8 Conflicting National Interests in Linear Trade Models

This chapter extends our analysis of chapter 4, indicating more of the foundation of the analysis of productivity growth in the classical linear model of international trade.[1] Economists have long understood that a unilateral productivity increase usually contributes to the welfare of the country whose productivity has risen. But the effects on the welfare of the other country—for example, was the U.K. benefited or hurt by the nineteenth-century increase in German steel productivity?—were unclear (and disputed) until the some fairly recent ground-breaking work, including that of Hicks (1953), Dornbusch, Fisher, and Samuelson (1977), Krugman (1979), and that of Stafford and his associates (see Johnson and Stafford 1993 and 1995; Hymans and Stafford 1995). Our analysis confirms their results, showing that such a one-sided productivity improvement can harm a country's trading partner if it enables the one with enhanced productivity in a particular good to increase its share of the two countries' total output of that good, or even to take over the production of that item altogether. But we will take the discussion further and generalize it considerably by relating it to the case of scale economies or the case of high entry costs, where means other than increased productivity, including various forms of government intervention, can be used by one country to acquire an industry from another. We will show, by studying the formal correspondence between linear models and scale economies models, that such a transfer of an industry from one country to another will generally (but not always) benefit the acquiring country at the expense of the other. Our analysis will have direct implications for the design of a nation's trade policy.

It is not much of an oversimplification to say that the classical model of international trade rests on an implicit assumption of universal constant returns to scale, except in the use of land, to which the law of diminishing returns applies. The central theme of this chapter is that much of the story revealed by our analysis of the scale economies case does carry over to situations where there are neither economies nor diseconomies of scale.[2] Our examination of this classical linear case will also offer some additional insights:

1. On the assumption that there is in any industry a maximal level of (labor) productivity attainable by a producer (given the current state of technological knowledge), one obtains a region of equilibria for families of linear models of the sort found for a world of scale economies. Here a family consists of a set of linear models identical in structure and parameter values, except that their productivity coefficients differ from one model to another. As in the case of scale economies, there exist both upper and a lower boundaries for this region that can be approximated closely with the aid of linear programming.

2. Any perfectly specialized solution, in which any good is produced in only one country, will be the equilibrium of some suitably selected linear model. These equilibria can usefully be subdivided into those where a country has attained maximal productivity in each good it produces and those where it has not. In the latter case, increases in the productivity of the producing nation will benefit both trading partners. However, when one of the countries' equilibria entails maximal productivity, then it can be harmed by increases in the productivity of the other country in an industry currently supplied exclusively by the maximal-productivity country, since the improving country may then be able to take the industry away from the current producer.

3. It is possible to determine from the point of view of one of the countries, J, the attributes of the other country that will best serve J's interests. This set of attributes will be said to constitute J's "ideal trading partner." In a broad class of cases, to be the ideal trading partner of country J that partner must be relatively impoverished, characterized by wages less than one-third as high as those in J.

4. The low relative wage that characterizes the ideal trading partner implies that it pays an industrial country, in terms of just its own self-interest, to help its trading partner improve its relative economic position only if that partner's prevailing wage is very low—generally something less than one-third of its own, as just noted. If its trading partner's relative wage is above that low threshold level, the wealthy economy can enhance its economic welfare only through developments

that lead to a decline in the relative wage of its trading partner. This epitomizes the inherent conflict of the interests in the trade of two countries of similar economic status. Once again we see in the linear model the same conflicts of national interests as in the model we discussed earlier involving economies of scale.

8.1 Multiple Equilibria in Linear Models: An Intertemporal Interpretation

The idea that there can be a region of equilibria for linear models may at first seem more than a bit odd. There are good grounds for the standard presumption that a linear model of international trade will usually yield only a single stable equilibrium rather than the thousands or millions of candidate equilibria that we have shown to characterize the scale economies case, and that together constitute the equilibrium region. This is correct, and we will, indeed, deal with models with the unique equilibria to be expected in the linear case. However, as already noted, rather than studying just a single linear model we will, instead, examine entire families of such linear models that are all the same in every respect but one. One model will differ from another in that in the first model the average productivity of labor in country J in the production of good *I* will be different from the corresponding productivity level in the second model. Each such model will then yield a different equilibrium, and we will focus on the set of equilibria corresponding to one entire family of models—one equilibrium per model. This is in contrast with our scale economies analysis, where all of the equilibria in the equilibrium region are possible outcomes of a single model.

