Topic 4: the factor-proportions (Heckscher-Ohlin) model of trade

Some obvious problems with Ricardian theory

1. Only one factor of production, with constant MPL in both goods.

2. Complete specialization.

3. All people gain from trade (there is no redistribution of income among people within an economy due to trade).

We can relax these restrictions considerably by studying this next model.

Basic ideas

A. Countries are abundant or scarce in particular factors.

B. Products (technologies) are intensive in the use of particular factors.

C. Then countries export the products that intensively use their abundant factors and import the products that intensively use their scarce factors. Note what this means: trade in goods is implicitly trade in the services of factors. Different factor endowments are the real driver of CA.

That's the simple version but the actual theory is more complicated so let's turn to that now.

Factor-proportions model

Assumptions:

1. There are 2 countries, say, Japan and China. They have different relative endowments: $\left({}^{\bar{K}_J}/_{\bar{L}_J}\right) > \left({}^{\bar{K}_C}/_{\bar{L}_C}\right)$

2. There are 2 factors, K and L. They are homogeneous and in fixed supply. They are mobile between industries but not between countries. Note this means that the wage rate (w) and price of capital (r) are the same in all goods within Japan and China, though they can be different between J and C.

3. There are 2 goods, say, shoes (S) and autos (A) which differ in relative factor intensity:

${}^{K_A}/_{L_A} > {}^{K_S}/_{L_S}$. That is, A is *K-intensive* and S is *L-intensive* in *both* J and C.

4. The technologies for producing A and S are CRS and are the same in both J and C.

The next 2 tables show data for factor intensities (US manufacturing) and endowments (several countries).

Table 8.1 Measures of Factor Intensity for US Manufacturing Industries									
	2000				2005				
Industry	Value Added	Production	Capital Exp.	Nonproduction	Value Added	Production	Capital Exp.	Nonproduction	Evident
	($ millions)	Labor (000)	per PL	labor per PL	($ millions)	Labor (000)	per PL	labor per PL	Intensity
Petroleum and coal products	$ 45,748	67	$ 74,624	0.51	$ 117,541	65	$ 169,501	0.58	Capital, Skill
Chemical products	$ 235,614	508	$ 41,112	0.75	$ 328,440	433	$ 38,971	0.76	Capital, Skill
Computer & electronic products	$ 291,125	848	$ 33,227	0.94	$ 226,319	465	$ 33,972	1.16	Capital, Skill
Mineral products	$ 55,722	408	$ 14,820	0.28	$ 64,545	360	$ 14,334	0.29	Capital
Transportation equipment	$ 240,989	1,349	$ 12,529	0.36	$ 254,665	1,104	$ 13,842	0.41	Capital, Skill
Food, beverages & tobacco	$ 255,245	1,244	$ 11,714	0.35	$ 316,389	1,177	$ 13,090	0.34	Capital, Skill
Wood & paper products	$ 114,260	914	$ 12,234	0.24	$ 120,651	765	$ 11,268	0.27	Capital
Miscellaneous products	$ 70,621	501	$ 8,219	0.49	$ 92,974	422	$ 11,044	0.61	Skill
Plastic & rubber products	$ 92,333	862	$ 10,086	0.26	$ 96,348	688	$ 10,127	0.29	Capital
Machinery	$ 148,798	920	$ 10,116	0.52	$ 142,488	683	$ 9,947	0.56	Skill
Printing	$ 63,446	597	$ 7,398	0.39	$ 58,930	457	$ 9,510	0.41	Skill
Metal products	$ 215,545	1,839	$ 8,729	0.30	$ 232,106	1,418	$ 8,545	0.33	Skill
Electrical equipment & appliances	$ 62,991	431	$ 9,069	0.37	$ 54,318	294	$ 6,551	0.43	Skill
Textile products	$ 35,225	475	$ 5,130	0.20	$ 32,395	285	$ 4,633	0.23	Labor
Leather products	$ 4,510	55	$ 2,813	0.25	$ 2,865	29	$ 3,527	0.29	Labor
Furniture & related products	$ 42,267	515	$ 4,011	0.25	$ 46,801	414	$ 3,404	0.29	Labor
Apparel	$ 28,210	423	$ 2,302	0.24	$ 16,319	171	$ 2,882	0.31	Labor
Source: Compiled by authors from US Department of Commerce, *Annual Survey of Manufactures*									

Table 8.2 Measures of Relative Factor Endowments							
	2000			2005			
Country	Capital Stock per worker	Arable land per worker (HA)	R&D Scientists per 1000 people	Capital Stock per worker	Arable land per worker (HA)	R&D Scientists per 1000 people	Evident 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

Sources: computed by authors with data available from World Bank, *World Development Indicators*; Food and Agricultural Organization, *FAO-Stat Database*; and Penn World Tables version 6.2.

FP model: demand assumption

The final assumption removes demand differences between countries as a source of comparative advantage, leaving just factor endowments and factor intensities (on the supply side) to determine trade patterns.

4. Preferences for goods are identical in both countries and these preferences do not change as countries achieve higher income levels.

