Heckscher-Ohlin Trade Model: Chapter 8

Problems with Ricardian model (unrealistic assumptions and outcomes):

a. 1 factor of production and everybody gains from trade;
b. Perfect competition and no distortions;
c. Constant marginal costs of production;
d. Complete specialization.

The factor-endowments or Heckscher-Ohlin (HO) model makes assumptions that are richer than these, though still restrictive. The main insight here is that comparative advantage depends on *factor proportions* (relative factor endowments of countries and relative factor intensities of goods).

We'll go through the model with basic diagrams. The mathematical approach in the text is interesting but not necessary to master.

Assumptions of HO model:

1. 2 countries, 2 goods, 2 factors.
2. Identical and homogeneous preferences for all individuals, so same preferences in both countries.
3. Perfect competition in all markets and no distortions.
4. Identical CRS production functions in both countries that differ in factor intensities.

$X = F(L_x, K_x)\ and\ Y = G(L_y, K_y)$ exist in both h and f.
$k_y > k_x\ for\ all\ \frac{w}{r} = \omega$ in both h and f (if both X and Y are produced).

Note we assume here that Y is capital-intensive and X is labor-intensive.

5. Endowments are in fixed supply and homogeneous. They are mobile between X and Y but not between h and f.

$$\bar{L}^h = L_x^h + L_y^h;\ \bar{K}^h = K_x^h + K_y^h \ \textit{and similarly for } f.$$

$$k^f = \frac{\bar{K}^f}{\bar{L}^f} > \frac{\bar{K}^h}{\bar{L}^h} = k^h$$

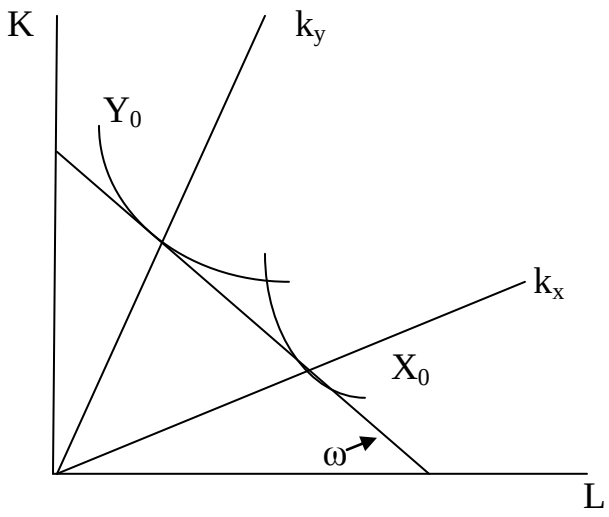
This last equation assumes that f is *capital-abundant* (labor-scarce) and h is *labor-abundant* (capital-scarce).

A preview of results we will prove:

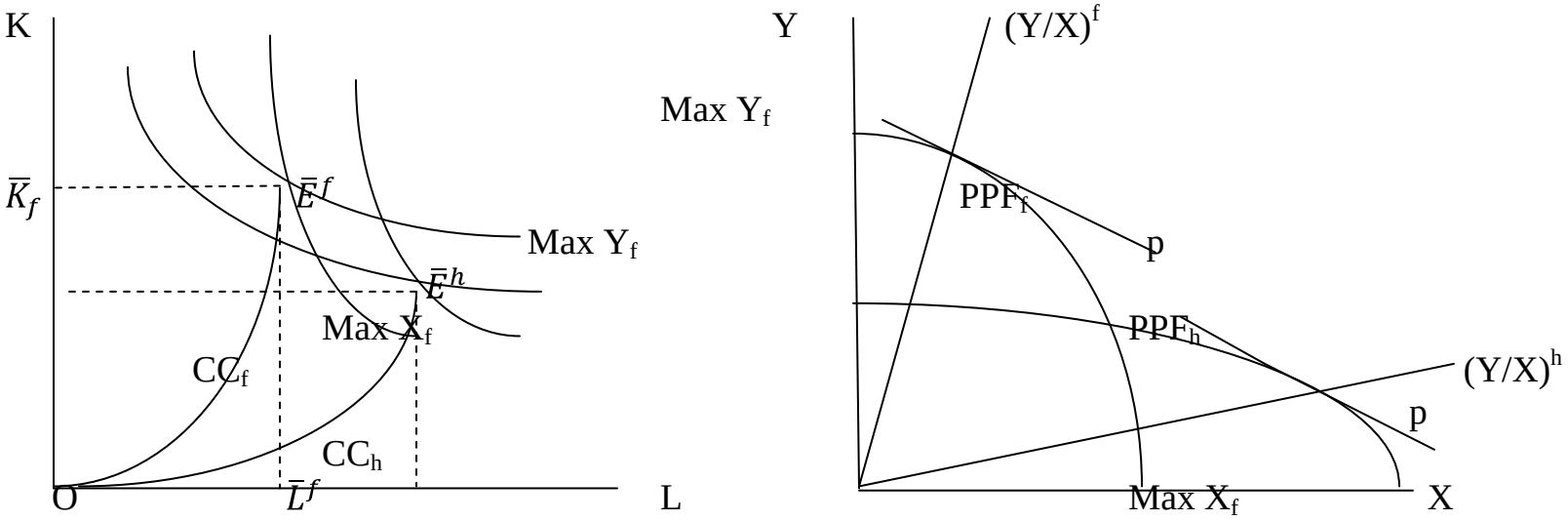
1. HO Theorem: each country exports the good that intensively uses its abundant factor.
2. Factor-Price Equalization Theorem: free trade in goods equalizes real factor prices and incomes in both countries.
3. Stolper-Samuelson Theorem: Free trade in goods reduces (raises) the real income of the scarce (abundant) factor. (More generally: a rise in the price of one good raises the real income of the factor intensively used in that good and reduces the real income of the other factor.)
4. Rybczynski Theorem: Growth in factor endowments, holding all prices fixed, shifts the output mix toward the more rapidly growing factor.

These are the fundamental insights of HO theory, though only 1 and 2 are really "trade" theorems; the others exist as relationships inside a country.

Recall our basic notion of factor intensities and cost-minimization for production equilibrium. We can relate this to endowments to figure out how intensities and endowments affect PPFs and CA.



With CRS we can blow these isoquants up or down with no effects on slopes or factor proportions. Now consider a situation with foreign having K, L endowments at point $\bar{E}_f$ below:



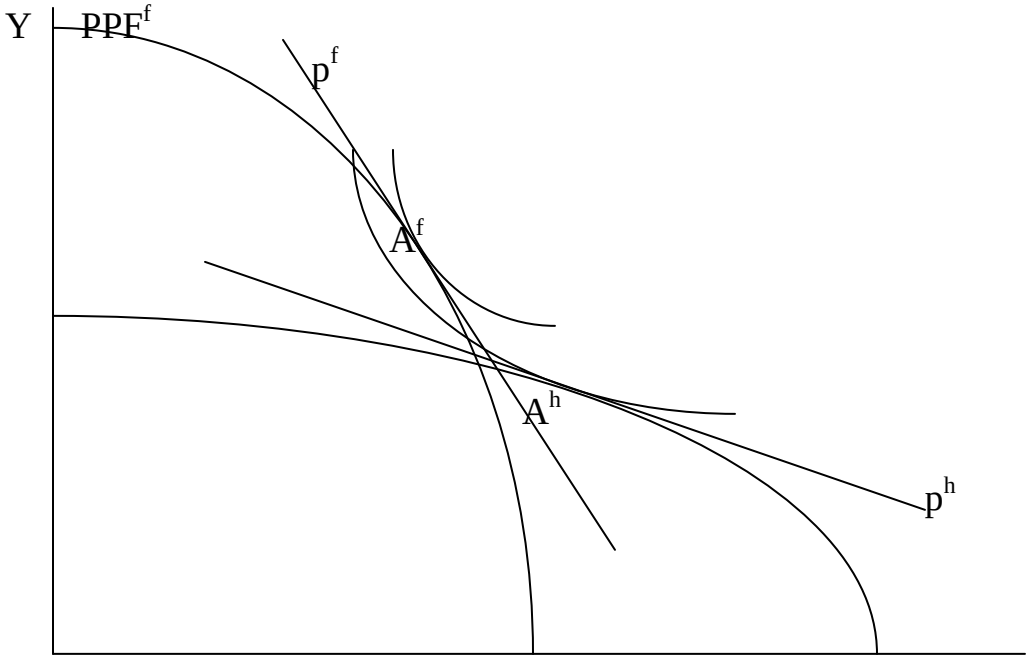
The box between origin O and this endowment point gives the Edgeworth production box for f and factor intensities determine the shape of the contract curve (CC) between labor-intensive X and capital-intensive Y. The isoquants labeled "max" show the maximum Y in f (if f allocates all its L and K to Y) and maximum X (if all allocated to X). The CC is mapped into the PPF for f in the right diagram above.

If $\bar{E}^h$ now indicates the endowment point for home we see h has more labor and less capital. Immediately we see that the max X is higher in h than in f and the max Y is lower in h than in f. Also the CC for the home Edgeworth box is "flatter" due to this endowment difference. See the PPF for h on the right diagram.

The effect of different relative endowments is to *bias* the PPF toward the good intensively using the abundant factor. (Rybczynski theorem will offer a formal proof.)

Note this means that for any price ratio p, f produces a higher Y/X ratio than h does.

Although it's a pain let's look at a graphical proof of HO theorem and what it all means. Figure 8.2 shows this in a better way but it's worth some practice here.



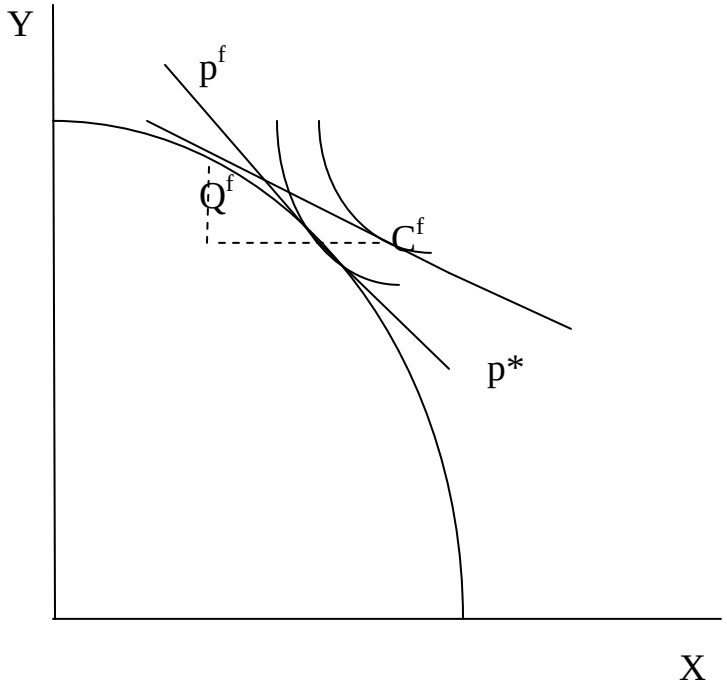
In autarky we see that:

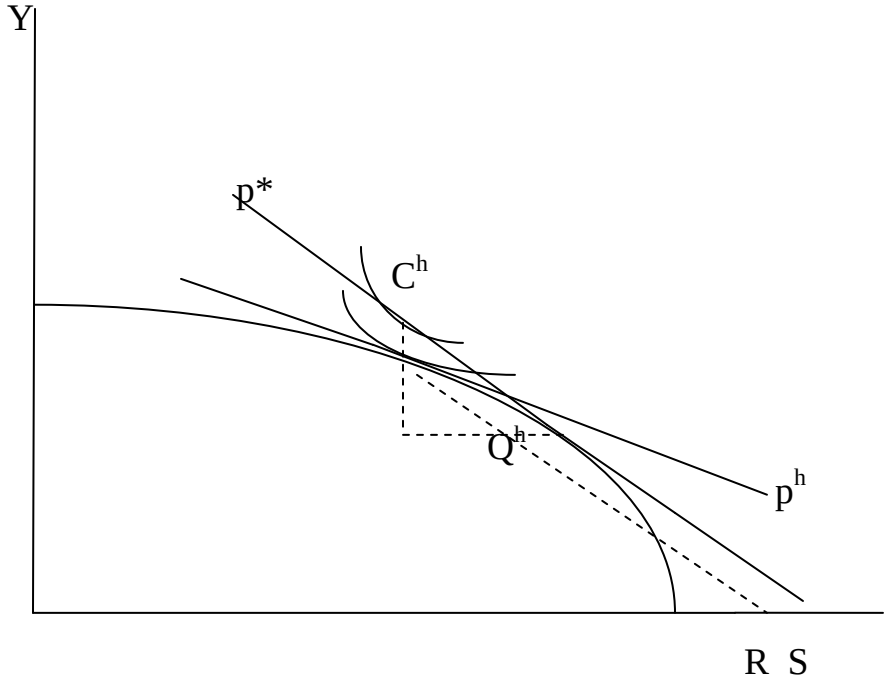
1. $(Y/X)^f > (Y/X)^h$. The combination of biased PPFs and identical homogeneous tastes ensures this.
2. $p^f > p^h$. Foreign has CA in good Y and home in good X due to different endowments and intensities.
3. $(w/r)^f > (w/f)^h$. This follows directly from point 2 and our earlier analysis of the 2-sector CRS production functions in chapter 2. Meaning: labor has a high wage where it is scarce (capital-abundant f) and a low

wage where it is abundant (capital-scarce h). This result rests on the assumption of identical technologies in h and f.

4. $k_y^f > k_y^h$ and $k_x^f > k_x^h$. Both industries are more capital-intensive in autarky in f than in h. This follows again from point 3 and the identical technologies. But it makes sense; in autarky the capital-abundant country would choose more capital-intensive techniques and similarly for labor-abundant country.
5. Immediately follows that $MPL_y^f > MPL_y^h$ and $MPL_x^f > MPL_x^h$. In autarky the MP's of labor are higher in both goods in the capital-abundant country. It follows that the real wages of labor are higher in f than in h since MPL's are equal to real wages. Similarly, real returns to capital are higher in labor-abundant h.