This focus on families of linear models enables us to examine the consequences of growth in the productivity of a country's trading partner. Each linear model in such a family serves as a still picture, a single frame in a motion picture of growth. This will permit us to analyze explicitly the effect on the economic welfare of one country that is caused by growth in the productivity of its trading partner.

8.2 The Graph in the Linear Model

We turn now to our equilibrium-region graph for the case of constant returns to scale, where the production function is assumed to take a particularly simple form. It is assumed that the quantity of good *I* produced in country J is equal to the quantity of labor $l_{i,j}$ used by the *I*th industry in country J multiplied by a constant $e_{i,j}$, which is the (average and marginal) productivity of country J labor in the production of good *I*. We assume that each of these productivity numbers has some upper bound, the maximal productivity level, for which we use the symbol $e_{i,j\max}$. The productivity of country J labor in industry *I* cannot currently exceed this amount.

As in the scale economies case, we have seen in chapter 4 that the equilibrium point derived from such a model can be represented by two dots in our, by now, familiar graph (see, e.g., points U_b and F_b in figure 3.5, page 37) one dot for each of the two countries. To obtain the many equilibrium points, we produce a family of linear models by just varying the productivity numbers. That is, suppose that we start off with any linear model given by the three equilibrium requirements described in chapter 7. Then change any or all of the productivity numbers, leaving everything else absolutely unchanged. The result will be two equilibria, the old and the new, which will be said correspondingly to be in the same family of equilibria.

A family of linear models will yield a set of equilibria for each country, each represented by a point in a region of the graph. The region of a country's equilibrium points is, as before, bounded from above, and this upper boundary, the upper national income frontier for the country in question, can be approximated by essentially the same calculation as in the scale economies case. For every *Z*, one determines the equilibrium that yields the highest absolute national income, subject to the requirements that the output share numbers for each good and each country are consistent with the definition of the country's national income. This is clearly a verbal description of a linear program, and it is exactly the program that was used to determine the upper frontier for scale economies models (chapter 7).

From among such a family of models and their equilibria we can select a smaller set of equilibria that we call maximal-productivity equilibria. These represent all the equilibria yielded by linear models in the selected family in which each country has developed skills sufficient to attain maximal productivity in each of those industries in which it is a producer. These maximal-productivity equilibria are extremely numerous and all lie in a subregion of the region that contains all of the equilibria for the family. We call this the maximal-productivity subregion. As in the scale economies case, this region tends to fill up with equilibrium points as the number of commodities in the model grows.

The maximal productivity subregion is important because it is here that we obtain the relationship between the $2^n - 2$ specialized equilibria of a given scale economies model and a set of the equilibria of the given family of linear models. As we will see in the following section, the relationship goes both ways. Suppose that we select any family of linear models and any one scale economies model then, first, if we calculate all the perfectly specialized equilibria for the scale economies model, we will find $2^n - 2$ corresponding equilibria among the set of maximal productivity equilibria for the given family subject to some straightforward conditions about the models and the equilibrium points, which will be described in the next section. That is, every equilibrium point in the set of specialized equilibrium points for the scale economies model will also be a (specialized equilibrium) point in the maximal-productivity subregion for the selected family of linear models. Second, starting from any set of $2^n - 2$ specialized equilibrium points in the maximal productivity subregion for the given family of linear models, provided that these points satisfy the obviously relevant precondition to be described in the next section, we can (easily) construct a scale economies model with the same specialized equilibrium points.

