Trade and Income Distribution
International Economics
Pugel, Chapter 5
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The following provides a simplified example to illustrate how a change in prices can impact on the distribution of income. The basic logic was presented by Eli Heckscher, in his article "Foreign Trade and the Distribution of Income," *Ekonomisk Tidskrift*, 1919, and extended and made more mathematically rigorous by Wolfgang Stolper and Paul Samuelson in their article "Protection and Real Wages", *Review of Economic Studies*, 9:1 (1941).

Recall that a Ricardian production function ignores diminishing returns, so the amount of X produced is given by (for example) Qx = 10 Lx, where 10 is the **productivity coefficient**, and tells us how many units of the product a worker can make in a given unit of time, say an hour.

The **activity requirement** tells us how much labor input is required to make one unit of the good. With the above production function, it will take one-tenth of a hour to make one unit of the good.

This also means that once we know the wage, we will know the cost of production of the good -- if the wage is, say, $ 15 an hour, and the good requires one-tenth of an hour to produce, it will cost $ 1.50 to produce.
It therefore cannot sell for less than $ 1.50, and ignoring other inputs and assuming perfectly competitive conditions, its price will be $ 1.50.

Check your understanding of the above by calculating the price of good Y if Qy = 5 Ly.

The key contribution of the Heckscher-Ohlin model was to consider more than one factor of production. Although Heckscher considered three (land, labor and capital) in his 1919 article, we limit ourselves to two (capital and labor). The production function Heckscher used is what has come to be known as a **Leontief production function** (after Wassily Leontief):

$$Qx = \min (10\ Lx,\ 5\ Kx)$$

Think of a production situation where a worker can prepare 10 pizzas an hour for baking, but the typical pizza oven can only bake 5 pizzas an hour. If you want to produce 100 pizzas, you must hire 10 workers AND have 20 pizza ovens. If you only have 15 pizza ovens, the workers will prepare 100 pizzas, but only 75 of them will be baked.

Note that we can easily calculate the capital**-labor ratio** required by this industry:
The capital labor ratio here will always be 2.0:

$$Kx / Lx = 20 / 10 = 2.0 \text{ for 100 pizzas and}$$
$$Kx / Lx = 40 / 20 = 2.0 \text{ for 200 pizzas and so forth.}$$

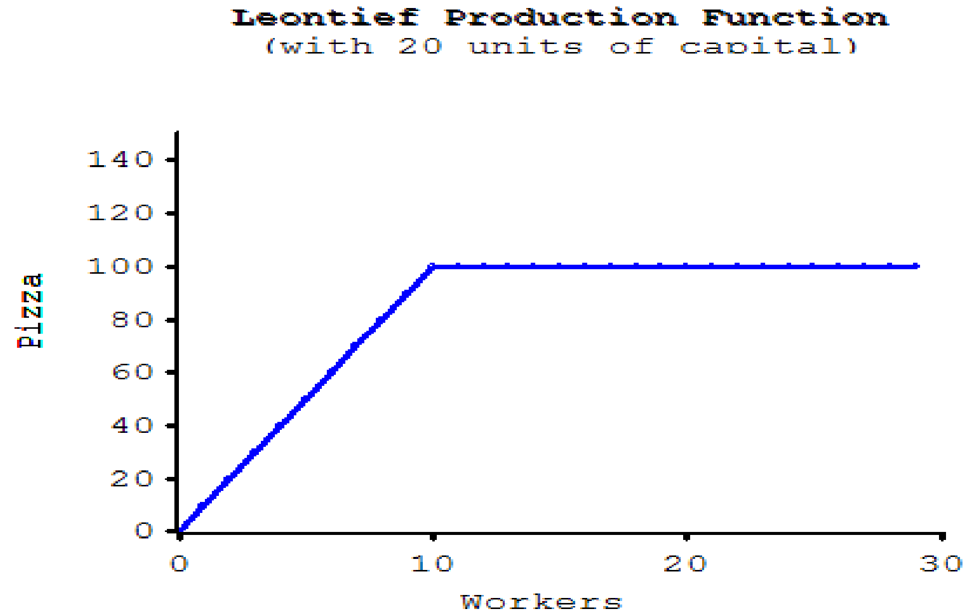
Consider a second good (call it cotton), with Qy = min (5 Ly, 10 Ky)
Ten workers will produce 50 bales of cotton IF they have 5 cotton gins available to them; if they have only 4 cotton gins, they will pick enough cotton for 50 bales, but only 40 will actually get ginned.