Now let's look at free trade with 2 PPFs (you can draw on one diagram but it's a pain):





In free trade we get:

1. $p^f > p^* > p^h$
2. Incomplete specialization in production.
3. The Y/X ratios in consumption in free trade are the same in f and h (if we've drawn these right, which we haven't quite been able to manage).
4. Capital-abundant f exports Y and imports X while labor-abundant h exports X and imports Y. This is the HO theorem. Note that trade is balanced, etc.
5. Note that p falls in f and p rises in h, which is why output of Y rises in f and output of X rises in h. But this also means:
    a. p goes down in f $\Leftrightarrow (w/r)^f = \omega^f$ falls also. Similarly, p goes up in h $\Leftrightarrow \omega^h$ rises. This happens along the PPF.
    b. More than this is true. Because technologies are identical in the 2 countries and both goods are produced we know from chapter 2 that if both countries face the same p* it must be that both factor prices are the same at ω*. That is, free trade => equal p* $\Leftrightarrow$ equal ω*. We get "relative factor price equalization" (RFPE).
6. But more than this: if ω* is common in h and f we get equalized marginal products since in these kinds of production functions (CRS, 2 factors) all that matters for capital-labor ratios is factor prices:

    $k_x^f = k_x^h;\ k_y^f = k_y^h$. But that implies

$MPK_x^f = MPK_x^h;\ MPK_y^f = MPK_y^y;\ MPL_x^f = MPL_x^h;\ MPL_y^f = MPL_y^h$ in free trade.

But since both countries produce both goods this means that real labor wages are the same in both countries and real returns to capital are the same in both countries. That is we also get "absolute factor price equalization" (AFPE).

Significance:

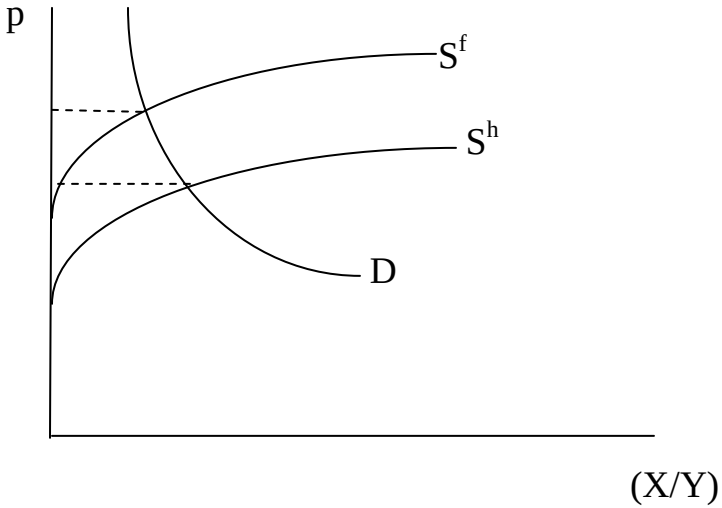
a. Labor and capital are equally well off in both countries with free trade. No incentives to migrate.
b. Labor loses real income in f (labor-scarce) but gains real income in h (labor-abundant). Capital loses real income in h (capital-scarce) but gains real income in f (capital-abundant). Moving from autarky to free trade

redistributes income by making abundant factor better off and scarce factors worse off in each country. This is the Stolper-Samuelson theorem.

c. What this really says is that *trade in goods is a complete substitute for trade in factors*. Why was the US so anxious to negotiate a FTA with Mexico in the 1990s?

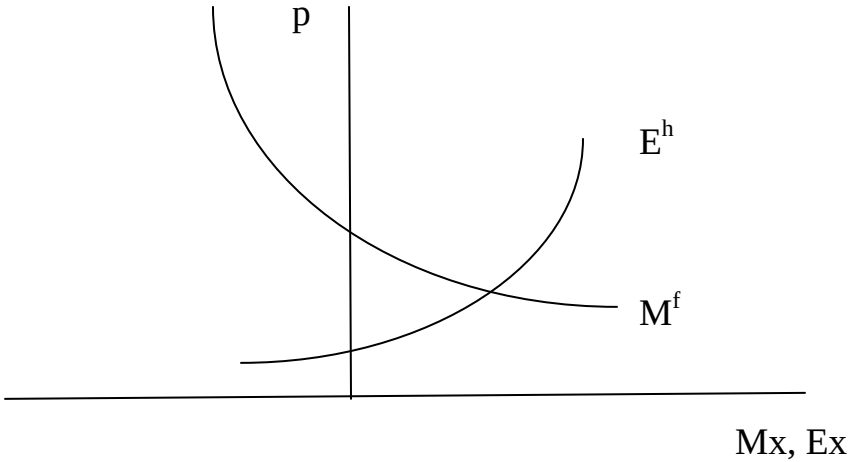
7. Both countries gain from trade, which you can see from higher indifference curves. For h the overall GFT is the movement from autarky to C^h. Note also the gain in real income is distance RS measured in X units. You should try to draw the gain from exchange and the gain from specialization.

There are easier ways to show such outcomes. For example, along the biased PPFs we know that f produces a higher ratio of (Y/X) than h at any relative price. That means it produces a lower ratio of (X/Y) than h. So we can represent the 2 countries' relative domestic supply curves as:



It immediately follows that the relative price of X is lower in h than in f, which determines CA (HO theorem).

And it's easier to show trade equilibrium with excess-demand curves:

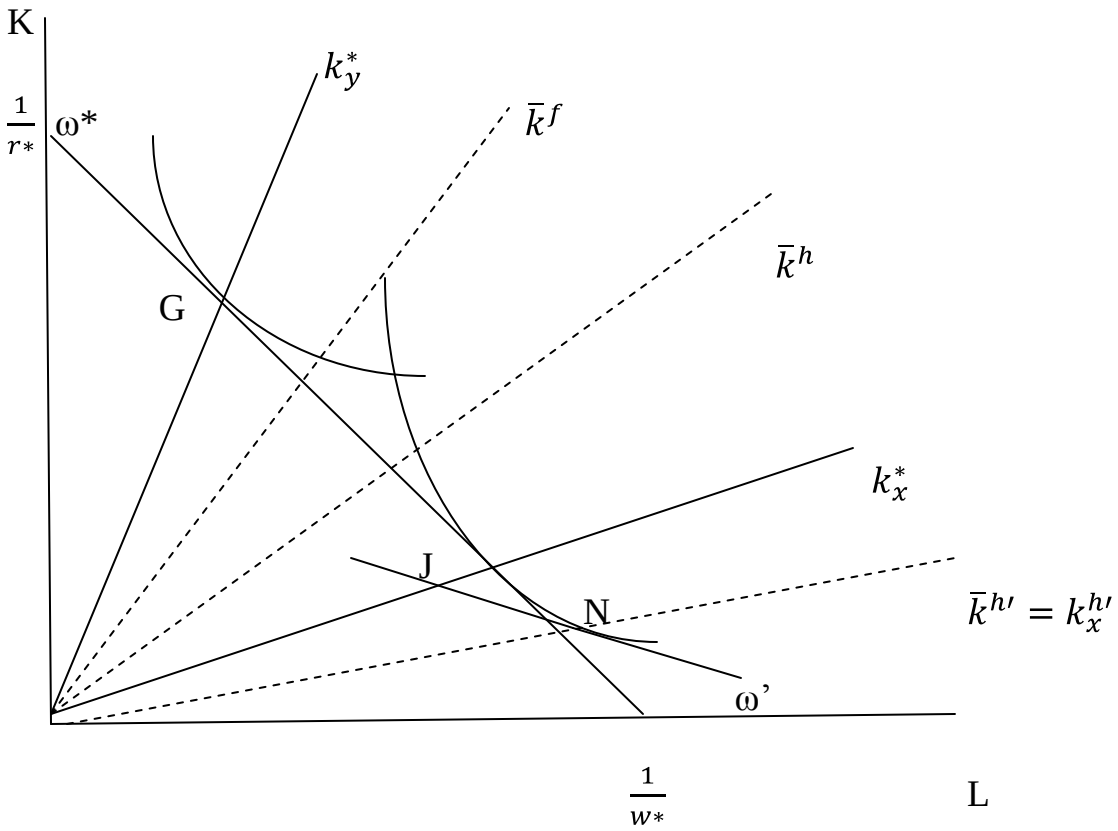


On this diagram show exports and imports of X and Y.
Note that both gain from trade since p* lies between autarky prices.
But now we know there is a redistribution of income from scarce to abundant factors as a result of trade.

