ARE 202: Welfare: tools and applications
Spring 2018

Thibault FALLY

Lecture notes 06 – Welfare in two-sector trade models

Welfare and Trade

Questions to tackle:

- Why do countries trade?
- Do countries gain from trade?
- What determines the magnitude of the gains? ("Terms of trade")
- What are the sources of the gains from trade?
- Within a country: winners and losers?
- Effect of a change in factor supply? (e.g. migration and FDI)

Simple standard two-sector models can already provide lots of answers

Why countries trade? Many explanations

1) Differences in technology → Ricardo

2) Differences in endowments → Heckscher-Ohlin

3) Increasing returns to scale → Krugman, Melitz

And others

4) Differences in tastes

5) Distortions (e.g. taxes, subsidies, imperfect competition)

Two-sector Trade models

1) Simple Ricardian model to illustrate:
   - Comparative advantage
   - Welfare gains from trade
   - Terms of trade effects

2) 2x2x2 Heckscher-Ohlin model:
   - Factor price equalization
   - Stolper Samuelson: Unequal gains from trade
   - Rybczynski theorem

3) Problem set #5: Krugman model
   - Gains from product varieties & returns to scale

Ricardo. A two-sector model

- 2 sectors $i = 1, 2$
- 1 factor: labor

Labor mobile across industries (not countries),
Perfect competition

a_i denotes the labor needed to produce one unit of good i

Let $p = p1/p2$ be the relative price of good 1 in autarky (good 2 is the numeraire)

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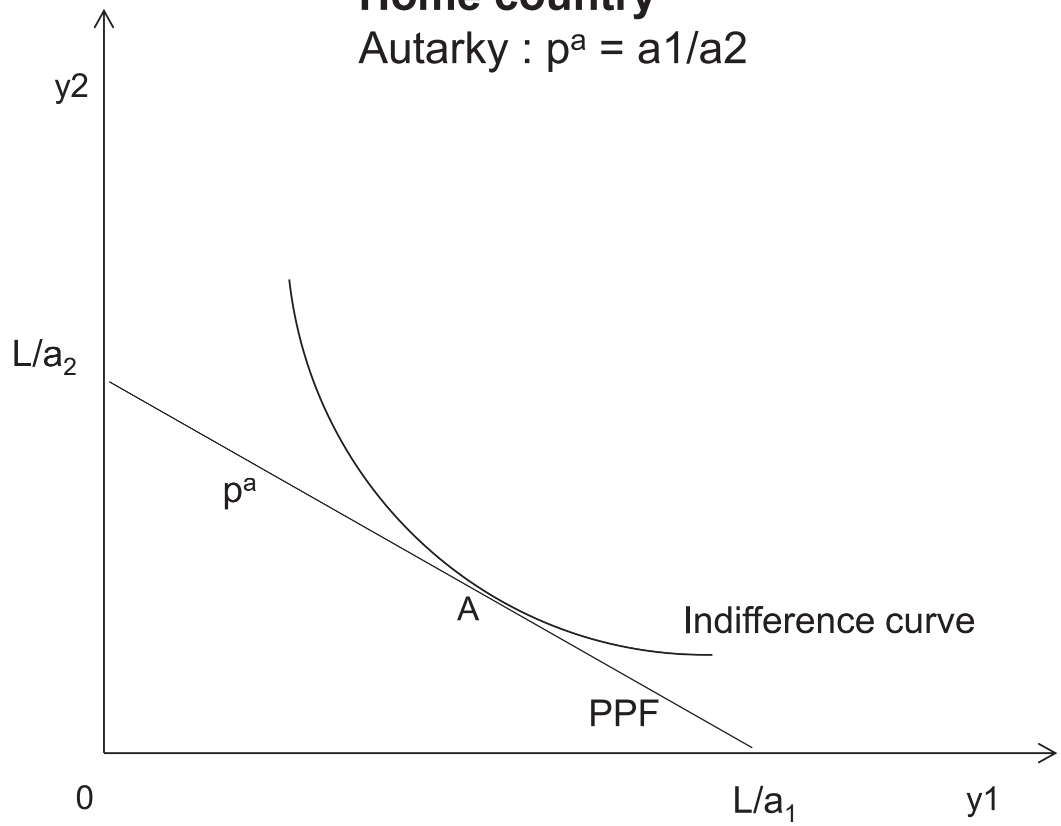
Let $p = p1/p2$ be the relative price of good 1 in autarky (good 2 is the numeraire)