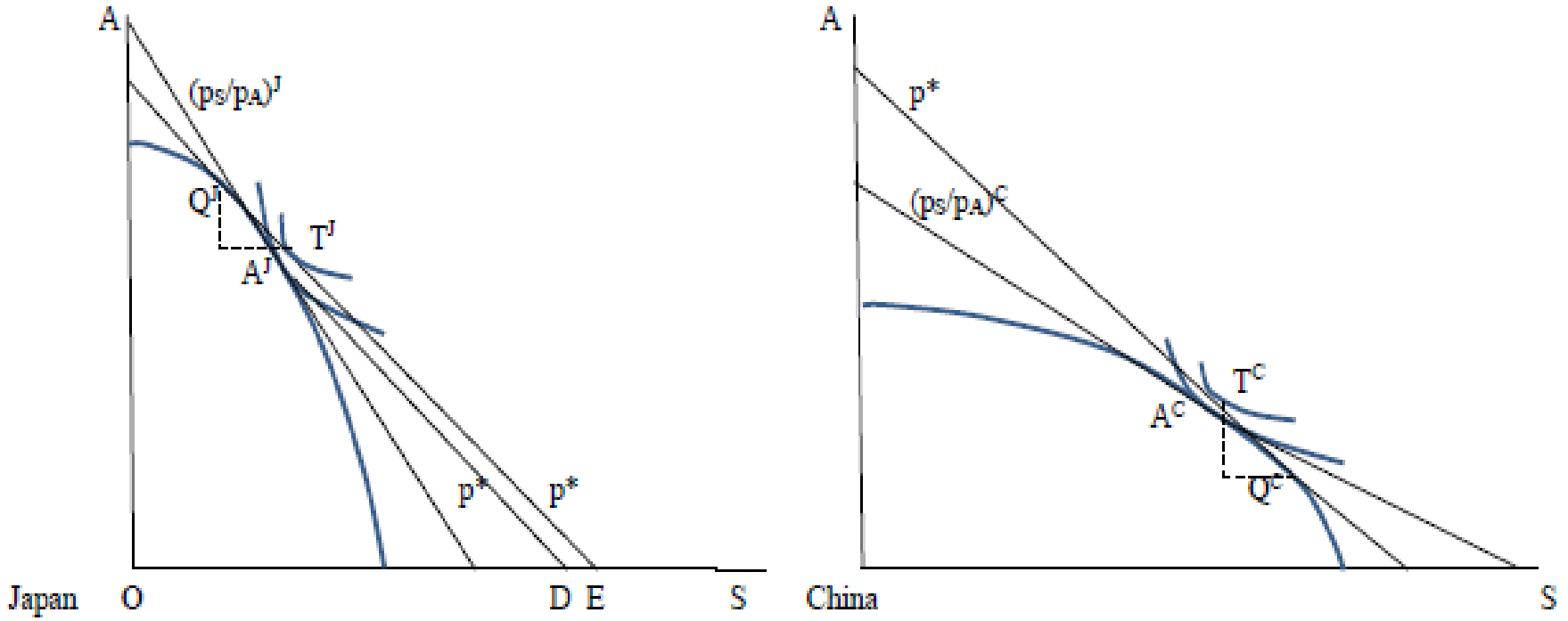
This means 2 things, which are convenient but untrue:

- The indifference curves are exactly the same in both C and J.
- As a country, say Japan, gets richer consumers continue to spend the same percentage of their incomes on each good. So whether the country is rich or poor it still spends, say, 15% of income on food, 20% on housing, 10% on clothing, 10% on vehicles, etc.

We will generally make this assumption but say a bit later about how demand differences do affect trade.

PPFs and equilibrium

How are these assumptions reflected in PPFs? They must be biased toward the good intensive in a country's abundant factor. (We'll consider why a bit later but it makes sense.)



PPFs and equilibrium

Note that because the PPFs are biased and demand patterns are the same, the Japanese autarky equilibrium at A^J lies further up and to the left on its PPF than the Chinese equilibrium A^C lies on its PPF.

This means the autarky price ratio in Japan is steeper than the one in China so we have:

$(^{p_S}/_{p_A})^J > (^{p_S}/_{p_A})^C$ *due to the biases in the PPFs*.

But this means Chinas has the comparative advantage (CA) in S and J has the CA in A. For example, we could have $(^{p_S}/_{p_A})^C = \frac{1}{2}\left(1S = \frac{1}{2}A\right) and\ (^{p_S}/_{p_A})^J = 3\ (1S = 3A)$.

Implication: with our assumptions the determination of CA is based completely on 2 supply-side factors:

- 1. Relative factor endowments of the 2 countries;
- 2. Relative factor intensities of the 2 industries.

Trade equilibrium and the Heckscher-Ohlin theorem

There is room for mutually beneficial trade where $({}^{p_S}/_{p_A})^C < ({}^{p_S}/_{p_A})^* < ({}^{p_S}/_{p_A})^J$.

In the diagram I have labeled the free-trade price ratio p^*. In free trade this becomes the price ratio that exists in both countries.

We see that the relative price falls in Japan (making A more expensive and S cheaper) and rises in China (making S more expensive and A cheaper).

China exports S, imports A => p_S goes up, p_A goes down in China.

Japan exports A, imports S => p_S goes down, p_A goes up in Japan.

We have the HO theorem: *Let two countries have different relative factor endowments and produce 2 goods with identical production functions, one of which is labor-intensive and one is capital-intensive.* ***Then in free trade each country will export the good that intensively uses its abundant factor and import the good that intensively uses its scarce factor.***

Equilibrium adjustments

This process continues until an intermediate p^* is established and trade balances (trade triangles are equal).

What adjustments happen in the 2 countries? Next 2 charts "blow up" the relevant parts of the earlier diagram.

OUTPUTS:

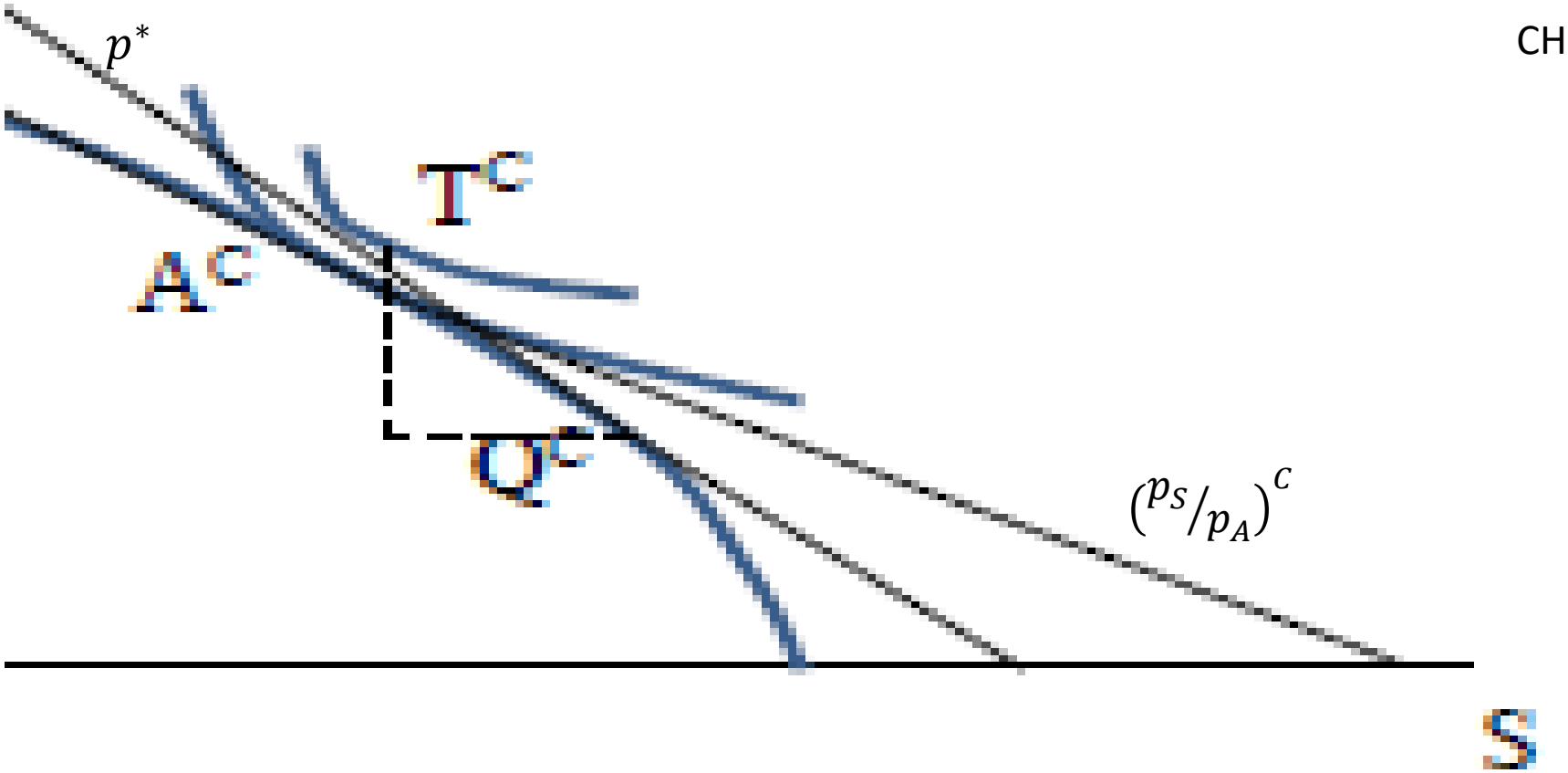
In China, output of S rises, output of A falls. In Japan, output of S falls, output of A rises.

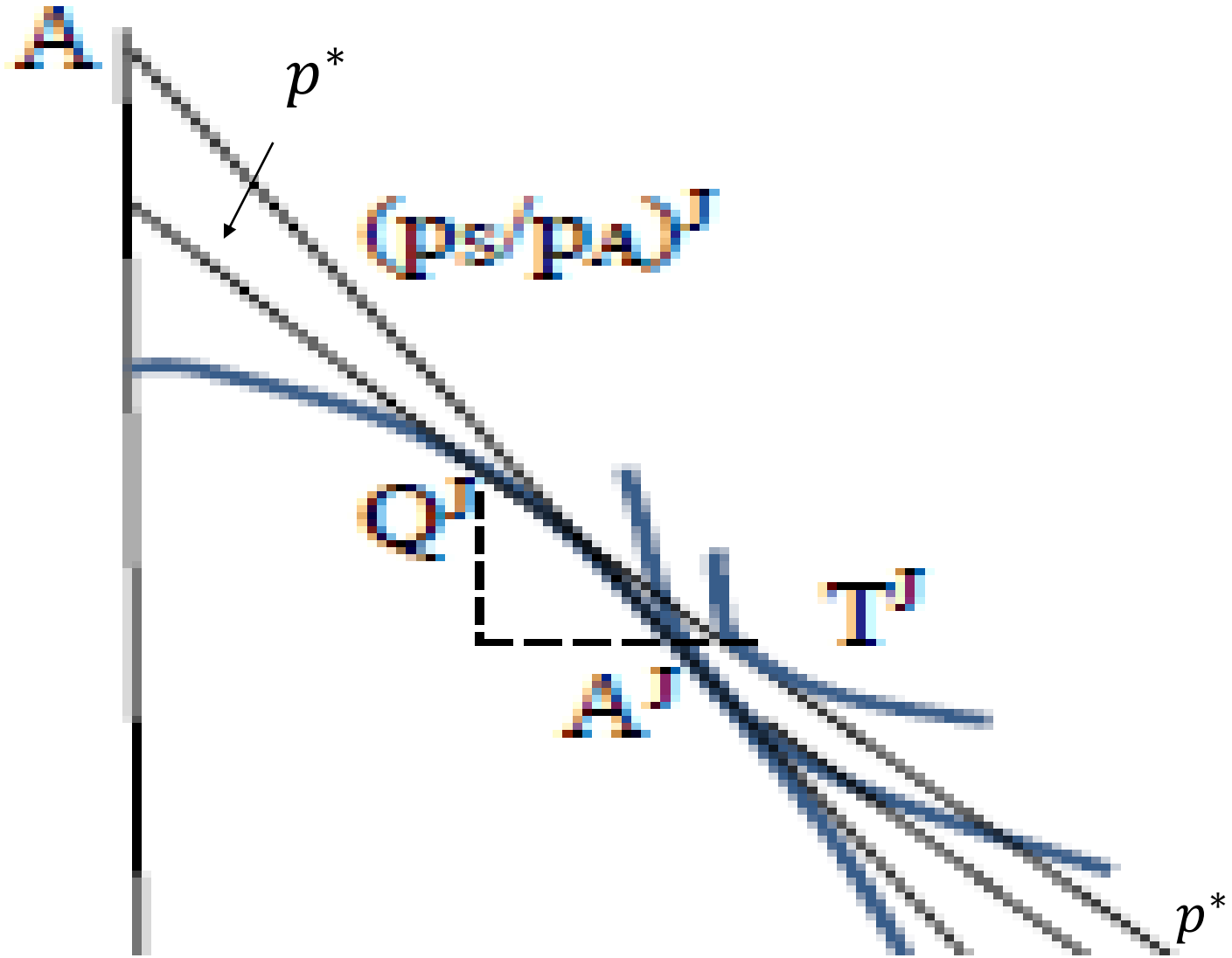
So there is a *tendency toward specialization* but only until the ratio of prices equals the MC ratios at points Q_C and Q_J .

