

# Heckscher-Ohlin model

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Some shortcomings of the models discussed so far

1. Ricardian model

- ▶ Only one factor
- ▶ Predicts complete specialisation

2. Specific factors model

- ▶ Only one mobile factor; short run model

The Hecksher-Ohlin (HO) model shares some similarities with the other models

1. It builds on the idea of comparative advantage
2. Production and trade patterns are based on factor endowments

The HO model is a long-run model focusing on the link between trade and income distribution. Some advantages

- ▶ Complex enough to account for various trade issues (eg. technology changes, tariffs)
- ▶ Offers clear testable predictions\*
- ▶ Can be analysed graphically

Besides focusing on the long term effects of trade, another main contribution of the model is the assumption that all factors are mobile without costs.

The HO model fits within a framework of four trade theorems.

## **Stolper-Samuelson**

*An increase in the relative price of a good will increase the relative remuneration of the factor which is intensively used in the production of this good and reduces the remuneration of the other factor.*

## **Rybczinski**

*For a given relative price, a higher endowment in one factor makes the production that uses this factor more intensively increase and the production that uses it less intensively decrease.*

## **Heckscher-Ohlin**

*Countries with relatively more of a resource will export goods for which that resource is more useful in production.*

## **Factor-price equalisation**

*Trade should cause resource prices to converge*

In the basic model we have

- ▶ Two countries: *Home*, *Foreign*
- ▶ Two goods:  $X$ ,  $Y$
- ▶ Two production factors: Labour  $L$  and capital  $K$

The HO-model is also known as the 2x2x2 model for obvious reasons.

The goods can be produced by a combination of labour and capital and production technology is assumed to be equal across countries. The model assumes an equilibrium in factor markets such that

$$L = L_x + L_y$$

$$K = K_x + K_y$$

Budget constraint is given by

$$I = wL + rK$$



There are a number of other assumptions

- ▶ Constant returns to scale, diminishing returns for one factor increase
- ▶ Production factors are mobile across sectors, static across countries
- ▶ Each country has a different factor endowment

Let *Home* be relatively richer in labour than capital compared to *Foreign*

$$\frac{L}{K} > \frac{L^*}{K^*}$$

*X* will be relatively more labour intensive.<sup>1</sup>

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<sup>1</sup>Productivity  $a_{ij}$  will depend on the relative factor prices  $\frac{w}{r}$ .

Analytically the advantage of the HO-model is that due to the inclusion of two production factors it can help explain why there is

1. Trade resistance
2. Incomplete specialisation

Two production factors implies that there will be decreasing returns to each factor.

- Increasing opportunity costs

Comparative advantage arises due to differences relative factor endowments

Let's start with a numerical example: A martini is produced mixing gin ( $G$ ) and vermouth ( $V$ ) and two different varieties can be produced

1. Regular martini with 2 parts gin and one part vermouth
2. Dry martini with 5 parts gin and one part vermouth

The prices of the regular martini  $p_m$  and dry martini  $p_d$  are fixed and you're given a supply of gin and vermouth.

- ▶ What are the prices of gin and vermouth?
- ▶ What is the output of regular and dry martinis?

To find the value for gin and vermouth we use the competitive prices of martinis. Let the price of gin be  $w_g$  and  $w_v$  for vermouth, in that case we have

$$p_m = \frac{2}{3}w_g + \frac{1}{3}w_v$$

$$p_d = \frac{5}{6}w_g + \frac{1}{6}w_v$$

Shuffling some terms around we get

$$w_g = 2p_d - p_m$$

$$w_v = 5p_m - 4p_d$$

Next we need to determine the output, deciding how to split the gin and vermouth for the production of regular and dry martinis. We have

$$V = \frac{1}{3}Q_m + \frac{1}{6}Q_d$$
$$G = \frac{2}{3}Q_m + \frac{5}{6}Q_d$$

So we get

$$Q_m = 5V - G$$

$$Q_d = 2G - 4V, \text{ if } Q_m > 0, Q_d > 0$$

Let's continue with an example considering an economy that produces two goods;

$$Clothes = CC(L_c, K_c)$$

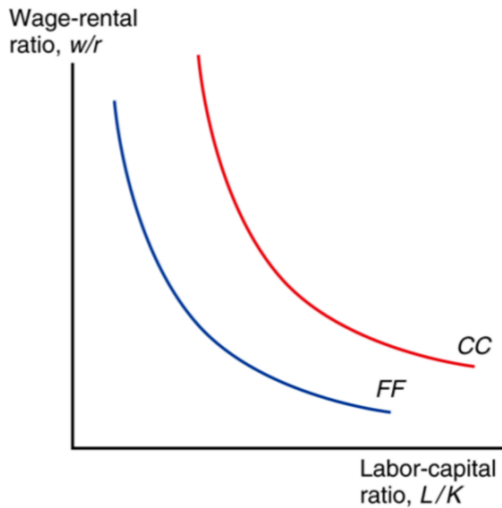
$$Food = FF(L_f, K_f)$$

The substitutability of  $\frac{L_c}{K_c}$ ;  $\frac{L_f}{K_f}$  are decreasing in  $\frac{w}{r}$ .

