair of chapters. This serves as well to push to the forefront the issue of the productivity of labor and how differences among countries in *relative* productivities provide the key to explaining trade patterns. Changes in these productivities can affect relative and real wage rates for labor in different countries.

If a country is unable to trade in world markets, relative commodity prices in the Ricardian setting are described by the *labor theory of value*: Within the country, labor, the only scarce productive factor, is homogeneous and all occupations pay the same wage rate in a competitive setting in which prices are driven down to the level of costs. The relative price of clothing in a two-commodity setting is given by the ratio of the hours required to produce a unit of clothing (a_{LC}) to the hours required to produce a unit of food (a_{LF}). The reciprocals of these numbers are sometimes used instead (e.g., labor's productivity in producing food is given by $1/a_{LF}$).

These productivity figures incorporate information not only about technology but labor skills and perhaps climate as well. (For example, one of the commodities used by Ricardo was wine, and climatic differences between Portugal and England certainly would affect labor productivities in producing wine.) Higher education levels or more appropriate attitudes toward discipline in the workplace show up in higher output per unit of labor, just as would be the case with superior technology. Improvements in labor productivity are created in the classroom, in the research labs, and in attitudes of labor.

Suppose the home country's supply of labor available for employment (L) is fixed. A production-possibilities curve resembling Figure 2.4(b) can then be drawn, Figure 4.1, because it is assumed the labor input figures for each commodity are known constants—they do not change with levels of output although they would be reduced if there is technical progress. The slope of the schedule is thus the constant ratio, a_{LC}/a_{LF}. If full employment prevails, as we assume, the labor supply, L, is assigned partly to clothing—given by the product of the labor required per unit of clothing, a_{LC}, and the output of clothing, x_C, and partly to food, $a_{LF}x_F$. (Economists sometimes refer to the *extensive* margin (x_i) and the *intensive* margin (a_{Li}).) The full-employment condition is thus the equation of the transformation schedule, shown in Equation 4.1:

$$a_{LC}x_C + a_{LF}x_F = L \tag{4.1}$$

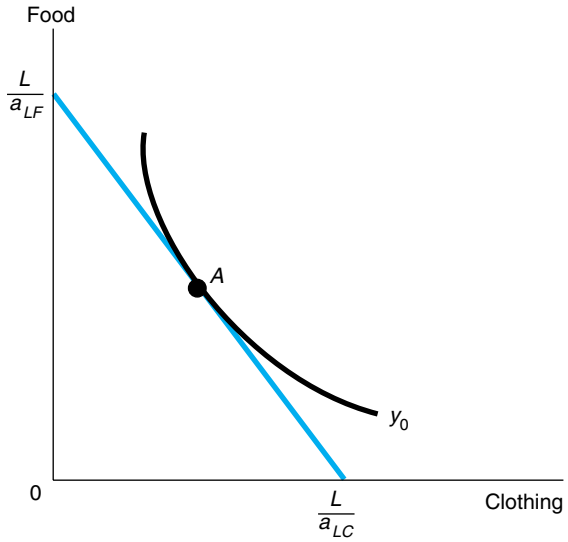
The endpoints of the transformation schedule show the maximum amount of each commodity that could be produced (by channeling all labor for that purpose), and the slope shows how much food must be sacrificed in order to release enough labor to produce another unit of clothing.

A closed economy must rely on its own production to satisfy its consumption needs. Therefore, relative prices in such an economy are shown by the constant slope of the transformation schedule. The pretrade consumption (and production) pattern would be illustrated in Figure 4.1 by point A, at which an indifference curve (y_0) is

FIGURE 4.1

The Ricardian Production Possibilities Schedule

The opportunity cost of producing clothing is shown by the slope of the straight-line transformation schedule, which is the ratio of labor coefficients a_{LC}/a_{LF}. Before international trade, the country produces and consumes at A, with welfare levels shown by the indifference curve, y_0.



tangent to the straight-line transformation schedule. These remarks easily generalize to a closed economy with any number of commodities. Relative prices are all technologically determined by the invariant labor productivities. As will soon become clear, this view of the determinants of prices is no longer applicable once the economy is opened to trade.

4.2 Free-Trade Equilibrium

The labor theory of value, identifying commodity price ratios with labor cost ratios, must come to grief in a world of international trade. Why? Because cost ratios differ between countries, whereas price ratios do not when commodities are freely traded. The resolution? A country may be forced by international competition to abandon some line of production. If so, it is precisely *because* the international price of that commodity falls short of the costs per unit required to produce it at home, so that no local production can take place.

Figure 4.2 illustrates a free-trade equilibrium in which it has been assumed the home country possesses a comparative advantage in the production of clothing, as reflected in Inequality 4.2:

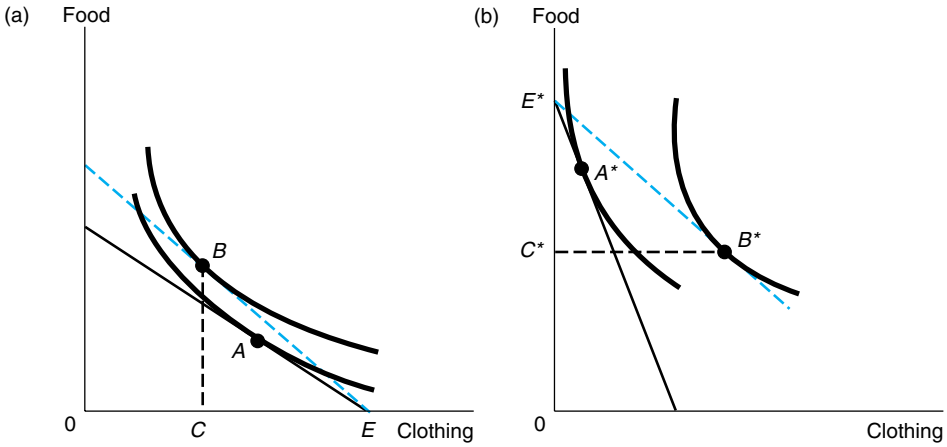
$$\frac{a^*_{LF}}{a^*_{LC}} < \frac{a_{LF}}{a_{LC}} \tag{4.2}$$