We also need a better graphical proof of FPE. With CRS we can consider any isoquants and isocosts to depict equilibrium. Let's use a unit-isocost line ($1) along with a unit-value isoquant. The latter is defined as combinations of K and L use such that for both X and Y the amount of output is worth $1 at given goods prices. That is:
Find levels of X and Y and change K and L such that $p_x X = \$1;\ p_y Y = \$1$.

(What happens to uv isoquant for X if price of X rises? Falls?)

We can show RFPE and AFPE as follows:



The uv isoquants are the same in both countries due to identical technologies. So if both h and f produce both goods their isoquants must be tangent to the unit-isocost line at G (for Y) and J (for X). Here we have RFPE since w*/r* is the same in both nations.

This determines the equalized capital-labor ratios in the 2 sectors across h and f. But since these are the same, so are MPLs and MPKs as noted above. So we have AFPE.

These capital-labor ratios in equilibrium determine a "cone of diversification" inside of which both h and f produce both X and Y for the given factor prices. But recall from our notes on chapter 2 that

$k_y^* > \bar{k}^f > \bar{k}^h > k_x^*$ That is, endowments must be inside factor intensities to produce both goods.

So our result is that RFPE and AFPE happen when we are in the cone of diversification, which means both countries produce both goods. Note this requires factor endowments to be more similar to each other than are factor intensities (sometimes called the "factor similarity condition"). Immediate implication: more likely to expect FPE among countries with similar endowments (eg, rich countries) than between rich and poor countries.

In this basic theory how do we get a case where FPE does not hold? Consider the case above where h is even more labor-abundant than permitted by given factor prices so it fully specializes in producing X at point N. Then even in free trade we get that $(w/r)^{h'} < (w/r)^*$. In this case f has a higher relative wage (and higher real wages but lower real returns to capital) and h has a lower relative wage (and lower real wages but higher real returns to capital).

Even so, the HO theorem holds (h exports X and f exports Y).

So *complete specialization can prevent FPE.* Can you think of any real-world significance of this theory?

Of course in real life we do not observe FPE, though there may well be a tendency in that direction. What elements can interfere with or prevent FPE?

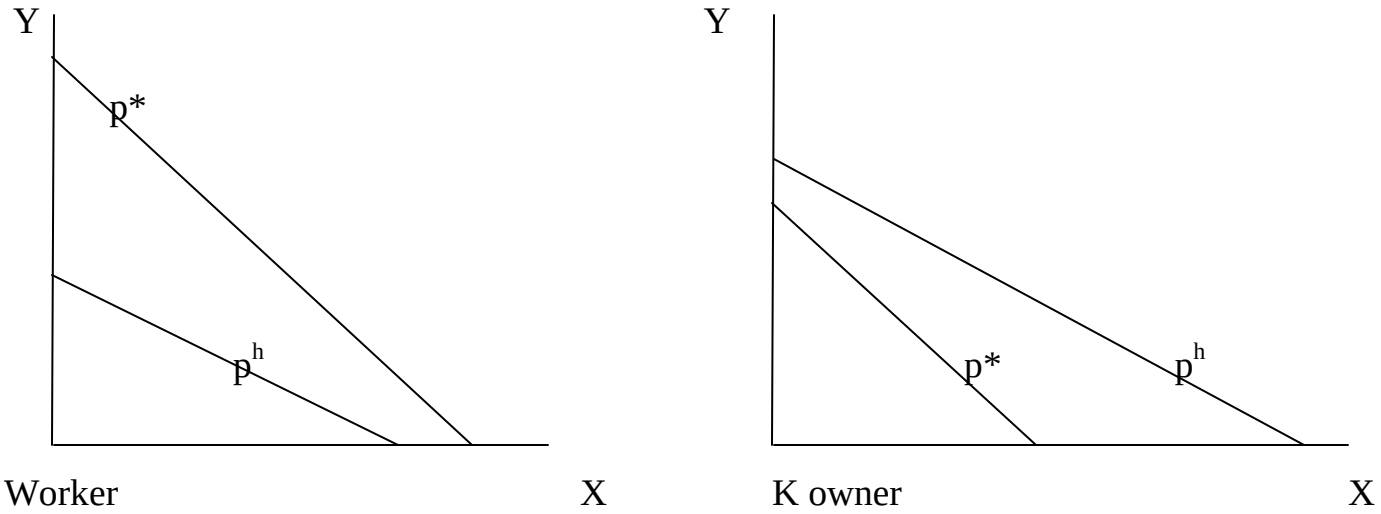
1. Complete specialization.
2. Different technologies.
3. Tariffs and transport costs (then prices in h and f are not equalized by trade).
4. Factor-market distortions (disrupts the linkage between goods prices and factor prices).

5. Increasing returns to scale and product differentiation.
6. Factor-intensity reversals (forget this).

A few more comments on Stolper-Samuelson theorem. Again, this is about redistribution through price and output changes. If the relative price of the labor-intensive good (X) rises and a country produces both goods, the real wages of labor go up and the real returns to capital go down. Same kind of statement for an increase in the relative price of capital-intensive Y.

What's going on here? Let p rise ⇔ ω rises ⇔ capital-labor ratios rise in both X and Y. This is only possible if the economy produces more X and less Y. (Intuitive: Y releases capital and labor in a lower ratio than it had so its K/L ratio goes up, but this ratio is higher than the one in X so its K/L ratio also goes up.) But then both MPLs go up and both MPKs go down and individual budget constraints shift as follows.

Consider h, where moving to trade raises the price of X the export good.



The endpoints of budget constraints are MP's of L and K in autarky and free trade. Prices reflect autarky and free trade prices. The increase in price of X shifts the b.c. for a worker out on both ends but shifts that for K owner in on both ends. So workers gain and K owners lose in home. Opposite in foreign.