- ▶ At firm's optimum the opportunity costs equal the relative price of factors
- ▶ As factors are mobile across sectors, the opportunity costs are equalised

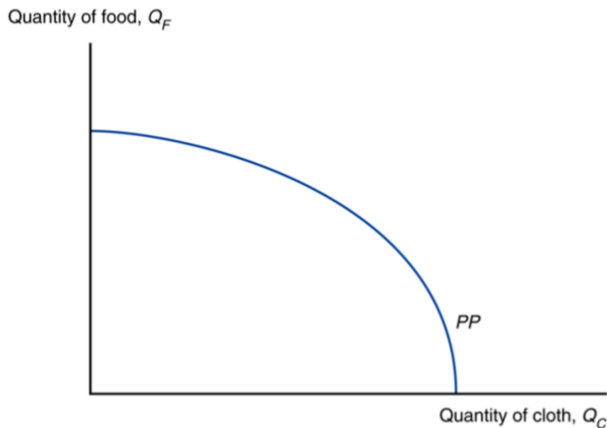
Let clothes be relatively labour intensive.

## Factor intensity





# PPF with factor substitution



The output price ratio is given by

$$\frac{p_c}{p_f} = \frac{MPL_f}{MPL_c} = \frac{MPK_f}{MPK_c}$$

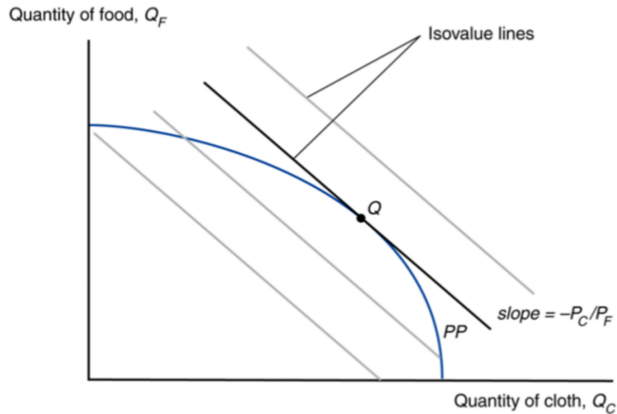
Production will be a given point on the PPF tangent to

$$-\frac{p_c}{p_f}$$

The economy will produce at a point that maximises the value of production  $V$

$$V = p_c Q_c + p_f Q_f$$

# Production function



Wage and capital rate are given by

$$\begin{aligned}w &= p_c \cdot MPL_c = p_f \cdot MPL_f \\r &= p_c \cdot MPK_c = p_f \cdot MPK_f\end{aligned}$$

Therefore, relative factor prices are given by

$$\frac{w}{r} = \frac{MPL_c}{MPK_c} = \frac{MPL_f}{MPK_f}$$

Production will be a given point on the PPF tangent to

$$-\frac{w}{r}$$

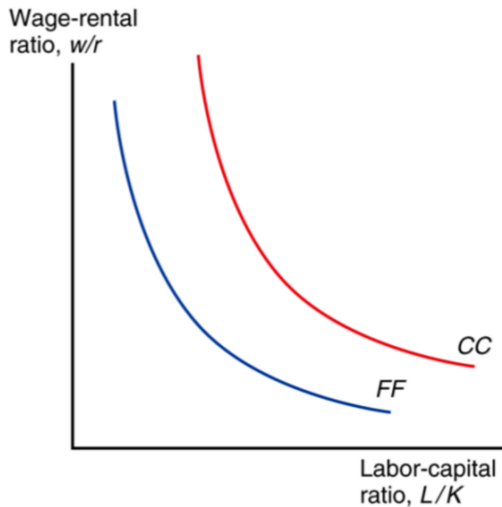
i.e. as  $w$  increases relative to  $r$  producers will use less labour and more capital

Concerning the mix of inputs we have that

$$\frac{a_{lc}}{a_{kc}} > \frac{a_{lf}}{a_{kf}}$$
$$\frac{L_c}{K_c} > \frac{L_f}{K_f}$$

i.e cloth production is relatively labour intensive whereas food production is relatively capital intensive.

