CHAPTER 2: FACTOR MOBILITY AND GOODS TRADE:
DO THEY SUBSTITUTE EACH OTHER?

Introduction

Autarky typically results in different countries having different commodity and factor prices. Think of protectionist pre-World War II Western Europe vis-à-vis the American market; or the former East-European bloc vis-à-vis the industrialized countries. For instance, Table 2.1 highlights the wage gap between Eastern Europe (with hourly wages below 1 US$) and the industrialized countries (with hourly wages typically above 10 US$), just after the collapse of the iron curtain. If barriers to labor mobility were removed or eased up, labor could have been expected to move from low-wage countries (e.g., Eastern Europe) to high-wage countries (e.g., Western Europe). Similarly, capital would have been expected to move in the opposite direction.

A crucial question is whether trade in goods can narrow the wage and capital rental price gaps, thereby reducing the incentives for factor mobility. Put differently: Is trade in goods a substitute for factor mobility? In the preceding chapter, the existence of a nontraded good prevented trade in other goods from equalizing factor prices across countries. Hence, trade in goods could not serve as a perfect substitute for factor mobility. The rationale for this result is quite natural: Since trade is not all-encompassing, it could not perfectly substitute for the mobility of the factors producing the nontraded goods as well. Thus, in
order to sharpen the analysis of the role of trade in goods as a substitute for factor mobility, we assume in this chapter that all goods are traded.

Our starting point is a standard international trade model with two countries, two goods, homothetic and identical preferences and constant returns-to-scale everywhere.

We first make an additional set of assumptions that together nullify all forces that can generate either commodity trade or factor mobility. By relaxing these assumptions, one at a time, we allow room for commodity trade and incentives for factor mobility. We can then also study their interaction and in particular whether trade in goods can substitute for factor mobility. Accordingly, we initially assume that:

(i) The two countries have the same relative endowments of capital and labor.

(ii) The two countries have the same technologies.

(iii) The number of goods and factors is the same. Specifically, we assume that there are two goods (X and Y) and two factors of production (labor (L) and (K)).

Under these assumptions, there will be no commodity trade between the two countries and no cross-country factor price differentials that can lead to international factor mobility.

Substitution

We relax assumption (i) and assume that the two countries differ only in their relative factor endowments. Suppose initially that labor and capital are internationally immobile. As we already mentioned, there are two goods - X and Y, two factors - labor (L) and capital (K),
and two countries - home \((H)\) and foreign \((F)\). This, of course, is the familiar Heckscher-
Ohlin-Samuelson model of international trade. Suppose, for concreteness, that good \(X\) is
more labor-intensive than good \(Y\) (in both countries, since they have identical technologies).
By this we mean that when both industries are faced with the same factor prices, industry
\(X\) will employ a higher labor/capital ratio than industry \(Y\). Formally:

\[
\frac{a_{LX}}{a_{KX}} > \frac{a_{LY}}{a_{KY}}
\]  

(2.1)

for all factor price ratios, where \(a_{ij}\) is the unit input requirements of factor \(i\) in the production
of good \(j\), and where \(i = L, K\) and \(j = X, Y\). By the factor price ratio we mean the ratio of
wage \((w)\) to the rental price of capital \((r)\).

We assume that country \(H\) is more abundant in labor (relative to capital) than
country \(F\), that is:

\[
\frac{\bar{L}^H}{\bar{K}^H} > \frac{\bar{L}^F}{\bar{K}^F},
\]  

(2.2)

where \(\bar{L}^i\) and \(\bar{K}^i\) are the endowments of labor and capital, respectively, in country \(i\), and
where \(i = H, F\).

Suppose that good \(Y\) is the numeraire with its price set to unity in both countries,
and denote by \(p^i\), \(r^i\) and \(\omega^i\) the price of good \(X\), the rental price of capital and the wage
rate in country \(i\), respectively, where \(i = H, F\).
First, observe the quite intuitive result due to Stolper and Samuelson (1941): An increase in the wage-rental ratio \((w/r)\) raises the unit cost of the labor-intensive good \((X)\) relative to the unit cost of the capital-intensive good \((Y)\) and therefore must raise the relative price \((p)\) of the labor-intensive good.

