Chapter 15

TRADE IN FACTORS OF PRODUCTION

15.1 Adding factor trade to goods trade

To this point, we have assumed that only goods are traded. This is obviously a unrealistic assumption in a world in which capital and, to a lesser extent, labor are mobile between countries. Anyone who has read history is aware of many examples of human migrations, such as those from Europe to North America in the nineteenth century. Those familiar with more contemporary business events are aware of the high level of capital movements and foreign investment that have characterized the world economy since World War II.

It is thus apparent that some factors of production are mobile. What are the effects of such factor movements on world trade and welfare? This question is of particular interest in countries which are the source of foreign investment as well as countries which the recipients of investment. Some arguments seem to suggest that both source and host countries are worse off.

International trade economists generally distinguish between several types of factor movements: (1) foreign direct investment, (2) portfolio investment, and (3) labor migration. A direct foreign investment is defined as an investment in which the investor acquires a substantial controlling interest in a foreign firm or sets up a subsidiary in the foreign country. Foreign direct investment (FDI) thus involves ownership and/or control of a business enterprise abroad. Companies that engage in foreign direct investment are known as multinational enterprises or transnational corporations. FDI will be the subject of the following chapter.

This chapter will be confined to an analysis of trade in factors, and is most relevant to portfolio investment and also to labor migration. Portfolio investment occurs when an individual or company buys foreign bonds or purchases foreign stocks in quantities too small to gain control of a foreign firm. We will assume throughout the chapter that portfolio investment and labor migration occur in response to differences in wage and rental rates between two countries. (The motives behind direct foreign investment are more complex; thus an analysis of this type of investment is postponed until the next chapter.) Of course, portfolio investment and labor migration occur for reasons other than differences in factor prices. These reasons might include escape from war or repression in the case of labor migration, or uncertainty over future economic conditions in the case of capital mobility. With this caveat in mind, we restrict our discussion to factor movements motivated by factor price differences. An number of special features of labor migration will be treated in a later chapter.

Portfolio capital movements and labor migration have very similar effects on production and trade. Thus we analyze the two together, generally referring arbitrarily to capital as the mobile factor. The two may differ with respect to the repatriation of earnings. Capital owners generally tend to remain in their home country, repatriating their foreign earnings and consuming at home. Migrants generally spend most of their earnings in their new country. Yet migrants often repatriate substantial sums (e.g., guest workers in Europe, Mexican and West Indian farm workers in the United States) and capital owners sometimes move with their funds (e.g., Canadians retiring to Florida, employees sent abroad to work on a company investment project). Thus we treat capital and labor movements as being essentially similar.

First, we will prove a simple gains-from-trade theorem, assuming that the earnings of "immigrant" capital or labor are repatriated or at least not counted as part of national income (i.e., national income is the income and consumption of the original (pre-factor trade) set of factor owners).

The gains-from-trade theorem of Chapter 5 showed that free-trade consumption is revealed preferred to autarky consumption under goods trade but no factor trade. The gains-from-trade theorem under factor as well as goods trade is a fairly straightforward extension of the proof in Chapter 5.

Let X_i denote production of good i and D_i denote consumption of good i. V_j will denote the *use* of factor j in production and $\bar{V}_j$ will denote the *endowment* of factor j. V_j and $\bar{V}_j$ can now differ due to imports or exports of factor i. $V_j > \bar{V}_j$, for example, means that the country is an importer of factor j. p_i denote goods prices and w_j is the price of factor j. Superscript * denotes free trade while superscript '*a*' denotes autarky.

Profit maximization in each industry i implies that the profits earned by from the free-trade outputs and inputs must be at least as large as the profits from the autarky inputs and outputs at free trade prices. Summing over all industries, this gives us.

$$\sum_i p_i^* X_i^* - \sum_i \sum_j w_j^* V_{ij}^* \geq \sum_i p_i^* X_i^a - \sum_i \sum_j w_j^* V_{ij}^a \tag{15.1}$$

The sum of factor use on the left-hand side gives the total value of factor payments for factors used in the free-trade equilibrium.

$$\sum_i \sum_j w_j^* V_{ij}^* = \sum_j w_j^* V_j^* \tag{15.2}$$

The sum of factor use on the right-hand side is the value of the country's factor endowment (since no factors are trade) at free-trade prices.

$$\sum_i \sum_j w_j^* V_{ij}^a = \sum_j w_j^f \bar{V}_j \tag{15.3}$$

Substituting (15.2) and (15.3) into (15.1), the latter can be written as

$$\sum_i p_i^* X_i^* - \sum_j w_j^* V_j^* \geq \sum_i p_i^* X_i^a - \sum_j w_j^* \bar{V}_j \tag{15.4}$$

This can be re-arranged to yield

$$\sum_i p_i^* X_i^* + \sum_j \left[w_j^* \bar{V}_j - w_j^* V_j^* \right] \geq \sum_i p_i^* X_i^a \tag{15.5}$$

The trade balance condition in free trade can be written as the sum of the value of exports over all goods i plus the sum of the value of factor exports (the difference between each factor's endowment and use) over all factors j must equal zero. This is where we are making the assumption, briefly discussed above, that the income of imported factors is not considered part of domestic income and the income of exported

factors is, as if both are fully repatriated to their country of origin.

$$\sum_i \left[p_i^* X_i^* - p_i^* D_i^* \right] + \sum_j \left[w_j^* \bar{V}_j - w_j^* V_j^* \right] = 0 \tag{15.6}$$

This can be rearranged to yield

$$\sum_i p_i^* X_i^* + \sum_j \left[w_j^* \bar{V}_j - w_j^* V_j^* \right] = \sum_i p_i^* D_i^* \tag{15.7}$$

Autarky market clearing condition is that the supply and demand of each good are equal.

$$X_i^a = D_i^a \tag{15.8}$$

Substitute (15.7) for the left-hand side of (15.5) and substitute (15.8) for the right-hand side of (15.5). The latter then becomes

$$\sum_i p_i^* D_i^* \geq \sum_i p_i^* D_i^a \tag{15.9}$$

Free trade consumption is revealed preferred to autarky consumption, which was to be proved. Free trade in goods and factors in a competitive, undistorted economy must be better than autarky.

15.2 Factor trade and goods trade as substitutes

A old and traditional idea in international trade theory is that trade in goods and factors are substitutes. This is credited to Mundell (1957) and indeed the idea was so persuasive that little research followed on trade in factors for many years: there was just not very much interesting to say. The idea is that if trade in goods is based on differences across countries in factor endowments, then allowing factors to move will substitute for trade in goods.

There are in fact two different senses in which trade in goods and factors can be substitutes, both perhaps implicit in the previous sentence but not always aligned in practice. First, they can be substitutes in a welfare sense: the gains from trade can be captured either through trading factors or trading goods. Second, they can be substitutes in a volume-of-trade sense: allowing for trade in factors should reduce the volume of goods trade. We will be interested in both of these concepts.

It later turned out the Mundell focused on a very special case, though anchored in the very popular Heckscher-Ohlin model. In that model, goods trade only arises from difference in factor endowments in the first place so it is pretty obvious that moving factors to make relative endowments equal is going to eliminate or substitute for goods trade. This does not diminish the importance of his contribution however, and we explore that in this section.

A very simple and intuitive approach to the problem is found in Jones et. al. (1986). Suppose that there is only a single produced good, *X*, and two factors of production, *L* and *K*. Suppose that countries h and f can only trade goods. It is clear in this very simple model that there is no way to capture any gains

from trade: the countries must have at least two things to trade.