Under autarky we obtain $p^a = a1/a2$

Home country
Autarky : $p^a = a1/a2$



Foreign country:

a^*_i denotes the labor needed to produce one unit of good i

Under autarky we obtain $p^{a*} = a^*1/a^*2$

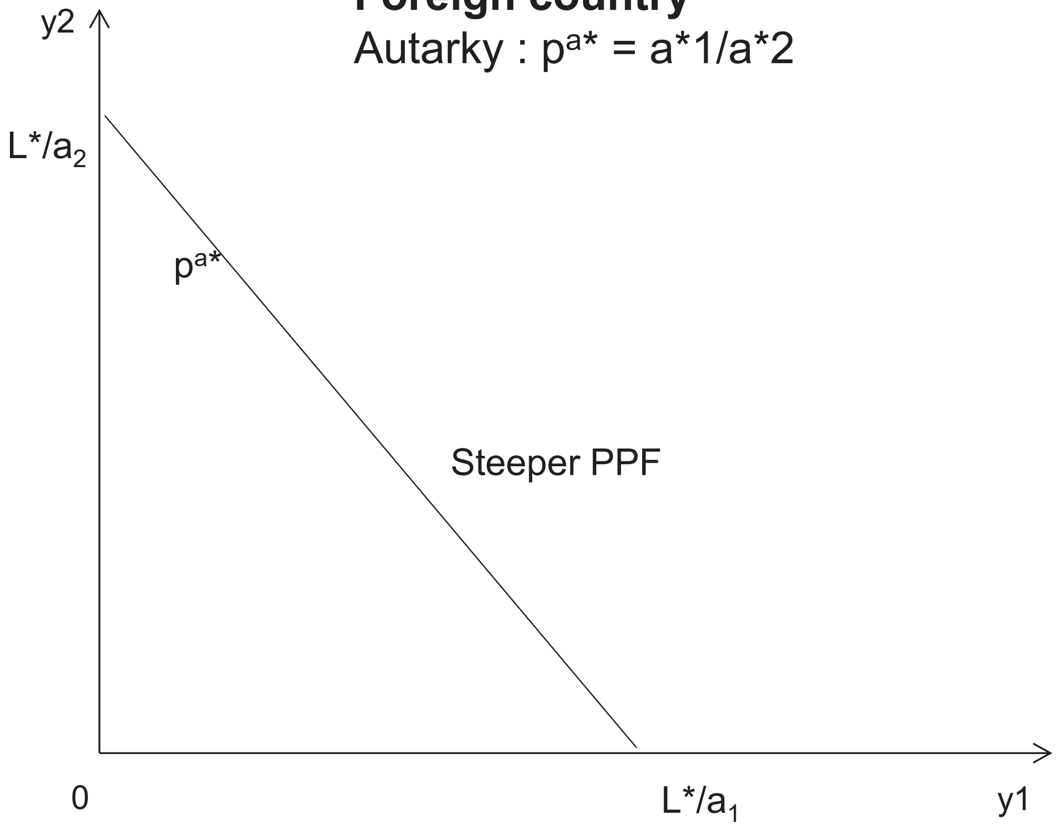
We suppose that the home country has a ***comparative advantage*** in producing good 1, which means:

$a1/a2 < a^*1/a^*2$

Consequence: $p^a < p^{a*}$
The relative price of good 1 is lower at home

Foreign country

Autarky : $p^{a*} = a^*1/a^*2$



Foreign country

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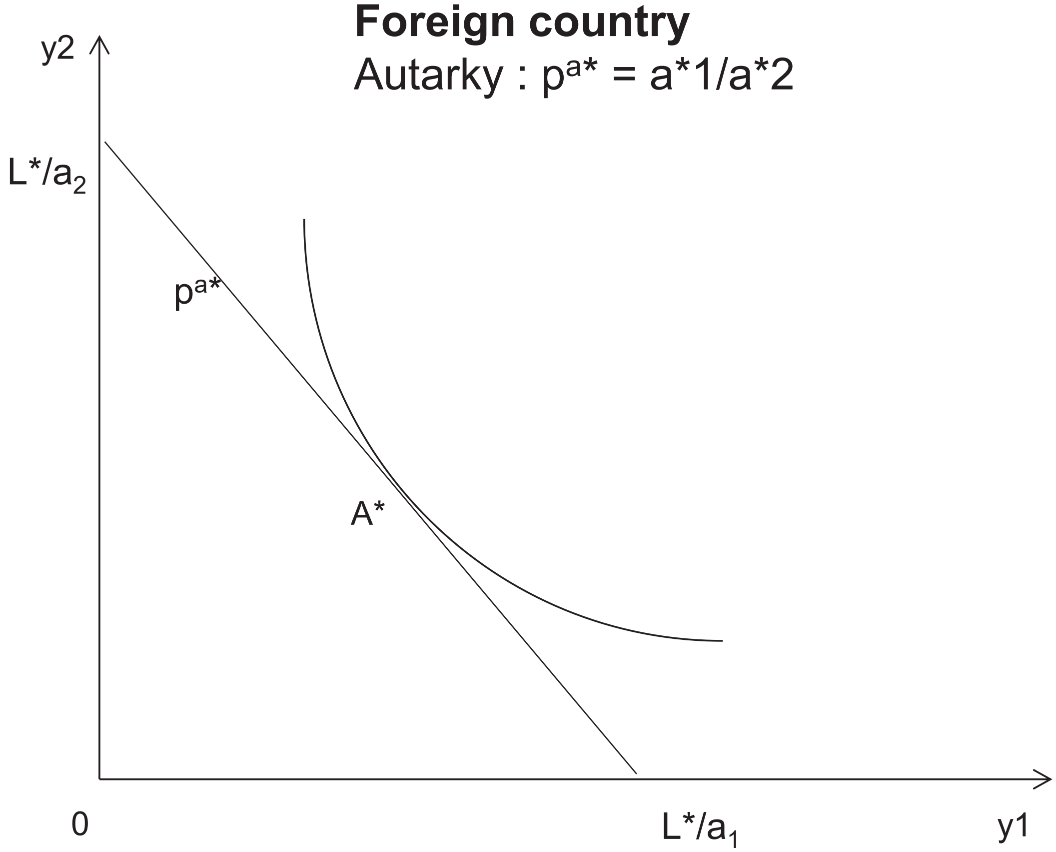
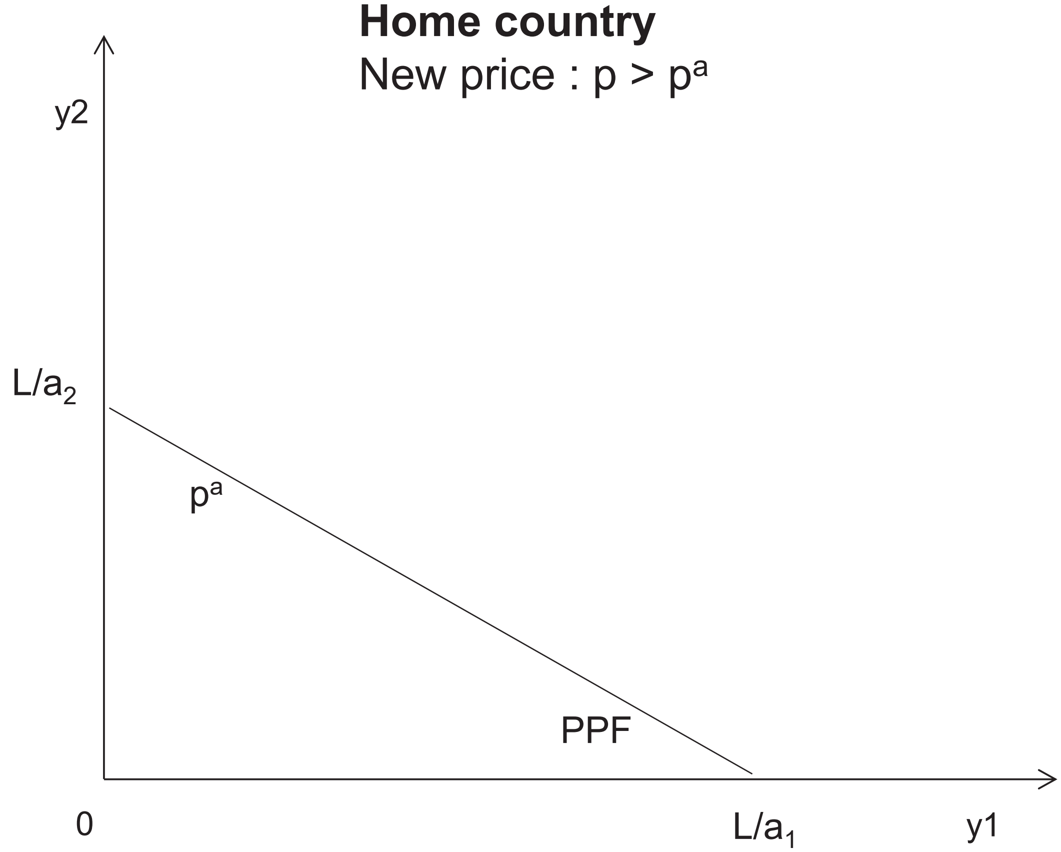


