Chapter 9

DIFFERENCES IN FACTOR ENDOWMENTS II: THE JONES SPECIFIC-FACTORS MODEL

9.1 The Jones specific-factors model

As noted in the previous chapter, the names Heckscher and Ohlin are often used in a general sense to refer to all models in which differences in factor endowments across countries are the cause of trade. An alternative is to refer to all such models as factor-proportions models. In other cases, the term Heckscher-Ohlin model is used in a much more restricted sense to refer to the two-good, two-factor, two-country case of the previous chapter. In this chapter, we will examine another popular version of a factor-proportions model, which has been developed and popularized by Jones starting in a 1971 paper.

The Jones' formulation retains two goods, but has three factors, making it seemingly more complicated. But two of the factors are "specific" factors, each having a use in only one industry and having no use in the other. The third factor is mobile and can costlessly move between the two sectors as both factors do in the Heckscher-Ohlin model. The fact that only one factor is mobile here makes the model simpler than the HO formulation. But as we will see, there are offsetting complications. In particular, while it is obvious that each final good is intensive in its specific factor, there is ambiguity about the mobile factor and what happens to outputs if the supply of this factor is increased. Defining the factor intensity of the mobile factor turns out to be complex and there does not emerge a simple, clean theorem about endowments and trade as there does in the Heckscher-Ohlin theorem.

There are several reasons why the specific-factors' formulation is appealing, and perhaps these will become clearer as we proceed. First, the factor-price equalization theorem does not hold and, oddly, trade economist are probably more comfortable with that theorem not holding: it just does not strike us as empirically very plausible. Second and more important, the specific factors' formulation generates results that seem much more plausible from a political-economy point of view. In the Heckscher-Ohlin model, a group of factor owners such as capital or labor are always bound together regardless of what industry they work in. Capital owners should lobby for the capital-intensive industry even if their capital is in the labor-intensive industry. The specific-factors' model instead implies factors are allied with the industry they work in (though again with ambiguity with respect to the mobile factor). Third, the specific-factors' model seems much more plausible for the short and intermediate run, in that it is costly or impossible to move factors between industries over a period of even a few years. Capital, for example, takes on industry-specific forms once installed, and it is not easy to transform shoe-making equipment into agricultural machinery. This is done over the long run by allowing one type to depreciate and channeling all new investment into the other type.

After a number of tries, we found that the general notation of the previous chapter proved more confusing than helpful in this chapter and so we return to a more traditional notation. We will retain the labeling of goods as X_1 and X_2. However, the mobile factor will be denoted L for labor, with L_1 and L_2 the amounts allocated to the two sectors. The specific factors will be denoted K_1 and K_2. These are in fixed supply and each is only useful in its own sector. Having said this, we don't want to take these labels too literally. The specific factors could be types of human capital that have no use in the other sector. The mobile factor could be land or unskilled labor.

The production side of the economy is given by

$$X_1 = F_1(L_1, K_1) \qquad X_2 = F_2(L_2, K_2) \qquad \bar{L} = L_1 + L_2, \quad K_1 = \bar{K}_1, \quad K_2 = \bar{K}_2 \qquad (9.1)$$

Figure 1 presents an intuitive version of the relationship between factor endowments and comparative advantage. Suppose that both countries have identical endowments of labor, and suppose that country h has an absolutely larger endowment of K_2 than country f and the latter has an absolutely larger endowment of K_1. Then it is clear that the production frontiers of the two countries must look something like those drawn in Figure 9.1, where HH′ and FF′ are the frontiers of countries h and f respectively. With L endowments equal, each country has a comparative advantage in the good using intensively its abundant factor. That sure sounds like Heckscher-Ohlin, but the caveat about the mobile factor is unfortunately not innocuous as we shall see.