## Recall factor intensity



With regard to resource use and production possibilities, let's assume a scenario where the economy's labour force grows. What will happen to

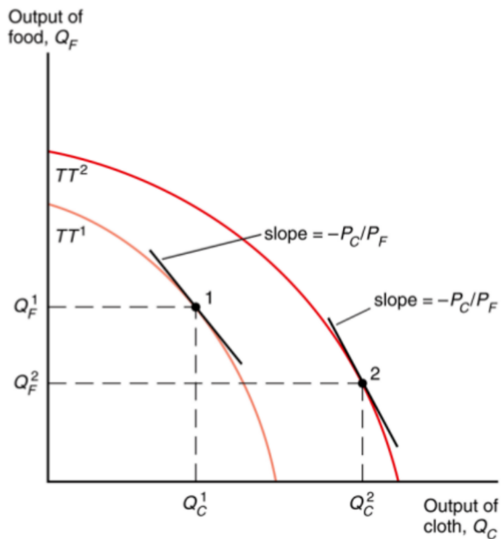
1. The labour to capital ratio?
2. Production possibilities
3. Ratio of labour to capital ratio used in both sectors

1. The labour to capital ratio will expand
2. Expansion of production possibilities is biased towards cloth, which is labour intensive
3. Ratio of labour to capital used remains constant given relative cloth price

So to employ the additional workers, the economy expand the production of the relatively labour intensive good and contracts the production of the relative capital intensive good.



# Resources and production possibilities



Prices are determined by

$$p_c = a_{lc} \cdot w + a_{kc} \cdot r$$

$$p_f = a_{lf} \cdot w + a_{kf} \cdot r$$

Under competition, the commodity price equals the production cost which depends on

- ▶ Wages paid to labour  $w$  and rents to capital  $r$
- ▶ Units of labour and capital used

Effect of change in  $w, r$  on production costs depends on mix of factors used.

- ▶ Change in  $\frac{w}{r}$  tied to changes in  $\frac{p_c}{p_f}$

## Stolper-Samuelson theorem

*An increase in the relative price of a good will increase the relative remuneration of the factor which is intensively used in the production of this good and reduces the remuneration of the other factor.*

i.e. a price change in output goods will hurt some input owners.

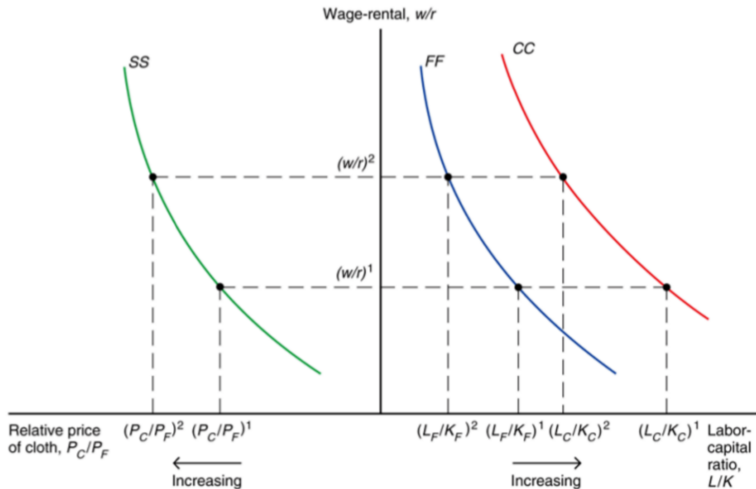
Theorem links input and output prices.

- ▶ Trade will change output prices: some people are hurt by trade

## Factor and commodity prices



# Commodity prices and input choices



Under the Stolper-Samuelson theorem, opening up to trade will lead to

1. Rise in real remuneration of relatively abundant factor
2. Fall in real remuneration of relative scarce factor

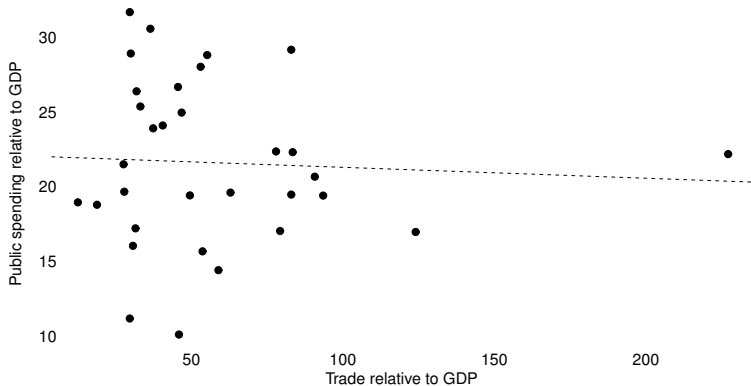
Therefore trade will create winners and losers.