What happens if both countries open to international trade?

If p is below p^a then all countries specialize in good 2
If p is above p^{a*} then all countries specialize in good 1

If p is strictly between p^a and p^{a*}:
-Home country specializes in good 1
-Foreign country specializes in good 2

Home country
New price : $p > p^a$



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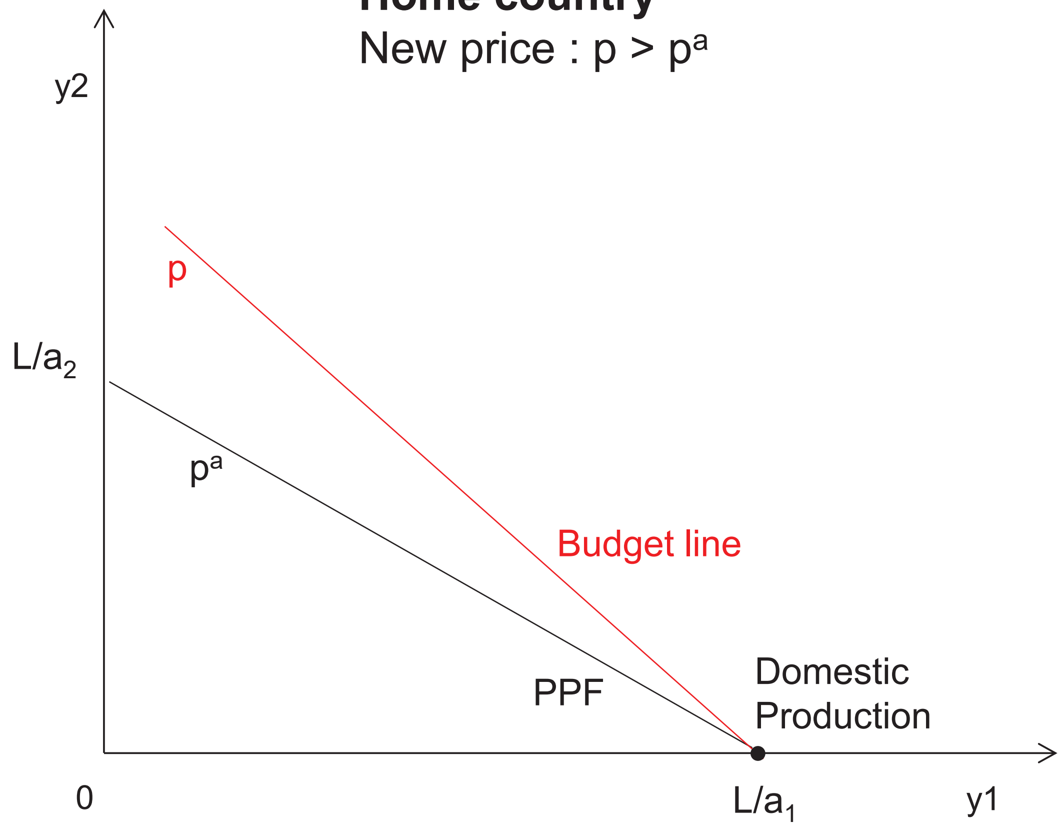