Figure 9.1

As in all competitive models, producers equate the value of the marginal product of a factor to its price. Let w denote the price of labor and r_1 and r_2 denote the prices of the two specific factors. In the specific-factors' model, the following equality express production equilibrium at goods prices p_1 and p_2 (as before F_{i1} is the marginal product of the first factor, labor in this case, in producing good i).

$$p_1 F_{11}(L_1, K_1) \;=\; p_2 F_{21}(L_2, K_2) \;=\; w_1 \qquad (9.2)$$

Differentiate the first equality with respect to the mobile factor L, noting that $dL_1 = - dL_2$ for factor-market clearing. Then divide the second equation by the first to get the marginal rate of transformation, which we know is equal to the price ratio p_1/p_2 in competitive equilibrium.

$$dX_1 \;=\; F_{11} dL_1 \qquad dX_2 \;=\; F_{21} dL_2 \;=\; -F_{21} dL_1 \qquad -\frac{dX_2}{dX_1} \;=\; \frac{F_{21}}{F_{11}} \;=\; \frac{p_1}{p_2} \qquad (9.3)$$

In the specific-factors' model, the slope of the production frontier is just the ratio of the marginal products of labor in the two industries. If the isoquants of the two industries exhibit smooth substitution, then the production frontier of each country must exhibit curvature as in Figure 9.1. Intuitively, begin with only producing good X_2. As we move down the frontier, we are taking labor away from the fixed factor K_2 in the X_2 sector, and so (K_2/L_2) rises, and the marginal product of labor rises. F_{21} in (9.3) rises. As we add labor to the X_1 sector, we are adding labor to a fixed factor, and so (K_1/L_1) falls and the marginal product of labor falls. F_{11} in (9.3) falls. Thus the marginal rate of transformation increase (or the slope becomes increasingly negative) as we move down the production frontier in Figure 9.1

Return now to (9.2). The two sides of this equation, the value of the marginal product of labor *(VMP*) in the two sectors, has a simple graphical representation shown in Figure 9.2. VMP_1 denotes for example, the left-hand side of (9.2). Similar to an Edgeworth box, the horizontal axis is the total supply of labor available to the economy, with the allocation to X_1 graphed from the left and to X_2 graphed from the right. The intersection of the two value-of-marginal-product curve determines the optimal allocation of labor between the two sectors and determines the wage rate. In what follows below, it is important to note that each curve in Figure 9.2 has two parameters: the price of the good and the amount of the specific factor in that sector. Increasing either p_1 or K_1, for example, shifts the curve for X_1 upward: the value of the marginal product of labor increases at any level of L_1.

Figure 9.2

9.2 Analogs to the four theorems of the Heckscher-Ohlin Model

(A) (Non) factor-price equalization. The first things we can note directly from Figure 9.2 is that factor-price equalization across countries is not going to hold (except by chance). There are two zero-profit equations to determine three factor prices from two goods prices. Factor prices are going to depend on endowments as well even if both countries produce both goods and commodity prices are equalized by trade. Start with two identical countries and commodity prices equalized by trade. If we expand the labor supply in one country, the horizontal axis of Figure 9.2 lengthens, the two curve move further apart and the wage must fall. Similarly and beginning again with identical countries, give one country more of one of the specific factors, say K_1, and the VMP_1 curve shifts up. This will increase the wage rate and reduce the price of the specific factor K_1. In summary, even with commodity prices equalized by trade and both countries producing both goods, if the two countries have equal endowment of two factors, the third factor will be cheap where it is abundant and expensive where it is scarce.

(B) Analog to the Stolper-Samuelson theorem. Suppose that we increase the price of good X_1: $dp_1 > 0$, $dp_2 = 0$. Again, this is readily analyzed with Figure 9.2. The curve VMP_1 shifts up as shown in Figure 9.3. Labor is reallocated toward the X_1 sector. With the specific factors fixed, it must be the case that K_1/L_1 falls and K_2/L_2 rises. Recall from Chapter 2 that, with constant returns to scale, the marginal product of a factor depends only on the *ratio* in which factors are used. Use the value-of-the-marginal-product conditions in (9.2) above and add those for the specific factors, and then divide through both sides of each equation by the price of the good; e.g., $p_i F_{i1} = w \;\; => \;\; w/p_{i1} = F_{i1}$. The changes in the capital-labor ratios in the two industries must imply that the increase in the price of X_1 gives us

$$\begin{aligned} d(w/p_1) &= d(F_{11}) < 0 \qquad d(w/p_2) = d(F_{21}) > 0 \\ d(r_1/p_1) &= d(F_{12}) > 0 \qquad d(r_2/p_2) = d(F_{22}) < 0 \end{aligned} \tag{9.4}$$