The situation is shown in the Edgeworth box of Figure 15.1. The dimensions of the box represent the total "world" endowments of capital and labor, the combined endowments of the two countries. The lower left corner is the origin for country h and the upper right-hand corner is the origin for country f. Isoquants are drawn for the production of *X* in each country. If the two countries have identical technologies, then the contract curve is the diagonal of the box, but identical technologies are in no way necessary for the argument.

Figure 15.1

Suppose that the endowment point for the two countries is at E in Figure 15.1. Thus the home country is relatively well endowed with capital and the foreign country is relatively well endowed with labor. At E, the *X* isoquants of the two countries are not tangent (not drawn). The *X* isoquant for home is steeper than that for foreign, indicating the *w/r* is higher in home than in foreign at the endowment point. This makes sense, since labor is the relatively scare factor in h and capital is the relatively abundant factor in h. The fact that factor prices are not the same in the two countries indicates that there are unexploited gains from trade, just as the inequality of commodity prices indicated unexploited gains from trade earlier in the book.

Free trade in factors of production starting at point E in Figure 15.1 leads to an equilibrium at point A in Figure 15.1, where the factor-price ratios of the two countries are equalized at $(w/r)^*$. Country h exports capital, its abundant factor, and imports labor to reach point A. Country f exports labor, its abundant factor, and imports capital. The isoquants X_h and X_f are the free-trade *production* levels of *X* in the two countries, but are also the free-trade *consumption* levels since *X* is not traded. Both countries mutually gain from trade.

It is interesting and important to point out that the exchange of capital for labor is not the only possible way of moving from E to A in Figure 15.1. Suppose, for example, that capital and *X* can be traded, but labor is immobile. Then home can export capital in the amount EB in Figure 15.1 to foreign. Point B then becomes the *production* point for the two countries. But foreign must pay home for the capital, and hence foreign exports *X* in the amount BA in Figure 15.1. Point A continues to be the *consumption* point of the two countries, while C is the production point.[1]

This last result is interesting in light of controversies over the export of capital in countries like the United States. In the case just mentioned in the previous paragraph, the US loses production of *X* (jobs in manufacturing?), and imports *X* instead. But this is in no way "bad". We end up at the same consumption point A in either case. Of course, factor price changes redistribute income, but these price changes are the same regardless of how we move from E to A.

To make the point more strongly, note that home could arrive at A by importing labor from foreign to arrive at C, which now becomes the *production* point. Home is now producing a lot of *X* which will make the critics happy. But home must pay for the imported labor, exporting *X* to foreign (or giving the additional production to the foreign labor) in the amount CA to again arrive at the *consumption* point A. The level of production of *X* (jobs in manufacturing) is not of direct welfare consequences. As we have noted several times in the book, production must not be confused with consumption as a measure of the gains from trade.

This exercise emphasizes the idea that, when trade is based on differences in factor endowments in the first place, there are several alternative ways to capture the gains from trade. These alternatives differ in what is traded, but the are substitutes in the sense that welfare ends up the same in the end, and that trade in goods can be displaced by direct trade in factors.

Now consider the basic Heckscher-Ohlin model, with two goods (X_1 and X_2) produced by two countries (h and f) using identical technologies and factors *K* and *L*. Suppose initially that there is free trade (and no transport costs) in commodities but that factors cannot be traded. Assume that the factor endowments of the two countries are sufficiently similar such that both countries produce both goods in free trade. In this situation, free trade with equalize factor prices across countries, as we noted in Chapter 8 (Figures 8.5 and 8.6). There is no incentive to trade factors, all gains from trade are captured through commodity trade. But there are two big assumptions underlying the factor-price-equalization theorem that we discussed in Chapter 8. First, endowments must be sufficiently similar such that both countries produce both goods. Second, commodity prices must be equalized by trade, ruling out any trade costs or tariffs.

Let us consider the first of these. Suppose that commodity prices are equalized by trade so that the unit-value isoquants for X_1 and X_2 are in the same position for both countries as shown in Figure 12.2. But the endowments of the two countries are sufficient different (E_h and E_f in Figure 12.2) such that both countries are specialized in the free-trade equilibrium. Then each country's factor-price ratio (*w/r*) is the slope of the relevant isoquant at its endowment point. County h has factor prices $(w/r)_h$ and country f has a factor-price ratio $(w/r)_f$. Each country has a high price for its scarce factor and a relatively low price for its abundant factor. If one or both factors are allowed to move, a country will export its abundant factor and/or import its scarce factor.

Figure 15.2

The general result is shown in Figure 15.3, where the factor-price-equalization set is as defined and discussed in Chapter 8 (Figure 8.6). If country's endowments are inside this set, the price of each factor is equalized across countries and there is no incentive for factors to move and no additional gains from trade. If, for example, the endowment is at point E in Figure 15.3 however, then allowing factors to move will lead them to migrate in the direction of the arrows as shown: *K* will move from h to f and/or labor *L* will move from f to h. In general, these movements will displace commodity trade and hence trade in goods and factors are substitutes in this sense. However, trade in factors will allow for additional welfare gains from trade and hence adding factor trade is a welfare complement to goods trade. On the other hand, if we started with unrestricted factor trade and no goods trade, factors would be traded to the diagonal as in Figure 15.1 and there would be no additional gains from allowing goods trade. So the situation is a bit more complicated than a simple statement that trade in goods and factors are substitutes, but that general notion is roughly correct at least with respect to the volume-of-trade definition of substitutes.

Figure 15.3

The second reason that factor-price equalization can fail in the Heckscher-Ohlin world is due to trade costs. Suppose that country h exports X_2 (i.e., h is relatively capital abundant as in Figures 15.2 and 15.3) and that there are trade costs for both goods. These raise the price of a good in the importing country above the price in the exporting country. The price of X_1 in h must be higher relative to its price in f: $(p_1/p_2)_f > (p_1/p_2)_h$. This shifts inward the unit-value isoquant for X_1 in h: with the price of X_1 higher,

less physical units of K and L are needed to produce one dollar's worth of X. Correspondingly, the X_2 unit-value isoquant is nearly to the origin for country f which imports X_2. This is shown in Figure 15.4. Country h has an equilibrium factor-price ratio $(w/r)_h$ while Country f has an equilibrium factor-price ratio $(w/r)_f$. The important point is that each country has a high price for its scarce factor and a low price for its abundant factor. Indeed, we commented on this outcome in Chapter 13 on trade costs in connection with Figures 13.1 and 13.2.

Figure 15.4

Now suppose that we allow trade in factors. Country h will export capital and/or import labor. This causes the factor-ratios used in the countries to converge, and reduces commodity trade as the scarce factor in each country becomes less scarce and the abundant factor becomes less abundant. But factor prices in the two countries cannot begin to converge as long as there is commodity trade, because the trade costs maintain the commodity-price differences and that difference in turn determines the factor-price differences. Factor trade will continue until all commodity trade is eliminated. In Figure 15.5 we show something we call the “no trade set”. This actually follows from Figure 13.1, where we note that there is a range of prices differences in the two countries such that the price differences are sufficiently small such that the countries will not want to trade goods. Beginning at endowment point E in Figure 15.5, factors will move toward the no-trade set and even continue to move toward the diagonal. Of course, this assumes that trade costs for factors are less than trade costs for goods.