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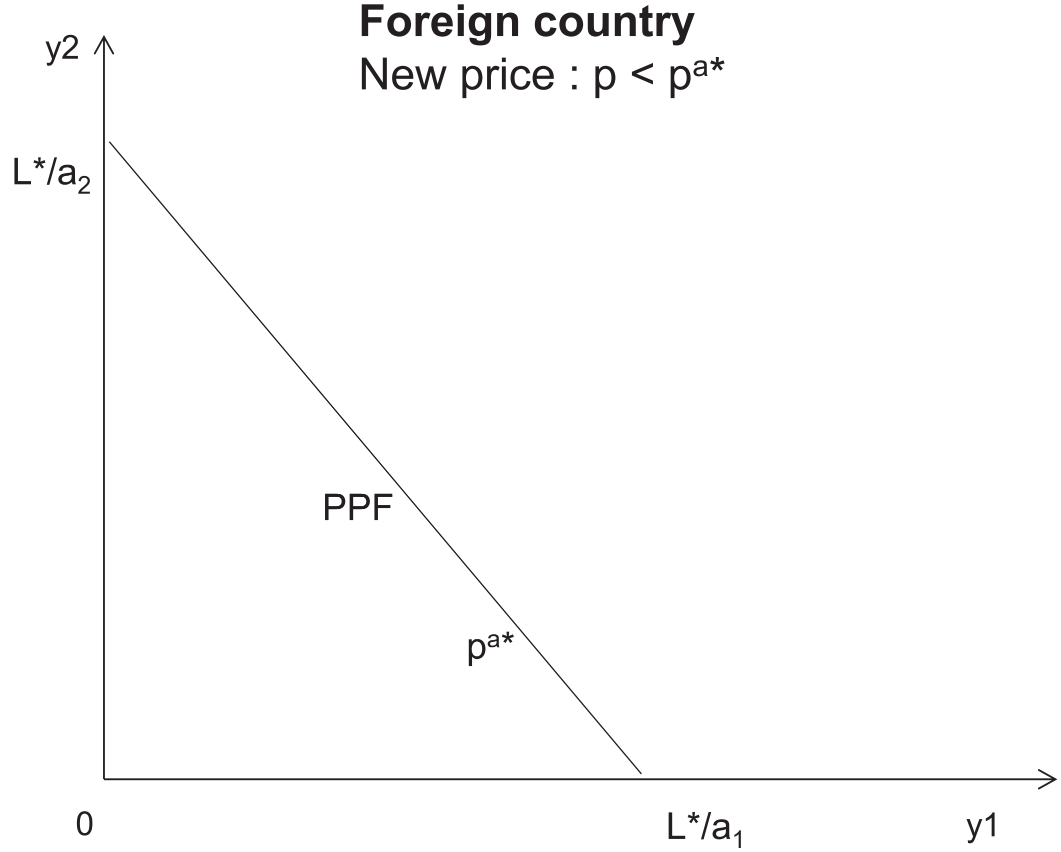