Figure 9.3

Recall the algebra we developed in the previous chapter, denoting the proportional change in a variable with a "hat". If a ratio increases, it must mean that the proportional change in the numerator is greater than the proportional change in the denominator. (9.4) gives use a version or analog to the Stolper-Samuelson theorem with a corresponding chain of inequalities for a change in p_2 holding p_1 constant. These chains are given by:

$$\hat{r}_1 > \hat{p}_1 > \hat{w} > 0 > \hat{r}_2 \qquad \hat{r}_2 > \hat{p}_2 > \hat{w} > 0 > \hat{r}_1 \qquad \hat{r}_1 \equiv \frac{dr_1}{r_1} \text{ etc.} \tag{9.5}$$

If the price of good i goes up, then the real income of the specific factor in i rises (the nominal price of the factor must rise by more than the good's price) and the real income of the other specific factor falls (even in terms of the good whose price has not changed). Thus price changes due to trade liberalization, trade protection, or changes abroad create a strong redistribution between the owners of the specific factors. Specific factor owners will lobby hard for their industry and owners of industry-specific physical or human capital will now be enemies of physical or human capital owners in the other industry. This strikes many who study political economy as a much more empirically plausible prediction than that of the Heckscher-Ohlin model's Stolper-Samuelson theorem. As noted above, this is one reason for the specific-factors-model's populatity.

Note from (9.5) however, that there is ambiguity about the change in the real income of the mobile factor L. Labor's wage change is caught in between those of the two goods prices. In the first chain of inequalities ($dp_1 > 0$, $dp_2 = 0$), the wage rise relative to the (unchanged) price of good 2, but falls in terms of the price of good 1 which has risen. Thus the real income or welfare of labor depends in part on preferences and is more like to increase if it has a preference for the good whose price has not gone up. In the case of trade liberalization where the relative price of the export good rises for example, this would mean having a preference for the import good would make it more likely that labor gains in welfare terms.

(C) Analog to the Rybczynski theorem. As you recall, the Rybczynski theorem was the effect of an endowment change on the change in outputs, holding commodity prices constant. There is an analog here as in the case of the Stolper-Samuelson theorem. And much of it can understood one again from equation (9.2) and Figures 9.2 and 9.3. First, an increase in one of the specific factors, $dK_1 > 0$. As shown in Figure 9.3, this shift up the VMP_1 curve and shifts labor toward the X_1 sector to go with the increased K_1. We note from the "X" diagram that w rises with p_1 and p_2 constant by assumption: with prices constant, F_{11} and F_{21} both rise, but this means that both K_1/L_1 and K_2/L_2 rises (in the latter case because L_2 goes down). The X_1 sector pulls in labor, but not in proportion to the rise in K_1. The rise in the capital labor ratio in X_1 means that $dK_1/K_1 > dL_1/L_1$ and therefore that $dK_1/K_1 > dX_1/X_1 > 0$, and $dX_2/X_2 < 0$. Repeating the argument for an increase in K_2 holding K_1, L and goods prices constant, we have our result.

$$\hat{K}_1 > \hat{X}_1 > 0 > \hat{X}_2 \qquad \hat{K}_2 > \hat{X}_2 > 0 > \hat{X}_1 \qquad \hat{K}_1 \equiv \frac{dK_1}{K_1} \text{ etc.} \tag{9.6}$$

Compare this to the result for the Rybczynski theorem in (8.19) of the previous chapter. Now we no longer have the “magnification” effect of an endowment change on outputs. The change in the endowment of a specific factor now has a less-than-proportionate change on the output of its industry. Quantitatively, the results looks much like that shown in Figure 8.8 of the previous chapter, but the biased in the change is quantitatively less in the present case.