Figure 15.5

This last point not withstanding, trade costs also suggest that trade in goods and trade in factors are substitutes in the volume-of-trade sense. However, they are not substitutes in the welfare sense: in the case shown adding factor trade to goods trade leads to added welfare gains.

15.3 Factor trade and goods trade as complements

As suggested above, for many other causes of trade other than differences in factor endowments, trade in goods and factors can be complements in both the volume of trade and welfare senses (Markusen 1983). Consider a very different situation in which trade is caused by differences in production technologies.[2] Assume that we have two economies with the following characteristics. (1) Countries h and f have identical factor endowments. (2) Countries h and f have identical technologies for producing X_2, but country h has superior technology for producing X_1. It is assumed that country h's X_1 isoquants have the same shape as the X isoquants for country f, but that the former are renumbered so that more output is produced from the same inputs (this is called "Hicks-neutral" technical superiority, named after John Hicks).

The situation is shown in Figures 15.6 and 15.7. Assumptions (1) and (2) imply that both countries have an identical Edgeworth boxes and identical contract curves in Figure 15.7. But their production frontiers differ, as shown in Figure 15.6. $X_{20}X_{f1}$ gives the production frontier for Country f. Country h can produce the same maximum amount of X_2 but more X_1 so country h's frontier is given by $X_{20}X_{h1}$.

Suppose that A in Figures 15.6 and 15.7 gives country f's production point in free-trade equilibrium. If country h allocated factors in the same way in Figure 15.6 (point B), country h would be

at point A in Figure 15.7, producing the same amount of X_2 but more X_1. This cannot be an equilibrium for country h because the marginal cost of producing X will be less in Country h relative to Country f. This is because beginning at A in Figure 15.6, fewer factors are needed for an additional unit of X_1 in country h relative to country f, due to h's superior technology. Thus, if $p^* = MC_{f1}$ in Figures 15.6 and 15.7 at point A, then we must have $p^* > MC_{h1}$ at B in Figure 15.6 (which is also point A in Figure 15.7). The equilibrium for country h must be at a point like C in Figures 21.5 and 21.6.

Figure 15.6

Figure 15.7

If the countries are producing at A and C in Figures 15.6 and 15.7, we can conclude two things. First, country h must be exporting X_1 and importing X_2 (Figure 15.6). Second, the wage-rental ratio must be higher in country h (Figure 15.7) since the capital-labor ratios are higher in h. This is different from the case considered in the previous section, in that here each country will have a relatively *high* price for the factor used intensively in its export industry. If we permit factors to migrate, labor will flow into country h and/or capital will be exported, if X_1 is labor-intensive as shown in Figure 15.7. Similar comments apply, of course, to country f.

The result of this factor mobility is that each country becomes relatively better endowed with the factor used intensively in its export industry. This adds a Heckscher-Ohlin or factor-proportions basis for trade, which tends to reinforce the basis for trade caused by the difference in technology. Factor mobility can then lead to an increase in the volume of commodity trade. Country h will now export X not only because it has superior technology but also because it is now relatively well endowed with labor.

In this simple model of trade based on differences in production technology, it thus turns out that factor movements and commodity trade are complements. This is true in both the trade volume and welfare senses: allowing factors to move starting with equal endowments increases the volume of goods trade and also welfare. Although this may seem to be a very special case, it is in fact true that the complementary relationship holds for a wide variety of models in which the basis for trade is something other than differences in factor endowments.

Consider then as a second example of complementarity the simple, symmetric model of external economies of scale introduced in Chapter 10. Assume that scale economies are sufficiently strong that they outweigh factor-intensity effects such that the production set is non-convex. Figure 15.8 draws the identical production frontiers for two identical economies. One country specializes in X_2 *at point* x_2^g (superscript g for goods trade) and one specializes in X_1 at point X_1^g, each trading half of its output for half of the other country's output so that they both reach the consumption point D in Figure 15.8. Figure 15.9 shows the factor market, with each country having the identical factor endowment E. While it is entirely arbitrary, assume country h produces output X_2 and country f produces X_1. Note from Figure 15.9 that each country will have a high price for the factor used intensively in its specialty good (given by the slopes of the isoquants at E.

Figure 15.8

Figure 15.9

Now suppose that the two countries can trade factors. Country h should import *K* and export *L* and vice versa for country f. Factor prices are equalized once country h reaches point A_2, producing X_2^f (superscript f for factor trade) and country *f* reaches point A_1, producing X_1^f in Figure 15.9. The output of both goods has increased, and these production levels correspond to points in Figure 15.10: country h produces at X_2^f and country f produces at X_1^f. The two countries will now trade to both reach consumption point $D^{f'}$ in Figure 21.7. Factor trade has led to an increase in the volume of commodity trade, and the endowments of the countries have become more dissimilar due to factor trade. There are also welfare gains as is clear from Figure 15.10.

There are a fair number of other examples like this, many explored in Markusen (1983). The point is that when the underlying cause of trade is something other than differences in factor endowments, equal relative endowments across countries is does not exploit all gains from trade and allowing factors to move increases the volume of trade in addition to welfare.

15.4 Agglomeration: combining monopolistic competition, trade costs, and mobile factors

During the 1990s and 2000s, there has been a great deal of interest in the nexus among monopolistic-competition, models, trade costs, and factor mobility. This is occasionally referred to as "new economic geography", a term the authors here don't much care for (what will we call the next wave of new stuff?). A central issue in this literature is the extent to which certain activities will naturally tend to agglomerate (firms clustering together in one location) versus spreading across countries.

In section 5.3 above on factor trade and goods trade as complements, we focused on the idea that each factor endowments across countries might not be a stable situation if factors are allowed to move. If factor trade is introduced, factors may move to make countries more different in endowments than they were initially. Agglomeration can arise naturally, something quite different from a Heckscher-Ohlin world in nothing would happen if countries are identical initially.

The mathematics of some of the newer models get complicated quickly, and much of this is beyond the scope of the book. What we will try to do is to present the intuition behind some of the basic concepts of this literature, beginning with a paper by Krugman (1991), followed later by the book of Fujita, Krugman and Venables (1999).

The basic Krugman model has a rather unusual factor structure, perhaps to give it analytical tractability. There are two sectors, a competitive homogeneous agricultural sector Y which uses a type of labor that cannot be used in the other sector and cannot be internationally mobile. So there is a fixed, sector-specific factor in Y. The other sector X is the now familiar Dixit-Stiglitz monopolistic-competition sector. It also used a single factor of production and this type of labor may be internationally mobile. So there is no intra-country mobility but the X-sector labor may move abroad. In addition, there is an assumption that Y incurs no international trade costs and its price is equalized across countries whereas X does incur a trade cost.

Let w_i denote the (nominal) wage of labor in country i in terms of the agricultural good *Y*, the latter's price being one and equal across countries. Recall that *X* varieties in each country have two

equations associated with them, a pricing equation that determines output of a representative variety and a free entry condition (markup revenues equal fixed costs) that determines the number of varieties. Let a unit of X just require one unit of (mobile) labor, so marginal cost is just w_i. Then the two equations and resulting output per variety are given by

$$p_i(1 - 1/\sigma) = w_i \qquad (p_i/\sigma)(X_{ii} + X_{ij}) = wfc \qquad X_{ii} + X_{ij} = (\sigma - 1)fc \tag{15.10}$$

Any variety of X that is produced in either country is produced in the same amount. However, in the Krugman production structure, prices can differ across countries and thus so will wages. The first equation of (15.10) establishes a tight link between a locally produced X variety and the wage.