To demonstrate graphically this result refer to Figure 2.1. For a fixed \(p\), the line \(XX\) represents the zero-profit locus for industry \(X\), given by \(p=rK_X + wL_X\). The absolute value of the slope of this line is \(a_{LX}/a_{KX}\). The line \(YY\) is the analogous locus for industry \(Y\), given by \(1 = rK_Y + wL_Y\). The absolute value of its slope is \(a_{LY}/a_{KY}\). The point of intersection between these two loci (point \(E\)) yields the equilibrium factor prices for the given price ratio \(p\). Now, if \(p\) rises, the zero-profit locus for industry \(X\) shifts outward from \(XX\) to \(X'X'\). The new factor-price equilibrium is at point \(E'\), in which the wage rate \((w)\) is higher and the rental price of capital \((r)\) is lower. Conversely, an increase in \(w/r\) raises \(p\).

Second, the quite intuitive result due to Rybczynski (1955) (the dual to the Stolper-Samuelson result) asserts that at a given factor price ratio, a higher labor-capital endowment ratio results in a higher \(X\) to \(Y\) output ratio (where good \(X\) is more labor-intensive than good \(Y\)). To see this refer to Fig.2.2. The line \(LL\) describes the locus of output pairs \((X,Y)\) that yield full employment of labor, given by \(\tilde{L} = Xa_{LX} + Ya_{LY}\). The absolute value of the slope of this line is \(a_{LX}/a_{LY}\). Similarly, the line \(KK\) represents full employment of capital, given by \(\tilde{K} = Xa_{KX} + Ya_{KY}\). The absolute value of its slope is \(a_{KX}/a_{KY}\). The equilibrium pair of outputs is at point \(E\). Now, suppose that \(\tilde{L}\) rises. This shifts outward the labor full-employment line from \(LL\) to \(L'L'\). The new pair of equilibrium outputs is point \(E'\) with a higher output of \(X\) and a lower output of \(Y\).

Combining the above two theorems, we can draw in Figure 2.3 the relative supply
curves $RS^F$ and $RS^H$ of the two countries. The relative supply of country $i = H, F$ is defined as $X^i/Y^i$. The Stolper-Samuelson theorem suggests that if the price of $X$ (namely, $p$) is the same in the two countries, so is the wage-rental ratio ($w/r$). Hence, the Rybczynski theorem suggests that the relative supply curves are then affected only by the relative factor endowments. Then, the relative supply curve $RS^H$ that describes the output ratio of the labor-intensive good ($X$) to the capital-intensive good ($Y$) in the labor-abundant country ($H$) is everywhere (that is, for each $p$) in a position to the right of the relative supply curve $RS^F$ in the capital-abundant country ($H$). Now, the assumption of the identical homothetic preferences implies that the two countries have the same relative demand curve ($RD$ in Figure 2.3), which is also the relative world demand curve $((X^H + X^F)/(Y^H + Y^F))$.

In autarky, equilibrium will be at point $A$ for country $F$ with a relative price ratio of $p^F$, and at point $B$ for country $H$ with a relative price ratio of $p^H$. Thus, the Stolper-Samuelson theorem implies that:

$$\frac{\bar{w}^H}{\bar{r}^H} < \frac{\bar{w}^F}{\bar{r}^F},$$

(2.3)

where $\bar{w}^i$ and $\bar{r}^i$ are the autarky prices of labor and capital, respectively, in country $i$ and where $i = H, F$.

Thus, when trade is allowed, good $X$ will be exported from country $H$ to country $F$ until commodity prices are equalized across countries. Of course, at the same time good $Y$ will be exported from country $F$ to country $H$. With free trade the equilibrium price ratio is determined at the intersection of the world relative supply curve with the world relative
demand curve. As was already pointed out, the curve $RD$ is the relative demand curve of each country and also that of the world. The world relative supply curve is a weighted average of the relative supply curves of the two countries and must therefore lie somewhere between them. The world supply curve is the curve $RS$ in Figure 2.3.