The subregion of maximal productivity equilibria for the family of linear models in question also is bounded from below, by another curve, the lower national income frontier of country J. This lower boundary is obtained by minimizing for each value of Z the national income in the linear program just described. The two frontier curves are, once more, always roughly hill shaped, and they encompass a crescent-shaped region of equilibria. As is familiar from the scale economies discussion in earlier chapters, for country 1 that region starts off at the bottom of the graph, that is, at the zero point. As we move to the right in the graph, the region always begins to move uphill until it finally reaches a peak, and then it begins to descend again and reaches a point on the right-hand axis of the graph. This point is higher than zero and represents the level of absolute income country 1 would obtain in autarky if all of its industries were to achieve maximal productivity. The reasons for this shape are exactly the same as in the scale economies case: As one moves from left to right in the graph, the world's industries tend largely to migrate into the hands of country 1. But moving ever rightward, country 1 acquires more and more of those industries. Up to a point the resulting increased division of labor between countries enhances world output. Thus, as the size of the world output "pie" grows, country 1's share of the pie simultaneously increases and country 1's welfare must rise—its upper national income frontier moves upward. Ultimately, however, too far a move to the right means that an inefficiently excessive share of the world's industries has been acquired by country 1, cutting total world production so much that country 1 must finally experience declining real income despite its rising share of that shrinking world pie.

The similarity of the shapes of the graphs for the linear models with that for the scale economies case extends also to the location of the peaks of the upper income frontiers. We again have the result that the peak of the frontier for country 1 (whose relative income, Z_1, one reads from left to right) will always lie to the right of the peak for country 2. This again shows the conflict in the interests of the two countries: A value of Z that permits one country to maximize its utility will always force the other country to a utility level well below the latter's maximum.

8.3 Differences between Two-Industry and Many-Industry Models

The conclusions that we have reached in studying linear models with trade in many products seem different, intuitively, from what one is led to expect from the more familiar two-industry models. It turns out that the number of industries does matter. The results we have just described are valid for models with a larger number of industries, usually six or more. Such large models turn out to be significantly different from small models, such as the familiar England–Portugal, wine–textile example.

To get at the reasons for the difference, let us consider that famous example. In that two-industry model the outcome in which Portugal specializes in wine and attains its maximal productivity, and England specializes in textiles and attains its maximal productivity, is best for both countries. It remains the best even when we consider, as we do, all the equilibria attained when productivities are lowered. This contrasts with our usual result, in which the outcome best for one country is a poor one for the other.

It turns out that the large models differ from the small ones in two significant ways: (1) large models do not have the extreme lumpiness of a two-industry model. In large models one country can capture a relatively small industry from the other and benefit from the improved terms of trade without a huge effect on world production, and (2) in large models there will usually be some industries in which neither country has an overwhelming natural advantage.

To see the role of the first of these difference without using an extensive analytical apparatus, let us consider the wine–textile example and simplify things by assuming that the demand for wine and textiles in both countries is the same, that both countries are of the same size, and that each will spend half its national income on wine and half on textiles—a special case of Cobb-Douglas demand.

If both countries are at their maximal productivities, with England much more productive at textiles and Portugal much more productive at wine, the outcome in which each specializes in the industry in which its absolute productivity is greatest is an equilibrium. At this equilibrium each country captures half of world income. Our experience with larger models leads us to consider whether England would gain from a move to an equilibrium in which it obtains more than half of world output. Would England be better off in an equilibrium in which it obtains 55 percent of world output, for example? Let us consider this possibility.

Since England receives all the textile income already, to reach 55 percent of the total it must capture 10 percent of the world's wine revenue. For this to be an equilibrium outcome, England must become competitive in wine. Since England is assumed already to have attained its maximum wine productivity, such competitiveness requires Portugal's productivity to fall close to England's. Since England and Portugal both spend half of their national income on wine, this reduced productivity in the wine industry yields much less wine both for England and for Portugal. There is an equilibrium at which England does get 55 percent of world income, but world output of wine, which was half of world output value, is dramatically decreased. England gets that small increased share, but calculations using this model confirm that the outcome is bad both for England and for Portugal.

However, if we replace the single wine industry with ten smaller Portuguese industries, the result generally is entirely different. We can assign each of these replacement industries exactly the same productivity advantage that Portugal in the previous example had in wine, and we can give the ten together the same total revenue as the single wine industry had. If these industries are all of the same size, then England needs to capture only one of them to get its additional 5 percent of world expenditure.

