Notes

Preface

1. Angus Maddison, *Monitoring the World Economy 1820–1992*, Paris: OECD, 1995.

Chapter 1

1. Specialists have long been aware that reality is more complex than the world described in the most rudimentary accounts of the theory. There have been significant writings discussing such concepts as an optimal tariff (e.g., Scitovsky 1947), the valid elements in the infant industry argument, and the possibility that economic efficiency can be damaged by a customs union agreement among a set of countries, dropping trade barriers against one another but leaving those against other nations intact (Viner 1950). These analyses suggest that a move toward laissez faire may not always be the path to perfection.

2. On the role of scale economies in trade analysis, there is a rich body of relatively recent writings by Grossman and Helpman (1991), Helpman and Krugman (1985) and Ethier (1982). In that literature it is recognized that where scale economies are present, one can still legitimately retain a belief in the virtue of unrestricted freedom of trade but can no longer treat this as an open-and-shut matter. Rather, it is shown in these writings that in a world characterized by scale economies, a defensible free-trade position must be based on a balancing of the trade-offs the issue entails.

3. One aspect of global trade that has frequently been noted but that we do not discuss in this book is the growing internationalization of companies themselves. It will become clear, as the model we use is discussed in greater detail, that this phenomenon, though important in many other ways, does not substantially affect our analysis which focuses on the national and industry levels. For our purposes an oil refinery in the United States contributes the value of the goods it produces to the U.S. gross domestic product, whether or not it is part of an international oil company.

Chapter 2

1. The classical economists were, of course, intelligent individuals who observed reality and recognized that all was not always for the best in this best of all possible worlds. They knew that the economy had its shortcomings and its problems. Yet the assertion

that international trade, when guided by unrestrained competitive market forces, must yield a unique and generally beneficent outcome is not a serious distortion of the implications of their model, whose logic will be reviewed briefly in this chapter.

2. We include in the diminishing returns case the possibility that productivity neither increases nor decreases when the scale of production rises. This is the widely used linear model.

3. At the end of the eighteenth century more than 90 percent of the U.S. labor force is estimated to have worked on the land; today the figure is less than 3 percent.

4. To illustrate, assume first that there are only three products in the two-country world: transistors *t*, aerial navigation gyroscopes *g*, and cellular telephones *c*. Then the U.K. may specialize in any one of *t*, *g*, or *c*, leaving the remaining two to France. That already gives three possible equilibria. But there are also three possible equilibria in which France specializes in just one of the products. We see that with two products to be traded between two countries there are six equilibria, for example, the one in which the U.K. produces *t* and France produces *g* and *c*, the one in which the U.K. produces *t* and *g* and France produces *c*, and so on. In reality, of course, many more than three products are traded, and as the number of products in the model increases the number of equilibria grows far faster than the number of products, as table 2.1 indicates. We see that by the time the model is extended to include the production of ten commodities, the number of equilibria already exceeds one thousand.

After the number of traded products exceeds 20, the number of equilibria really takes off, exceeding 100 million in a 27-product world. Since in the real world the number of products with some substantial scale economies that enter into international trade undoubtedly is at least well into the thousands, it should be obvious that the large number of possible equilibria discussed here is no bit of science fiction.

Those readers who have studied the logic of combinations and permutations will recognize that we are discussing the number of combinations of n products that can be assigned to one or the other of two countries. Since each commodity can be assigned either to the U.K. or to France, the number of such combinations is 2^n. If we rule out the possibility of total exclusion of either country from the production of anything, the number of combinations becomes $2^n - 2$. This is the basic formula for the number of perfectly specialized equilibria on which many of the calculations in the next chapter are based.

Chapter 3

1. Our illustrative numbers are chosen to keep the arithmetic simple. Our numbers are much larger than the actual GDP figures for the two countries.

2. If we were to plot the nonspecialized equilibria, they too would lie under the upper boundary. However, some can lie below the lower boundary. These represent particularly poor outcomes.

3. Zero is possible because we are discussing, at this point, only the goods that are exchanged in international trade. But in addition to the goods and services that are exchanged in international trade and on which we focus here, there are others such as retailing, homebuilding, and so on, that are not traded. These provide an underpinning

for national income, whatever the division of the traded goods. We will discuss this and some related observations in chapter 9.