In this illustration it is assumed in free trade there are equilibrium terms of trade that call for each country to be completely specialized in producing (and exporting) the commodity in which it has a comparative advantage. The rationale for the gains from

FIGURE 4.2

Free-Trade Equilibrium

Pretrade equilibrium at home is shown by point *A* in the left-hand diagram, (a); abroad it is shown by *A** in the right-hand diagram, (b). Equilibrium terms of trade are illustrated by the slope of the dashed line for each country. With trade the home country produces at *A* and consumes at *B*; the foreign country produces at *E** and consumes at *B**. Each country gains from trade. The trade triangles match.



trade is similar to that described for the basic trade model in Part I. What is special about the Ricardian model is the potentially drastic consequence of trade for patterns of production. In each country not only are some resources attracted to the export sector, *all* resources flow there. Clearly this reflects the assumption of constant opportunity costs as opposed to increasing opportunity costs (along a bowed-out production-possibilities curve). Each country gains from trade, with free-trade consumption points, *B* and *B**, lying on higher indifference curves than do pretrade consumption bundles, *A* and *A**. Note that the absolute values of labor productivities have no role to play in determining the pattern of trade or the terms of trade. These depend on comparative cost *ratios*.

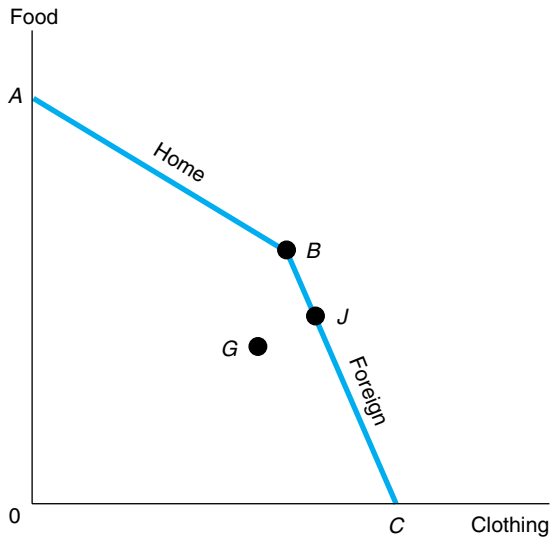
Country Size

Does the assumption of constant (labor) costs necessarily require each country to become completely specialized with trade? No. For example, if one country is much larger than the other, the world terms of trade could settle at the cost ratio of the large country. If the world were made up of the United States and Mexico, it would be impossible for Mexico, with a presumed comparative advantage in tomatoes, to supply the entire American market. In such a case, world prices would have to reflect American costs, so that some American tomato production also would take place.

FIGURE 4.3

The World Transformation Schedule

The locus *ABC* shows world output possibilities with free trade. Free trade generally enlarges world outputs over autarky (e.g., the move from *G* to *B*).



World Production Possibilities

If these two countries engage in free trade, it is possible to sketch out a *world production-possibilities schedule*. Figure 4.3 depicts such a locus, and two extreme points on it are easy to calculate: Point *A* adds up the maximum possible food output in the two countries and point *C* does the analogous job for clothing production. From point *A* the diagram shows that if the world wants to produce any clothing, the country with the comparative advantage in producing clothing (the home country) should be first off the mark. The foreign country will be drawn into clothing production only after the home country can no longer expand its production, and then only if "the price is right." The foreign country, with the comparative *dis*advantage in producing clothing, can be enticed to do so only if the world relative price of clothing reaches the height of its cost ratio, shown by the slope of its transformation schedule. Locus *ABJC* in Figure 4.3 represents the best attainable outputs for the world in a free-trade equilibrium.

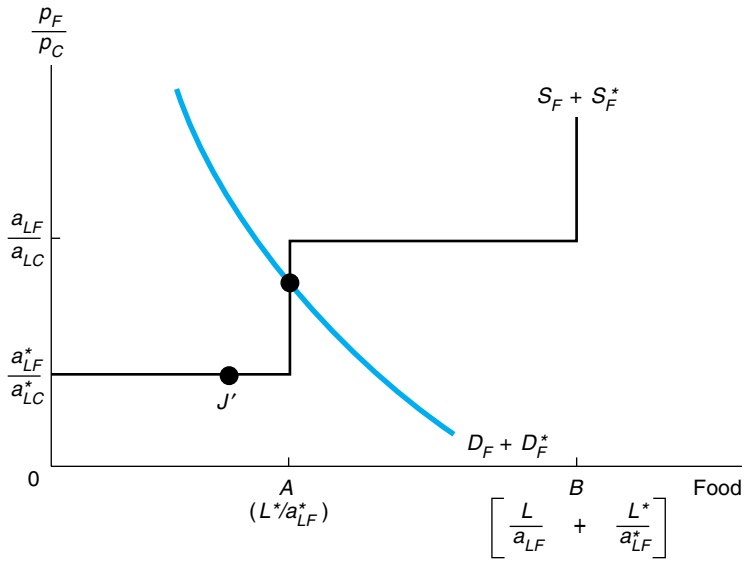
The World Market for Food

The trade triangles in Figure 4.2 illustrate the free-trade equilibrium. The world transformation schedule in Figure 4.3 illustrates in a different way the world supply conditions, and world demand conditions could easily be illustrated by indifference curves if the two countries shared the same (homothetic) taste pattern. Suppose so, and imagine one such curve tangent to the world transformation schedule at point *J*. This would correspond to the foreign country producing both commodities and the home country specializing completely in clothing. The kind of equilibrium illustrated in Figure 4.2, with the world price ratio lying strictly between the cost ratios in each country, would

FIGURE 4.4

The World Market for Food

The world supply curve is composed of two horizontal steps, each at the price corresponding to a country's relative labor cost of food; the vertical sections are at outputs *A* and *B*.



be shown in Figure 4.3 by a world indifference curve passing through the "kink" point, B, with slope equal to an intermediate price ratio.