In this new setting there can be a new equilibrium in which Portugal has undergone a reduction in its productivity in one of the ten industries. In this new competitive equilibrium England is the sole producer in that industry, while Portugal remains the producer with unchanged productivity in the other nine. England now has 55 percent of world income but without the large damaging effect on world output that there was before. Productivity has gone down only in the small industry newly acquired by England and this represents only 5 percent of world income. This contrasts with the effect of reduced productivity in the single huge wine industry. Actual calculations then show that this new equilibrium is better than its predecessor for England and worse for Portugal. For England its share increase more than counterbalances the much reduced effect on world productivity.

A second difference between the two-product and many-product cases is attributable to the existence in the latter of some industries in which productivity differences are large, and some in which they are small. In today's world there are many industries in which acquirable knowledge and skill matter more than any inherent natural advantage. In contrast with industries in which one or the other country has major natural advantages, such as very favorable climate or abundant raw materials, productivity in such industries is not very different in different countries. These provide a pool of industries that can more easily be taken over by a country in moving from one equilibrium to another equilibrium at which it has a greater income share. Such a move can be carried out with relatively little loss in world output and so benefit the industry-acquiring country while harming the other. We sometimes refer to these industries as "swing" industries.

In such a takeover the increased share effect is present, but the productivity effect, the loss of world output when the takeover occurs, tends to be much smaller than it would have been had productivities in the taken-over industries differed sharply between countries. Again, this is an effect that simply may not be present in two-industry models. In the wine–textile example England has an advantage in textiles and Portugal in wine. There are no other industries, so there cannot exist any intermediate industries, those in which neither country has a substantial productivity advantage.

These two differences explain why in two-industry models there is likely to be an equilibrium such that any movement from it will harm both countries, while in a many-industry model such a move will benefit one country at the expense of the other. In the latter case it is easier for a country to obtain a larger share of the world output pie without causing the pie to shrink substantially.

8.4 Correspondence Theorems

The qualitative similarity between the regions of equilibria in the linear and the scale economies cases derives from a correspondence (to which we turn next) between the equilibria and their regions for the two cases. This correspondence was described very roughly in the preceding section. From any given equilibrium of a scale economies model, one can construct a linear model with a directly corresponding equilibrium, meaning that the two equilibria have the same income-share values, Z_j, as well as the same output shares for each good in each country, and the same average productivity of labor, at the given output, for any good actually produced in country J. Specifically, it is possible to prove:

CORRESPONDENCE THEOREM 1 One can find the linear model in a given family that yields a maximal-productivity equilibrium corresponding directly to a particular scale economies equilibrium.

The linear model is found simply by taking the scale-economies production functions $f_{i,j}(l_{i,j})$, calculating from them the average productivity figure, $f_{i,j}(l_{i,j})/l_{i,j}$, for each good I produced in country J and then, in the family of linear models, setting the corresponding productivity parameter, $e_{i,j}$, equal to that ratio. In addition, for any good I that is not produced by country J in the given scale economies equilibrium, the linear parameter is given a value so small that country J is not competitive in the production of good I. This procedure can always be carried out, subject only to the requirement that none of the calculated average productivity values for the scale economies model exceeds the maximal productivity figure for the same country and commodity in the linear model. This last requirement is the first of the two correspondence theorem preconditions that was mentioned in an earlier section.

Next suppose that we start with a family of linear models and plot the $2^n - 2$ of its maximal productivity equilibrium points that are perfectly specialized. Is there a scale economies model that yields exactly those same equilibrium points? In addition, if such a scale economies model exists, how can that model be determined? That is, given any such set of equilibria for a family of linear models, can we describe the scale economies model, if any exists, that yields the same equilibria? In answer, we can prove:

CORRESPONDENCE THEOREM 2 Any set of $2^n - 2$ equilibria, with different assignments of the traded goods for specialized production by the two countries and deriving from a family of linear models, will correspond to the equilibria of a single economies of scale model with n traded goods if and only if, for any two linear models in the family in question, the corresponding equilibria satisfy the following scale-economies–compatibility condition: If the equilibrium of one of two linear models in the given family lies to the right of the other, then the productivity level for any good I produced by country 1 at the rightward equilibrium point must be no higher than the corresponding productivity at the leftward equilibrium point. Similarly the productivity level for any good I' produced by country 2 must be no lower at the rightward equilibrium point than at the equilibrium point to its left.