The **capital-labor ratio** in the Y industry will be one-half:

$$Ky / Ly = 5 / 10 = 0.5 \text{ for 50 bales of cotton.}$$

We decide on the **factor intensity of an industry** by comparing their capital-labor ratios: in the above example, we say that pizza production is **capital intensive** and cotton production is **labor intensive**.
Note that in practice, we measure the amount of capital by the value of the machinery rather than the number of machines; my example assumes that a pizza oven costs as much as a cotton gin.

This production function will show diminishing returns, although not smoothly diminishing returns. Consider the pizza example and start with 20 pizza ovens. At first, production increases with the number of workers hired: one worker produces 10 pizzas an hour, 2 produce 20 pizzas and hour, and 10 produce 100 pizzas an hour. But adding an 11th worker will not get you any more pizza at all -- the marginal product of the 11th worker is zero. A graph of the Leontief production function would look like this:



There are two activity requirements for each industry:

For the X industry, in order to produce one unit of X we need one-tenth of a unit of labor and one-fifth of a unit of capital. Just as in the Ricardian case, **the activity requirement is the reciprocal of the productivity coefficient**.

Exercise: What are the activity requirements in the Y industry?

Prices will be computed the same way as in the Ricardian case as well.

Notation: w = wage per month
r = return to capital per month

$$P_x = 0.1\,w + 0.2\,r$$
$$P_y = 0.2\,w + 0.1\,r$$

So far, this is much like Ricardo. The key difference is that, given the prices of the products, we can solve for the wage rate and the return to capital. If, for example, we have Px = 80 and Py = 100,

$P_x = 80 = 0.1\,w + 0.2\,r$ and therefore (multiply by 10) $800 = w + 2\,r$
$P_y = 100 = 0.2\,w + 0.1\,r$ and therefore (multiply by 20) $2000 = 4w + 2\,r$

Subtracting the first (Px) equation from the second (Py) equation, we get 1200 = 3 w or **w = $ 400**.

Substitute this into either the Px equation above to find that 800 = 400 + 2 r or **r = $ 200**.

Exercise: what happens if, after trade, we export X so that the price of good X rises to $ 95 ?

[Answer: w = $ 350, r = $ 300: the price of the capital intensive good rose, and the return to capital rose. The relative price of the labor intensive good fell, and wages fell]

A graphical illustration of what is happening is given below. The graph is of what is known as a **factor price frontier**, which illustrates how the price of a good can be divided up among its factors of production.

Recall the basic equations we have been using. Rearranging them may be helpful in plotting the factor price frontier:

$$Px = 80 = 0.1\ w + 0.2\ r \quad \text{or} \quad w = 800 - 2\ r$$
$$Py = 100 = 0.2\ w + 0.1\ r \quad \text{or} \quad w = 500 - r$$

Imagine the country has just been swept by a Marxist revolution and the return to capital will be zero.
The post-revolutionary disorder prevents all income from going into a common pool for redistribution, so the revolutionary government decrees that workers in any industry will receive all income from the industry.
The entire price of both goods will go to the workers, so workers in the X industry will get 80 / 0.1 = $ 800 per month and workers in the Y industry will get w = 100 / 0.2 = $ 500 per month.