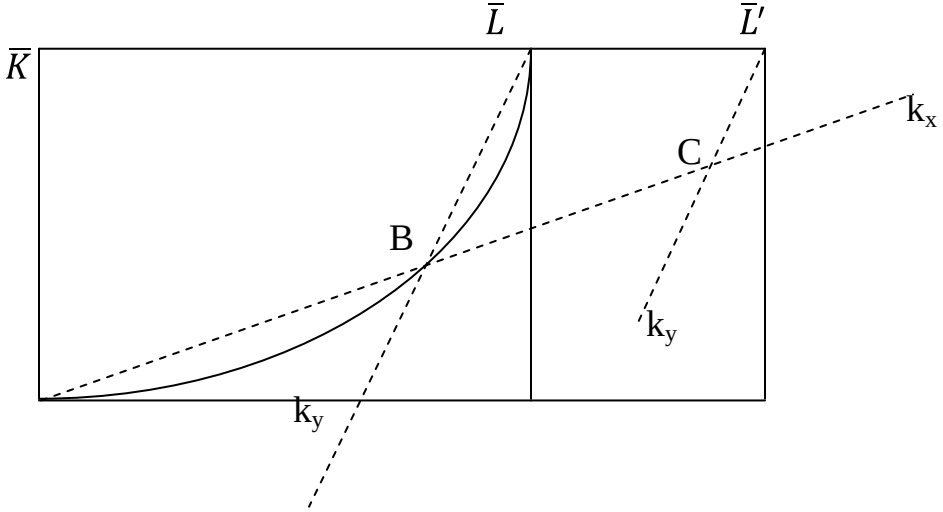
Intuitively, the rise in price of X expands output of X, setting up an excess demand for L and excess supply of K in home. This changes real incomes of factors. This adjustment stops once we reach complete specialization for then capital-labor ratio is fixed in the good produced and real factor prices don't change from that point.

A final point here: if a rise in relative price of X has this impact we can state a *magnification effect*:

$$\%\Delta w > \%\Delta p_x > \%\Delta p_y > \%\Delta r$$

That is, wages rise relative to both prices and returns to capital fall relative to both prices.

We have another theorem to consider: Rybczynski Theorem. This is about changes in factor endowments, which we can think of as growth. Suppose we hold p and ω constant and increase the endowment of labor, holding the endowment of capital fixed. What will happen to outputs of X and Y? An Edgeworth Box shows the outcome:



We can see the initial equilibrium on the contract curve at B. Now expand the labor supply and hold p and w/r constant. Fixed relative factor prices mean that the capital-labor ratios don't change so we move to a new equilibrium at C. But at C the output of X is higher and output of Y is lower (compare line segments).

Rybczynski Theorem: Hold goods prices and factor prices constant and increase the endowment of one factor, holding the other constant. Then output of the good intensive in the growing factor must rise and output of the other good must fall (as long as both goods are produced).

One implication: PPFs are biased as mentioned above (see Figure 8.8).

Practical importance: As a country expands its capital stock it can shift from being labor-abundant to being capital-abundant. So countries can "move up" the chain of goods through high investment rates. (Try to show this with a PPF for a country rapidly expanding its capital stock – which way would its PPF shift?)

Another element of practical importance: the open economy is really different from a closed economy. We tend to think that if there is a rise in the labor supply it will drive down wages or an increase in capital stock will drive up wages and reduce capital prices. This analysis suggests that open (especially small) economies can have these endowment changes with little or no change in factor prices. Instead the output mix shifts toward the growing sector without a change in prices.

This helps explain a puzzle in labor economics: why does immigration into the United States have limited effects on wages in the US?

We can easily generalize Rybczynski: let labor force grow more rapidly than capital stock and hold all prices constant. Then the expansion of the labor-intensive good output must be higher than the expansion of both factors while the expansion (or contraction) of the capital-intensive good must be lower than that.

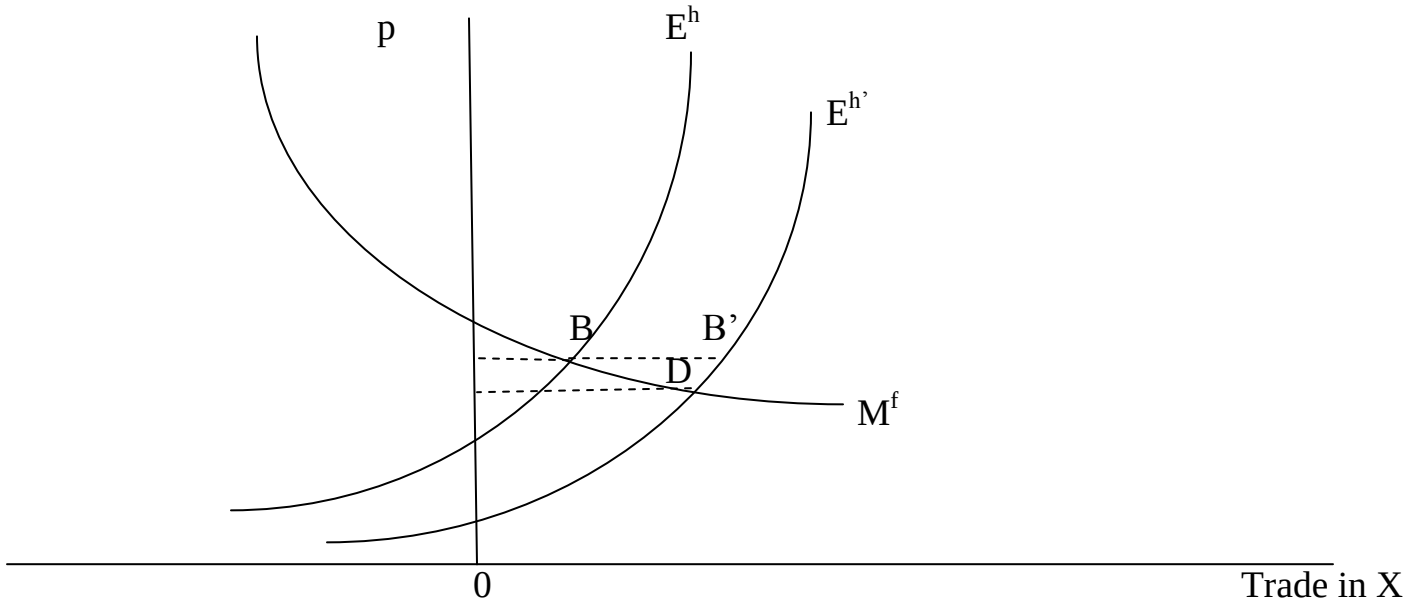
Simple proof: Let percent rise in L be higher than percent rise in K. We can decompose this into (1) an equal percent rise in both, which would expand output of both X and Y by same percentage; and (2) a further expansion of L, which must obey Rybczynski so that from this component X rises further but Y falls.

Again we have a *magnification effect*:

$$\%\Delta X > \%\Delta L > \%\Delta K > \%\Delta Y$$

Can see that if a country invests rapidly in K while its L force does not rise much it will shift its output mix more toward capital-intensive goods.

For what kinds of countries does it make sense to think about fixed prices during endowment growth? What would happen if a large, labor-abundant country grew its endowment of labor?



If h expands its labor supply it will generate a higher PPF more biased toward good X. At the existing free-trade p* there would be an excess supply of X on world markets and p* would fall.