The intuitive reasons underlying the theorem and its precondition are the following: In a scale economies model the productivity of labor must, by definition, rise as the amount of labor devoted to an industry increases. Now, as we move to the right in the graph, country 1's share of world income and of the world's industries increases. With a fixed labor force and full employment, this means that there must be a fall in employment in the average industry of the rising number of industries possessed by that country. Indeed, it is easy to prove that in our model employment in each of those industries must fall. Hence, if this move is to be consistent with scale economies, productivity in such an industry must decrease. Similarly, with a move to the right in the graph, country 2 must spread its fixed labor force over a smaller number of industries than before, increasing the quantity of labor per industry so that, if there are economies of scale, average labor productivity in country 2 must rise. Consequently only if the scale economies–compatibility condition of theorem 2 is satisfied by the family of linear models is it possible for there to exist a single scale economies model that can yield the same set of equilibria.

What is more, once the condition of the theorem is satisfied, it is not difficult to construct a single scale economies model that does the trick—that yields the selected $2^n - 2$ equilibria of the given family of linear models. For this purpose we recall that aside from the production functions, all the relationships and parameter values in a family of linear models are, by definition, identical. One then constructs the desired scale economies model in the following two steps: First, for all parts of the scale economies model other than its production function, use the relationships and parameter values common to the given family of linear models. Second, to complete the scale economies model, determine only its production function, call it $f_{i,j}(l_{i,j})$. To do this, at any of the selected equilibrium points, set the average product of labor of country J in good *I*, $f_{i,j}(l_{i,j})/l_{i,j}$, equal to the corresponding and fixed average productivity figure, $e_{i,j}$, in the linear model that yields the equilibrium in question. It should then be plausible that the resulting production relationship is what we are looking for. It has scale economies because it satisfies the scale economies–compatibility condition of the correspondence theorem 2, and it clearly shares all other pertinent relationships and parameter values with the given family of linear models.

The importance of that result for our purposes is that the unfamiliar features that have emerged from the growing literature on scale economies in international trade analysis are not peculiar to the scale economies case alone. Rather, these features arise also in the more familiar linear case whose well-known attributes may facilitate understanding of the new scale economies observations.

8.5 The Attributes of a Trading Partner Who Serves Country 1's Interests Ideally

Even if both countries gain by trading, the magnitude of the benefit to either of the parties depends on the number and identity of the industries that devolve upon the other, and the productive techniques its trading partner employs in those industries. The question we consider next is: What assignment of industries to country 2 and what levels of productivity of country 2 in the industries assigned to it will maximize the benefits of trade to country 1? That is, we will examine what assignment of outputs and what levels of productivity for country 2 will make it into the ideal trading partner for country 1, as evaluated exclusively in terms of country 1's selfish interests.

Let us first consider the case in which country 1 has attained maximal productivity in all of its industries. In terms of our graphs, the ideal trading partner for country 1 entails production arrangements for country 2 that bring country 1 as close as possible to the summit point on its absolute income (upper utility) frontier. Country 2's position, then, is shown by the dot marked A_1 in figure 8.1. Several things become apparent from this graph. First, because the peak of the country 1 frontier always lies to the right of that for country 2, we may expect that the ideal trading partner for country 1 will be one that produces a fairly limited share of the world's commodities. In the particular model resembling that in figure 8.1 (which entails 22 industries), only six of those products are supplied by country 2 when it is an ideal trading partner, with the remaining 16 produced by country 1. This result is not what standard analysis might have led us to expect. In this case, even in a world of evolving linear relationships (i.e., changing values of the productivity parameters), a country's welfare is enhanced by a very uneven distribution of industries among countries, with countries other than itself engaged in production of a very limited set of the world's traded commodities. Our result is more compatible with views common among nonspecialists, asserting simply that the ideal trading partner for country 1 is an economy that has succeeded in capturing a very modest share of the world's industries.