- In our example *Home* capital owners and *Foreign* labourers won't be happy.

The government can implement policy such that losers can be compensated through fiscal transfers from winners.

# Compensating trade losers

source: OECD

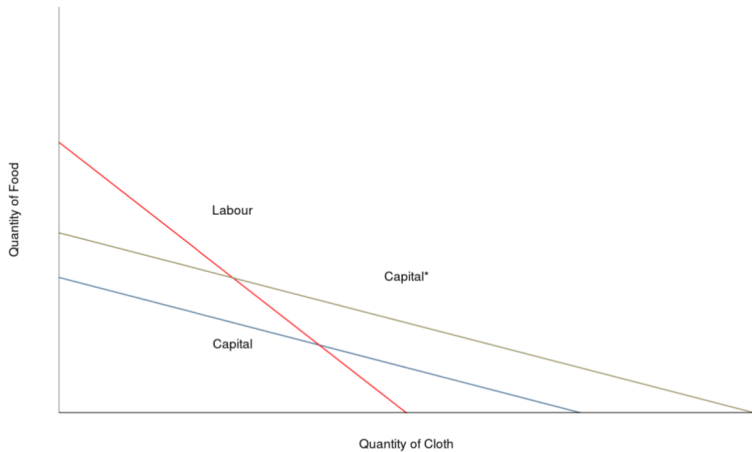


## Rybczynski theorem

*For a given relative price, a higher endowment in one factor makes the production that uses this factor more intensively increase and the production that uses it less intensively decrease.*



# An increase in capital

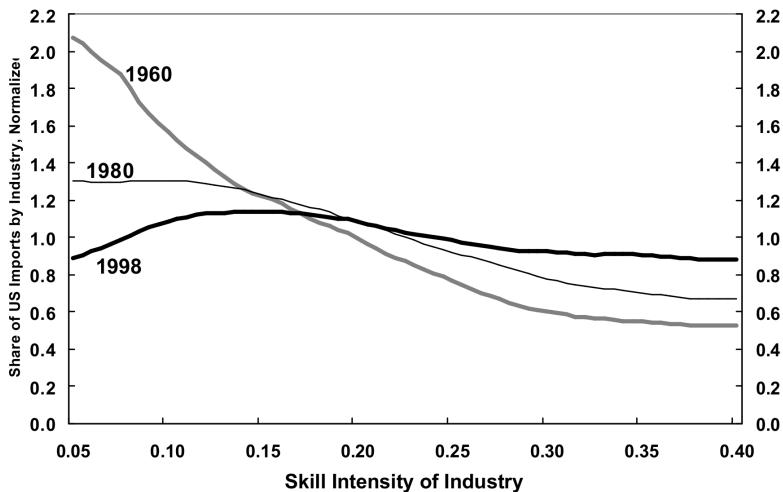


Following the Rybczynski theorem, the effect of the higher endowment on the trading economy depends on the size of the economy. For a small economy an increase in factor endowments is beneficial since it can lead to

1. Export-biased growth: can export/import more, and thus consume more
2. Import-substitution growth: can import/export less, but still consume more

Source: Romalis (2003)

**Figure 2: Rybczynski Effect for the Asian Miracle Economies\***  
**Combined US Import Shares 1960-1998**  
(\*Singapore, Hong Kong, Taiwan, Korea)



In contrast, for a large economy an increase in factor endowment could have adverse effects since prices are endogenous

- ▶ e.g. Brazil is a price-setter in the coffee industry

The deterioration of terms-of-trade through export-biased growth might offset the positive impact of the higher endowments. This effect of impoverishing growth can serve as a justification for import-substitution policies.

Concerning trade patterns recall that both countries have the same technology level, and *Home* is relatively labour abundant.

$$\frac{Q_c}{Q_f} > \frac{Q_c^*}{Q_f^*}$$

Therefore *Home* will export the relatively more labour intensive good. Consumption will depend on the output price and the equilibrium consumption ratio is given by

$$\frac{D_c}{D_f} = \frac{D_c^*}{D_f^*}$$

## **Heckscher-Ohlin theorem**

*Countries with relatively more of a resource will export goods for which that resource is more useful in production.*

i.e. more capital means exporting capital intensive goods, more labour means exporting more labour intensive goods.

The HO-model predicts convergence of relative prices following trade, similar to the Ricardian model.

The relative prices will change in favour of the abundant resource in each country. For example the price of cloth will

- ▶ Increase in the relatively labour abundant country
- ▶ Decrease in the relatively labour scarce country

# Convergence of relative prices





In our example model, opening up to trade will increase the relative price of cloth meaning that *Home*

- ▶ Will increase production and decrease consumption
- ▶ Become a cloth exporter and food importer

This also entails that *Foreign* will export food and import cloth.