The free trade relative price ratio is thus $\tilde{p}$, which lies between the two autarkic relative price ratios: $\bar{p}^H < \tilde{p} < \bar{p}^F$. By the Stolper-Samuelson theorem, the equalization of good prices (at $\tilde{p}$) implies also factor price equalization. In this case, factor mobility is redundant: Trade in goods is a perfect substitute for factor mobility. One can say that although factors of production do not directly move from one country to another, they nevertheless move indirectly between them, because they are embodied in the goods that are traded.

To see this point, one can follow Vanek (1968) in calculating the factor content of the trade in goods. For this purpose, let us distinguish explicitly in our notation between output and consumption. Denote by $Q^j_i$ and $C^j_i$, respectively, the output and the consumption of good $i = X, Y$ in country $j = H, F$. Denote also by $M^H_L$ and $M^H_K$, respectively, the net labor and capital imported (indirectly, via trade in goods) by country $H$ from country $F$. One can show (see Appendix 2A) that:

\begin{equation}
M^H_L = s^H (\tilde{L}^H + \tilde{L}^F) - \bar{L}^H
\end{equation}

and
where $s^H$ is the share of country $H$ in world-wide income.

Equations (2.4) and (2.5) give a simple measure of the factor content of trade which depends only on initial factor endowments and the cross-country distribution of world income. Since country $H$ exports good $X$ which is labor-intensive and imports good $Y$ which is capital-intensive, the factor content of its net imports follows a similar pattern: The labor component is negative while the capital component is positive. That is, country $H$ implicitly exports labor and implicitly imports capital via its trade in goods.

Thus, as Mundell (1957) first pointed out, trade in goods is a perfect substitute for an export of $-M^H_L$ units of labor from country $H$ to country $F$ in exchange for an import of $M^H_L$ units of capital by country $H$ from country $F$.

Non-Substitution

The result of the preceding subsection is rather special, even in our setup where all goods are traded. In fact, if we relax either assumption (ii) or assumption (iii), trade in goods will no longer serve as a perfect substitute for factor mobility. When the number of goods exceeds the number of factors of production, trade in goods may still narrow down the autarkic factor price gap but not eliminate it altogether, leaving sufficient room for factor mobility. Furthermore, when technologies differ across countries, trade in goods may even exacerbate the factor price gap, thereby generating more (not less) pressure for factor mobility.
More Goods than Factors.

Suppose now that we relax assumption (iii) about the equal number of goods and factors of production. Specifically, suppose that we have a third traded good \( Z \). This case remains in the realm of the Heckscher-Ohlin-Samuelson model where trade in goods (which serve to equalize goods prices) narrows down factor price gaps, but does not eliminate them altogether. Suppose with no loss of generality that good \( Z \) is the least labor-intensive of all three goods, that is:

\[
\frac{a_{LX}}{a_{KX}} > \frac{a_{LY}}{a_{KY}} > \frac{a_{LZ}}{a_{KZ}}.
\]  

(2.1’)

First, observe that under free trade each country will produce only two goods. This can be seen in Figure 2.4 which reproduces Figure 2.1. For given goods prices (by international trade) the zero profit loci for goods \( X, Y, Z \) are given by the lines \( XX, YY, ZZ \), respectively. Note again that the slope of each line is given by the corresponding labor-capital intensity and hence the line \( XX \) is steeper than the line \( YY \) which, in turn, is steeper than the line \( ZZ \). Unless, by sheer coincidence, all three lines intersect each other at the same point, only two goods can be produced. It also follows from this figure that the only possible combination of pairs of goods that are produced are either \( (X, Y) \) or \( (Y, Z) \). The combination \( (X, Z) \) which sets the factor prices at point \( E_{XZ} \) is impossible: At this set of factor prices, industry \( Y \) makes a strictly positive profit. Thus, the only feasible pairs of factor prices are \( (r_1, w_1) \) at point \( E_{XY} \) or \( (r_2, w_2) \) at point \( E_{YZ} \). At the first point \( (E_{XY}) \), \( Z \) will not be produced because its price falls short of its unit cost. Similarly, at the second
point \((EYZ)\), \(X\) will not be produced for the same reason.