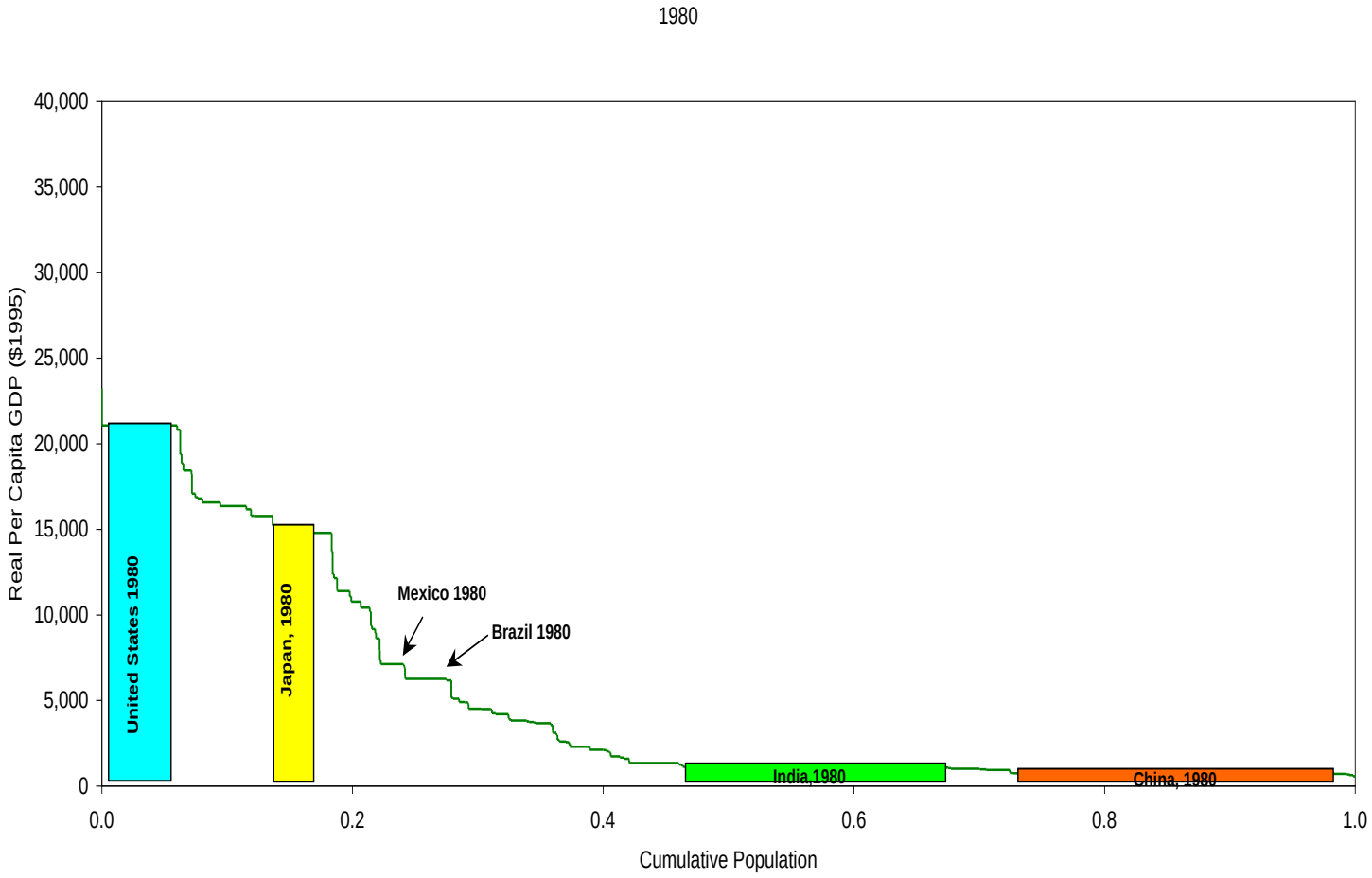
Can we say anything about welfare comparing B with D? Surely f is better off since the price of its import good fell. How about h? Note that if world price did not fall (B') then MPLs and MPKs would be the same at B' as at B in h and there would be no change in individual welfare. But at D the lower price of X (remember SS theorem) must imply lower MPLs (and lower real wages of labor) but higher MPKs (and higher real returns to capital) in h. In this case it is not possible to determine if aggregate welfare in h is higher or lower; it depends on how much these factor prices change.

But this is a possibility of *immiserizing growth*: higher labor force can make the labor-abundant economy worse off. And note the interesting implication: a higher volume of trade does not necessarily imply a higher level of economic welfare.

SUMMARY

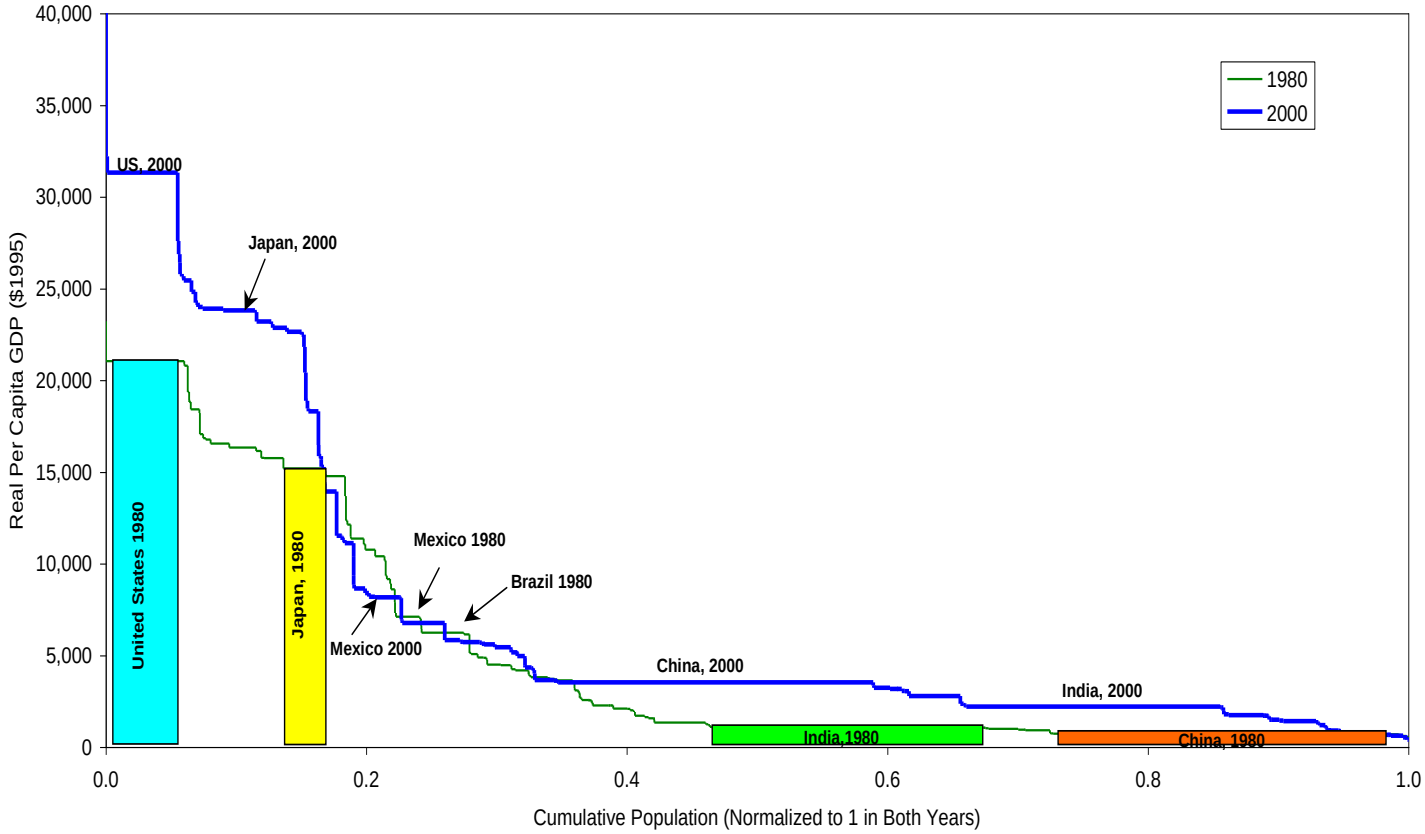
A. Under HO assumptions, factor endowments and intensities determine CA and trade pattern.
B. Both countries gain from trade but there is a redistribution of real income toward abundant factors. This provides one obvious reason why opinions differ regarding the benefits of globalization.
C. International trade sets up a tendency toward FPE; under extreme circumstances it can generate full FPE. This means that trade in goods is a substitute for trade in factors.
D. Factor-endowment growth can happen without much change in factor prices. Instead it tends to shift output mix toward outputs intensive in growing factors.
E. If you're worried about globalization and FPE driving down real wages, one good answer is to raise the endowments of capital and skilled labor so much that the economy does not produce labor-intensive goods. This "complete specialization" will insulate workers from the effects of wage competition. Other options are trade adjustment assistance, retraining, etc.