A more traditional demand/supply diagram for the world market in one of the commodities (food) is drawn in Figure 4.4. The world supply curve is a step-function: Only if food's relative price rises to the foreign cost ratio, a_{LF}^*/a_{LC}^*, can any food be produced, and if p_F/p_C rises above the home cost ratio, a_{LF}/a_{LC}, both countries will devote their entire labor forces to producing food. Kink-point B in Figure 4.3 corresponds to the vertical riser for prices in between the two cost ratios. With the foreign country specialized in food there, world output equals L^*/a_{LF}^*. The world demand curve may cut in this section, as portrayed, or perhaps at a point such as J', corresponding to point J in Figure 4.3. Either of these diagrams confirms that any world equilibrium must require at least one country to be completely specialized, and perhaps both.

4.3 International Wage Comparisons and Productivities

The Ricardian setting is the first of several models displaying an economy with a given technology and resource base (not mobile internationally) in which a full equilibrium can be determined, either in autarky, with national demands balanced by national supplies, or in a free-trade equilibrium with a supply/demand balance at the world level. In either case equilibrium determines output levels, commodity prices, and factor prices. (This is not quite true because as we observed in Chapter 2, only price *ratios* can be determined in the absence of information on monetary aggregates.) Of particular interest here is the connection between wage rates and productivities, especially in the case of international trade when countries might specialize to different commodities.

In any economy, wage rates are closely linked to productivity. This relationship is exact in a model that assumes competition exists. Begin the argument by considering

the general relationship between costs and prices in the home country. In a competitive *equilibrium* the unit costs of producing any commodity cannot fall short of that commodity's market price. The reason is simple: If unit costs in food production were less than the price of food, the consequent profits would signal new entrants into the food industry. Enlarging food output would drive down the price of food; increasing the demand for labor would cause the wage rate to be bid up. This process, whereby new firms are attracted to the food industry, would continue until unit costs were raised enough to equal price. Unit costs can, however, exceed price, even in a competitive equilibrium. You may wonder why an entrepreneur would continue producing food if it is priced lower than the labor costs of production. In this competitive model the answer is none would. Therefore, local food production would be zero.

The Competitive Profit Conditions

Although we have emphasized the importance of *relative* prices in determining trade patterns, it becomes convenient now to refer to absolute prices in terms of a common unit of account. For example, the wage rate at home will be referred to as w, meaning dollars per labor-hour. An expression such as w/p_F eliminates the nominal currency unit of account and denotes food units per hours of work. With this in mind, consider the *competitive profit conditions* shown in Inequalities 4.3 and 4.4:

$$a_{LC}w \geqq p_C \tag{4.3}$$

$$a_{LF}w \geqq p_F \tag{4.4}$$

These inequalities formally express the argument in the preceding paragraph. A competitive equilibrium must be characterized by an equality between unit cost and price if production is carried on in that equilibrium. Unit cost never can be less than price in a competitive equilibrium. Unit costs may exceed price, but only if all producers leave the industry. A similar set of conditions would, of course, apply to the foreign country, except that the wage rate abroad, denoted by w^*, need not be the same as at home, although with free trade the price of either commodity will be identical in the two countries.

Productivity and Wages

Labor's physical productivity is measured in each industry by the inverse of the labor coefficient. For example, $1/a_{LC}$ is the number of units of clothing that can be produced with an input of one hour of labor.[2] If this is multiplied by the price of clothing, to obtain $p_C \cdot (1/a_{LC})$, a measure is derived of the value of labor's productivity in clothing. Therefore, the competitive profit condition can be restated as:

(i) In any industry with positive output, the wage rate must equal the value of labor's (average or marginal) productivity.

(ii) In any industry forced to shut down because of international competition, it is because the prevailing wage rate would exceed the value of labor's productivity.

[2]Because the input coefficients, a_{LC} and a_{LF}, are assumed to be constant, $1/a_{LC}$ denotes both labor's average product and its marginal product.

International Wage Comparisons

In studying the link between productivities and wages for our two countries, it becomes convenient to embed them in a world of many countries producing just food and clothing. This allows us to consider not only the case in which our two countries have balanced trade with each other, with the home country exporting clothing and the foreign country food, but to consider, as well, world market outcomes in which our two countries share a common trade and production pattern. Indeed, we start with such a situation: Suppose the relative price of clothing in world markets is so low that even the home country, which possesses a comparative advantage in clothing, is driven to put all its labor into food. What will be the resulting wage comparison? At home,

$$a_{LF}w = p_F$$

whereas abroad,

$$a^*_{LF}w^* = p_F$$

Both countries face a common world food price, p_F. Dividing these two equalities reveals that:

$$\frac{w}{w^*} = \frac{1/a_{LF}}{1/a^*_{LF}} \tag{4.5}$$

Thus the concept of *absolute* advantage comes into its own: If the foreign country's labor force is twice as productive in producing food as the home country's, its workers will earn twice as much if world prices drive both of them to produce the same commodity, food. Similarly, a very high price of clothing in world markets would encourage both of our countries to specialize in clothing, and their relative wages would be a direct reflection of productivities in the clothing sector. These provide the limits for relative wages.

Now suppose the world's relative price of clothing lies between the cost ratios in the two countries (as in Figure 4.2), with home producers responding by producing just clothing. Thus:

$$a_{LC}w = p_C$$

while in the foreign country,

$$a^*_{LF}w^* = p_F$$

Dividing these two yields Equation 4.6:

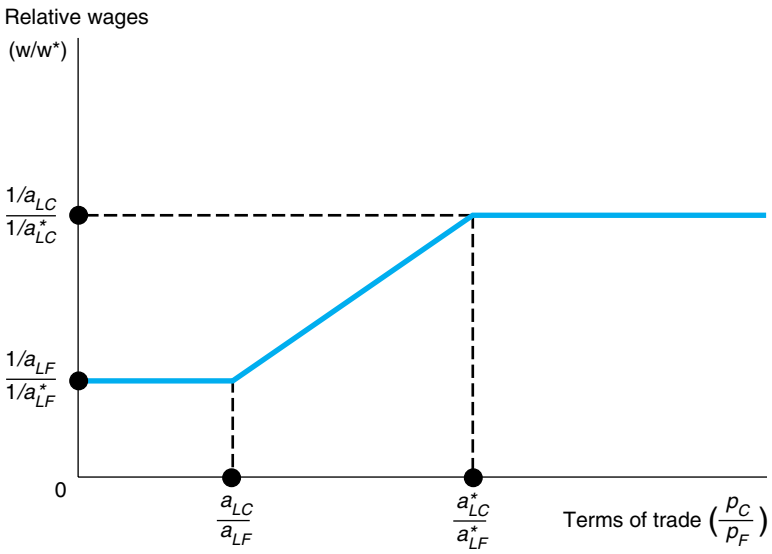
$$\frac{w}{w^*} = \frac{1/a_{LC}}{1/a^*_{LF}} \cdot \frac{p_C}{p_F} \tag{4.6}$$