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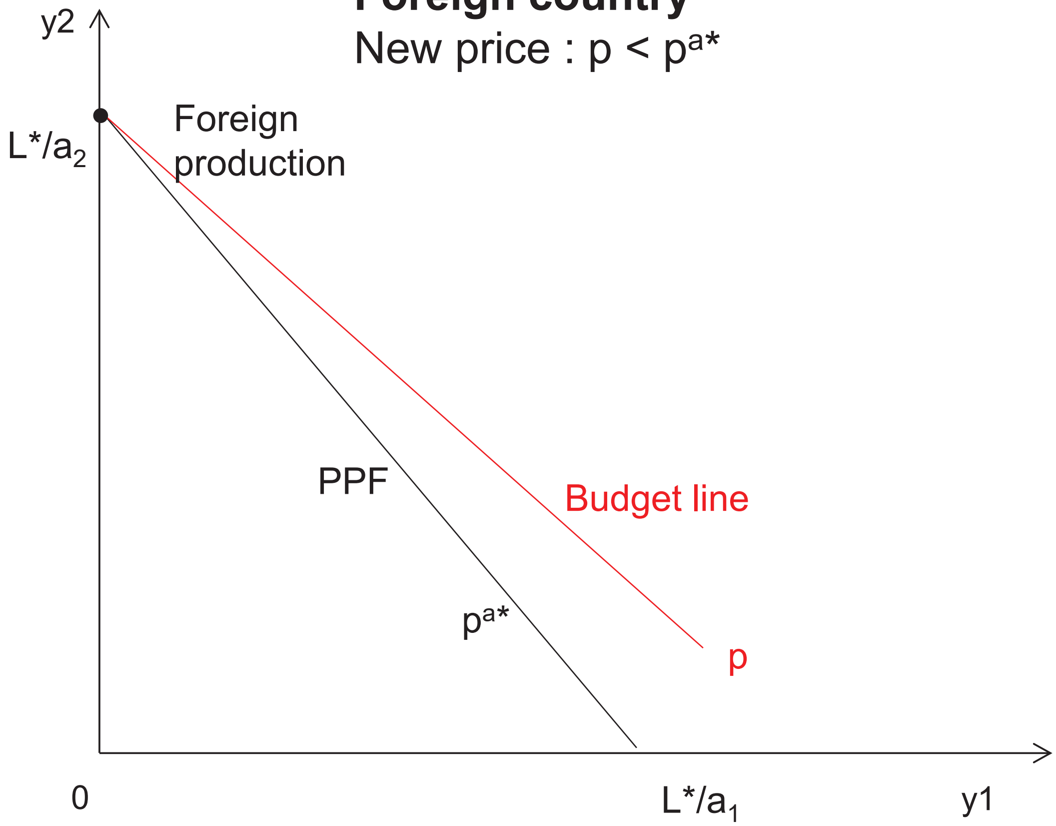