Now consider the price index in country i. Up to this point, we have used the term price index to refer to the price of buying one unit of the X "composite" good. But now we will need to the price index for buying on unit of utility, which considers the prices of both X varieties and good Y. Let e_x denote the price index for the composite X good (previously we just used e) and let e denote the price index for utility. Using the same Cobb-Douglas function for utility between Y and X and the price index (expenditure function) for X goods, we showed way back in Chapter 2 (3.9) the over price index for utility:

$$U = \left[\sum_i X_i^{\alpha}\right]^{\frac{\beta}{\alpha}} Y^{1-\beta} \qquad e = e_x^{\beta} p_y^{1-\beta} \qquad e_x = \left[N_i p_i^{1-\sigma} + N_j (p_j t)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{15.11}$$

Since we are using the price of Y as numeraire, $p_y = 1$, the overall utility price index for country i given in the second equation of (15.11) reduces to

$$e_i = \left[N_i p_i^{1-\sigma} + N_j (p_j t)^{1-\sigma}\right]^{\frac{\beta}{1-\sigma}} \tag{15.12}$$

The real wage of X sector workers, is perfectly measured by the nominal wage divided by the utility price index, also referred to as the ideal consumer price index. Making use of the first equation of (15.10), the real wage in country i is given by

$$\frac{w_i}{e_i} = \frac{p_i(1 - 1/\sigma)}{\left[N_i p_i^{1-\sigma} + N_j (p_j t)^{1-\sigma}\right]^{\frac{\beta}{1-\sigma}}} \tag{15.13}$$

This is where things get complicated as well as interesting, so we are going to talk through the intuition and refer to some figures. Suppose first that the two countries are absolutely identical, including the assumption that the X-sector labor force is evenly divided between the two countries. Then (15.13) takes on the same value in both countries.

Now move a few workers from country f to country h. We assert that this will have the effect of driving down w_h and p_h and driving up w_f and p_f (the demand coming from the fixed number of agricultural workers in each country is crucial to these results). As a first step in understanding the consequences, hold the number of varieties in each country fixed. For country h (i = h) in (15.13), the nominal wage in the numerator falls. p_i in the denominator falls by the same amount as the numerator, but p_j rises. Thus even if the denominator falls when the two effects are combined, it cannot fall as much as the numerator. Holding the number and distribution of varieties constant, (15.13) must fall for country

h the importer of labor and rise for country j the exporter of labor. In this case, the initial situation with the mobile labor force distributed 50-50 and the countries identical is a *stable* equilibrium: any labor movement raises the real wage in the emigrant country and lowers it in the immigrant country.

However, that is not the end of the story. The movement of *X*-sector workers from country f to country raises the equilibrium number of varieties produced in country h and lowers the number produced in country j. From (15.12) and (15.13) we see that this has the effect of lowering e_h and raising e_f. For country i, a number of available varieties switch from being high-cost imports to low-cost local goods, increasing purchasing power in country h from a given nominal wage. By simple inspection of (15.13) therefore, we cannot tell whether or not the movement of workers from f to h raises or lowers the real wage in h relative to f. If the movement raises the real wage in h relative to f, we say that the initial symmetric equilibrium is *unstable*: the movement of a few workers from f to h will create an incentive for further movement.

The term "indeterminate" is some times used to mean we simply don't know (ignorance) and sometime it is used to mean different outcomes can occur depending on parameter values, a more positive type of statement. In the present case, it is the latter. The symmetric initial equilibrium will be stable or unstable depending on the level of trade costs and other parameters. Figure 15.11 shows some simulations of the basic Krugman model. The share of the mobile *X* sector workers is plotted on the horizontal axis and the real wage in country h divided by the real wage in country f is plotted on the vertical axis. Countries are identical when the worker share is 0.5 in the middle of the horizontal axis.

Figure 15.11

Figure 15.11 plots results for three levels of trade costs (these are gross trade costs: t = 1 is costless trade). A negatively sloped curve or portion thereof through the mid-point denotes a *stable* equilibrium: adding workers to h (moving to the right) lowers the real wage in h relative to f. A positive slope indicates adding some workers to h will lead to a divergence, higher wages in h, and hence to further movements away from the symmetric equilibrium. When trade costs are high (t = 3.0), the symmetric equilibrium is globally stable: migration will return the countries to the symmetric equilibrium if for some reason they start even very far away from it with workers concentrated in one country.

For an intermediate trade cost (t = 2.0), the symmetric equilibrium is *locally stable*, but there are two other crossings of the curve at a relative real wage of one. These two outer equilibria are *unstable*: any little movement toward the center will raise the wage in the labor-scarce country and movement will continue to the central symmetric equilibria. Any little movement from one of the asymmetric equilibria toward the boundary (i.e., movement away from the center) lowers the wage in the labor-scare country and a cumulative movement will continue until all mobile workers have deserted that country. At a lower trade costs (t = 1.5) in Figure 15.11, the central symmetric equilibrium is globally unstable. Any little movement in either direction lowers the wage in the labor-scarce country relative to the labor-abundant country and a cumulative movement continues all the way to the boundary.

The structure of the model used here and popularized staring with Krugman (1991) is unusual in its factor-market structure, and this has led many trade economists to wonder as to its generality. To partly dissuade us from the view that this model's result rests solely on its extremely special nature, the present authors reformulated the model allowing for Y to again have a fixed (sector-specific) factor that is internationally as well as intersectorally immobile as before, but the mobile labor factor is used in both Y and in X. This means that more labor drawn away from the Y sector must bid up the nominal wage rate

in terms of Y. Results of a simulation for this model are shown in Figure 15.12. The central symmetric equilibrium for the case shown (t = 1.75) is unstable as it can be in the Krugman model for low trade costs. However, in this model there are always two other equilibria which are stable. These equilibria occur when the labor-scarce country begins to specialize in Y only. A that point, further losses of must raise the real wage in that country and so mobile labor will never desert the country entirely. These asymmetric equilibria are *stable* in the model of Figure 15.12 rather than *unstable* in Figure 15.11 (t = 2.0). But clearly, the essence of the Krugman result about the *possible* instability for identical countries does not hinge on the model's very special nature.

Figure 15.12

Markusen and Venables (2000) also show the same result shown in Figure 15.12 in the traditional two-good two-factor Heckscher-Ohlin structure. The symmetric equilibrium with countries identical is unstable to movements of the factor used intensively in the X sector, but a stable outcome is achieved before all of that factor deserts one country. As in Figure 15.12, the asymmetric outcomes are stable.

15.5 Summary: what you should know

For many decades, the study of international trade focused on trade in goods while analyses of factor mobility and trade in factors of production was generally left to inter-regional analysis and urban economics. This may have been due to the fact that the Heckscher-Ohlin model was the center piece of international economics. In that approach, trade in goods is induced by differences in factor endowments across countries and so trading factors directly tends to be a substitute for trading goods. The term substitutes is often used in both a volume-of-trade sense (allowing factor trade reduces the volume of goods trade) and in a welfare sense (gains from goods trade is reduced if factors are traded). There didn't seem to be much else interesting to say.

In the early 1980s, it was however pointed out that the Heckscher-Ohlin model is essentially the only case in which this substitutability result holds. For almost any other cause of trade, trade in factors and goods can be complements in both the volume-of-trade and in the welfare sense. Examples include Ricardian differences in technology, production distortions such as taxes, external economies of scale and so forth. If countries have initially identical relative factor endowments, allowing factors to move both increases the volume of trade in goods and world welfare.