Concerning factor price equalisation the HO-model predicts equalisation among countries that trade, in contrast with the Ricardian model.

1. Free trade equalises relative output prices
2. Stolper-Samuelson theorem links output and factor prices, so factor prices are equalised

Trade will also increase the price of relatively abundant factors as there is an increase in the demand for the goods produced by these factors.

According to the Heckscher-Ohlin model trade is likely to reduce global income inequality.

Consider two factors

1. Skilled labour
2. Unskilled labour

In this case trade liberalisation should lead to imports of goods intensive in unskilled labour in a skilled-labour abundant country.

- ▶ This leads to an increase in the relative price of goods intensive in unskilled labour
- ▶ And increases the returns to unskilled labour relative to skilled labour

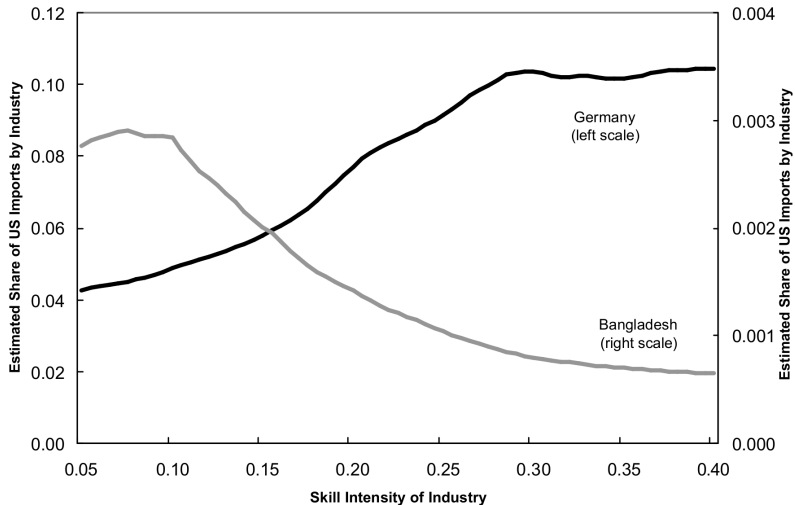
The result of this process is a reduction in wage inequality.<sup>2</sup>

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<sup>2</sup>Across countries.

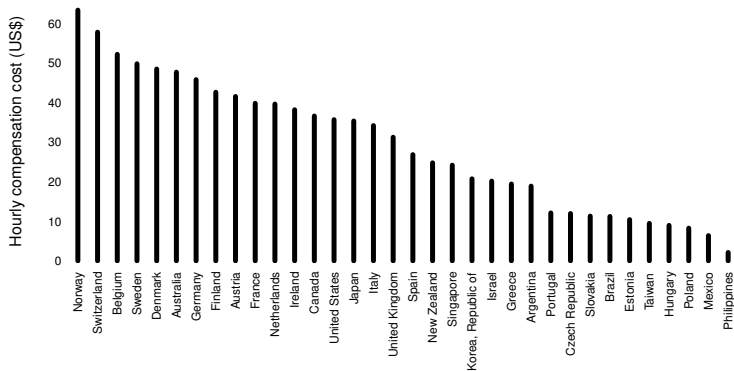
Source: Romalis (2003)

**Figure 1: Heckscher-Ohlin Effect for Germany and Bangladesh**  
**Skill Intensity and US Import Shares in 1998**



# Absence of wage equalisation across countries

source: US Bureau of Labor Statistics



# No Great Equalisation

source: Leamer (2007)

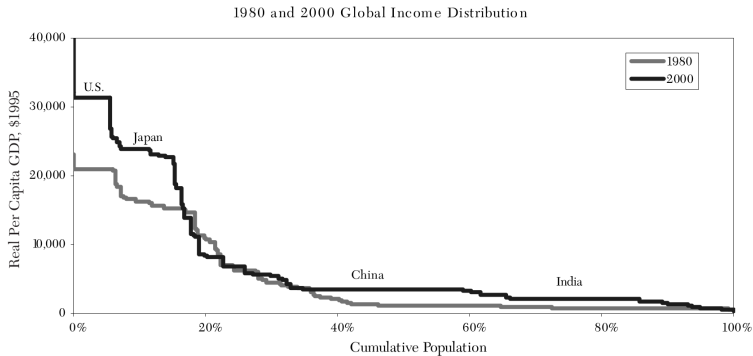


Figure 7. Global Labor Pools in 1980 and 2000

Opening up to trade we would expect to see wage equalise according to the factor price equalisation theorem. Why isn't this happening?