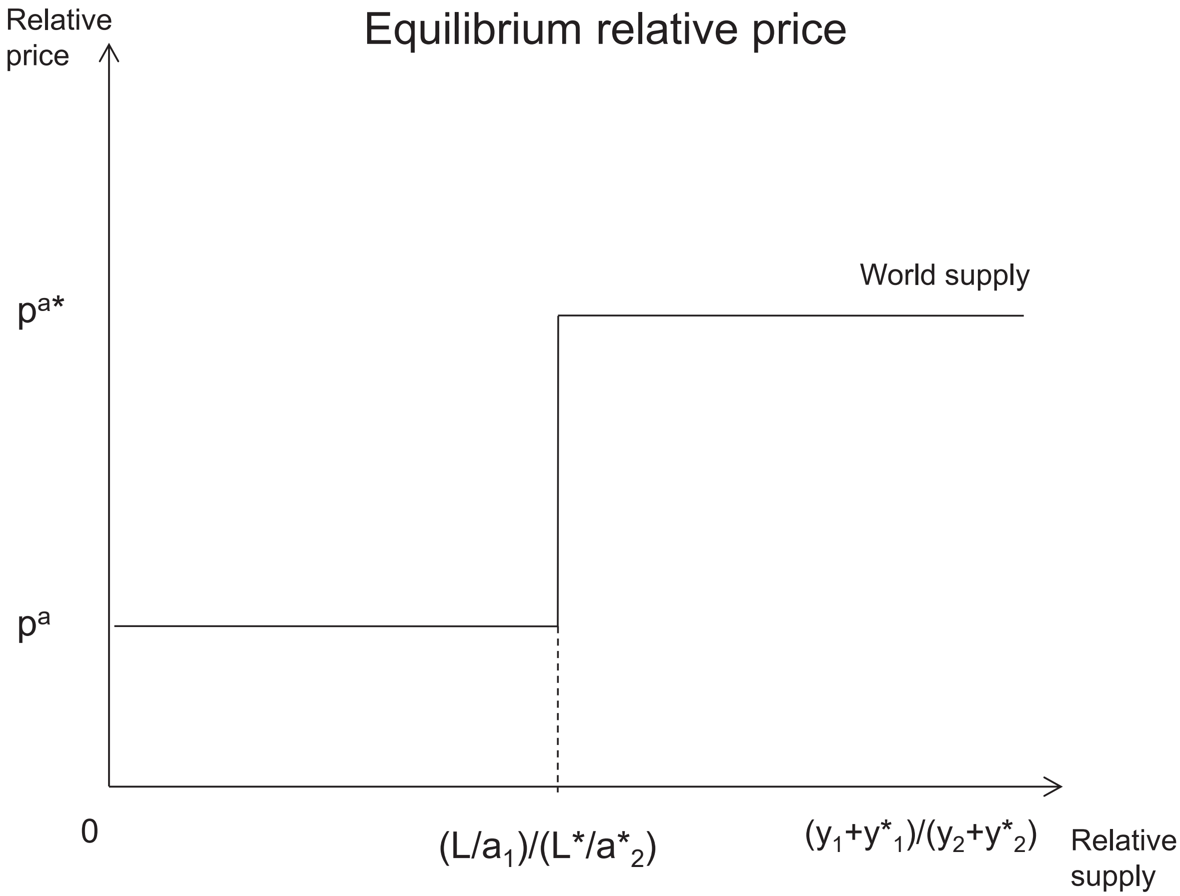
Aggregate supply curve

- If p is strictly between p^a and p^{a*}:
  - Home country produces amount (L/a_1) of good 1
  - Home country produces amount L^*/a_2^* of good 2

→ Relative supply of good 1 equals $(L/a_1)/(L^*/a_2^*)$

- If p is strictly below p^a: no supply of good 1
- If p is strictly above p^{a*}: no supply of good 2