The role of the mobile factor L is less straightforward. Figure 9.4 shown the effect of an increasing labor supply, stretching the length of the “X” diagram. Provided that both *VMP* curves are strictly negatively sloped (with respect to their origins), then some added labor is allocated to each sector. We must have

$$\hat{L} > \left[\hat{X}_1, \hat{X}_2\right] > 0 \tag{9.7}$$

Figure 9.4

However, which good has the larger output increase is unclear. It turns out that which good increases relatively more, an issue important for determining the direction of trade, does depend on which one is more labor intensive as measured by factor shares, but it also depends on other properties of the two production functions. In particular it depends on the slopes of the two *VMP* curves in Figure 9.4. Note for example, that if VMP_1 is flat in Figure 9.4 (horizontal), then all of the added labor must go to the X_1 sector. Conversely, if VMP_2 is vertical, all of the added labor must go to sector X_2.

Differentiate the two production functions in (9.1) and then form proportional changes by (1) dividing both sides by the level of output of the good, (2) multiplying and dividing the right-hand side by the price of the good and (3) multiplying and dividing the right-hand side by the labor allocation to the good. We then have

$$\frac{dX_1}{X_1} = \left[\frac{p_1 F_{11} L_1}{p_1 X_1}\right]\frac{dL_1}{L_1} \qquad \frac{dX_2}{X_2} = \left[\frac{p_2 F_{21} L_2}{p_2 X_2}\right]\frac{dL_2}{L_2} \tag{9.8}$$

From our work in Chapter 8 and from the value-of-the-marginal-product conditions in (9.1), we see that the terms in brackets are the shares of labor income in the total value of production in each of the two sectors. Using the same notation as in Chapter 8, we can write these shares as

$$\theta_{i1} = \left[\frac{p_i F_{i1} L_i}{p_i X_i}\right] = \left[\frac{w L_i}{p_i X_i}\right] \tag{9.9}$$

Substituting (9.9) into (9.8), then we get (9.10). Which good increases more depends on the share of labor in each sector, which is a sensible definition of labor intensity.

$$\frac{dX_2/X_2}{dX_1/X_1} = \frac{\theta_{21}}{\theta_{11}}\frac{dL_2/L_2}{dL_1/L_1} \tag{9.10}$$

However, we are unfortunately not done. The changes in outputs also depend on which sector is allocated more of the increase in labor. A good way to think about this is to consider again Figure 9.4 from the point of view of each industry and think about firms in each industry reacting to an increase of fall in the wage rate. The elasticity of demand in for labor in an industry can be defined as the proportional increase in demand for labor in response to a proportional increase in the wage rate, holding the price of the output constant. It is typically also defined for holding the prices of other factors constant, but in our case we define it for holding the quantity of the other factor, the sector-specific factor, constant. When defined in this manner and using η_i to denote the elasticity so defined, (9.10) becomes the following.

$$\frac{dX_2/X_2}{dX_1/X_1} = \frac{\theta_{21}}{\theta_{11}}\frac{\eta_2}{\eta_1} \qquad -\left[\frac{dL_i/L_i}{dw/w}\right]_{dK_i = 0} \equiv \eta_i \tag{9.11}$$

With the wage on the vertical axis in Figures 9.1-9.4, a flat *VMP* curve has a high elasticity and a steep curve a low elasticity. As noted in the previous paragraph, an industry responds more to an increase in the labor endowment when there is a higher elasticity of demand for labor (or low in the other industry) as well as when the share of labor in that industry is high.

Now we can summarize our finding to create an analog to the Heckscher-Ohlin theorem about the direction of trade. Unfortunately, it is not as simple and clean as the original.

Specific-factors analog to the Heckscher-Ohlin theorem. (i) for two otherwise identical countries, if one country h has more of specific factor 1 and/or country f has more of specific factor 2, then country h exports good 1. (ii) for two otherwise identical countries, if country h has more labor then country h is more likely to export good 1 if the share of labor in industry 1 is higher than in industry 2 and the elasticity of demand for labor with respect to the wage rate is higher in industry 1.

9.3 Introduction to the CES function (may be skipped without loss of continuity but useful later)

This may be a good time to introduce a general class of functions called the constant-elasticity-of-substitution (CES) function. We decided not to do this earlier in Chapter 2 in order to keep things moving. This section may be skipped, but it will be of use later, particularly in the chapter in monopolistic competition.