4. The U.K. position is represented by a dot in figure 3.3, while the French position in the same equilibrium is represented by a dot in figure 3.4; so where we combine them in figure 3.5 that equilibrium must still be represented by two dots, one for U.K. and one for France.

5. The U.K. peak, *U*, *must* always lie to the right of the French peak, *F*, because, as we have seen, *U* lies to the right of the world peak and *F* must lie to its left.

Chapter 4

1. Retainability and productivity change can also easily be combined, but the result, though more complicated, does not change the basic picture presented here.

2. Specialists will recognize that the discussion of this chapter applies equally to the more general case of diseconomies of scale, in which smaller firms have a cost advantage over large ones.

3. As sufficient time passes, productivity limits (i.e., the bounds of what is inherently possible) will also change. But at any given moment they are more or less fixed. In the mathematical models that underlie this discussion it is possible to vary the limits, but the substantive results, and in particular, the graphs that emerge, are the same as those discussed here. However, the economic interpretation of the results is enriched if the variability of the limits is taken into account, so we will return to this point later in the chapter.

4. Mathematical analysis shows that there can be small gaps just under the upper boundary curve. These gaps become smaller and smaller as more industries are included in the model. For models with 10 or more industries the gaps would scarcely be visible in a diagram of this size and could not affect our economic conclusions.

5. The same reasoning as in chapter 3 holds here: To the right of the world income peak, the world income "pie" starts to shrink in size, but since the U.K. share of it is rising as we move further to the right in the graph, the U.K. national income continues to rise. Eventually the effect reaches its limit, after which the rising U.K. share cannot offset the shrinking world income. Only then does U.K. income start to decline.

6. The mathematical analysis of this model and that of the retainable-industries model are in fact identical, and they lead to the same regional shape. The very close connection between the two models is discussed in chapter 8, where we describe what we call the correspondence theorem.

7. We are implicitly assuming that the industries are such that the maximum productivities of both countries are not too different. Note that we are discussing the manufacture of products such as athletic shoes, an acquirable skill, rather than, say, gold mining, which is difficult without gold in the ground.

8. In our analysis we can in fact allow the maximal productivities in an industry to increase. Then both countries can increase their productivities without changing their relative productivities, that is, their productivities compared to each other. As one might expect, in this case there is absolutely no change in the shapes of the regions in

our diagram. The boundaries are simply higher up, reflecting the higher productivity. Our economic conclusions, which depend only on shape, remain the same. This is in accord with both common sense and the usual view of economists. In a competitive situation it is the relative productivity of one country's industry compared to the other country's industry that makes one succeed and the other fail, and that has not changed.

Chapter 5

1. As our measure of income, we used Robert Summers and Alan Heston's *Penn World Table 5.6* with their extremely sophisticated estimates of per-capita real gross national product (GDP) for a group of 101 countries (for details, see Summers and Heston 1991). These data are for national incomes divided by the population of each country, with comparable statistics of per-capita income which are adjusted for inflation. To fit these comparisons with our two-country analysis, we can treat Western Europe as a single entity in its trade with the United States.

2. Japan's per-capita income also places it in the zone of conflict.

3. Our analysis has been carried out in terms of a world composed of only two countries. This patently unrealistic premise was adopted to simplify the analysis and its discussion. However, we show in chapter 9 that the analysis is also valid for the case of more than two countries.

4. There are, of course, many other things that differentiate potato chips from computer chips. For example, leadership in computer chips may provide some spillover effects that benefit other industries. The term "spillover effects" refers to benefits of or harm from an economic transaction that affect persons who are not direct participants in the transaction. However, here we are examining only differences that matter for our analysis, which, in its simplest form, assumes away any spillover effects.

5. The unsuccessful attempts to enter the flat panel display market are a recent example of the difficulty that the United States has in doing this.

6. Obviously, this tended to raise prices for U.S. consumers at least temporarily. Economists have consequently questioned the desirability of such "voluntary" acts, which, in effect, encourage foreign sellers to act like monopolists, restricting sales and raising prices.