More recently, trade in factors and its relation to production specialization and trade in goods has received a lot of attention in the economic geography literature, which brings some of the tools of trade theory (especially monopolistic-competition) to traditional regional models with mobile factors. Of special interest in this literature are the possibilities of multi-equilibria, the creation of industrial agglomerations, and the possible instability of "spreading" (non-agglomerated or symmetric) equilibria. The interactions between trade costs, factor mobility and production are complex. The movement of a factor used in a monopolistic-competition sector to one country may lower that factor's nominal wage, but it also lowers the price index for buying goods such that the real wage of the factor may rise. When that occurs, symmetric outcomes in which regions are identical can be unstable: if some factors arbitrarily move, they set off a cumulative movements that leaves industry agglomerated in one region and leaving the other region producing a competitive good (aka "agriculture"). Spatial differentiation and specialization, which is exogenously determined in Heckscher-Ohlin, becomes the endogenous outcome in this newer literature.

Empirical work on these issues is progressing. It is tricky insofar as the mere observation of industrial agglomeration does not prove it is due to the phenomena highlighted in the "new" economic geography. Many observed agglomerations are simply due to firms being drawn to the same immobile site-specific resources (e.g., ski resorts in Colorado, Hokkaido, or the Alps).

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1. A country's GNP (gross national product) refers to the income of its citizens, while GDP (gross domestic product) is the value of production in the country. In the presence of factor trade, the two are not the same. In the case just mentioned, point C in Figure 21.1 gives the two countries' GDP (production). Point A gives their GNP (consumption). For Country H, GNP equals GDP plus the earnings of its capital now located in Country F. Conversely, GDP exceeds GNP for Country F, since some of the value of production accrues to factors owned by Home.