1. In real life free trade does not exist
2. Distortion through monopolies, labour unions, government policy
3. Constant returns to scale might not hold
4. Technologies are not the same across countries
5. Labour and capital are not homogenous

One advantage of the HO-model is that it is relatively straightforward to analyse graphically which can be done using the Lerner diagram.

- ▶ The diagram relates goods and factor prices for the HO-model

A distinguishing feature of this type of diagram, compared to the other diagrams that will be used, is that it used unit-value isoquants.



Let's start with a simple example of an economy with a single sector that produces good  $X$  using inputs  $K$  and  $L$

- ▶ We assume constant returns to scale.

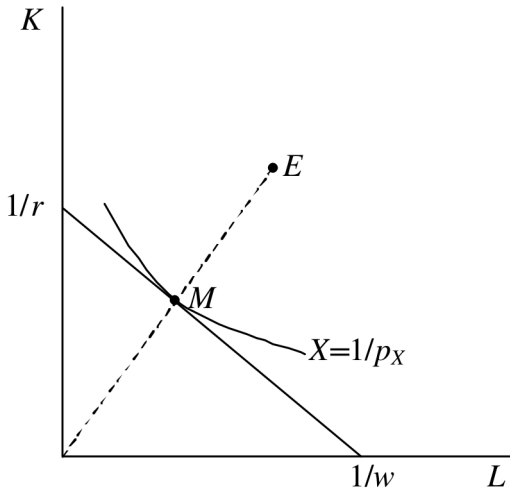
The diagrams in the next slides will show two lines

1. isocost line: combination of  $K$  and  $L$  that costs 1 euro
2. isoquant line: combination of  $K$  and  $L$  that produces 1 euro  $X$

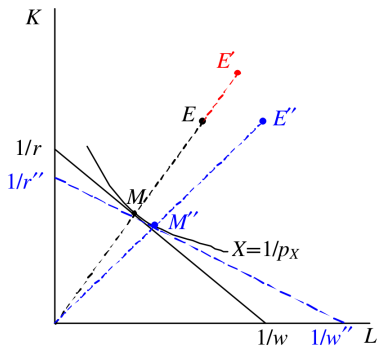
The unit-value isoquant and isocost are given by

$$X = \frac{1}{p_x}$$
$$rK + wL = 1$$

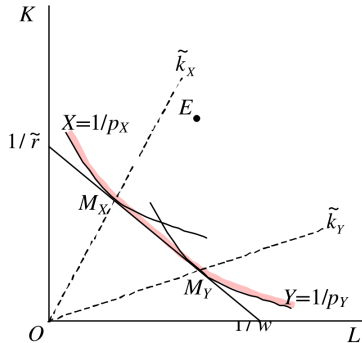
The country has endowments  $E$ .



We can change the endowment level proportionally  $E'$  or increase labour  $E''$



Let's consider an economy with two sectors,  $X$  and  $Y$ , with prices  $p_X$  and  $p_Y$ .

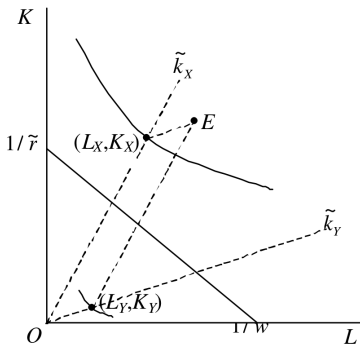


From the figure it follows that for factor endowments within the cone factor prices must be same. Consider two countries under free trade with

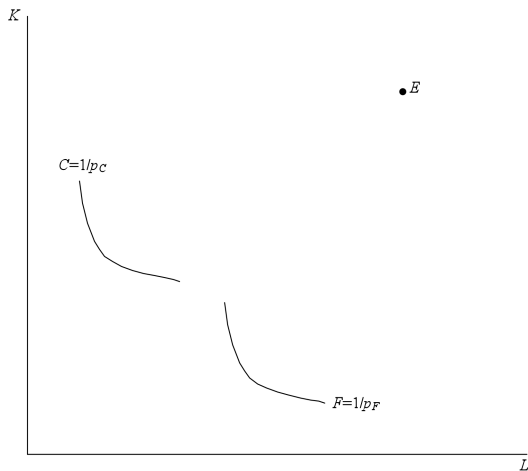
- ▶ The same technologies
- ▶ Similar endowment levels
- ▶ Facing the same world prices

They will end up in the same diversification cone, meaning that they have the same factor prices. This is the central message of the **factor price equalisation** theorem.