Therefore, if countries produce different commodities, a comparison of their wage rates reflects not only the productivities of their labor forces in the good produced in that country, but the terms of exchange between commodities as well. All of this is

FIGURE 4.5

Relative Wages and the Terms of Trade

If the terms of trade lie strictly between the cost ratios in the two countries, an improvement in the home terms of trade has a proportionally favorable effect on the home relative wage. If the terms of trade allow both countries to produce the same commodity, relative wages reflect labor's productivity in this commodity.



summarized in Figure 4.5, showing that if the terms of trade lie strictly between the cost ratios in the two countries, a 10 percent increase in clothing's relative price would raise home wages by 10 percent relative to foreign wages.

Suppose the home country is more efficient than the foreign country in *every* line, although relatively even more efficient in clothing than in food. With trade, the home country then imports food from abroad. Does this mean residents at home are purchasing food from a (foreign) source that is more expensive than food locally available? No. Despite the fact that a^*_{LF} is (by assumption) higher than a_{LF}, this is compensated for by the fact that foreign wages must be lower than those at home. This discussion of the limits to the wage rate comparison shows that if one country's labor has an absolute advantage in every occupation, it must receive a higher wage rate.

Viewed from the high-wage country, what can be made of the argument that cheap foreign labor threatens to undermine our competitive position in a wide array of industries? This is the so-called *pauper-labor argument* and is invalid because low foreign wage rates are solidly grounded in (and caused by) less efficient labor productivities.

Recent International Wage Disparities

The Bureau of Labor Statistics in the U.S. Department of Labor publishes hourly compensation costs (in U.S. $) for production workers in manufacturing. For 2003 these show (rounded-off) wage rates of $30 for Germany (West only), $20 for Japan, and $10 for South Korea. Where does the United States fit in? It comes in at $22.

Much has been made of low-wage rates in countries such as China and India, especially in comparison with those in the United States. Although wage rates are much

lower, so is productivity. In 2002 Ceglowski and Golub calculate that on average the Chinese level of productivity was approximately 9% of the American figure. However, the wage rate was only 3% of that in the United States. Evidently an undervalued Chinese exchange rate is largely responsible for China's relative low unit labor costs.[3]

4.4 A Many-Commodity and Many-Country World

The real world is made up of many countries, producing and exchanging many commodities. A great advantage of the Ricardian model is its drastic simplicity in how goods are produced (only labor, with constant cost technology). As a consequence the model can yield insights into this complicated higher dimensional world. This is especially the case in understanding how a small country would react when exposed for the first time to free trade in a world of many countries and commodities. This small country has relied on its own technology, as summarized by a set of labor input coefficients for all the commodities it consumes. Following Ricardo's model, it is assumed the country's technology is determined by local conditions and need bear no resemblance to technology and labor skills found in other countries. It is also assumed the country is "small," so that once this nation is allowed to trade, preexisting world prices are not disturbed. The small country is a price-taker, much like an individual or firm in a competitive market.

What Gets Produced at Home?

What will this country produce and trade when contact is made with the world economy? Suppose the new trading country adopts the same currency as the rest of the world.[4] How do local costs of production compare with world prices? Given local technology, everything depends on the wage rate. If the wage rate is ridiculously low, the new country might find it could produce all, or almost all, commodities at a cost lower than the world price. This could not represent an equilibrium, for the wage rate would be bid up. Suppose the wage rate is so high that costs locally exceed world prices for all commodities. This clearly would not represent equilibrium either. Would it be correct to split the difference and argue that the wage rate probably will settle at a level allowing the country an edge in monetary costs in, for example, half the commodities, while for the other half world prices are below local costs? No. If local technology is really unrelated to that in the rest of the world, this small country likely will produce only *one* commodity, and its wage rate will be determined by labor productivity in the single commodity in which this country has the greatest comparative advantage.

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[3]These figures are reported in Janet Ceglowski and Stephen Golub, "Just How Low Are China's Labor Costs?", unpublished manuscript, 2005.

[4]This is not the place to launch into a discussion of different currencies and the exchange rates that link them together (see Part IV). It will become clear, however, that a country can change its exchange rate as it pleases so long as the wage rate is changed proportionately.

So which commodity is best produced at home? Calculate for each commodity, i, the ratio between the world price p_i and the technical labor-hours required in this country to produce one unit of commodity i, a_{Li}. This ratio, p_i/a_{Li}, shows the quantity of dollars obtainable per labor-hour if labor is used to produce i and the output is sold at world prices. Clearly, the commodity with the highest p_i/a_{Li} ratio is the most attractive. The forces of competition ensure that this ratio is precisely the wage rate. If the wage were lower than this, entrepreneurs would rush to employ all the labor they could to produce i, which would yield a positive profit over and above payments to labor. Such competition would drive up the wage. Could the wage be higher than the highest p_i/a_{Li}? No, because then to produce any commodity would involve losses. If the wage exactly equals the highest p_i/a_{Li}, it would exceed (barring ties) such a ratio for any other commodity.

If such a small country would hear complaints from all the industries that trade has shut down that trade is unfair to workers in these industries, what can be made of this argument? The reason these industries are wiped out by trade is that the wage rate in the country is *too high*! If all labor is of the same homogeneous quality (as we have assumed), they all find work in the country's industry displaying labor's greatest comparative advantage and all laborers gain. Output and employment in that industry become much higher than in autarky because it now produces for the world market.

All this assumes the country is small. But suppose, instead, it is large enough that its entrance into the world's trading arena has an effect on world prices. Being relatively large, the country may well end up producing more than one tradable item, with world prices now adjusting to reflect the country's own technology for producing these goods. We now turn to a scenario in which the world comprises two large countries and in which new discoveries result in improved technology in one of them, with repercussions on prices, trading patterns, and relative wages.