Note how important the concave PPFs are here (rising marginal costs along the PPFs). So in China the relative cost of S rises until (absolute value of) the slope of PPF = $MRT_C = p^*$

In Japan the relative cost of A rises until $MRT_J = p^*$

CHINA





JAPAN

Equilibrium adjustments

CONSUMPTION:

Because the price of S rises and of A falls in China, expect China to consume more A and (probably) less S.

Expect Japan to consume more S and (probably) less A.

TRADE:

See the trade triangles. Japan exports A, China exports S. Trade is balanced in physical terms (equal trade triangles).

And it is balanced in value terms (value of exports = value of imports). (To see this, note the (absolute value of) slope of China's trade triangle is p^*. But that is rise over run, or $IM_A^C \Big/ EX_S^C$.)

That is, for China, $IM_A^C = EX_S^C \left(\frac{p_S}{p_A}\right)^*$, which implies that $p_A^* IM_A^C = p_S^* EX_S^C$.

But that implies $p_A^* EX_A^J = p_S^* IM_S^J$.

Gains from trade

GAINS FROM TRADE (GFT):

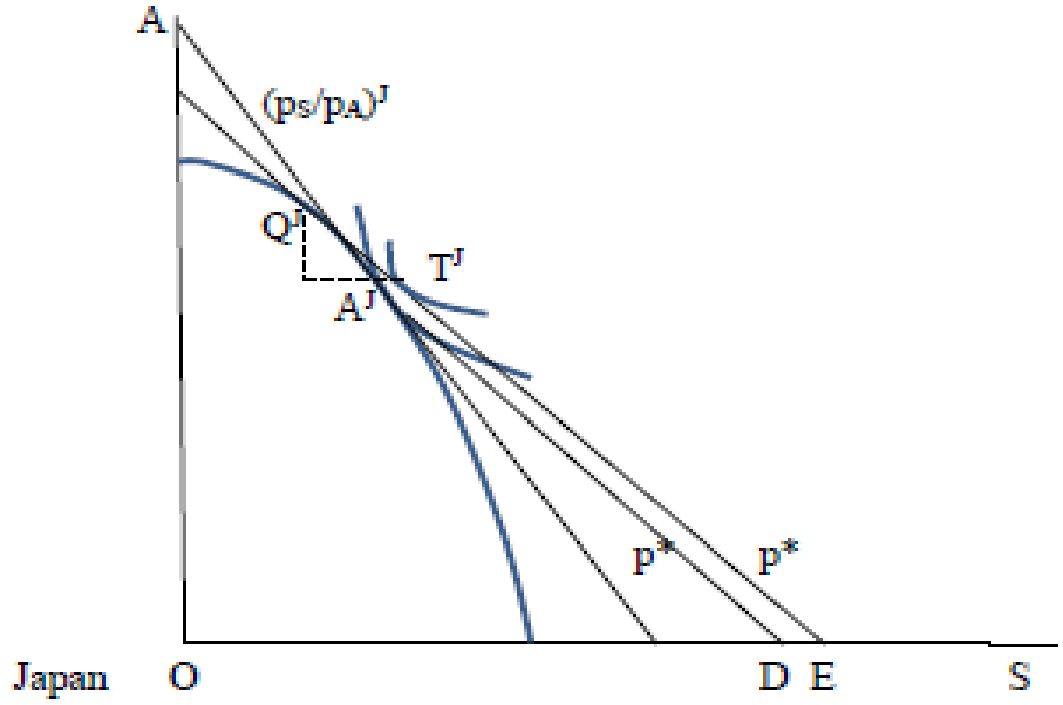
Both J and C are on higher indifference curves (CICs) and economies consume outside the PPF. This is good enough.

But real GDP rises also (next slide).

Real GDP rises

Recall from earlier notes (part 2 on microeconomic tools) that real GDP can be measured as the endpoints of the price lines tangent to the PPF in any equilibrium.

But to compare equilibrium points we need to use the same prices for comparison and the natural comparison is world prices. Recall Japan:



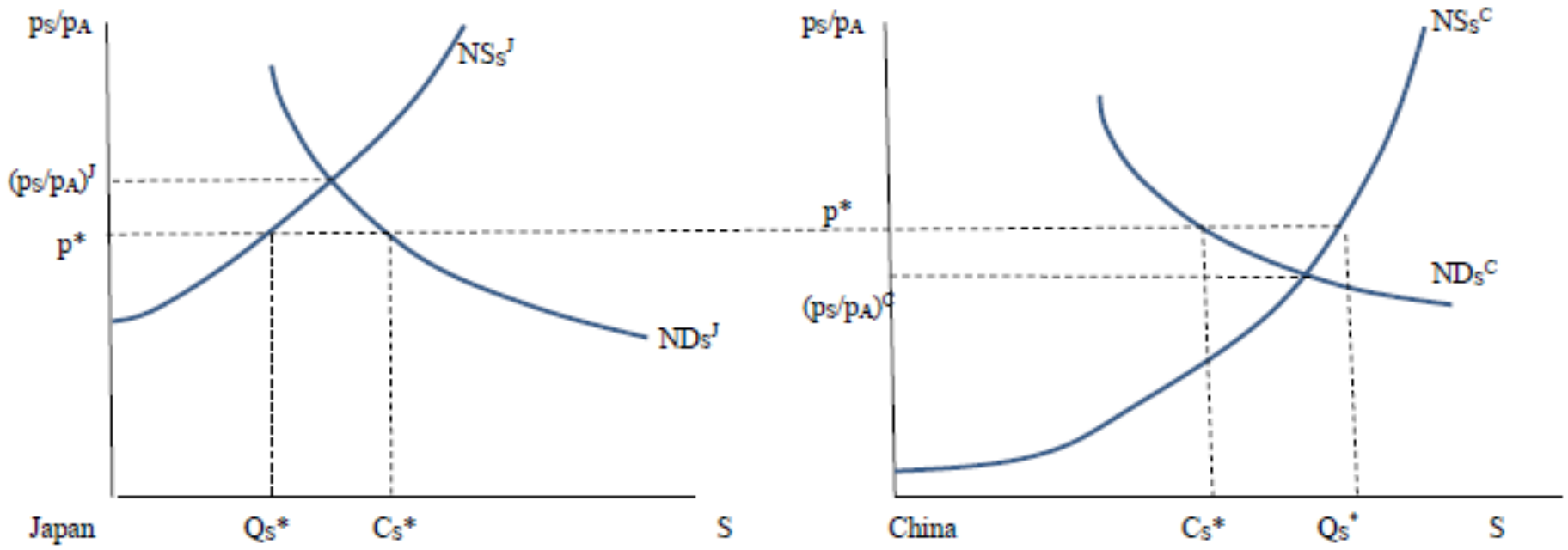
Free-trade output is at Q^J, generating real GDP of OE (in units of S) at world prices p*.
Autarky output is at A^J, generating real GDP of OD (in units of S) at world prices p*.