What do the data tell us? Has globalization engineered a "flat world" as Thomas Friedman would say?



This was the distribution of "wages" (real GDP per capita) in 1980 across the world. If we think of this as a pool of water and stopped holding up the higher end the equalized water level would have been around $5,000. This is the great fear of globalization, at least among unskilled workers.

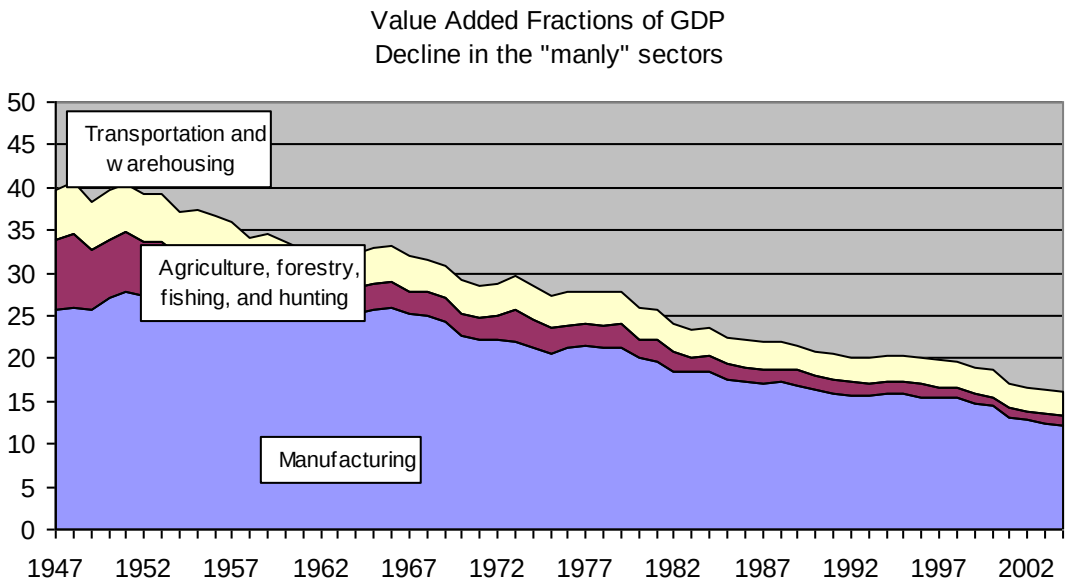
What happened?

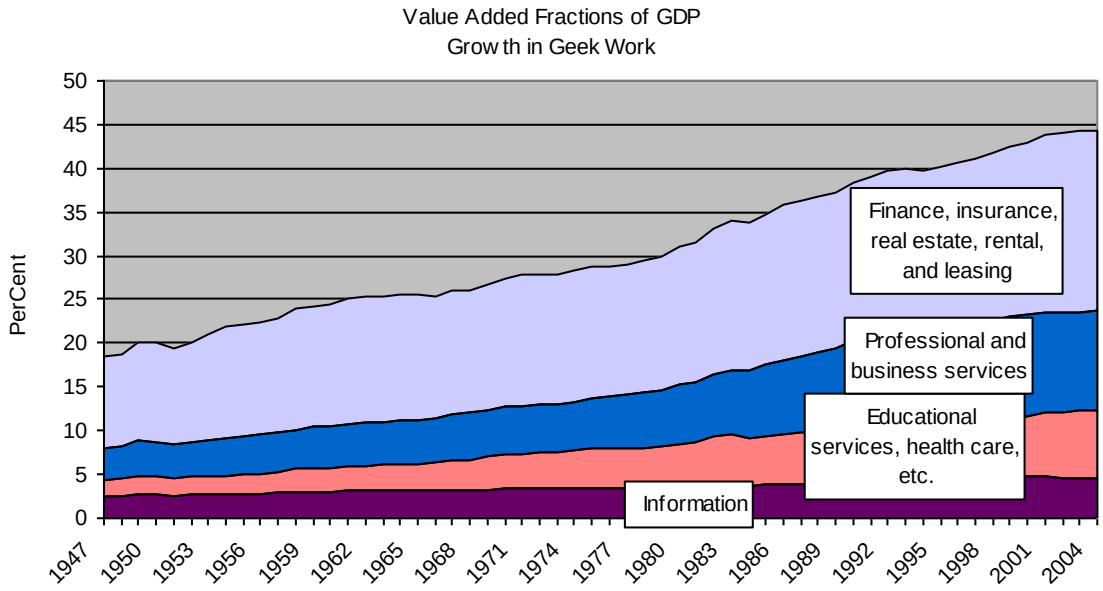


The solid (blue) line on top shows the distribution of real GDP per capita in 2000. We see higher real wages in the developed world and higher in China and India. Mexico and other labor-abundant middle-income economies saw lower average incomes, largely due to competition from China.

Why did US aggregate incomes go up?

Shift of value added out of manufacturing to "geek work":





And a substantial rise in inequality (see notes from Chapter One).