Refer back to Chapter 2 and look at the three special cases in equations (2.3) with isoquants shown in Figure 2.3. These three cases are in fact special case of the CES function. This function and the definition of the elasticity of substitution are as follows.

$$X = \left[\delta V_1^{\beta} + (1-\delta)V_2^{\beta}\right]^{\frac{1}{\beta}} \qquad \sigma \equiv \frac{d(V_2/V_1)}{V_2/V_1} \bigg/ \frac{d(w_1/w_2)}{w_1/w_2} = \frac{1}{1-\beta} \tag{9.12}$$

Figure 9.5 gives a graphical interpretation of the elasticity of substitution. σ gives the response in the relative use of factors, the V_2/V_1 ratio, in response to a change in relative factor prices, the w_1/w_2 ratio. A flat isoquant is going to have a high elasticity of substitution: there is a big change in V_2/V_1 in response to a given change in w_1/w_2. The three special cases in (2.3) and Figure 2.3 (set δ = 1/2 in (9.12)) have elasticities of substitution as follows.

Figure 9.5

(i) $X = V_1 + V_2: \quad \sigma = +\infty \quad (\beta = 1)$

(ii) $X = \min[V_1, V_2]: \quad \sigma = 0 \quad (\beta = -\infty)$

(iii) $X = V_1^{0.5} V_2^{0.5}: \quad \sigma = 1 \quad (\beta = 0)$ (9.13)

The simplistic-looking Cobb-Douglas in (iii) is just a special case of the CES with β = 0, though this requires taking limits to establish the result. As suggested by (9.13), these functions are quasi-concave (the isoquant curve the right way) for values of β between 1 and minus infinity. For values of β greater than one the isoquant curve the other ("wrong") way and the firm would only ever use one factor.

Now let us use a slightly more complicated weighting or "calibration" which turns out to be somewhat simpler in the end. Choose the weighting on the two factors such that if $V_1 = \alpha$ and $V_2 = (1 - \alpha)$, then $X = 1$. This calibration is given as follows (check that the statement in the previous sentence is true):

$$X = \left[\alpha\left(\frac{V_1}{\alpha}\right)^{\beta} + (1-\alpha)\left(\frac{V_2}{1-\alpha}\right)^{\beta}\right]^{\frac{1}{\beta}} \qquad X = \left[\alpha^{1-\beta}V_1^{\beta} + (1-\alpha)^{1-\beta}V_2^{\beta}\right]^{\frac{1}{\beta}} \tag{9.14}$$

Producer optimization requires that the value of the marginal product of a factor equal its price. For factor V_1, this gives us

$$pF_1 = w_1 \quad => \quad p\frac{1}{\beta}[\ ]^{\frac{1}{\beta}-1}\beta\alpha^{1-\beta}V_1^{\beta-1} = p[\ ]^{\frac{1}{\beta}-1}\alpha^{1-\beta}V_1^{\beta-1} = w_1 \tag{9.15}$$

with a similar equation holding for factor V_2. Divide (9.15) by the corresponding equation for V_2 to get the following.

$$\left[\frac{\alpha}{1-\alpha}\right]^{1-\beta}\left(\frac{V_2}{V_1}\right)^{1-\beta} = \frac{w_1}{w_2} \qquad \frac{V_2}{V_1} = \frac{1-\alpha}{\alpha}\left(\frac{w_1}{w_2}\right)^{\frac{1}{1-\beta}} \tag{9.16}$$

Totally differentiate the second equation.

$$d\left(\frac{V_2}{V_1}\right) = \frac{1-\alpha}{\alpha}\left(\frac{w_1}{w_2}\right)^{\frac{1}{1-\beta}-1}\frac{1}{1-\beta}d\left(\frac{w_1}{w_2}\right) = \left(\frac{V_2}{V_1}\right)\left(\frac{w_1}{w_2}\right)^{-1}\frac{1}{1-\beta}d\left(\frac{w_1}{w_2}\right) \tag{9.17}$$

where the second equation in (9.17) follows by using the second equation of (9.16). (9.17) can then be rewritten in proportional change form to give the elasticity of substitution.

$$\frac{d(V_2/V_1)}{V_2/V_1} \bigg/ \frac{d(w_1/w_2)}{w_1/w_2} = \sigma = \frac{1}{1-\beta} \qquad (9.18)$$

This establishes the assertion above that the elasticity of substitution is related to β by the formula $\sigma = 1/(1 - \beta)$.