[Note that if r = 0, the equations simplify: Px = 80 = .1 w so wage = 80 / 0.1 = 800]

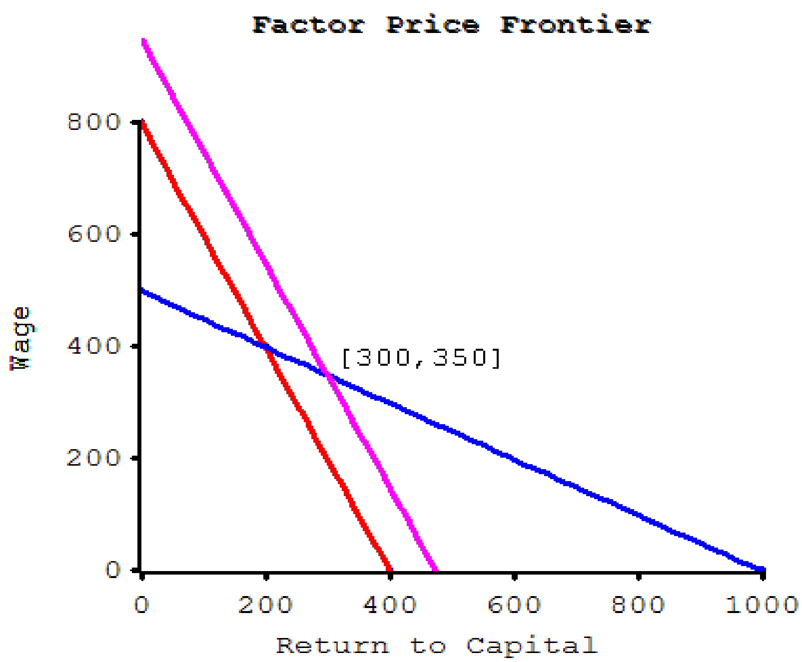
We have the intercepts of the equations on the wage axis of the factor price frontier.

Now imagine that the country is taken over by an extreme right-wing counterrevolution, which reduces the workers to slavery and redirects all income to capitalists. Capitalists in the X industry will get 80 / 0.2 = $ 400 per month per unit of capital and capitalists in the Y industry will get 100 / 0.1 = $ 1000 a month.
We have the intercepts on the return-to-capital axis of the factor price frontier.

The divergences between wages would, in a free economy, lead workers to move to the industry in which wages were higher. Likewise, the divergence between returns to capital would lead capitalists to move into the industry in which returns to capital are higher. The economy will reach equilibrium when Wx = Wy and Rx = Ry.

The red line shows how the price of good X can be divided up between the factors of production;
the blue line shows how the price of good Y can be divided up between the factors of production.
Their intersection at r = 200 and w = 400 shows the equilibrium.

If the price of good X increases to $ 95, the red line would shift out so that the maximum possible wage would be $ 950 and the maximum possible return to capital $ 475. The shift is shown below, with the new line in magenta:



Note that the drop in real wages is even bigger than this nominal drop from $ 400 to $ 350, since the price of good X increased. Even after adjusting for the price increase, the real return to capital rose: the price of good X went up from $ 80 to $ 95 or by 18.75 percent; the return to capital went up from $ 200 to $ 300, an increase of 50 percent. In a more general model, Ronald Jones found that there is a **magnification effect** of a price change on the factors of production: if the price of the capital intensive good increases, the return to capital will increase by a greater percentage than the price change; if the price of the labor intensive good decreases, the wage rate will fall by more than the price of the good.

Note also that the result, generalized to any production function showing diminishing returns by Stolper and Samuelson, is a **long-run equilibrium** result. Defenders of trade agreements often argue that any problems are temporary and will disappear in the long run. But Heckscher, Stolper and Samuelson produced a result that does not necessarily hold in the short run, but **will** hold in the long run. Wages in different industries will not adjust immediately, and as a result there may be temporary unemployment in the industry exposed to competition from imports. The unemployment problem will be temporary, at least in the sense it will not last more than a generation -- the children of those laid off will go into another industry even if their parents cannot.

But even after the unemployment problem goes away, we will be left with permanently lower wages in the above example.

Exercise: Suppose that the country described above had a comparative advantage in the labor intensive good, so that after trade it found the price of good Y rising to $ 115. Assume the price of X remained at $ 80. Repeat the above analysis. Include the appropriate graph, with the shift of the Py line indicated by a dashed line.

[Answers: w = $ 500 and r = $ 150; note that with the price of the labor intensive good rising, wages will rise and the return to capital will fall]