4.5 Winners and Losers from Productivity Shocks

Meetings of international organizations such as the World Trade Organization (WTO), the World Bank, and the International Monetary Fund used to be considered rather dull affairs as far as the media were concerned. Riots in the streets of Seattle at the 1999 meetings of the WTO and subsequent disturbances in places like Cancún, Mexico, all served to highlight the public awareness that globalization and changes in world trade seem to create losers as well as winners. Unskilled labor in advanced countries seemed to be in danger of job losses to emerging production sites in China, India, and other developing countries. Environmentalists were also concerned that expanded trade would seriously contribute to global warming. Of course any shock to productivity and prices, such as new discoveries leading to so-called Dutch Disease problems (discussed in Chapter 5) can easily lead to unemployment, even if temporary. Changes in the patterns of world trade are no exception, but economists often try to look beyond the period of temporary disruptions and at the type of equilibria expected to emerge once resources are reallocated. Academic economists have had their voices

heard as well, especially on the issue whether increased globalization is a boon to all countries.[5] The message we sounded in Part I about the mutual gains expected by all countries in the move from autarky to free trade is not the issue. Instead, once countries are engaged in trade, further changes represented by increased globalization may *not* be of benefit to all.

This chapter's Ricardian model is not general enough for the purposes of discussing whether globalization can create winners and losers *within* countries—the next few chapters address that issue. But the simple structure of the Ricardian model makes it ideal in investigating how growth, productivity changes, and changes in world prices directly affect the *international* distribution of income.

Consider the repercussions of an improvement in technology that is localized to one sector in one country. This clearly represents an improvement in overall world welfare. As for the repercussions of this productivity shock, three possibilities exist: (1) Both countries might gain, (2) the country that experiences the productivity improvement might lose, or (3) the other country might lose. That is, if greater globalization is brought about by such localized technological progress, both countries might share in the gains or one country might lose as the other gains. To link up with current policy debates, denote the two countries as the United States and China. Between them they produce many commodities. Let the United States have a *comparative* advantage in the lower numbered commodities with China possessing a comparative advantage in the higher numbered ones. In a free-trade equilibrium the two countries either produce one of the commodities in common (suppose this is commodity *15*) or are specialized to different commodity groups (the United States producing, say, the first fourteen commodities and China specialized to the rest).

We begin by assuming that both countries share in the production of commodity *15*. By the competitive profit conditions, their wage rates are connected by the relative productivities for the commodity produced in common. If the United States has an absolute advantage in the fifteenth commodity, the American wage rate will be higher than in China. Suppose, now, that China develops a superior technology for producing some commodity that it alone produces, say that of the twentieth, but that this does not alter the ranking of commodities by comparative advantage. This is a case in which both countries must gain. To see this, let (arbitrarily) the nominal price of the commonly produced fifteenth commodity be set at unity, which fixes the nominal wage rate in each country. The price of commodity *20* must therefore fall by an amount exactly equivalent to the extent of technical progress, with no other commodity price changes in either country. The consequence: The *real* wage rate in *each* country must increase. That is, the real income of workers (the only income recipients) in both countries goes up by an amount proportional both to the price fall and to their consumption levels of

[5]The *New York Times* posted a widely read article on September 9, 2004, entitled, "Elder Challenges Outsourcing's Orthodoxy," concerning Paul Samuelson's suggestion that some economists, such as Alan Greenspan, former chairman of the Federal Reserve, and Jagdish Bhagwati of Columbia University, had gone too far in celebrating the widespread gains from globalization. As Samuelson pointed out, some countries are adversely affected by changes in the terms of trade that are brought about, say, by growth of countries such as China and India. Samuelson's article, published in the *Journal of Economic Perspectives* (Summer 2004, pp. 135–146), uses the Ricardian model discussed in this chapter.

the commodity that has gone down in price. International trading links have ensured that the initial localized gain in world welfare gets spread to both trading nations.

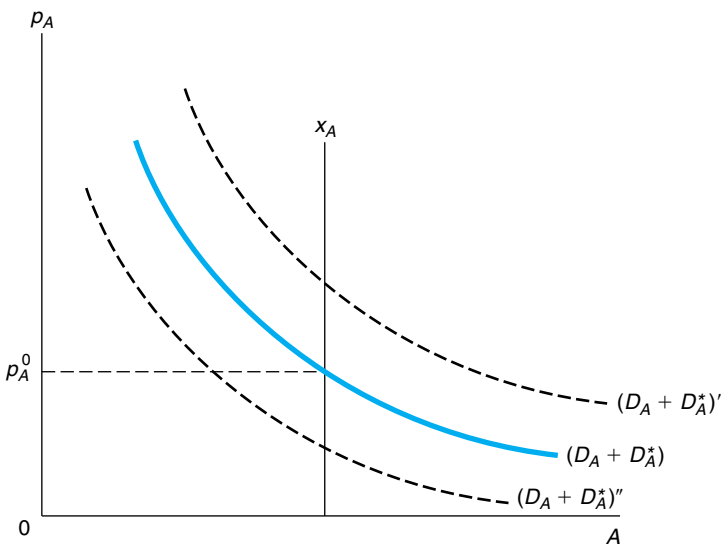
Suppose, instead, that the United States produces the first fourteen commodities and China the remainder. With no commodity produced in common, the price level (and nominal wage rate) in one country is divorced from that in the other. Now let the Chinese again experience an improvement in their labor productivity in producing the twentieth commodity (without disturbing the ordering of commodities by comparative advantage). If commodity *15* is again selected to be the *numeraire*, so that its nominal price is fixed at unity, the nominal level of Chinese wages is also unaltered (because China produces this commodity) as are the prices of all other goods produced by China (except for the reduced price of commodity *20*). But what happens to the price level of all fourteen commodities produced in the United States? Their prices relative to each other all remain the same, so let us lump them all together and label this aggregate commodity *A*. If the price of this aggregate commodity remained the same (as in our earlier case when the two countries produced a commodity in common), clearly every worker in both countries would gain because of the reduced price of commodity *20*. But if no commodity is produced in common, the American price level could rise (in which case American workers would gain) or could fall, and if that fall were sufficiently large, American workers could lose.