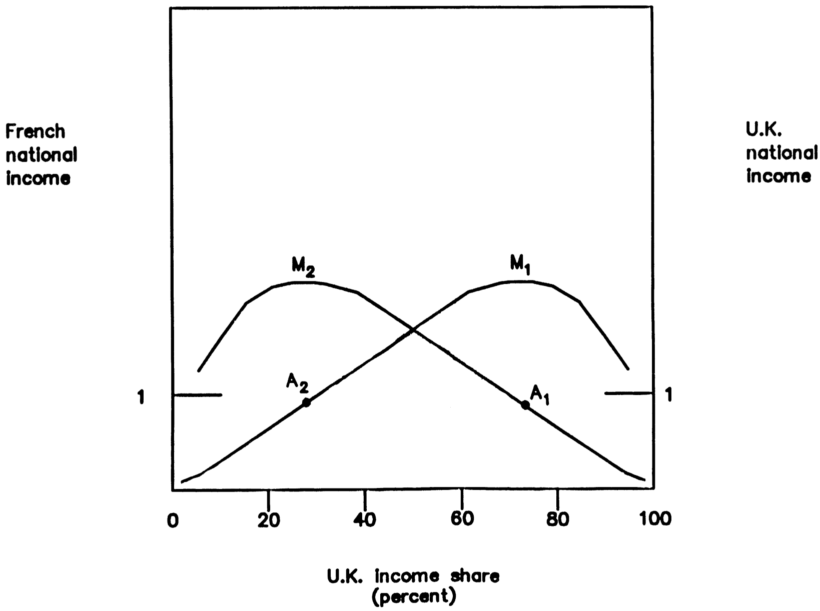

Figure 8.1
Ideal trading partners

The qualitative result is supported quantitatively by analysis of the special case where the maximal productivity levels are the same for both countries. In that situation it is possible to carry out rigorous calculations of general validity. Such a calculation shows that where the countries are identical in size (i.e., in the magnitude of their labor forces), a country's ideal trading partner will always turn out just 24 percent of the world's commodities.

The fact that the peak of country 1's upper income frontier lies to the right of that of country 2 also means that the position of ideal trading partner for country 1 entails a sacrifice for country 2 that can be substantial. When it is the ideal trading partner for country 1, country 2's equilibrium point (point A_1 in figure 8.1) lies well to the right of the peak, M_2, of its own upper income frontier. Thus country 2's ideal trading partner equilibrium point will lie below (and, plausibly, far below) the highest point in its own equilibrium region. Country 2 must give up some, and possibly a good deal, of its maximum potential income in order to qualify as an ideal trading partner for country 1.

A third observation emerges from the analysis of the preceding section. As is plausible intuitively, when a country is the sole producer of some good, a *ceteris paribus* increase in its productivity in that commodity will always benefit itself and the country with which it trades. Consequently, to serve as ideal trading partner, country 2 must always attain maximal productivity in each of the (few) industries in which it is a producer. This is again plausible. If Japan imports all of its oil, it obviously serves the interests of Japan if the petroleum-supplying nations produce oil as efficiently and cheaply as possible.

Finally, we see that the story can be very different when there is a rise in country 2's productivity in a commodity it is not initially producing. A substantial rise in such a productivity figure in, say, industry *I* can constitute a threat to country 1's position in that industry. It may enable country 2 to compete away some or all of the product *I* sales of country 1, thereby cutting the latter's real income. Thus the analysis sheds light on the effects upon the well-being in one country of an improvement in the productivity of its trading partner. The issue, for example, is whether the rise in productivity in a number of Japanese industries threatens the welfare of western Europe and the United States. More careful economic analysis has suggested that the matter is not open and shut. Viewed superficially, the standard theory seems to claim that a rise in productivity in one country must be beneficial to all. On this view, indeed, the benefits of increased world output and lower prices are generally transmitted throughout the globe, with trade barriers serving as a primary impediment to universal distribution of the gains. Our analysis does show that if country 1's trading partner initially produces an extremely small number of commodities, then a rise in the trading partner's productivity in at least a few of the industries from which it is initially excluded can be mutually beneficial. However, once the trading partner's share of the world's industries exceeds the modest number that makes it the ideal trading partner for country 1, then a further rise in country 2's productivity in commodities it is not initially producing threatens to cut the real income of country 1.