Implication: free trade permits partial specialization toward Japan's more efficient good (CA good), which raises real GDP.

Same would be true for China; show this.

Equilibrium with national S & D curves

Here is equilibrium in terms of national supply and demand. Japan imports shoes and China exports shoes.



Clicker question

Which of the following statements is FALSE in the HO (factor-proportions) model?

A. In free trade countries implicitly export the services of their abundant factors.

B. Free trade will cause the prices of scarce factors to fall.

C. Each country has a higher real GDP in free trade than in autarky.

D. Both countries completely specialize in the good in which they have a comparative advantage.

E. Free trade permits countries to consume outside their PPFs.

Brief model comparison

Let's compare the 2 models we have so far.

Ricardo	HO
Constant opp. Costs	Rising opp. Costs
Different technologies	Identical technologies
CA depends on L productivity	CA depends on endowments and intensities
Trade generates complete specialization	Trade generates partial specialization
Trade allows consumption outside PPF (GFT)	Same

Both models provide important insights and help explain some aspects of actual trade flows.

Factor endowments, trade, and factor prices

Let's dig deeper here and study how trade in this model affects wages and prices of capital.

A key point: the HO model says *countries implicitly export the services of abundant factor(s) and import the services of scarce factor(s)*.

This means that free trade generates higher demand for the abundant factor, so its price rises. And it generates lower demand for the scarce factor, so its price must fall.

But a key question: is it just nominal or also *real* factor prices that change? Why is this an issue? If trade (exports) drives up the prices of autos *and* the price of capital in Japan, how do we know what happens to the real price of capital, $^{r}/_{p_A}$? And if trade (imports) drives down the prices of shoes *and* the wage rate in Japan, how do we know what happens to the real wage, $^{w}/_{p_S}$?

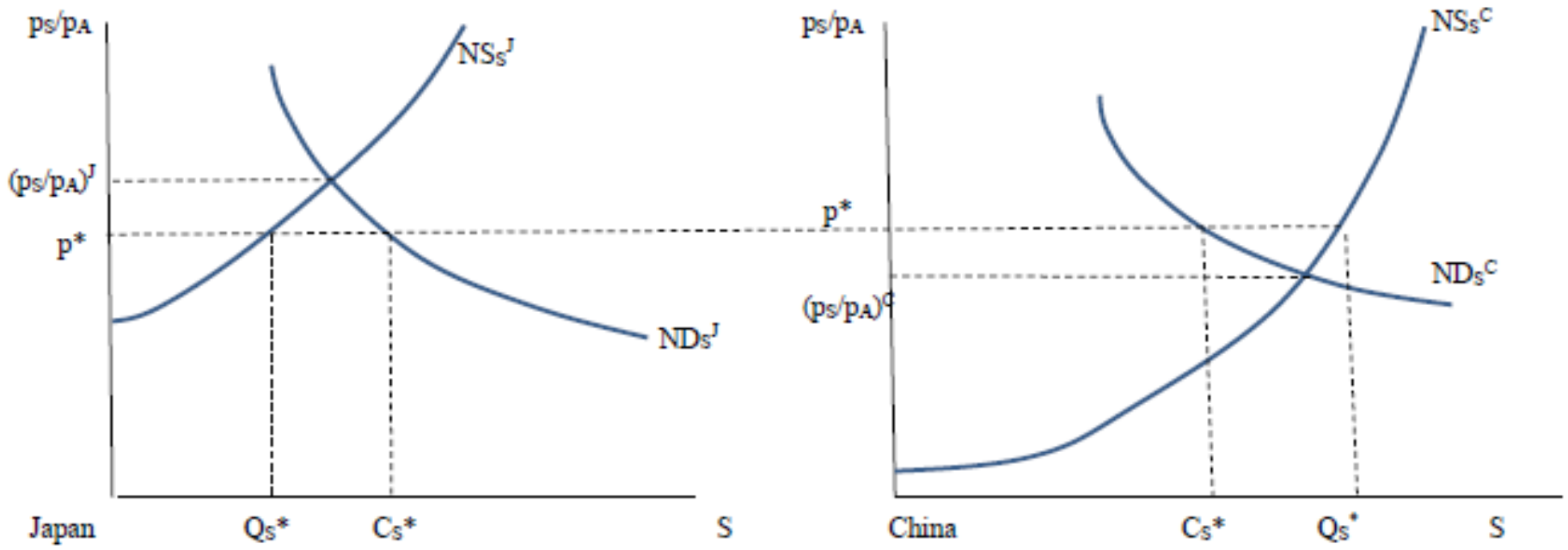
Let's see this in basic theoretical terms. First, we know that in autarky shoes are expensive (and autos cheap) in Japan compared to China:

$(^{p_S}/_{p_A})^J > (^{p_S}/_{p_A})^C$

Now suppose that J and C both faced the same relative price ratio as China's autarky ratio, $(^{p_S}/_{p_A})^C$. Looking at the national S & D curves (diagram reproduced next slide), at this price ratio Japan would produce fewer shoes (and more autos) than it does at its own autarky price ratio.

Equilibrium with national S & D curves

Here is equilibrium in terms of national supply and demand. Japan imports shoes and China exports shoes.



Factor endowments, trade, and factor prices

So in autarky, Japan produces more shoes (and fewer autos) than it would at China's autarky price ratio.