Now let's use this in our analysis of the response of outputs to a change in the endowment of the mobile factor L. Let V_1 be labor and let V_2 be the sector-specific factor. Let $w_2 = 1$ be numeraire for simplicity. Then the second equation of (9.16) allows us to write the demand for labor as the following equation, and the wage elasticity of demand for labor holding the specific factor constant follows directly.

$$L = \left(\frac{\alpha}{1-\alpha}K\right)w_1^{-\sigma} \qquad -\frac{dL}{L}\bigg/\frac{dw}{w} = \sigma = \eta \qquad (9.19)$$

Repeating this for both industries, equation (9.11) becomes

$$\frac{dX_2}{X_2}\bigg/\frac{dX_1}{X_1} = \frac{\theta_{21}\sigma_2}{\theta_{11}\sigma_1} \qquad (9.20)$$

Of particular interest to much of new trade theory with monopolistic competition, including geography models, is the cost function associated with the CES production function. We will postpone this until Chapter 12 when we take up this issue again.

9.4 A special case of specific-factors and an introduction to the CET function (may be skipped without loss of continuity)

In many situations, a research might not be particularly interested in the factor market side of an economy and may want to deal directly with the final goods market. In doing so, they may use the analog of the CES for multiple outputs which is called the constant-elasticity-of-transformation function (CET). In doing so, it is not very clear about what is being assumed about the underlying structure of production, just that there is some sort of joint-production of multiple goods from one process. But it turns out that the CET function has a simple interpretation as a special case of the specific-factor model.

Consider an extremely special case of our specific-factors model in which both production functions are Cobb-Douglas and both have the same share weights on labor and the specific factors.

$$X_1 = L_1^{\beta}K_1^{1-\beta} \qquad X_2 = L_2^{\beta}K_2^{1-\beta} \qquad \bar{L} = L_1 + L_2 \qquad (9.21)$$

Invert both of these, giving the labor used in a sector

$$L_1 = \left(K_1^{\frac{\beta-1}{\beta}}\right)X_1^{\frac{1}{\beta}} \qquad L_2 = \left(K_2^{\frac{\beta-1}{\beta}}\right)X_2^{\frac{1}{\beta}} \qquad (9.22)$$

Add these two equations together, noting that gives us total labor supply which is fixed by assumption. Then raise both sides to the power β.

$$\bar{L}^{\beta} = \left[\left(K_1^{\frac{\beta-1}{\beta}}\right)X_1^{\frac{1}{\beta}} + \left(K_2^{\frac{\beta-1}{\beta}}\right)X_2^{\frac{1}{\beta}}\right]^{\beta} \qquad (9.23)$$

Notice how this resembles the CES function, except now the exponents on the X_i's are greater than one rather than less than one. This means that the curvature of the X_1X_2 locus, the production possibilities frontier, will have the opposite curvature of an input isoquant: the production frontier is bowed out. The weights on the outputs in the CET are the specific factors, and note that their exponents are negative. Thus an increase in K_1, for example, produces a higher level of X_1 production holding X_2 constant.

Differentiate (9.23) and note that the slope of the production frontier will equal the price ratio in competitive equilibrium. Then use this to get the relationship between the production ratio and the price ratio, which depends on the supplies of the two specific factors.

$$-\frac{dX_2}{dX_1} = \left(\frac{K_2}{K_1}\right)^{\frac{1-\beta}{\beta}} \left(\frac{X_2}{X_1}\right)^{\frac{\beta-1}{\beta}} = \frac{p_1}{p_2} \qquad \frac{X_2}{X_1} = \left(\frac{K_2}{K_1}\right)\left(\frac{p_1}{p_2}\right)^{\frac{\beta}{\beta-1}} \tag{9.24}$$