7. According to a Lou Harris survey of 405 large companies in 1991, the greater the share of a firm's labor force outside the United States, the more likely it was to have downsized at home.

8. Charles E. Wilson, then chairman of General Motors, in testimony before the U.S. Senate Committee on the Armed Services, 1952.

9. In chapter 9 we show how the model can be modified to incorporate more features of the real world that were deliberately omitted from the discussion so far, for the sake of simplicity. These include industries in which a number of countries are producers; the role of (mostly) nontraded goods and services such as health care, housing construction and haircuts; and trade among more than two countries. It is encouraging that as we add more realism to the model, the economic conclusions we obtained from the original, simpler model persist unchanged.

Chapter 6

This chapter discusses some theoretical points arising from the materials in chapter 2 of part I.

1. Zero profit is, of course, assumed in the most traditional model of international trade, following Marshall's *Principles*, and since utilized by many others including Kemp (1969) and Ethier (1982). (For a review of the earlier literature based on this premise, see Chipman 1965, p. 740 ff). This model assumes that the economies are external to the firm but internal to the industry, and that they can be attributed to the private investment in infrastructure and ancillary activities that growth of the industry in question elicits. Our qualitative analysis, however, is not dependent on the zero-profit assumption, but it does facilitate the construction of a program for the calculation of the equilibrium points and the boundaries of the region of equilibrium points.

2. The reader may note that we do not explicitly include a balance-of-trade requirement for equilibrium, even though trade obviously cannot be in equilibrium if the value of imports is unequal to the value of exports. However, it is easily shown that if all of a country's income is spent on the purchase of commodities, a set of outputs and prices that satisfies our equilibrium conditions must automatically make the value of each country's exports equal to its imports: for then the value of the country's income, which, by definition, equals its domestic sales of its domestic products plus the value of its exports, must also equal the domestic sales of its domestic products plus the value of its imports. Hence the value of the country's exports must equal the value of its imports.

3. We have produced graphs that extend the analysis to three countries and that yield what are basically the same qualitative conclusions as those for the two-country case. These are provided in chapter 9.

4. There is a residual problem here. The wage rate so obtained depends on the employment figures, the employment figures depend on world demand, and world demand depends on the wage rate. However, it is easy to show that this yields a one-variable (linear) equation that can be used to solve for the wage rate.

5. If one is testing for local rather than global stability, the attempted entry that is tested for reversal by market forces must be on a small scale by hypothesis; otherwise, the deviation from the initial equilibrium will, by definition, not be small, so the change in question will not be local.

Chapter 7

This chapter provides some of the technical details of the analysis in chapter 3 of part I of this book.

1. If our graph is expressed in terms of a country's cardinal utility rather than its absolute income, exactly the same analysis clearly applies if the country's utility is a monotonically increasing function of its absolute income, and the qualitative properties of the frontiers are unchanged. Clearly, however, if utility is ordinal, conclusions about concavity of the frontiers cannot hold.

2. For a rigorous derivation of the shape of the frontier under assumptions that are somewhat more restrictive, see Gomory and Baumol (1996).

3. In carrying out our calculations, the mathematical program does not employ the full set of equilibrium conditions. Rather, it employs a single linear constraint that is consistent with these conditions. This constraint asserts simply that the share of world income accruing to a given country is equal to the sum of that country's share of world expenditures on the different goods it produces. This single constraint and its role is explained later in this chapter.

4. We also have a (more complicated) integer programming calculation that perfectly matches the boundary.

5. In an unpublished paper, Avinash Dixit has shown that convexity is sufficient but not necessary for scale economies.

Chapter 8

1. For easier reading, as the discussion here proceeds, from time to time the pertinent results of chapter 4 will be recapitulated.

2. The results of this chapter also apply to a world of diminishing returns, and not just to the linear case. To show this, it is only necessary to approximate such production functions by dividing them into linear segments. The linear programming technique described below for analysis of the purely linear case ensures that the segments will be used in the right order, with the most productive utilized first and the next most productive adopted only after its predecessor has been used to capacity. That is obviously in line with Ricardo's observation that the market will first make use of the most productive lands.