2. This analysis is due to Purvis (1972) and Markusen (1983).

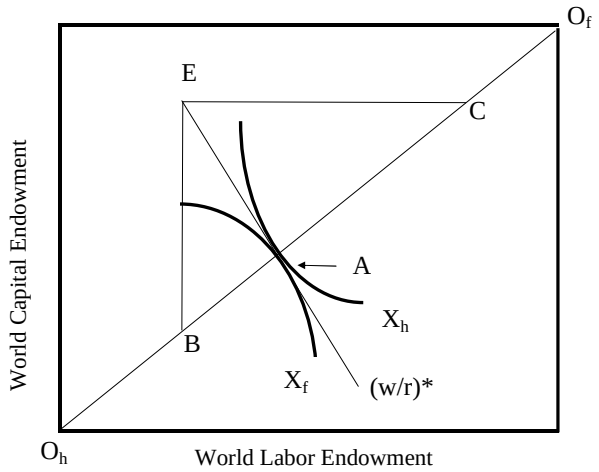


Figure 15.1 Equivalence of alternative types of trade

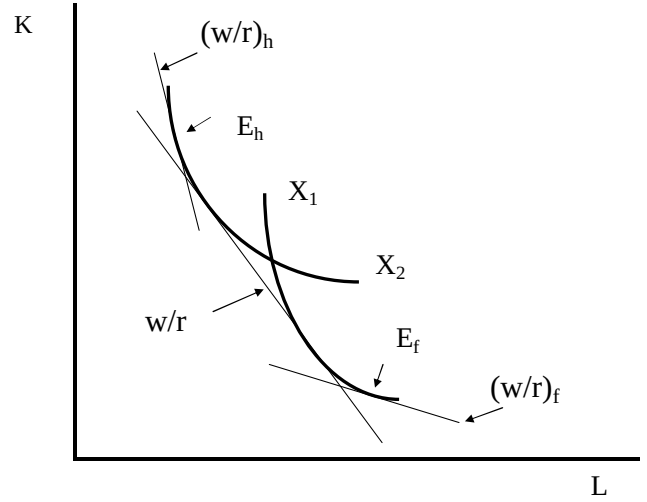


Figure 15.2: Specialization and Relative Factor Prices

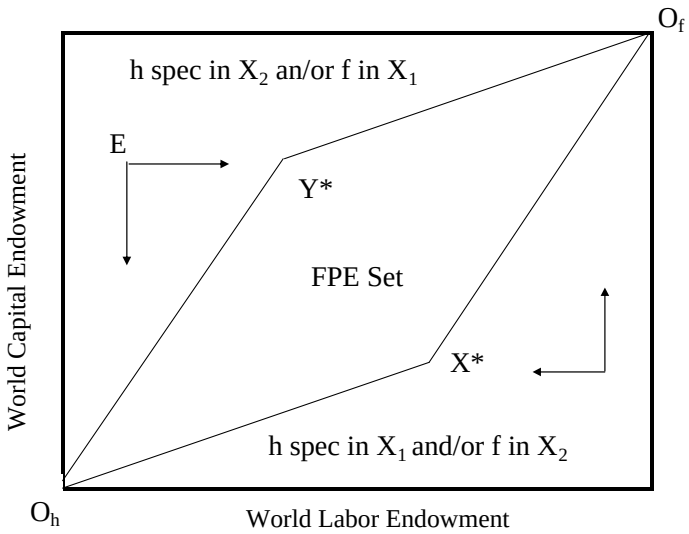


Figure 15.3: Factor trade outside the FPE set

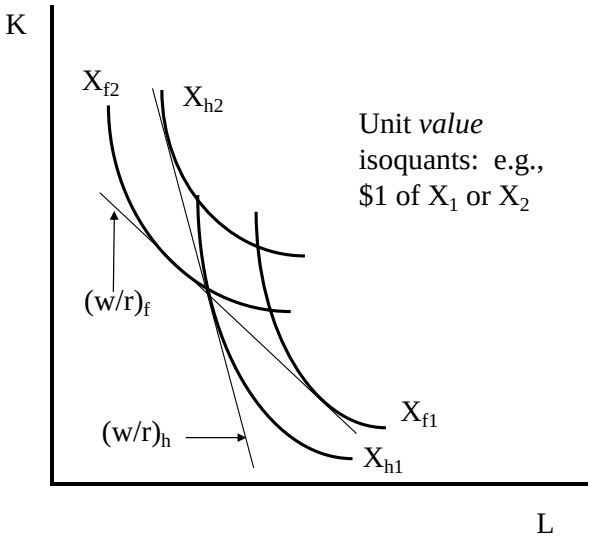


Figure 15.4: Trade Costs and Factor Prices

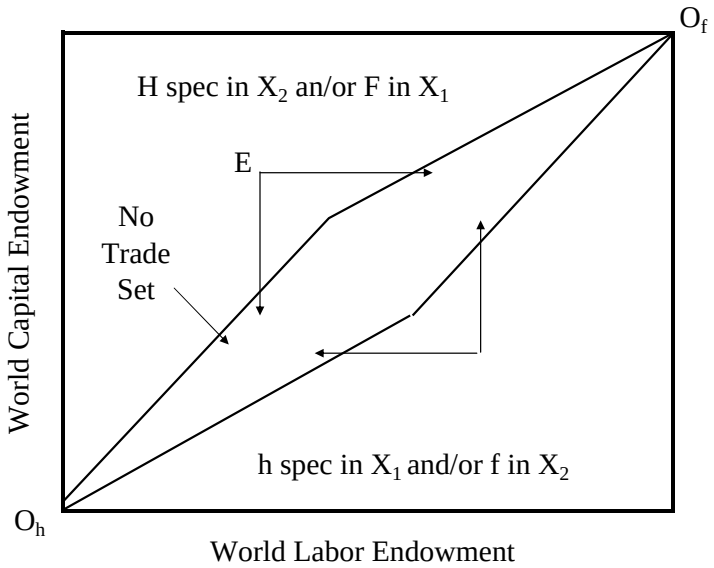


Figure 15.5: Factor trade with trade costs

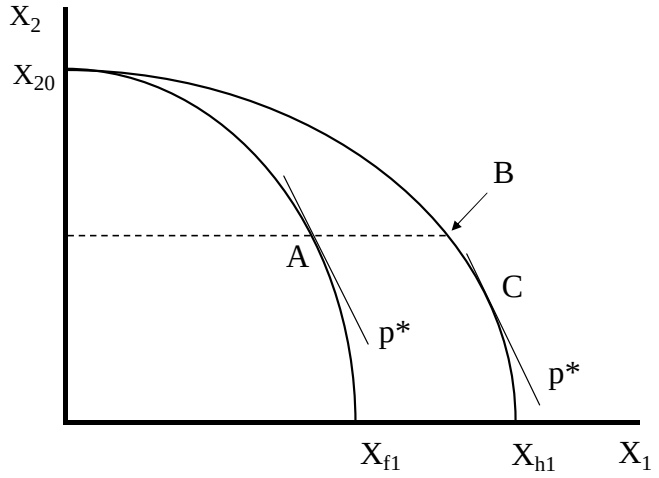


Figure 15.6: Country h has technical advantage in X_1

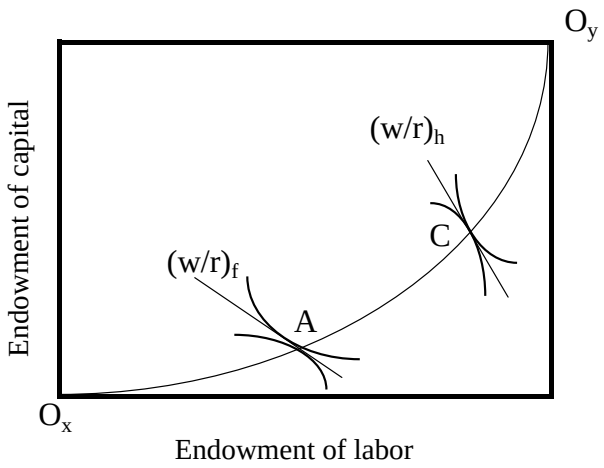


Figure 15.7: Factor prices with technology differences

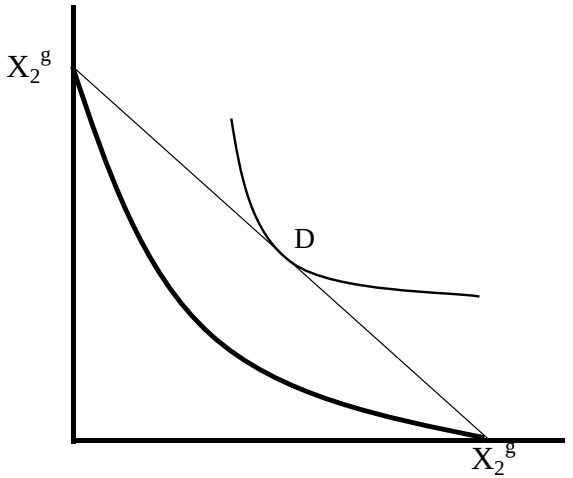


Figure 15.8: Specialization with identical countries