The possibility that country 1 can suffer a loss in welfare as a result of a rise in productivity in country 2 may, perhaps, be surprising at first, given the rise in total world output that is likely to result. But a simple observation may make the result more plausible. Consider a linear model with two countries of equal size and identical demand functions. If some but not all of the productivity parameters in country 1 are twice as high as those in country 2, with the other parameters equal in the two countries, then country 1 can expect to gain from trade and be better off than it would be in autarky. But if country 2 increases its productivity to the point where its productivity parameters are all equal in value to those of country 1, then all gains from trade will obviously disappear. Country 1 will be driven from a result that is better for itself than autarky to one that is no better than autarky, and it will have been the increase in country 2's productivity that is responsible for country 1's loss in welfare. To summarize, for a country to constitute an ideal trading partner, it must exhibit three characteristics. It must be the producer of a modest share of the traded commodities, leaving it with low relative wages and a small share of world income; it must be a maximally efficient producer of just those goods that it does supply; and it must be an inefficient producer of all the remaining commodities, so that it constitutes no competitive threat in those industries.

One can think of a number of low-income agricultural countries that are probably nearly ideal trading partners for some of the leading industrialized economies. We can also determine an upper bound for the relative level of wages in the country that is the ideal partner, at least in the case where the sizes of the labor forces and the maximal productivities in the two countries are the same. Where these conditions are satisfied, we can make use of the explicit general equation for the upper income frontier that this case permits, and show that the ratio of wages in the two countries can never fall far below 3:1. That is, the ideal trading partner is always condemned to have a real wage level that is, in circumstances most favorable to it, only slightly more than one-third as high as that in the other country. Clearly, from the point of view of the ideal trading partner, that status is far from ideal.

One further important conclusion follows from the analysis. A deviation of any sort in the country 2 parameter values from those of the ideal trading partner must be harmful to the interests of country 1. If the changed parameter values increase the real income of country 2, that must harm country 1. Similarly, if those parameter values change in a manner that reduces the real income of country 2, that must also harm country 1.

8.6 Evolving Productivity and Intertemporal Performance Patterns

The notion of a family of linear models can be used to explore growth in productivity and its consequences. For this purpose we need only compare a sequence of linear models, each with higher values of its productivity parameters than those of the model that preceded it in the sequence. We can then prove the intuitively plausible

THEOREM 3 (Convergence toward maximal productivity) In a model of learning-by-doing, technology transfer and the absence of erosion (obsolescence) of the stock of knowledge, all trajectories of the productivity levels of industries in which country J is a producer will converge toward that country's maximal productivity levels. That is, all trajectories will entail movement toward points within the region of maximal productivity.

This evolutionary path of a country's productivity returns us to an issue we dealt with in the previous section: the benefits and costs to a country as the productivity of its trading partner increases. We have already seen that this process will sometimes be advantageous and sometimes be disadvantageous to the country other than the one whose productivity levels are increasing. Frank Stafford of the University of Michigan (along with several coauthors) has, however, analyzed the subject in a different way, looking more closely at the consequences for the individual industries involved. It is useful to recapitulate briefly some of the most pertinent of the results of his investigation.

To facilitate the discussion, we will say that country 1 is uncompetitive in the production of good *I* if country 1 cannot supply I as cheaply as country 2. We will use the phrases, "Country 1 is competitive in good *I*" and "Both countries are marginally competitive in *I*," analogously. The results are most easily summarized by dividing the pertinent range of the changing productivity parameter into three zones: zone 1 in which country 2 is uncompetitive in *I*, zone 2 in which the two countries are marginally competitive in *I*, and zone 3 in which country 1 is uncompetitive in *I*. Then the analysis asserts that, so long as the two countries remain in zone 1, a rise in Country 2's *I* competitiveness has no effect on the income of either country. In zone 3, where country 2 is the sole producer of *I*, a rise in country 2's *I* productivity benefits both countries proportionately. However, in the central zone 2, where the two countries are and remain marginally competitive, a rise in country 2's *I* productivity benefits country 2 at country 1's expense. The higher the country 2 productivity level in that zone, the greater is the real income of country 2 and the smaller is the real income of country 1. It follows that country 2 is always unharmed and generally gains on balance from a rise in the average productivity of labor in some industry, and while in some circumstances the result can also be beneficial to country 1, in other circumstances the effect on country 1's real income will be unambiguously detrimental. Sophisticated trade theorists such as Jacob Viner would undoubtedly not have been shocked at this result that offers some legitimate grounds for the fears of nonspecialists about international trade rivalry, but the result does diverge from the conclusions suggested by some more naive discussions of trade theory.