To probe these possibilities consider Figure 4.6, showing initial world demand and supply for the American aggregate commodity *A*. With the American labor force assumed fixed and fully employed, the supply curve is drawn vertical and remains in position because the technical progress takes place in China. The world demand curve, $(D_A + D_A^*)$, however, may shift after technical progress, in either direction. Consider world demand at the initial price, p_A^0, after the technology shock. World real incomes (in both countries at the initial price) increase, and this by itself would tend to shift the

FIGURE 4.6

Technological Progress

Commodity *A* represents an aggregate of all commodities produced in America. Technological progress is assumed to take place in commodity *20*, produced only in China, and no commodity is produced in common by both countries. If prices in China for all commodities produced there (except commodity *20*) are kept constant, the price of America's aggregate, p_A, will increase if income effects are stronger than substitution effects, but will fall if substitution effects are stronger.



world demand curve to the right. However, even though America produces none of the commodity (*20*) that has gone down in price, this commodity might be a good substitute in taste patterns (in both countries) for some or all of the commodities in the American aggregate, and this force by itself would encourage a leftward shift in world demand.

If these two effects, the substitution and income effects, exactly balance, there would be no shift in demand.[6] Consider, now, the two alternative possibilities: (1) If income effects are relatively stronger than substitution effects, the demand curve shifts to the right, say to $(D_A + D_A^*)'$ in Figure 4.6. Furthermore, if the resulting rise in the relative price of all goods produced in America is sufficiently large, China will end up worse off than originally. This outcome follows from the strong deterioration in China's terms of trade and is an example of Chapter 3's discussion of immiserizing growth. (2) By contrast, if substitution effects are relatively strong, the world demand curve in Figure 4.6 would shift to the left, to $(D_A + D_A^*)''$, and if commodity *20* is an especially good substitute in consumer tastes with some or all of the goods comprising the American aggregate, A, the technology shock in China could so drain world demand away from A that American terms of trade deteriorate despite the fall in the import price for commodity *20*.

To conclude, a favorable improvement in Chinese productivity in producing some commodity not produced in the United States could benefit both countries, or might actually hurt China (if demand elasticities throughout the world are very low), or, by contrast, might hurt American real wages (if demand elasticities are high and biased toward reducing demand for American-produced commodities).[7]

4.6 Nontraded Commodities

Thus far the Ricardian model has neglected the costs involved in transporting commodities from one location to another, as well as artificial impediments (tariffs, quotas) to international trade. Realistically, no commodity can be freely shipped from one country to another. Theory abstracts from many aspects of reality, however, and trade theory often neglects the costs of transport and the discrepancies they create between prices of traded commodities in different locales. For some purposes, however, it is convenient to consider those commodities for which transport costs are so high that no international trade can take place. The Ricardian model's production structure is so simple that introducing commodities whose markets are purely local is a relatively easy task.

Recall the case of a country too small to be able to influence world prices. If these prices do not reflect the small country's own technology, that country picks the best of

[6]This case, in which substitution and income effects precisely balance, leads to constant expenditure shares on every commodity.

[7]As an exercise (see Problem 7) consider what would happen if both countries produce commodity *15* and China's technology for this commodity improves somewhat but not enough to wipe out American production in this sector.

the traded goods to produce, the one with the highest p_i/a_{Li} ratio. The wage rate equals this maximum figure for dollars per labor-hour in producing tradables. Suppose there is also some commodity (call it N) that cannot be obtained from the rest of the world (for example, personal services supplied by local labor—lawyers, physicians, etc.), but for which there is local demand. Let a_{LN} represent the (constant) labor cost of obtaining one unit of the nontraded commodity. Then N must be priced so that

$$p_N = a_{LN}w \tag{4.7}$$

That is, the price of the nontraded good is determined by local technology and prices of traded goods (that serve to determine the wage rate).

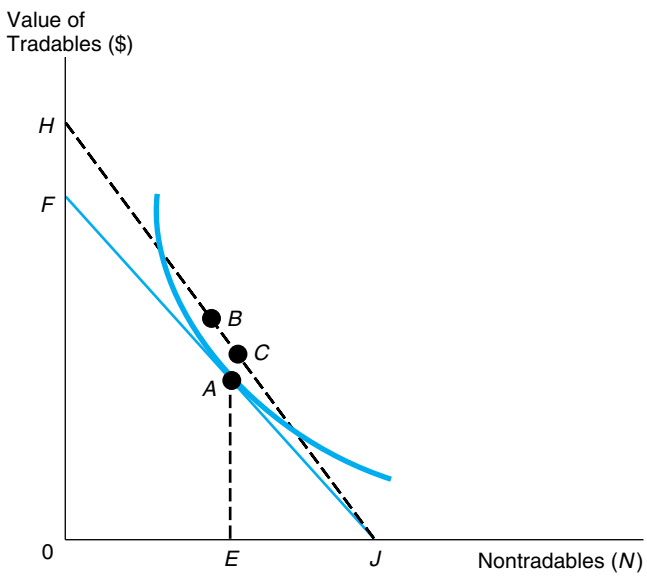
A Composite Traded Commodity

Suppose world prices for all the commodities that can enter trade are fixed. It is then possible to think of a *composite* traded commodity, an aggregate of all the individual traded commodities as was the aggregate, A, in Section 4.5. The demand for such a composite behaves in the same regular way as the demand for any single commodity. Because all tradables are assumed to have a fixed price relationship with each other, any arbitrary unit of output of the composite can be adopted. In particular, the dollar value can be considered a unit. Consider the transformation schedule FAJ in Figure 4.7. Distance $0F$ measures the maximum dollar value of tradables that can be produced if all labor is devoted to producing the tradable item, call it i, that maximizes the number of dollars that can be earned per hour's worth of labor. If, instead, the entire labor force produced the nontradable commodity, quantity $0J$ (in natural physical units) of

FIGURE 4.7

Nontradables and Tradables

A composite traded good can be formed if world prices of tradables are constant. Equilibrium production and consumption response for nontradables can be shown by the tangency of transformation schedules and indifference curves.



commodity N could be produced. With Ricardian technology, the transformation schedule must be a straight line whose slope is the dollar price of the nontradable. Figure 4.7 also shows an indifference curve tangent to FAJ at point A, the free-trade equilibrium for this small country.