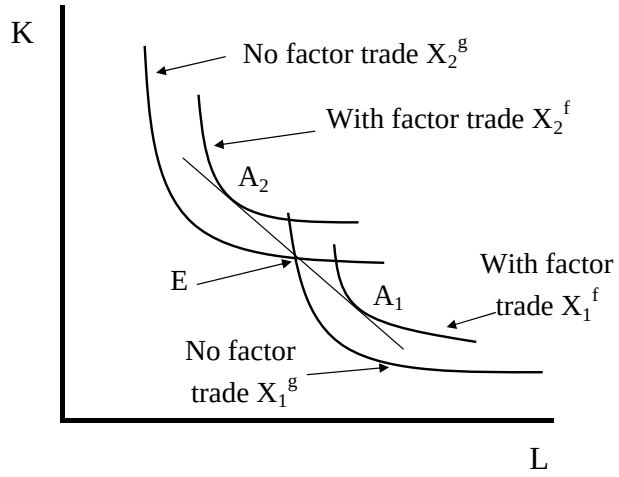


Figure 15.9: Adding factor trade

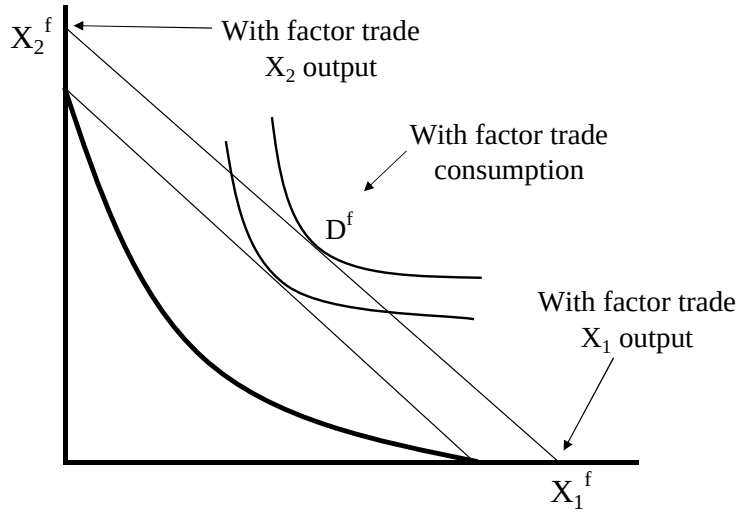


Figure 15.10: Factor trade and goods trade

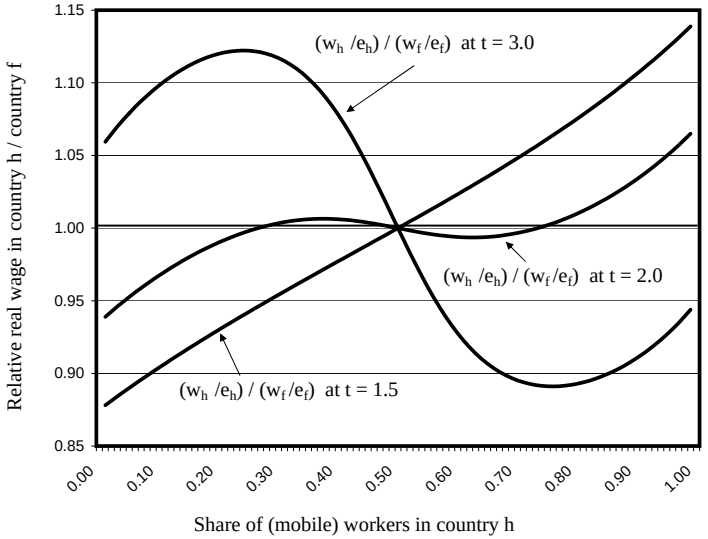


Figure 15.11: Agglomeration versus spreading in relation to trade costs

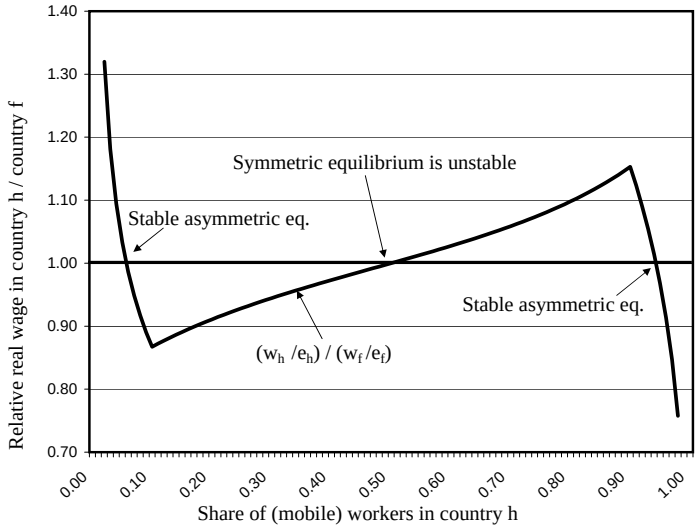
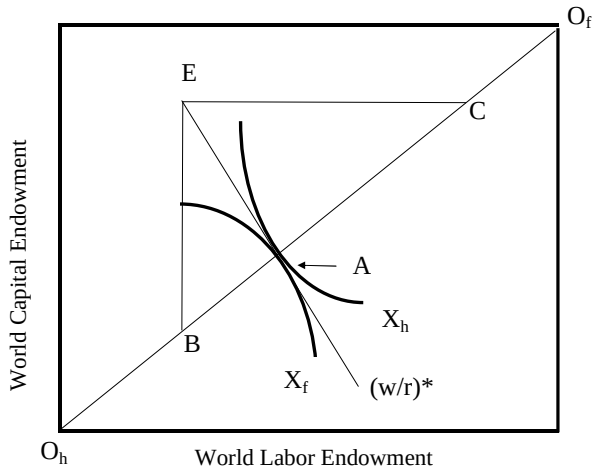


Figure 15.12: Alternative formulation: mobile factor also used in Y



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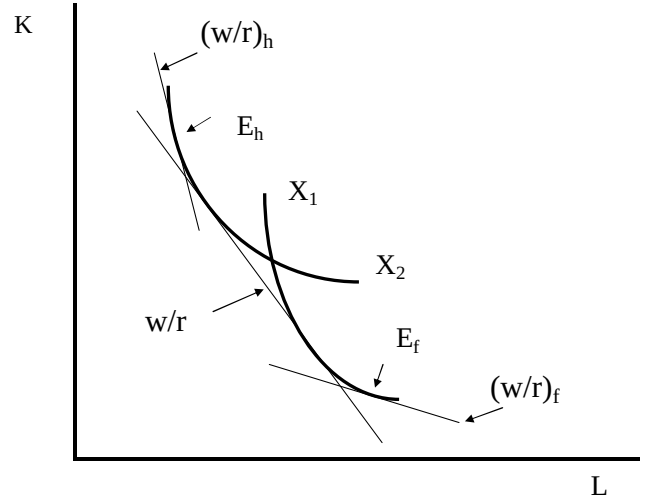

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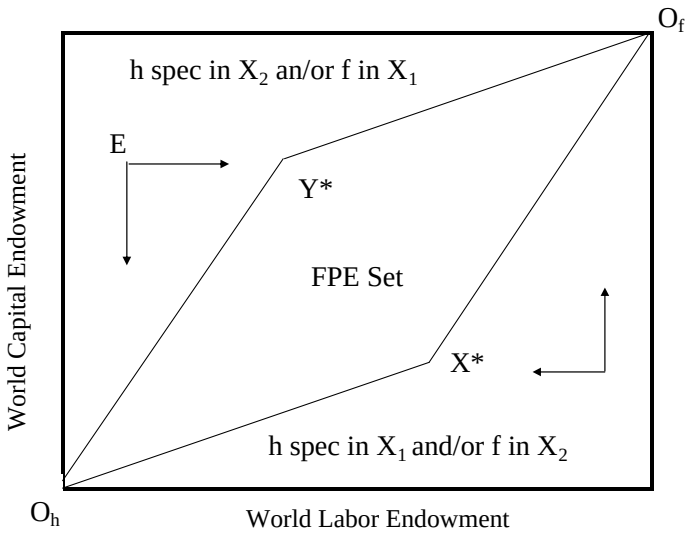

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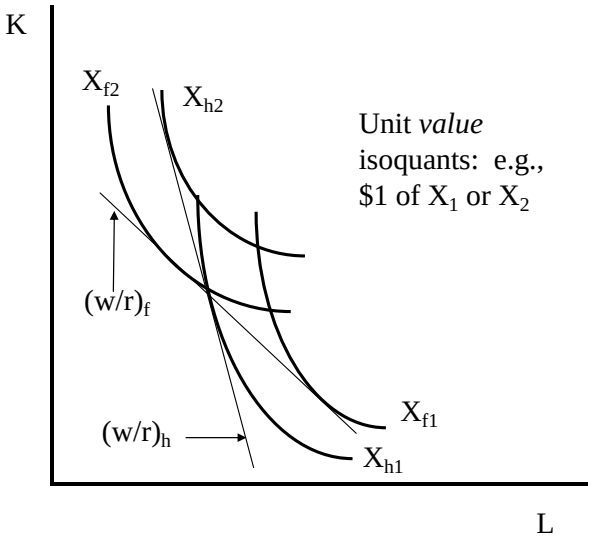

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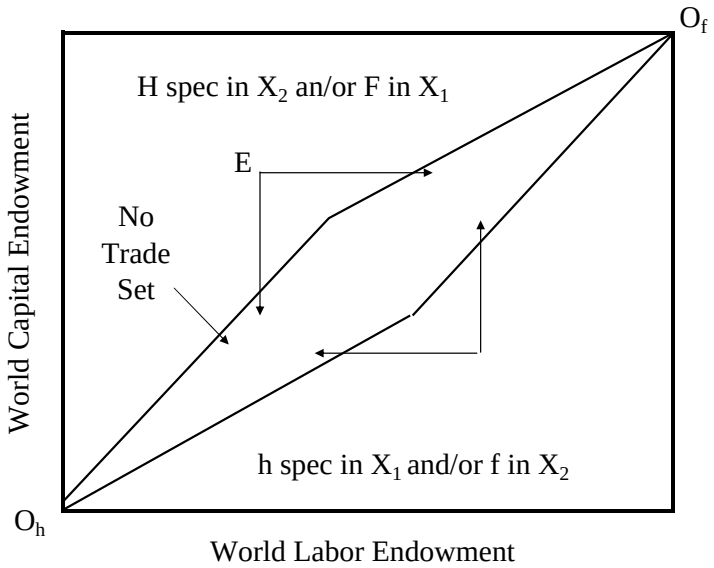