If we differentiate the last equation an convert it to proportional changes as we have done several times before, then we get an expression for the elasticity of transformation around the production frontier, which we can denote by ϵ.

$$-\frac{d(X_2/X_1)}{X_2/X_1} \bigg/ \frac{d(p_1/p_2)}{p_1/p_2} \equiv \epsilon = \frac{\beta}{1-\beta} \tag{9.25}$$

Figure 9.6 illustrates the elasticity of transformation for a CET function much as Figure 9.5 did for the CES. The elasticity of transformation is a measure of the responsiveness of the output ratio X_2/X_1 to changes in the price ratio p_1/p_2. A flat transformation curve has a high elasticity of transformation. Note from (9.23) that transformation curve approaches a straight line as β approaches 1 and the elasticity of tranformation approaches infinity.. Note also, for example, that when $\beta = 1/2$ and $K_1 = K_2$, then (9.23) is the equation of a section of a circle (the exponents on the X_i's equal 2). From (9.25) this tells us that an elasticity of transformation of one is the equation of a circle and the production frontier is a section of a circle.

Figure 9.6

We will not deal further with the CET in this book, and we simply note that it is a very value tool in applied general equilibrium modeling where the real data tells us that industries produce multiple outputs (joint products). Typically the data show multiple outputs and inputs for each sector. The typically way that a modeler deals with this is to assume *separability* between inputs and outputs, so that the technology of the industry is written as

$$G(X_1, X_2) = F(V_1, V_2) \tag{9.26}$$

where G is CET and F is CES.

9.5 Summary: what you should know

There are many possible formulations for factor-proportions models in which differences in relative endowments across countries link with differences in factor intensities across industries. The Heckscher-Ohlin model of the previous chapter is one and the Jones' specific-factor model is another.

The Jones' formulation is popular in a number of applications including political economy models of lobbying for example. The fact that factors are allied within industries rather than across industries seems to have some intuitive appeal. The Jone's formuation also escapes from factor-price equalization which many find an improbable result from Heckscher-Ohlin.

While simpler than Heckscher-Ohlin in many ways, the specific-factors model is unfortunately more complicated in others. This is particularly true with regard to the role of the mobile factor and its role in creating comparative advantage. It is not the case that the role of the mobile factor can be discerned from factor intensities (as measured by factor shares) alone, we must also know the elasticities of substitution across industries to predict this factor's impact on trade.

Analogs to the Stolper-Samuelson and Rybczynski theorem are developed. Specific factors are the big gainers or losers from commodity price changes, which may be cause by trade liberalization or its opposite, increased protectionsim, or by change in the rest of the world's economy. The model suggests that specific factor owners such as physical capital or human capital that is industry specific (has little use outside their industry) or land and resources, will be particularly fierce lobbyists on trade policy.

The chapter concludes with short sections developing the CES and CET functions and showing a couple of applications they have within the context of the specific-factors model. While it may have seemed logical to include these in Chapter 2, we made the decision to postpone their introduction in order to move things alone. The CES function will return to play an important role in the analysis of monopolistic competition in Chapter 12, and also in discussions about economic geography.