A word of warning: Figure 4.7's depiction of an equilibrium where an indifference curve is tangent to the transformation curve may remind you of the way in which equilibrium for a *closed economy* is described. The reason for this is that the details of the composition of trade are suppressed in the diagram. Distance $0E$ represents the quantity of nontradables, N, that is produced. It also shows how much N is consumed in equilibrium. These must balance. Distance AE shows two things: It shows the dollar value of *production* of tradable commodity i, the good reflecting the optimal use of labor among the set of all tradables. It also shows the aggregate value of *consumption* of *all* tradables. Hidden from view is the allocation of this amount over all the commodities purchasable on world markets. Figure 4.7 does not deny trade; instead, point A shows a position of *balanced trade*. It shows that the aggregate value of consumption of all tradables (spread out over many commodities) equals the aggregate value of production of all tradables (concentrated on one product, commodity i).

Technological Change in a Single Tradable Commodity

Suppose, now, that conditions of production at home change, with no change in world prices. In particular, suppose that some new process is discovered whereby the quantity of labor required to produce a unit of commodity j is reduced, so much so that p_j/a_{Lj} now exceeds p_i/a_{Li}. With Ricardian-type technology, the impact on this economy is simple but drastic. It is drastic in the sense that local production of commodity i is wiped out. The new method of producing commodity j establishes it as the new best way of earning dollars on the world market, at the expense of the previous best-traded industry, i. However, an asymmetry now becomes apparent: The nontradable sector is not competed away in the manner in which commodity i is. In Figure 4.7 the change in technology leads to the new schedule $HBCJ$. If all labor were devoted to tradables, approximately 20 percent greater value could be produced by switching from i to j. The wage rate is driven up by this amount, as is the dollar price of nontradables. The N sector can pass on its higher costs to consumers; the ith sector, competing at given world prices for i, cannot.

The rise in p_N may cause consumption and production of nontradables to fall, as is shown in the move from A to B in Figure 4.7. Indeed, this would be the case if demand for tradables as a group were elastic. The new indifference curve, however, could be tangent at C; substitution effects might be weak and newly created incomes might spill over primarily in the direction of nontradables. That is, despite the wage-provoked increase in the price of nontradables, this sector of the economy actually may expand.

The kind of reaction described here, in which progress in one tradable sector spells trouble for another, may be caused by changes in world prices instead of technical progress. Chapter 5 returns to this kind of question in a model in which nonlabor resources also are required for production.

4.7 Summary

The Ricardian model is both the oldest and the simplest model of trade in which the details of production are fully incorporated. It is an especially useful model to examine an important general question: If one country in a trading equilibrium experiences a productivity improvement in some commodity that it produces, how are real incomes affected in other countries? And how do the repercussions of consequent price changes affect the real income of the originating country?

The simplifications embedded in the Ricardian model serve to highlight some basic truths about world trade, and these may require modification in the next several chapters. In particular:

1. The pattern of trade is dictated solely by the supply side. In particular, in the two-commodity case the home country must export clothing and import food if the invariant labor productivity in clothing in the home country is *relatively* higher than that abroad. This assumption was embodied in Inequality 4.2. In more general models, both supply and demand differences contribute to the relationship between pretrade commodity-price ratios in the two countries and therefore to the pattern of trade. (In an extended Ricardian model, with many countries and commodities, demand does play a role in determining trade patterns.)

2. If the world terms of trade lie strictly between the cost ratios in the two countries, each will specialize completely in the production of one commodity (clothing in the home country and food abroad). This severe shift of resources is not characteristic of the models of trade to be considered next, in which a country might engage in trade while supporting an import-competing industry.

3. The Ricardian model places extreme emphasis on differences in technology between countries, without explaining why methods of production should differ. Subsequent models incorporate the influence of nonlabor factors of production affecting labor productivities and allow a distinction between similarity in technical knowledge and similarity in techniques of production actually adopted. (Rice may be grown differently in Thailand and in Louisiana, even though no technological secrets may be guarded.)

4. The spillover effects of technological change in one country on real incomes at home and abroad are simple to analyze in a Ricardian model because technology firmly binds relative costs of goods produced within a country. Progress in one country may benefit all. Alternatively, the home country may lose (the case of immiserizing growth) or foreigners may lose (if the markets for their products are strongly disrupted by the reduction of costs at home).

5. Some commodities do not enter international trade because of high transport costs. In a world in which technology and/or prices for some traded commodities change, nontraded commodities are not subject to as intense competitive pressure as tradables. In the Ricardian model for a small country, progress in one tradable sector may completely wipe out another sector. These extremes are moderated in models that we examine in subsequent chapters.

CHAPTER PROBLEMS

1. Draw the array of world outputs that free trade allows, as is illustrated in Figure 4.3. What is the menu of the *worst* combinations of outputs? Show that it is made up of two linear segments if full employment is maintained in each country.
2. In the discussion of Section 4.5 suppose in a three-commodity setting that both the United States and China produce commodity *3*. What can be said about the distribution of income between these countries if American demand switches a small amount from commodity *2* to commodity *3*? If American technology for producing commodity *1* improves?
3. Suppose costs of production depend only on labor costs and to produce a unit of each commodity in each country takes the number of labor-hours shown.

	Commodity A	Commodity B	Commodity C
Home	10	10	10
Foreign	3	5	7

   a. In which commodity does the home country possess the greatest comparative advantage?
   b. If the foreign wage rate is $1 per labor-hour and a free-trade equilibrium is reached, what is the most that the home wage rate can be? Why?
   c. If the foreign wage rate is $1 per labor-hour, what would a possible home wage rate be so that the home country can produce only one commodity? Which commodity would it be?
4. In a Ricardian world, with labor the only factor of production being paid, the following table gives the constant labor costs per unit of producing different commodities for countries α and β.