Assuming that preferences are such that the demand for each good is always positive, it must be the case that all three goods are produced somewhere in the world. Which one of the two countries produce the pair \((X,Y)\) and which one produces the other pair \((Y,Z)\) depends on the relative endowments of capital and labor in the two countries.

One can observe from Figure 2.5 (which reproduces Figure 2.2.) that the factor price ratio \((w_1/r_1)\) is only compatible with a certain range of the capital-labor endowment ratio. Note that at that factor price ratio only \(X\) and \(Y\) are produced. Let the line \(LL\) represent the full employment of labor condition for the given factor price pair \((w_1/r_1)\). Now, if the endowment of capital is \(K^*_s\), then the full employment of capital condition is depicted by the line \(K_sK_s\), in which only \(X\) is produced. Similarly, if the capital endowment is \(K^*\), then only \(Y\) is produced. Thus, the factor price ratio \(w_1/r_1\) is compatible with a range \((K_s/L, K^*/L)\) of capital-labor endowment ratios. Similarly, the factor price ratio \(w_2/r_2\) is compatible with another range of capital-labor endowment ratios. The latter range must be to the right of the former range, as depicted in Figure 2.6. This follows from two observations: (i) at the higher \(w/r\) ratio, which characterizes the production of the pair \((Y,Z)\), only the capital-labor intensity rises in each of these two industries. (ii) Industry \(Z\) is more capital intensive than industry \(X\) and hence the pair \((Y,Z)\) requires more capital relative to labor than the pair \((X,Y)\), even for the same \(w/r\) ratio.

At the free-trade equilibrium, we see from Figure 2.6 that the factor price ratio is \((w_1/r_1)\) in country \(H\) and \((w_2/r_2)\) in country \(F\). The convergence of goods prices may narrow down the factor price gaps, but does not fully eliminate them.

**Complementarity between Trade in Goods and Factor Mobility.**
If we relax the assumption of identical technologies, trade in goods may even widen factor price gaps. Hence, trade in goods may even increase the pressure for factor mobility. Furthermore, if such mobility is allowed the volume of trade in goods may even increase. In order to focus attention on the differences in technologies, let us reinstate assumption (i) about identical relative factor endowments across countries and assumption (iii) about equal number of goods and factors of production. In this subsection we follow the analysis of Markusen (1983).

For simplicity and concreteness, suppose that country $H$ has a more productive technology for producing good $X$ than country $F$, in a Hicks-neutral sense, that is:

\[ G^H_X(K_X, L_X) = aG^F_X(K_X, L_X), \quad a > 1, \]  

and that the technologies for producing $Y$ are identical, that is:

\[ G^H_Y(K_Y, L_Y) = G^F_Y(K_Y, L_Y), \]  

where $G^i_j$ is the production function of good $j$ in country $i$, and where $j = X, Y$ and $i = H, F$.

In this case we show that trade in goods does not suffice to equalize factor prices. Indeed, under free trade the wage in the home country, which is technologically superior in the labor-intensive good, is higher than in the foreign country; and the opposite holds true with respect to the rental price of capital:
\[ w^H > w^F \text{ and } r^H < r^F. \]  

(2.8)