This piecewise linear approach does not work in the case of scale economies, since the mathematics would again try to use the most productive segments of the production function first. But that is impossible under scale economies, where productivity increases only after output has reached a large volume, that is, after having passed the small output levels with their low productivity.

Chapter 9

1. A similar argument applies to the zone of pure cooperation. It is also readily extended to the n country case where the relative volumes of these two zones are, for analogous reasons, multiplied by r^n, for some $r < 1$. This, in essence, is the logic that underlies proposition 2.

2. The analysis is provided in some detail in Gomory and Baumol (1992).

3. The analysis in the text can readily be extended to make it generally applicable to the case of a few large producers. There we can expect the marginal revenues of expanded production of a homogeneous commodity to be equal for all producers. Since profit maximization requires each producer's marginal cost to be equal to its marginal revenue, it follows here also that the marginal costs of all producers of a given good must be equal in equilibrium.

4. A second reservation is pertinent here. If the number of industries in the model is very small, an expansion of industry I in country 1 can raise country 1 wages, thereby offsetting the reduction in costs resulting from scale economies, and the opposite can be true in country 2 as a result of a decrease in its output of good I. Obviously, however, where

good *I* constitutes only a small share of a country's total output of all goods, a change in the production of good *I* will have only a negligible effect on that country's overall wage rate, so this second reservation will not be relevant.

5. Where the ratios between total purchase and minimum or maximum efficient scale are not integers, the analysis requires minor modifications. For details and extension of the analysis to determination of the efficient number of suppliers where each supplier provides a multiplicity of products, see Baumol, Panzar, and Willig (1988, chs. 2 and 5).

Chapter 10

1. For the classic survey of work in the area before the mid-1960s, see Chipman (1965). A very helpful summary of pertinent work of more recent vintage is provided in Bhagwati and Srinivasan (1983). For a fine survey-history of the debate between proponents of free trade and advocates of protection, see Douglas A. Irwin (1996).

2. Pigou adds: "Benefit might also be secured by a *permanent* bounty at a different rate from that contemplated above, so arranged as to force the industrial system from the summit of the hill-top on which it is found to any position, that overtops its present site, on the slope of a higher hill."

These observations, incidentally, draw attention to the more recent literature (going back to the work of Tibor Scitovsky) on "optimal tariffs," that is, the tariff levels that most effectively benefit the countries that adopt them.

3. Thus Graham showed that free trade equilibrium can leave a country worse off than it would be in autarky. We add the proof (chapter 7) that under scale economies there will always be such equilibria that are both undesirable and stable, and that when the number of traded goods is not small there will be many such equilibria.

4. Recent writers, particularly those using game-theoretic approaches, have emphasized that scale economies are not necessarily incompatible with the coexistence of a small number of rival firms. Each can adopt strategies that effectively prevent others from driving it out of the market. Even if this is a realistic possibility, it entails no conflict with our analysis. Our analysis does not require the absence of unspecialized equilibria. It only requires that in the presence of scale economies of the sort considered, every possible specialized assignment is a potential equilibrium.

5. Although Marshall apparently coined the term "external economies," he was hardly the first to discuss the concept (e.g., it occurs in Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations*, E. Cannan, ed., vol. 1, p. 307). More surprisingly, perhaps, Marshall does not seem to have discussed the concept or its implications to any considerable extent, either in the *Principles of Economics* or in his other books, rather, leaving the task to Pigou.

6. As Viner later realized after the matter was discussed with him by his draftsman, the mathematician Y. K. Wong, this argument is not quite right. The correct point is that when marginal cost is declining, the MC curve must cut the horizontal demand curve of the firm from above, thereby making it profitable for the firm to expand its output from the level at which MC equals price.

7. There are several reasons why scale economies need not always lead to perfect specialization and monopoly. In international trade, in the country that benefits from them,

wages may also be raised by expanding exports of the goods in question, thereby possibly offsetting the competitive benefits of the scale economies if they are relatively weak. Or rival producer countries of a good may each possess special advantages such as helpful natural resources that enable each to retain a position in the market. In the case of scale economies internal to firms, game theory tells us that a set of rival firms can adopt strategies that enable them all to survive, most obviously by entering into a cartel arrangement, though the stability of such an arrangement may be a delicate matter.