Why does the theorem hold? The explanation is slightly different for the cases of the three zones, with that for the intermediate zone of universal marginal competitiveness perhaps the most difficult. The argument underlying the result for zone 1, in contrast, is trivial. In that zone, country 2 starts off and remains a non-producer of I because it is uncompetitive in that good. Consequently a rise in its competitiveness in that item has no effect on anything, because of the continued absence of any activity in that industry by country 2. At the other extreme, in zone 3, country 2 is the only producer of I. The growth in output per worker-hour in country 2 then makes the good steadily cheaper for both countries and so gives them both more of the good for a given expenditure. Something similar holds for country 2 in the intermediate zone 2, where both countries produce good *I*.

But why does country 1 lose out in zone 2 when country 2's productivity in good *I* rises? The answer, which was provided by the current authors (1995a), is not that country 1 receives less of good *I*. On the contrary, since country 1 produces some or all of the good I that it consumes, with the good *I* productivity of labor in that country constant, an hour of labor will earn just enough to purchase exactly as much of good *I* as before, despite the growth in the other country's *I* productivity. Curiously, country 1 loses out to a degree because it gets less to consume of some goods other than *I*. There are two cases in which this is clearly true. First, is the case of goods other than *I* of which country 2 continues to be the sole producer despite its rising productivity in good *I*. For, with the resulting increase in country 2 wages, imports of those items by country 1 will grow ever more expensive. The rising price does not damage the welfare of country 2 because its increased wage provides additional purchasing power that offsets the price rise. Country 1, however, obtains no such rising wage offset, so the increased prices of the goods it buys from country 2 reduce the real national income of country 1 but not that of country 2. The second case deals with goods that are transferred to country 2 from country 1 because rising wages in country 1 have made it uncompetitive in those commodities. Paradoxically, country 1 also loses out in getting less to consume of these goods in which it has become competitive. The reason is not far to seek. Consider a good *I**, which formerly was produced exclusively by country 2 at a price of $5. Suppose that country 1 could have produced that item for $6 per unit. Rising wages in country 2 resulting from increased *I* productivity now raise the cost of production of *I** in that country to $6.25, so country 2 becomes uncompetitive in production of good *I**. The cost to country 1 of a unit of good *I** therefore rises from our illustrative $5 to $6, without any offsetting rise in country 1 wages like that enjoyed by country 2. In the case of country 2, the wage offset is even more effective than it would have been if it had continued to be the producer of good *I** because the transfer of *I** production to country 1 limits the price rise to $6, rather than letting it go all the way to $6.25, as it would have to if country 2 were to have continued as *I** producer.

In sum, we see how rising *I* productivity in country 2 benefits it both by a greater abundance of good *I*, and by a rise in wages that at least keeps pace with the resulting rise in prices of other goods. But country 1 in this case loses out because rising country 2 prices increase the cost of country 1's imports, with no offsetting rise in country 1's purchasing power, despite any industries that may as a consequence be transferred to it from country 2.

The results must nevertheless be interpreted with caution. First, the discussion, as reported, takes no account of the premise of the analysis that at any time there is a ceiling upon each productivity parameter. Second, the increase in *I* productivity in country 2 may span several zones. It may, for instance, bring country 1 from being marginally competitive in good *I* (zone 2) to a state of uncompetitiveness in *I* (zone 3). Then country 1 will lose out from the rise in country 2's productivity when they were in zone 2, but the further rise in country 2's *I* productivity when zone 3 is attained will benefit country 1. The net gain or loss to country 1 from the entire change therefore cannot be determined in general terms by the analysis of this section. Only our basic graph, as employed in the preceding section, offers an unambiguous and general evaluation of the effects on a country's welfare of a rise in the productivity (and hence in the share of world income) of its trading partner.

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