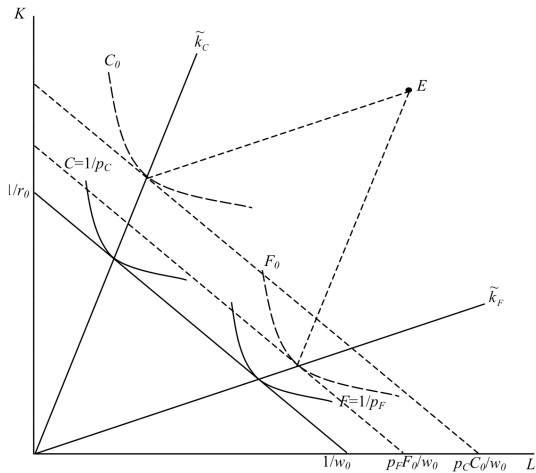
Can include the Edgeworth box in the diagram.



## Example: how to draw a Lerner diagram

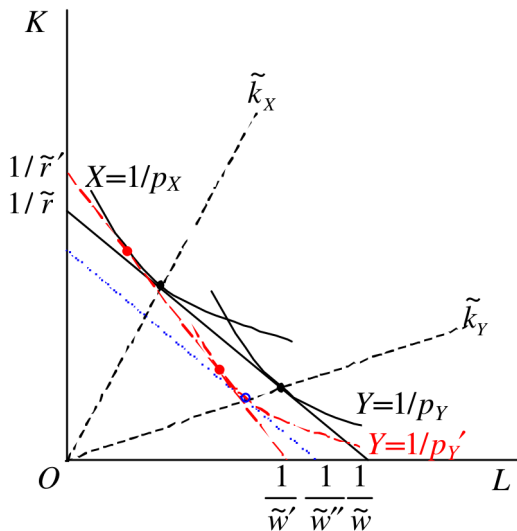


## Example: how to draw a Lerner diagram





# Stolper-Samuelson theorem



Summarising what is happening in the figure on the previous slide

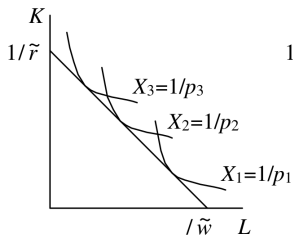
1. Increase  $p_y$  holding  $p_x$  constant
2.  $Y$  unit value isoquant will shift towards origin
3. Common tangent of  $X$ ,  $Y$  isoquant will become steeper (red dotted line);  $\frac{w}{r}$  increases
4. Nominal wage increases, nominal rent decreases
5. For real wage draw parallel isocost line tangent to new isoquant line which identifies wage  $\widetilde{w}''$  that changed by same percentage as  $p_y$
6. Given that  $\widetilde{w}' > \widetilde{w}''$  price increase causes a real wage increase

We can include more goods than factors in the HO-model and at least two types of equilibrium are possible

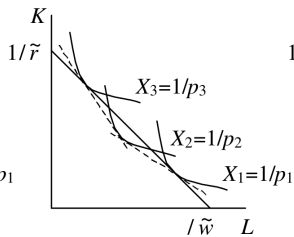
1. Simultaneous production of all goods
2. Production of some goods in some countries; possibly leading to complete specialisation

Which kind of equilibrium depends on the differences of factor endowment relative to factor intensity. Here we will consider a model with three goods and two factors.

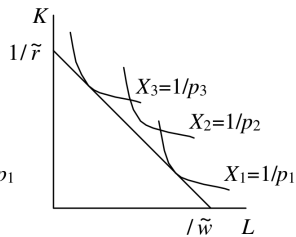
Case 1



Case 2



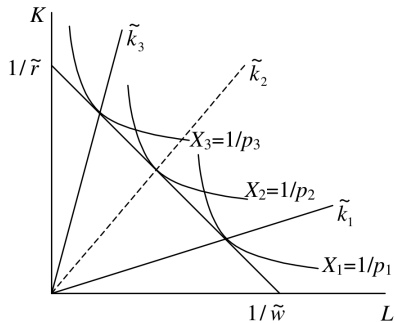
Case 3



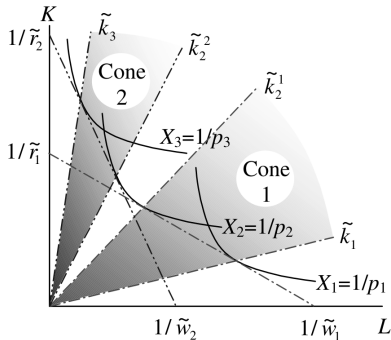
Case 1 and 2 present two different equilibria

1. Case 1 shows the wage and rental rates consistent with breaking-even in the production of all three goods
2. Case 2 is an equilibrium where at the given factor prices produces of  $X_2$  would make a profit
3. Case 3 shows a price for  $X_2$  which is inconsistent with the wage and rental rate
  - ▶ Production of  $X_2$  is not possible anywhere in the world under free trade

# Equilibrium case 1



## Equilibrium case 2



Cone 1 has a lower capital-to-labour ratio and lower wages.