But S is labor intensive and A is capital intensive so it must mean this adjustment raises the demand for labor and reduces the demand for capital in J compared to C.

So we get this result in autarky:

$$(\frac{w}{r})^J > (\frac{w}{r})^C$$

This is not surprising, it simply reflects relative factor abundance. Labor is scarce in Japan, so it has a high price. Capital is abundant so it has a low price. The opposite is true for China.

Let's put all this together in autarky relationships:

$$(\frac{\bar{K}}{\bar{L}})^J > (\frac{\bar{K}}{\bar{L}})^C \Rightarrow (\frac{w}{r})^J > (\frac{w}{r})^C \Leftrightarrow ({}^{p_S}/_{p_A})^J > ({}^{p_S}/_{p_A})^C$$

Factor prices and factor intensities

Now for some tedious, but important, economic theory. (You saw most of this in micro principles.)

Remember the meaning of *factor intensities*. Autos are capital-intensive and shoes are labor-intensive if $^{K_A}/_{L_A} > {}^{K_S}/_{L_S}$.

But what do these capital-labor ratios depend on? Several things actually but we will focus on the most essential one: the ratio of the price of labor to the price of capital, $^{w}/_{r}$.

Basic idea: if $^{w}/_{r}$ goes up (labor gets more expensive relative to capital), firms in *both* industries (autos and shoes) *substitute capital for labor* and the capital-labor ratio rises in both. That is,

$$(^{w}/_{r}) \uparrow \Rightarrow {}^{K_A}/_{L_A} \uparrow and \ {}^{K_S}/_{L_S} \uparrow (and, in\ turn, {}^{L_A}/_{K_A} \downarrow and\ {}^{L_S}/_{K_S} \downarrow)$$

This is true in both Japan and China. Now recall our ranking in autarky:

$(\frac{\bar{K}}{\bar{L}})^J > (\frac{\bar{K}}{\bar{L}})^C \Rightarrow (\frac{w}{r})^J > (\frac{w}{r})^C$ so labor is expensive in Japan (capital is cheap) and labor is cheap in China (capital is expensive).

Factor prices and factor intensities

It follows that in autarky the capital-labor ratios in both A and S are higher in Japan than in China:

$(\frac{w}{r})^J > (\frac{w}{r})^C \Rightarrow \left({}^{K_A}/_{L_A}\right)^J > \left({}^{K_A}/_{L_A}\right)^C and \left({}^{K_S}/_{L_S}\right)^J > \left({}^{K_S}/_{L_S}\right)^C$ (Note this makes sense: if Japan is capital abundant and labor-scarce compared to China, we should observe this difference.)

Let's summarize where we are at this point:

1. Japan is capital-abundant and China is labor-abundant. This means the PPFs are biased and that explains why in autarky shoes are relatively expensive in J and relatively cheap in C (and autos are relatively cheap in J and expensive in C).

2. It also means that labor is expensive and capital is cheap in J (opposite in C).

3. As a result, both A and S use higher capital-labor ratios in J than they do in C.

Marginal productivities and real factor prices

What determines the productivity of labor and capital in this “factor proportions” model?

In the real world, a lot of things. But here it is just the capital-labor ratio in production of A and S.

Again, the basic idea: if the K/L ratio rises in production in autos, it means each L has more K to work with. That should raise the marginal product of labor in autos. (Simple way to see this: let there be 5 units of K per L, now raise K to 7 per L, holding the amount of L fixed. The fact that each L has more K to work with makes labor more productive.)

But this works in both directions: a higher K/L ratio makes capital less productive but a lower K/L ratio (that is, more L per K) makes K more productive.

General statement: As $\left({}^{K_A}/_{L_A}\right)^J$ rises, the MPL_A^J goes up and MPK_A^J falls. The same is true for shoes.

And these general relationships are true in China also.

Marginal productivities and real factor prices

Put this together:

As $(\frac{w}{r})^J$ goes up, both $\left({}^{K_A}/_{L_A}\right)^J and \left({}^{K_S}/_{L_S}\right)^J$ also rise. That means both $MPL_A^J \; and \; MPL_S^J$ go up and both $MPK_A^J \; and \; MPK_S^J$ go down.

As $(\frac{w}{r})^J$ goes down, both $\left({}^{K_A}/_{L_A}\right)^J and \left({}^{K_S}/_{L_S}\right)^J$ also go down. That means both $MPL_A^J \; and \; MPL_S^J$ fall and $MPK_A^J \; and \; MPK_S^J$ rise.

These relationships also hold in China.

To summarize this in autarky: because Japan uses more capital-intensive ratios in both goods than China we have

Both $MPL_A \; and \; MPL_S$ are higher in Japan than in China.

Both $MPK_A \; and \; MPK_S$ are higher in China than in Japan.

Marginal productivities and real factor prices

We can now just extend our logic from the Ricardian model (which had only labor):

Real wages equal the marginal products of labor and real returns to capital equal the marginal products of capital.

Another way to see this is thinking about equilibrium in the factor markets.

Define: the *value of marginal product of labor* in a good (e.g., A) is $VMPL_A = p_A MPL_A$. This shows you how much revenue an additional worker generates in production. Firms would be willing to hire more workers until the additional cost of hiring (just the wage) equals this additional revenue.

State this equilibrium condition as: $w = VMPL_A = p_A MPL_A$ But that means *real wage in terms of buying good A* is $^{w}/_{p_A} = MPL_A$.

The same logic for capital would say that the *real return to capital in terms of buying good A* is $^{r}/_{p_A} = MPK_A$.

For our 2 countries:

In Japan, real wage in A = MPL_A^J and the real wage in S = MPL_S^J .

In China, real wage in A = MPL_A^C and real wage in S = MPL_S^C .

In Japan, real capital return in A = MPK_A^J and real capital return in S = MPK_S^J .

In China, real capital return in A = MPK_A^C and real capital return in S = MPK_S^C .

Marginal productivities and real factor prices: effects of trade

But we already know the autarky ranking of MPL's so we immediately get that real wages in both goods are higher in Japan than in China. And real returns to capital are higher in China than in Japan. Again, this reflects factor endowment abundance and scarcity.

Comment briefly on what we would expect in terms of L and K flows if factors were permitted to move across borders.