To see this, we plot the production possibility frontiers for the two countries in Figure 2.7. Note that the frontier for \( H \) is achieved by pulling the frontier for \( F \) to the right by the multiplicative factor \( \alpha \). Thus, the slope at \( B \), for instance, is \( 1/\alpha \) times the slope at \( F_1 \). It is important to notice that \( F_1 \) and \( B \) represent the same point (say, point \( F_2 \)) on an identical contract curve in an identical Edgeworth Box of the two countries (Figure 2.8). (The two countries have the same Edgeworth Box because they have the same factor endowments; and they have the same contract curve because their technologies differ only by a Hicks-neutral multiplicative coefficient). Thus, if both countries produce at the same point in the Edgeworth Box (say, point \( F_2 \) in Figure 2.8, corresponding to \( F_1 \) and \( B \) in Figure 2.7), then they cannot have the same commodity price ratio, which is required under free trade (recall that the commodity price ratio is equal to the slope of the production possibility frontier). Hence, with equal commodity prices which is required under free trade, country \( H \) must produce less \( Y \) (and more \( X \)) than country \( F \). Thus, suppose that country \( H \) is at \( H_1 \) and \( H_2 \) in Figures 2.7 and 2.8, respectively, while country \( F \) is at \( F_1 \) and \( F_2 \) in Figures 2.7 and 2.8, respectively.

Since the two countries have the same (homothetic) demand patterns, while country \( H \) produces a higher \( X \) to \( Y \) ratio than country \( F \), it follows that country \( H \) exports good \( X \) (in which she enjoys a superior technology) and imports good \( Y \). Given the convex shape of the contract curve, it follows that the factor price ratio \( w/r \) is higher in country \( H \) than
in country $F$. Since both countries produce good $Y$ with the same technology and under the same price (namely, unity), it follows that the inequalities in (2.8) hold. Thus, commodity trade does not equalize factor prices.\footnote{Furthermore, depending on demand patterns and the degree of factor substitution in production, it may well be the case that free commodity trade widens, rather than narrows, the factor price differentials.}

Now, suppose that factor mobility (labor and capital) is allowed alongside trade in commodities. Labor will move from country $F$ to country $H$, and capital will move in the opposite direction. By the Rybczyinski theorem, at the initial commodity trade price, there will be an excess supply of good $X$ in country $H$, and its imports of $Y$ will further rise. Indeed, country $H$ with its superior technology will specialize in the production of good $X$. Thus, factor mobility reinforces trade in commodities. In this setup of international technological differences in certain industries, factor mobility and commodity trade complement each other.

Alternatively, complementarity between commodity trade and factor mobility can also be generated by external economies-of-scale. Being external to the individual firm, economies of scale still preserve perfect competition. Suppose for concreteness that there are external scale economies in the production of good $X$. If countries differ in absolute size, but have identical relative factor endowments, Markusen (1983) shows that the larger country will export good $X$. As this good is more labor-intensive, the relative price of labor ($w/r$) in the free commodity trade equilibrium is higher in country $H$. Allowing labor to move from country $F$ to country $H$ will further increase the excess supply of good $X$ in country $H$, via both the Rybczyinski effect and the external-scale-economies effect, thereby generating an even higher volume of trade.
In a study on East-West migration, that came out just after the breakdown of communism, Layard et al. (1992) emphasize the role of trade in goods as an alternative to labor migration: “Given the difficulties posed by the prospect of very large-scale migration from East to West, and the risk that such large-scale migration could actually leave worse-off the remaining population in the East, we need to ask what alternatives are available. Ideally, policy should try to bring good jobs to the East rather than Eastern workers to the West. International trade ...can act as a substitute for migration. A free trade pact that ensures Eastern European countries access to the Western European market is the best single migration policy that could be put in place. In the amazing post-war reconstruction of Western Europe, the openness of the U.S. market was a crucial factor. Western Europe now has the opportunity of providing a similar service to the East.”

The gains from trade in goods notwithstanding, we have pointed out that such trade can be a complement to labor (and capital) mobility. It does not necessarily equalize wages and may even widen the wage gap, thereby generating more incentives for labor mobility in the presence of technological advantage of one country over the other. Note also that the productivity advantage could merely reflect some superior infrastructure (roads, telecommunication systems, ports, energy, etc.) which is certainly the case in the East-West context. Thus, important policy elements should be investment in infrastructure (possibly funded by foreign aid) and direct foreign investment, which tends to also diffuse technology and raise productivity. Once productivity gaps are narrowed down, trade in goods can further alleviate the pressure for factor mobility.