A remaining question is "What determines whether world equilibrium will be one or two cones?"

To answer this we can use the concept of Integrated World Economy (IWE) by Dixit & Norman (1980)

- ▶ This is a hypothetical situation in which factors are mobile across countries, which would lead to FPE

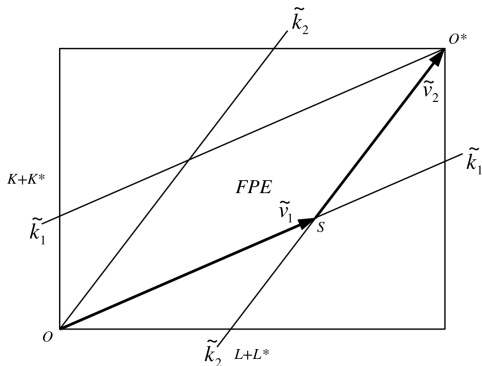
If production factors are confined to countries but there is FPE, the IWE production of goods could be replicated

- ▶ Resulting in a one-cone equilibrium

Two-cone equilibrium follows when there are two sets of factor price in the world.



## 2-Factor, 2-Good, 2-Country FPE

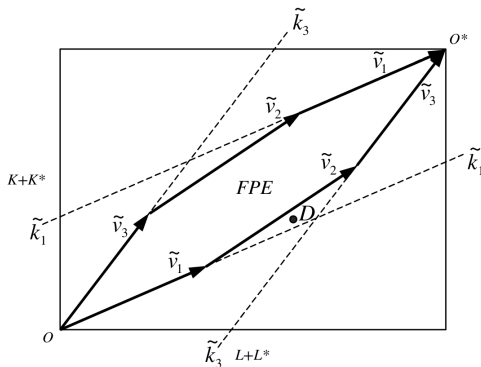


$\tilde{k}_1$  and  $\tilde{k}_2$  is capital employed in industry 1 and 2,  $S$  is world factor allocation.

Any point within the FPE parallelogram replicates the IWE with immobile factors.

The model can be expanded to include an additional good.<sup>3</sup>

2-Factor, 3-Good, 2-Country FPE



<sup>3</sup>Note that  $\tilde{k}_2$  is dropped as vectors  $v_i$  are strung together.  
NB - this won't be part of the exam.

The HO-model does have some shortcomings, mainly related to the model's assumptions

1. Proof of theorems requires that both countries produce both goods
  - ▶ Doesn't hold when factor prices are radically different
2. Assumption that technology is the same everywhere
  - ▶ Technological differences will affect factor productivity and thus returns to factors
3. Capital is static
4. Output goods have the same price everywhere

The model was formulated in 1933, and the assumptions may have been reasonable for that time but a poor reflection of the world nowadays.

Additionally the model ignores trade barriers and transport costs

- ▶ These may prevent output prices and factor prices equalising

This leads us to the **Leontief paradox**

*Country with higher capital to worker ratio has a lower capital to labour ratio in exports compared to imports*

Paradox named after Leontief how computed the input-output table for the 1947 US economy

- ▶ Used input-output matrix for commodity production
- ▶ Combined with matrix of direct factor inputs

Calculations were based on assumption that only final goods are traded.

One complication with the input-output data was that Leontief had only information on capital and labour inputs in the US.

- ▶ There was no information on the direct factor inputs for the goods that the USA imported from the RoW

To deal with this he used the HO-model assumption that all countries

- ▶ Have access to the same technology
- ▶ Face the same factor prices

He found the following capital to labour ratios (in USD per person-year)

$$\text{Imports} : \frac{K}{L} = 18.200$$

$$\text{Exports} : \frac{K}{L} = 13.700$$

i.e. exports were more labour intensive than imports; this is a bit of a surprise given that the USA was the most capital abundant country at the time. This also contradicts the trade pattern prediction of the HO-model.

Leamer (1980) pointed out that Leontief's application of HO theory was wrong if

1. Trade is unbalanced
2. There are more than two factors in the world



There are additional explanations for the Leontief paradox

1. Free trade lowers income of relatively scarce factor: provides lobby incentive
2. Consumption preferences
3. Production technologies are not identical across countries

Empirically there seems to be a lot of missing trade considering global factor endowments

- ▶ Western industrialised countries are relatively capital abundant, but have small labour shares
- ▶ Countries in the global South have plenty of labour, but not so much capital

Would expect to see large trade flows between these parts of the world, but there is relatively little trade between developing and industrialised countries, which could be due to

1. Cross-country differences in technology
2. Home bias in consumption