	Wheat	Cars	Tankers	Atomic Reactors	Tractors
α	10	10	10	10	10
β	5	8	10	12	14

   a. In which goods does country α have an absolute advantage? Why?
   b. In which goods does country β have a comparative advantage? Why?
   c. Which country would export tankers? Explain.
5. Consider the world to consist of two countries (home and foreign) made up of individuals with identical (and "homothetic") taste patterns. Portray these by a set of smoothly bowed-in indifference curves (which are radial blowups of each other in the homothetic case). Suppose production in the home country requires two labor-hours per unit of food and only one labor-hour per unit of clothing, whereas the foreign country's figures for food and clothing are just the opposite. The foreign country's labor force consists of 1 million labor-hours.
   a. If the home country is small relative to the foreign country, one of the countries will produce both goods. Which country? What will be food's relative price?
   b. If the home country is large relative to the foreign country, one of the countries will produce both goods. Which country? What will be food's relative price?

c. Construct world supply and demand schedules for food, with p_F/p_C on the vertical axis and world food output on the horizontal.

6. A small country has been in total isolation, with labor input coefficients (labor is the only factor of production) shown by $a_{L1} = 10$; $a_{L2} = 8$; $a_{L3} = 12$; and $a_{L4} = 7$.

a. In this autarky state how many units of the first commodity would be required to exchange for a single unit of the third commodity?

b. This country is now open to free trade with the rest of the world. Dollar prices in the rest of the world are given by $p_1 = 1$; $p_2 = 8$; $p_3 = 10$; and $p_4 = 2$. What is the pattern of production in this small country after trade is opened up?

c. Show what happens to the real income of a worker in the small country who consumes only the fourth commodity before and after trade.

7. In Section 4.5 it was assumed that China gets better at producing a commodity not produced in America. But suppose both countries do produce commodity *15* in common, and that Chinese productivity in producing this commodity improves, but not to the extent that would wipe out American production. What happens to American real income? Would American real income be reduced if America *is* a net importer of commodity *15*?

SUGGESTIONS FOR FURTHER READING

Graham, Frank. *The Theory of International Values* (Princeton: Princeton University Press, 1948). Many numerical examples of the many-commodity Ricardian case.

Jones, Ronald W. "Technical Progress and Real Incomes in a Ricardian Trade Model," Chapter 17, in R. W. Jones, *International Trade: Essays in Theory* (Amsterdam: North-Holland, 1979). A more complete discussion of Section 4.5.

Krugman, Paul. *Pop Internationalism* (Cambridge: MIT Press, 1996). An easy but valuable read. See especially pp. 49–68.

Ricardo, David. *The Principles of Political Economy and Taxation* (New York: Penguin, 1971). Chapter 7 is the classic source, with the examples of England and Portugal producing wine and cloth cited in most textbooks.

Samuelson, Paul A. "Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization," *Journal of Economic Perspectives*, 18 (2004): 135–146. A critique of arguments for the benefits of greater globalization.

APPENDIX

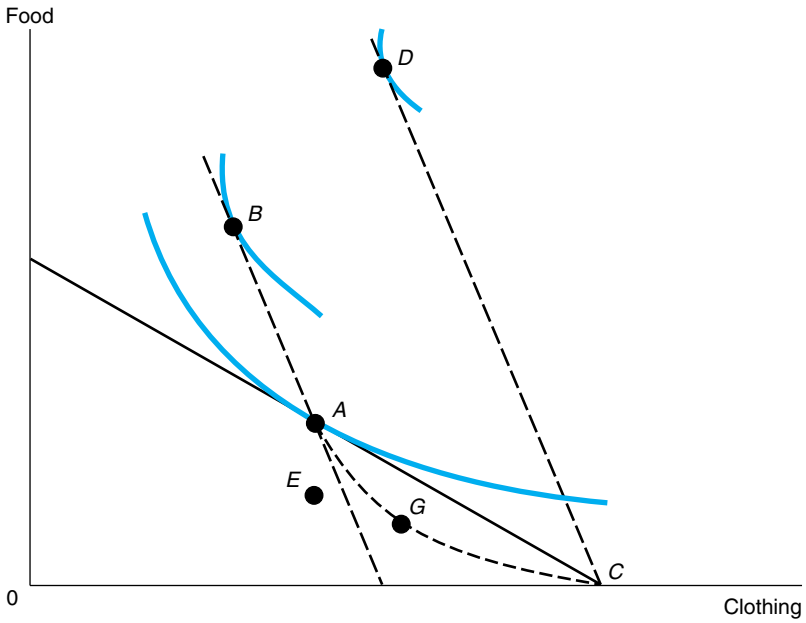
Transitional Unemployment

Much of the current criticism of movements toward freer trade, especially in the United States, focuses on the possibility that labor in some sectors is thrown out of work. There is no doubt that changes in world prices or technological progress can affect some

FIGURE 4.A.1

Unemployment in Transition

Autarky equilibrium is at *A* and free-trade equilibrium production is at *C*. The transition from *A* to *C* may involve some temporary unemployment, as shown along path *AGC*, but the economy still gains. Even if production is at *E*, the economy is better off than consuming at *A* in autarky.



sectors adversely, and that during the transition phase to a new equilibrium there could easily be found certain factors of production that suffer a period of unemployment. But would the social arithmetic then conclude that such changes in world prices or technology are harmful? One defense would suggest that *after* the adjustments have taken place, the community will have benefited. Figure 4.A.1 illustrates how a movement from autarky to free trade when a country is presented with trading opportunities at different prices could result in gains even *during* the transition process when some labor becomes unemployed.

In autarky the community produces and consumes at point *A*. If it could trade at prices reflecting lower relative prices for food (and thus a higher relative price for clothing), the free-trade production point moves to *C*, with complete specialization in clothing, and consumption moves to point *D*, showing a substantial increase in real income. Note that in Chapter 2 we discussed the case in which resources are trapped in their separate occupations so that production remains at *A* even with trade. Consumers still gain by the movement from *A* to *B*. The dotted curve *AGC* in Figure 4.A.1 shows a possible transition path along which labor is increasingly hired in the clothing sector, but not at the same rate at which it is released from producing food. At point *G*, for example, some labor is unemployed, and such labor has lost out. But a budget line drawn through *G* with free-trade prices would reveal that the community is better off than in autarky, so that some unemployment may not imply overall losses. Indeed, consider point *E*: Here no extra labor has been hired by the clothing sector while some labor has been laid off in the food sector. And yet the community would still gain from trade with production at *E*. To convince yourself, draw a budget line through *E* at free-trade prices and compare the indifference curve that can be reached with the original curve tangent at *A*.