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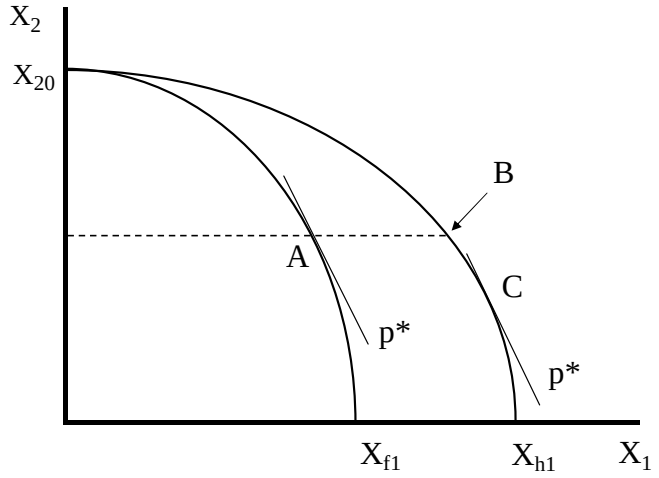

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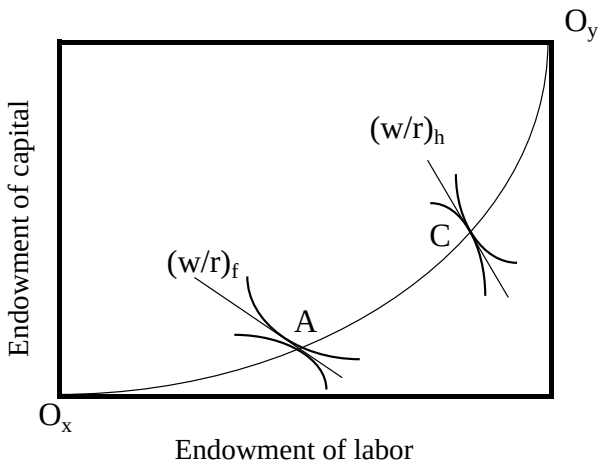

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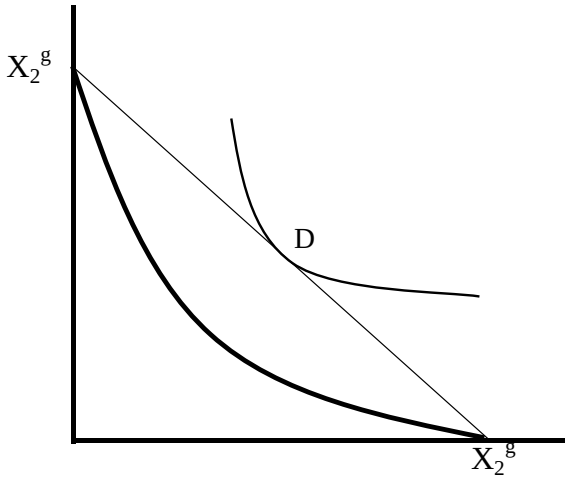

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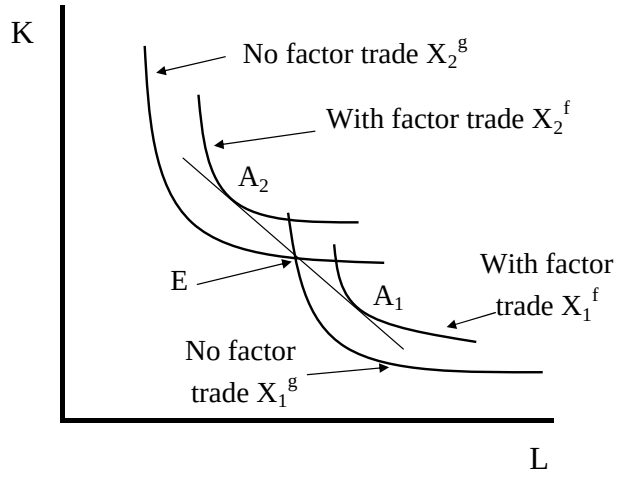

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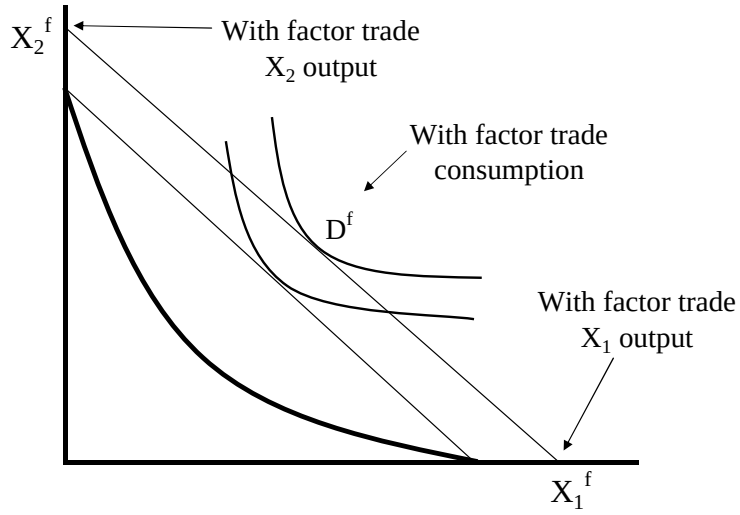

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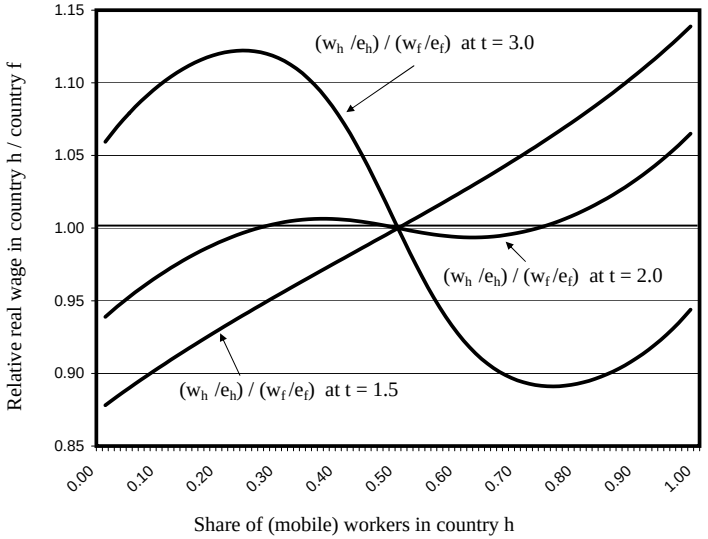

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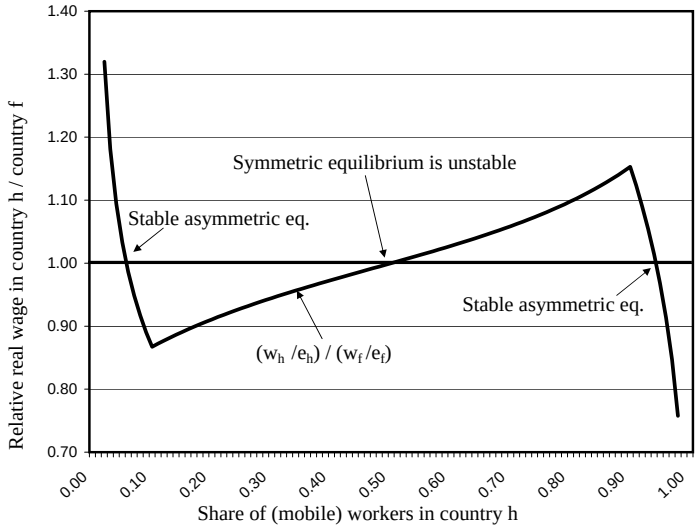

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