In view of the empirical falsification of the factor price equalization theorems³, Davis (1992) introduced Hicks-neutral differences in technology across countries, uniform over all
industries. He tested the hypothesis concerning convergence of relative industry wages across countries. The evidence found “strongly rejected the hypothesis of increasing uniformity across countries in the relative industry wage structure”, despite the ongoing trend of trade liberalization.
APPENDIX 2A: FACTOR CONTENT OF TRADE

In this appendix we derive equations (2.4) and (2.5) which express the factor content of trade. Denoting by $Q^i_j$ and $C^i_j$, respectively, the output and the consumption of good $i = X, Y$ in country $j = H, F$, we can calculate the net import vector of country $H$ by:

$$M^H \equiv \begin{pmatrix} M^H_X \\ M^H_Y \end{pmatrix} = \begin{pmatrix} C^H_X - Q^H_X \\ C^H_Y - Q^H_Y \end{pmatrix} \equiv C^H - Q^H.$$

Full employment in country $i = H, F$ requires that:

$$AQ^i = \begin{bmatrix} \bar{L}^i \\ \bar{K}^i \end{bmatrix} \equiv \tilde{V}^i,$$

where

$$A = \begin{bmatrix} a_{LX} & a_{LY} \\ a_{KY} & a_{KY} \end{bmatrix}$$

is the unit-input-requirement matrix. (Note that the matrix $A$ is the same for the two countries because trade has equalized factor prices, the arguments of the $a_{ij}$ coefficients).

From the assumption of identical homothetic preferences it follows that:
\[
C^H = s^H (Q^H + Q^F) = s^H (A^{-1}\tilde{\nu}^H + A^{-1}\tilde{\nu}^F) \equiv s^H A^{-1}\tilde{\nu},
\]

where \(s^H\) is the share of country \(H\) in worldwide income and \(\tilde{\nu} \equiv \tilde{\nu}^H + \tilde{\nu}^F\) is the world factor endowment vector.

Hence,

\[
M^H = C^H - Q^H = s^H A^{-1}\tilde{\nu} - A^{-1}\tilde{\nu}^H.
\]

Therefore, the factor content of the net import flows which is \(AM^H\) can be expressed as:

\[
AM^H = s^H \tilde{\nu} - \tilde{\nu}^H = s^H \begin{bmatrix}
\tilde{L}^H + \tilde{L}^F \\
\tilde{K}^H + \tilde{K}^F
\end{bmatrix} - \begin{bmatrix}
\tilde{L}^H \\
\tilde{K}^H
\end{bmatrix},
\]

which is equations (2.4) and (2.5) in matrix form.
Table 2.1: Wage Gaps and Population (1990)

<table>
<thead>
<tr>
<th>Eastern Europe</th>
<th>Wage per hour (US$)</th>
<th>Population (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poland</td>
<td>0.7</td>
<td>38</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.7</td>
<td>11</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>0.8</td>
<td>16</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.2</td>
<td>9</td>
</tr>
<tr>
<td>Rumania</td>
<td>0.6</td>
<td>23</td>
</tr>
<tr>
<td>Yugoslavia</td>
<td>1.1</td>
<td>24</td>
</tr>
<tr>
<td>USSR (European)</td>
<td>0.9</td>
<td>222</td>
</tr>
<tr>
<td>Eastern Europe (total)</td>
<td>0.9</td>
<td>343</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industrialized countries</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany (West)</td>
<td>11</td>
<td>61</td>
</tr>
<tr>
<td>France</td>
<td>8</td>
<td>56</td>
</tr>
<tr>
<td>Italy</td>
<td>11</td>
<td>57</td>
</tr>
<tr>
<td>UK</td>
<td>8</td>
<td>57</td>
</tr>
<tr>
<td>EC (total)</td>
<td>9</td>
<td>340</td>
</tr>
<tr>
<td>EFTA (total)</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Western Europe (total)</td>
<td>10</td>
<td>365</td>
</tr>
<tr>
<td>USA</td>
<td>13</td>
<td>250</td>
</tr>
<tr>
<td>Canada</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Australia</td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

Source: Layard et al. (1992).