Clicker question

Which of the following is true in comparing autarky in capital-abundant Japan and labor-abundant China?

A. Shoes are relatively cheap in Japan.

B. China has higher real wages than Japan.

C. Japan produces both goods with higher capital-labor ratios than China does.

D. If it were possible, capital would move from Japan to China and labor from China to Japan.

E. Both C and D.

The effects of trade

Effects of moving from autarky to free trade

Now consider how international trade in goods affects all of this. Consider the result in Japan of moving from autarky to free trade with China.

In Japan, $(p_S/p_A)^J$ falls to the equalized p^* But that means output of S falls and output of A rises in Japan. *There is a tendency toward specialization in the good of CA and exports. But it is incomplete specialization*.

This output shift generates an excess demand for capital and an excess supply of labor in Japan, which means that w falls and r rises until we reach a new output equilibrium with more A, less S produced and both K and L are fully employed.

Result: free trade raises the nominal price of the abundant factor and reduces the price of the scarce factor.

Trade and factor-price equalization

By the same analysis in China: $(^{p_S}/_{p_A})^C$ rises, so the nominal wage rises and nominal r falls.

What we have then is that as $(^{p_S}/_{p_A})^J$ falls, so does $(\frac{w}{r})^J$. And as $(^{p_S}/_{p_A})^C$ rises, so does $(\frac{w}{r})^C$.

This happens due to adjustments in output along the PPFs: Japan produces more autos (less shoes) and China produces more shoes (less autos).

But we can say more than this. Free trade generates equalized relative prices: p* becomes the new price ratio in both C and J. And that means the relative factor prices must be driven together also:

$(^{p_S}/_{p_A})^{J*} = p^*$ = $(^{p_S}/_{p_A})^{C*} \Leftrightarrow (\frac{w}{r})^{J*}$ = $(\frac{w}{r})^*$ = $(\frac{w}{r})^{C*}$ in free trade. That is, free trade in goods generates equalized goods prices. This in turn generates *relative factor price equalization*. This is true so long as both countries produce both goods (partial or incomplete specialization).

The reason this happens is our assumption that Japan and China have the same production technologies for A and S. This means that they share the same technological relationships between relative goods prices and relative factor prices. So when goods prices are equal, so are factor prices.

Trade and relative FPE

Let's state this as a theorem:

FPE theorem: Let 2 countries have identical CRS production functions in 2 goods. Then free trade in goods establishes equalized relative factor prices between the countries as long as both countries remain incompletely specialized.

But we still have a remaining puzzle to work out. We know the following at this point:

In Japan, the wage falls and the price of autos (exported) rises so $(w/p_A)^J$ must fall. Japan has a lower real wage in buying autos.

But because the price of shoes also falls, what do we know about the real wage in shoes $(w/p_s)^J$?

And we know that the price of capital rises in Japan, so $(r/p_s)^J$ rises; a higher capital income in buying shoes.

But the price of autos rises so what do we know about $(r/p_A)^J$?

Similar questions exist for China. How can we tell if labor and capital are better off or worse off?

Trade and absolute FPE

We can say something much stronger in the context of this model. In steps:

1. Free trade equalizes the prices of goods: $p_A^{J*} = p_A^{C*} = p_A^* \; and \; p_S^{J*} = p_S^{C*} = p_S^*$

2. This means free trade establishes relative FPE $(\frac{w}{r})^{J*} = (\frac{w}{r})^* = (\frac{w}{r})^{C*}$

3. But because factor prices determine capital-labor ratios in production these are also equalized (if both countries produce both S and A): $\left({}^{K_A}/_{L_A}\right)^{J*} = \left({}^{K_A}/_{L_A}\right)^{C*} and \left({}^{K_S}/_{L_S}\right)^{J*} = \left({}^{K_S}/_{L_S}\right)^{C*}$.

4. But this means the MP's are equal:

$$MPL_A^{J*} = MPL_A^{C*}; MPL_S^{J*} = MPL_S^{C*}; MPK_A^{J*} = MPK_A^{C*}; and \; MPK_S^{J*} = MPK_S^{C*}$$

5. But because the MP's give us real factor prices it follows that:

$$({}^{w}/_{p_A})^{J*} = MPL_A^{J*} = MPL_A^{C*} = ({}^{w}/_{p_A})^{C*}; ({}^{w}/_{p_S})^{J*} = MPL_S^{J*} = MPL_S^{C*} = ({}^{w}/_{p_S})^{C*}$$

$$({}^{r}/_{p_A})^{J*} = MPK_A^{J*} = MPK_A^{C*} = ({}^{r}/_{p_A})^{C*}; ({}^{r}/_{p_S})^{J*} = MPK_S^{J*} = MPK_S^{C*} = ({}^{r}/_{p_S})^{C*}$$

Trade and absolute FPE

REMARKABLE RESULT

What this outcome means is that *free trade generates identical real factor prices, or the same real living standards for both factors in both countries.*

This is called the absolute FPE theorem.

Note that if this outcome actually happened it would remove all incentives to migrate across borders.

Stolper-Samuelson theorem: trade and income distribution

To answer the earlier questions, we see now that the MPL in Japan falls in both goods, so both $(w/p_A)^J$ and $(w/p_S)^J$ fall in moving from autarky to free trade. Similarly, the MPK in Japan rises in both goods, so both $(r/p_A)^J$ and $(r/p_S)^J$ rise.

And in China, the MPL rises in both goods so both $(w/p_A)^C$ and $(w/p_S)^C$ are higher, while the MPK falls in both goods so both $(r/p_A)^C$ and $(r/p_S)^C$ go down.

(Recall that in autarky Japan had higher real wages in buying both goods and China had higher real returns to capital in buying both goods. Now they are equalized.)

So this must mean that the real wages of labor in terms of both goods fall in Japan and real returns to capital in terms of both goods fall in China as a result of free trade. Also real wages of labor rise in China and real returns to capital rise in Japan.

Put differently, free trade reduces the real income of the scarce factor and raises the real income of the abundant factor in both countries.

Stolper-Samuelson theorem: trade and income distribution

Stolper-Samuelson theorem: Let free trade equalize goods prices and let both countries produce both goods, with identical, CRS production functions. Then trade reduces the real income of the scarce factor and raises the real income of the abundant factor in terms of both goods.