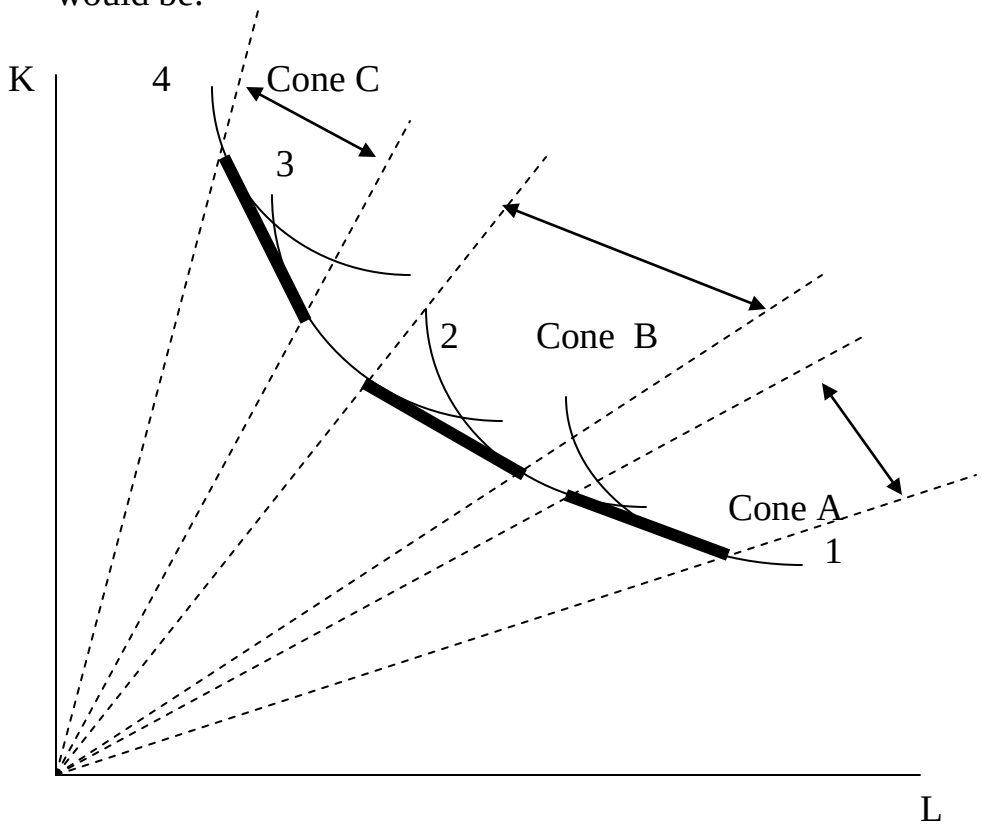
The sources of all these changes? This is a very complex question but the main ones are:

1. New equipment for knowledge workers (both investment and skill-biased technical change; this has raised returns to owning capital and being skilled and creative).
2. New communication tools permit global competition for low-wage jobs through FDI and outsourcing.
3. Expansion of global low-skilled labor forces from China, India, Vietnam, etc. have reduced US unskilled labor wages and destroyed jobs in manufacturing.

All of this suggests we are in a transition to post-industrial society. But the adjustment is hard for lower-skilled workers; Stolper-Samuelson effects definitely are operating in the US.

Some further notes of interest.

1. What does HO theory tell us about factor prices with multiple goods and countries but two factors? Keep the primary assumptions in place but let there be 4 goods. The analogue to our "cones" diagram above would be:



Here there are 4 unit value isoquants. Good 4 is most K-intensive and good 1 is most L-intensive. The solid black lines indicate relative (w/r) ratios at different points, where there is a tangency between two isoquants and the factor-price line.

Types of specialization are as follows.

For any country , if it has an endowment ratio in Cone A it produces both goods 1 and 2.
In Cone B it produces both goods 2 and 3.
In Cone C it produces both goods 3 and 4.

The above cases reflect "incomplete specialization" ("diversification") but note that the relative (w/r) gets higher as we move from Cone A to B to C.

If the country's endowment ratio lies below Cone A it specializes in good 1 and has lowest w/r.
If it lies between cones A and B it specializes in good 2 and its (w/r) is between those in A and B.
If it lies between cones B and C it specializes in good 3 and its (w/r) is between those in B and C.
If it lies above cone C it specializes in good 4 and has highest w/r.

Result: even with free trade generating equalized goods prices, countries can find themselves producing 1 or 2 goods; in the latter case they are in different cones.

The primary point here as regards the real world is this: countries can sustain high real wages by specializing in more capital-intensive (or skill-intensive or education-intensive) goods. But how do they achieve this specialization? By making sure their economies remain capital-abundant (or skill-abundant, etc.).

Can you think of economies that seem to specialize in this way?

2. Let's take a look at some data on factor intensities and factor endowments.

	2000			2005			
Industry	Production	Capital Spending	Nonproduction	Production	Capital Spending	Nonproduction	Evident
	Labor (thousands	per PL	labor per PL	abor (thousands	per PL	labor per PL	Intensity
Petroleum and coal products	67	$ 74,624	0.51	65	$ 169,501	0.58	Capital, Skill
Chemical products	508	$ 41,112	0.75	433	$ 38,971	0.76	Capital, Skill
Computer & electronic products	848	$ 33,227	0.94	465	$ 33,972	1.16	Capital, Skill
Mineral products	408	$ 14,820	0.28	360	$ 14,334	0.29	Capital
Transportation equipment	1,349	$ 12,529	0.36	1,104	$ 13,842	0.41	Capital, Skill
Food, beverages & tobacco	1,244	$ 11,714	0.35	1,177	$ 13,090	0.34	Capital, Skill
Wood & paper products	914	$ 12,234	0.24	765	$ 11,268	0.27	Capital
Miscellaneous products	501	$ 8,219	0.49	422	$ 11,044	0.61	Skill
Plastic & rubber products	862	$ 10,086	0.26	688	$ 10,127	0.29	Capital
Machinery	920	$ 10,116	0.52	683	$ 9,947	0.56	Skill
Printing	597	$ 7,398	0.39	457	$ 9,510	0.41	Skill
Metal products	1,839	$ 8,729	0.30	1,418	$ 8,545	0.33	Skill
Electrical equipment & appliances	431	$ 9,069	0.37	294	$ 6,551	0.43	Skill
Textile products	475	$ 5,130	0.20	285	$ 4,633	0.23	Labor
Leather products	55	$ 2,813	0.25	29	$ 3,527	0.29	Labor
Furniture & related products	515	$ 4,011	0.25	414	$ 3,404	0.29	Labor
Apparel	423	$ 2,302	0.24	171	$ 2,882	0.31	Labor

Some measures of factor intensities for manufacturing industries, US.

	2000			2005			
Country	Capital Stock	Arable land	R&D Scientists	Capital Stock	Arable land	R&D Scientists	Evident
	per worker	per worker (HA)	per 1000 people	per worker	per worker (HA)	per 1000 people	Abundance
Singapore	$ 239,044	0.00	8.08	$ 247,608	0.00	10.45	Capital, R&D
Japan	$ 182,196	0.07	9.55	$ 194,375	0.07	10.55	Capital, R&D
USA	$ 153,689	1.19	8.64	$ 181,856	1.13	8.97	Capital, R&D
Australia	$ 149,347	4.91	6.86	$ 169,374	4.68	6.76	Capital, Land
Germany	$ 160,918	0.29	6.38	$ 162,214	0.29	6.71	Capital, R&D
Canada	$ 142,345	2.82	6.69	$ 156,814	2.55	6.55	Capital, Land
Finland	$ 149,338	0.84	13.42	$ 155,699	0.85	15.00	Capital, R&D
Rep. of Korea	$ 102,235	0.08	4.80	$ 123,959	0.07	7.56	Capital, R&D
UK	$ 102,447	0.20	5.43	$ 117,232	0.19	5.86	R&D
Mexico	$ 48,140	0.64	1.12	$ 50,827	0.58	1.11	Labor
Brazil	$ 39,311	0.70	0.77	$ 37,885	0.63	0.77	Labor
South Africa	$ 31,060	0.95	0.96	$ 30,532	0.86	0.99	Labor
China	$ 13,183	0.18	0.95	$ 20,090	0.18	1.44	Labor
India	$ 7,556	0.42	0.29	$ 9,465	0.37	0.31	Labor

Some measures of factor endowments, selected countries.