8. The intuitive argument is not quite right as it stands, but it is appropriately suggestive.

9. But Bhagwati's work on immiserizing growth (1958) should give us some reason for concern about this conclusion.

10. A fundamental assumption here, it will be recalled, is that all of the productivity parameters are bounded in each industry in each country by some natural or technological limit. Specifically, the analysis considers all average productivity values to satisfy $e_{i,j} \leq e_{i,j}^{max}$. A similar assumption is employed by Krugman (1985, p. 38), but is used by him for a different purpose.

11. See also the citations to the mercantilist literature and the illuminating quotations in Irwin (1996, pp. 116–118). Irwin also emphasizes the contributions to the literature by John Rae, William G. Sumner, Henry Sidgwick, C. F. Bastable, Paul-Gustave Fauveau, Frank Taussig, and James Meade (ch. 8). In our view, Irwin does not give adequate credit for originality and penetration to Alexander Hamilton. Also noteworthy is Irwin's conclusion that "a specific theoretical rationale for infant industry protection was never worked out" (p. 230).

12. Schumpeter (1954, p. 505) tells us: ". . . as regards his best-known contribution to the education of German public opinion on economic policy, the infant-industry argument, this is clearly Hamiltonian and part of the economic wisdom List imbibed during his stay in the United States."

13. This was not so in earlier models of trade in differentiated products because they assumed entry to be unrestricted and firms to be symmetrical.

14. Our results do not depend on the zero-profit assumption, though it does make the mathematics easier. One can modify our model by dropping the externalities premise and taking each commodity to be produced by a monopoly as a result of the scale economies. One can then substitute for the requirement of zero profit in each industry a set of profit-maximization conditions, essentially asserting that in each industry marginal cost equals marginal revenue.

15. Even here there are, in a general sense, predecessors. Thus, while Cournot, for example, uses calculus techniques in his comparative statics analysis of the effect of a change in cost on monopoly price (1838, 1929, pp. 61–62), Marshall employs a graphic comparative statics analysis, as we do (*Principles*, bk. V, ch. xiv). As a result he can deal effectively (if somewhat clumsily) with larger changes and global as well as local maxima, even when the usual concavity assumption for the profit function does not hold (e.g., see note 1 on pp. 483–484).

Chapter 11

1. We should presumably expect something similar to emerge from the static (neo)classical model of international trade with its assumption of constant or diminishing returns

to scale and its unique equilibrium. Since in this model, unlike that with scale economies or high entry costs, the apportionment of the task of production of each commodity is governed entirely by comparative advantage, a *ceteris paribus* trend toward equalization of factor proportions should reduce the forces, making for specialization of the individual trading countries in different sets of products, and should lead to increased similarity among countries in their product lines.

2. This index is analogous to Balassa's Revealed Comparative Advantage (RCA) measure (Balassa 1965), which is used to measure trade specialization.

3. RELPSHR is defined as a country's share of total output of a particular industry relative to a country's share of total GDP, rather than relative to its share of total manufacturing output. This is to avoid distortion as a result of the fact that some countries, such as Germany in 1970 and Japan in 1993, had specialized in production in manufacturing far more than other countries. Countries with a large manufacturing sector will, clearly, tend to have a large number of industries with values of RELPSHR exceeding unity.

4. R&D intensity is measured by the share of R&D outlays relative to sales of the sector.

5. One unfortunate property of the RELPSHR measure is that it is both asymmetric and highly skewed, with a range from zero to infinity. As a result industry production shares greater than average receive greater weight in the computation of the correlation coefficient than those less than average (which range in value from 0.0 to 1.0). A better measure is the logarithm of RELPSHR, which has a more normal distribution and gives equal weight to production shares both below and above average.

6. Since the cross-country average value of LN(RELPSHR) is generally zero (the average value of RELPSHR is one), the sum of squared values is similar to a variance measure, showing how different a country's industry production is from the average for the 14 countries.

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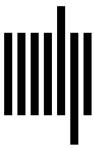

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