So note what this means: we now have an explanation for trade in which opening up to trade redistributes income and creates winners (abundant factors) and losers (scarce factors).

So trade in goods implicitly arbitrages differences in factor endowments, effectively equalizing them by trading their services as embodied in goods.

Does this income redistribution mean economies lose from trade? No, for we already saw that trade raises real GDP. So this means the income gains to the abundant factors exceed income losses to the scarce factors and compensation could be paid in principle.

Context and comments

FPE is a powerful result. It basically says that if countries tend to export goods that intensively use their abundant factors and import the goods intensively using their scarce factors, there will be a global tendency toward equalization of real labor and capital incomes.

And Stolper-Samuelson is a powerful result. It says scarce factors lose from trade and abundant factors gain from trade.

We can explain this analysis a little more. Implicitly there is a *substitution principle*: trade in goods substitutes for trade in factors (because countries export implicitly their abundant factors and import implicitly their scarce factors through trade in goods).

So trade tends to drive factor prices in different countries together, just as would L and K migration directly (in principle).

Clicker question

In the factor-proportions (or HO) model, which of the following statements is FALSE?

A. Countries export the good that intensively uses their abundant factor.

B. Free trade in goods effectively substitutes for international labor and capital movements.

C. In each country the scarce factor gains higher real income and the abundant factor suffers lower real income.

D. If both countries produce both goods in free trade, both relative and absolute factor prices will be equalized between countries.

E. In autarky, the real wages of labor are higher in the capital-abundant country than in the labor-abundant country.

Brief comment on trade and migration policy

IMPLICATION: preventing labor and capital migration is not enough to protect the incomes of scarce factors. Free trade in goods will also reduce those incomes.

But if you raise barriers to imports (e.g., tariffs), that will prevent factor prices from moving together and set up incentives for factors to migrate.

So if you are worried about the distributional effects of cheap imports you might need both trade and migration barriers.

Example: consider the joint effects of barriers to labor immigration from Mexico and trade barriers on imports of L-intensive goods from Mexico. The tariffs on goods would reduce export prices in Mexico, lowering the real income of workers there (note this assumes that Mexico is labor-abundant). This would raise the incentives to migrate to the US. (Good example in early 2000s: import quotas on tomatoes from Mexico, which seemed to reduce Mexican wages and induce more illegal migration.)

Most trade economists think NAFTA has tended to raise real labor incomes in Mexico (a debated topic), which helps explain the reduced illegal immigration from there over time. More on this later.

Back to context on FPE and SS

There is considerable evidence to support these ideas, particularly when we consider trade between among rich, skill-abundant countries. There is also weaker evidence for FPE in trade among poor, labor-abundant countries.

But we should emphasize the very strong assumptions on which they are based. All of the following are necessary conditions for FPE and SS to hold.

- Perfectly competitive goods and factor markets (no monopolies or labor unions, no distortions).
- Homogeneous K and L that can move without cost between industries within the country.
- Free trade in goods actually equalizes prices of goods across countries. (But goods could be differentiated, monopolized, and there could be transport costs and tariffs.)
- Technologies must be identical and CRS. (If they are not CRS we can get different results. Suppose there are good with strong IRS, such as software, films, and airplanes. Bigger countries would produce more goods with IRS and would therefore have higher labor productivity and higher real wages.)

Back to context on FPE and SS

And the following must be true:

- Incomplete specialization: both countries produce both goods in free trade.

What if this were not true? Suppose that in our example Japan ends up producing only autos (it gets to the endpoint of its PPF in free trade) and no shoes. Let China produce both goods.

In this situation (follow this carefully):

1. All of Japan's K and L go to produce autos. But Japan's K/L endowment ratio is higher than China's because it is capital abundant. This means autos production in Japan is more capital-intensive than both autos and shoes production in China, even in free trade.

2. In turn, in free trade the real wages are higher in Japan than in China (and the real returns to capital are lower in Japan).

CRITICAL POINT:

Even in free trade, complete specialization in capital-intensive goods keeps the real wages of labor in Japan higher than they would be with FPE. If a country wishes to sustain high real wages it should invest in capital, skills, R&D, and infrastructure to avoid producing unskilled-labor-intensive goods.

Context: examples

Several countries have exceptionally high wages in part because they produce almost no labor-intensive, low-wage goods. (And the textiles and apparel they do produce are design-intensive and appeal to high-wage consumers.) Examples: Switzerland, Sweden, Finland, Singapore.

What do they produce primarily? Finance, design, technology, consulting, etc.

A tale of two cities

It's easier to make this point using US wages across cities.

	Mean hourly wage	Mean annual wages	Employment per 1,000 jobs
Florence SC			
◦ Sewing Machine Ops	$9.86	$20,090	3.0
◦ Software App Developers	$38.88	$80,870	0.5
Seattle WA			
◦ Sewing Machine Ops	$14.61	$30,390	1.1
◦ Software App Developers	$64.33	$133,810	29.1

Final point in factor-proportions model

What if countries experience changes in factor endowments? This issue is addressed by the

Rybczynski Theorem: Let goods and factor prices be held constant and suppose a country always produces both goods. Then a rise in one factor endowment will cause the country to produce more of the good intensive in that factor and less of the other good. (There is a shift in output mix).

Basic proof: Consider a rise in the K endowment in Japan, holding L fixed. If factor prices are constant then firms produce with unchanged K/L ratios (remain equally capital-intensive or labor-intensive) as the K endowment rises. Now a rise in the K endowment must favor output of A (autos) but for it to expand Japan must see the S (shoes) sector contract to free up the needed labor. Overall the output of A rises, output of S falls.

This means that as capital accumulates for a given labor force, the economy shifts its output toward K-intensive goods (PPF shifts toward that bias).

And this is why Japan's PPF is biased toward A and China's toward S. Japan has a higher K/L endowment ratio so its PPF favors A and China's favors S.

A key insight: Growth in relative endowments matters over time. Countries with high K investment rates will move production into more K-intensive goods. Same for investments in skills (Human Capital). Comparative advantage can change from L-intensive to K-intensive and Skill-intensive goods over time.