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Figure 9.1

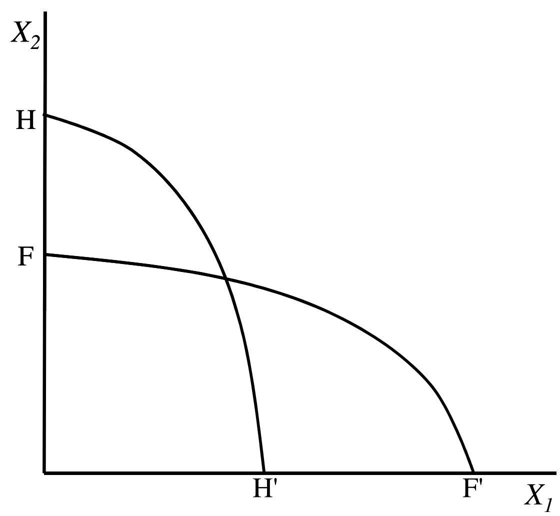

Figure 9.2

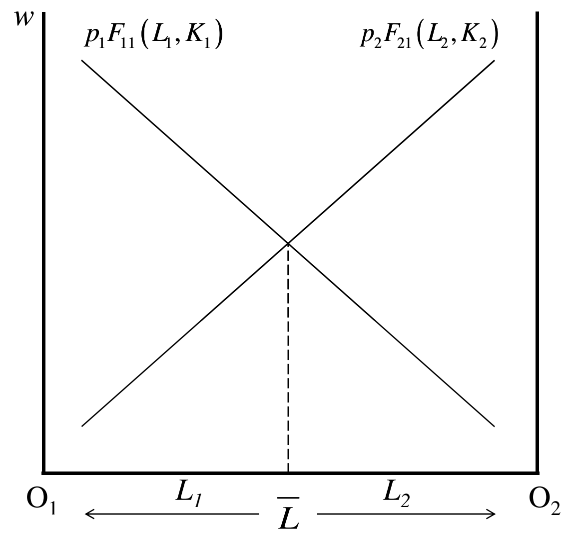

Figure 9.3

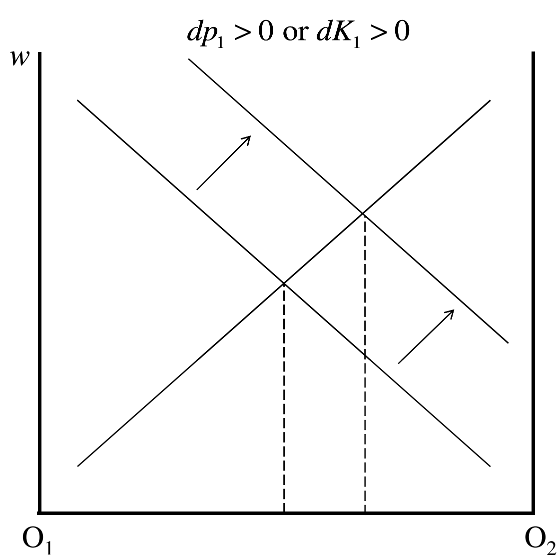

Figure 9.4

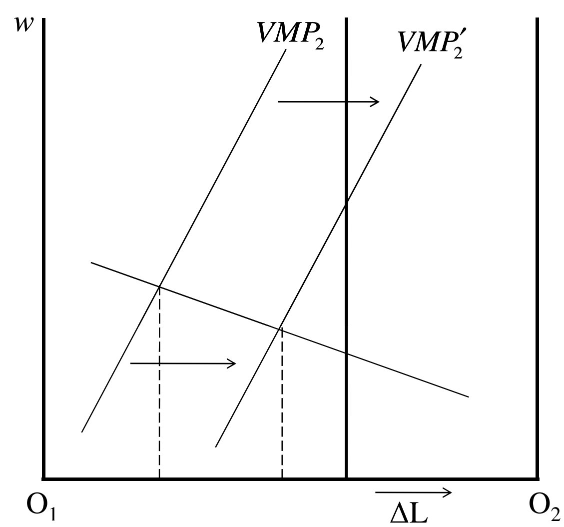

Figure 9.5

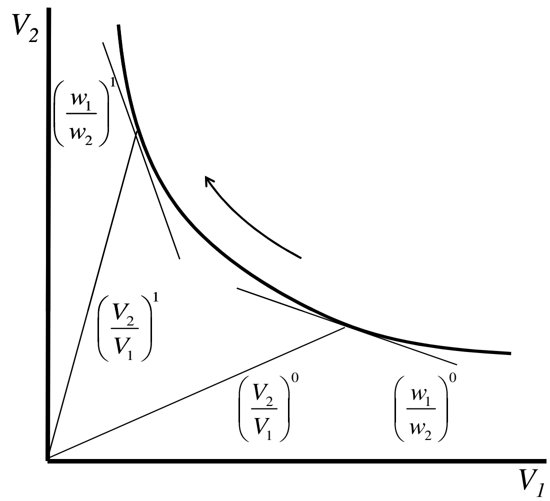

Figure 9.6