Equilibrium relative price



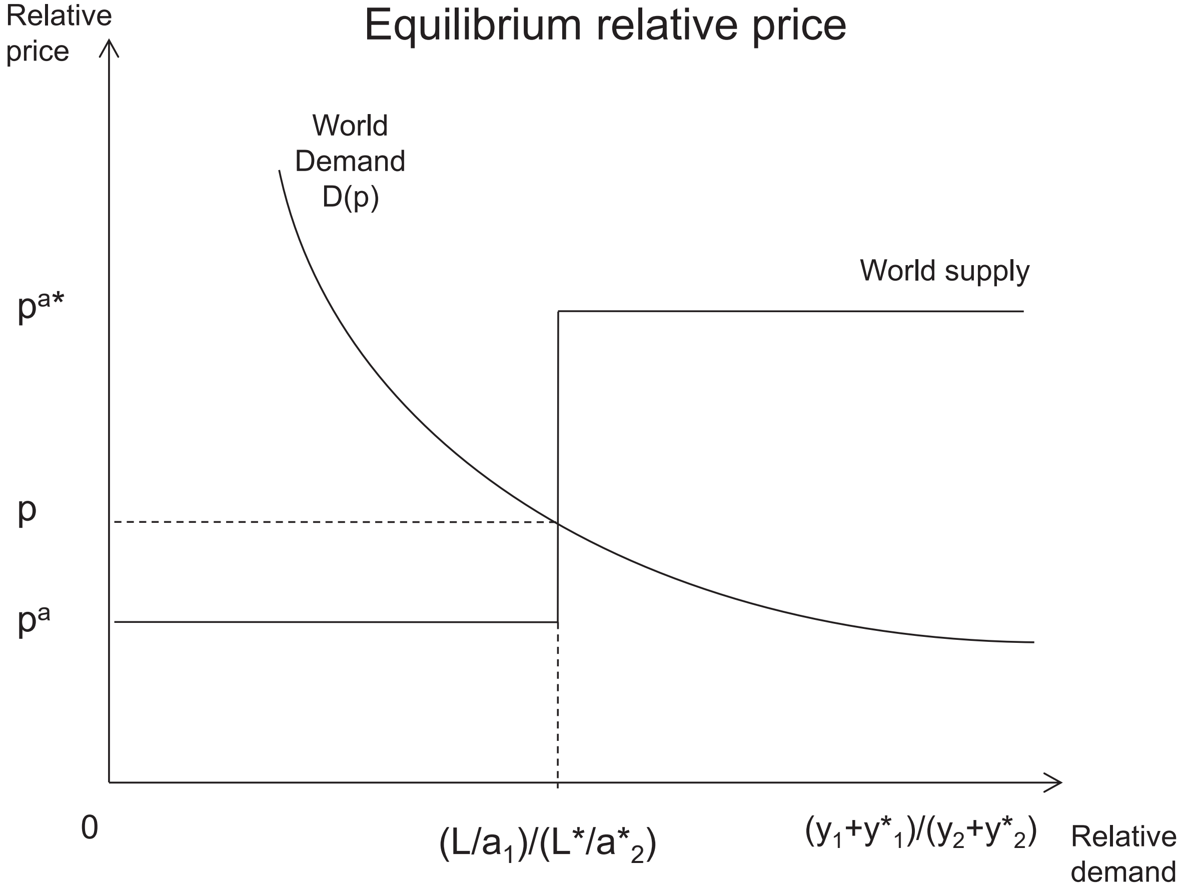
Aggregate demand curve

- Assume identical and homothetic preferences

- Demand for good 1: $Y_1 = (E+E^*).y_1(p_1,p_2)$
- Demand for good 1: $Y_2 = (E+E^*).y_2(p_1,p_2)$
  (homogeneous of degree -1 in prices)

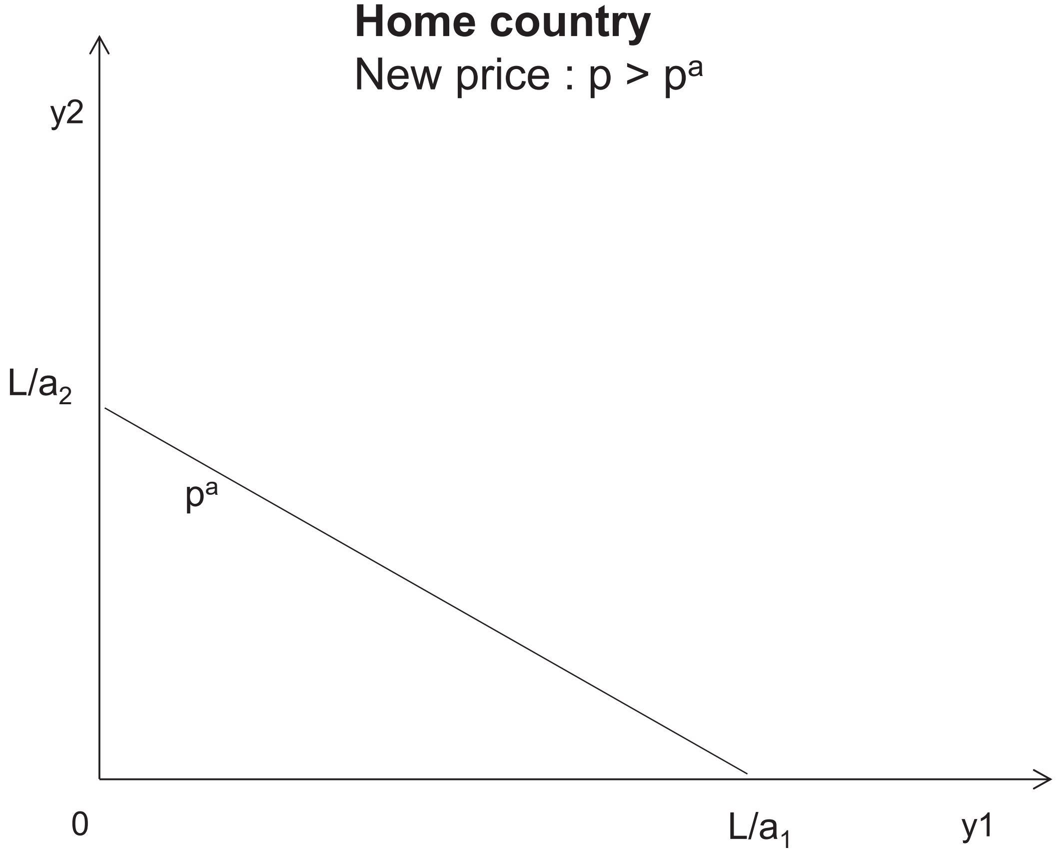
→ Demand for good 1 relative to good 2: D(p)
  (independent of E and E*)

Equilibrium relative price



Home country

New price : $p > p^a$



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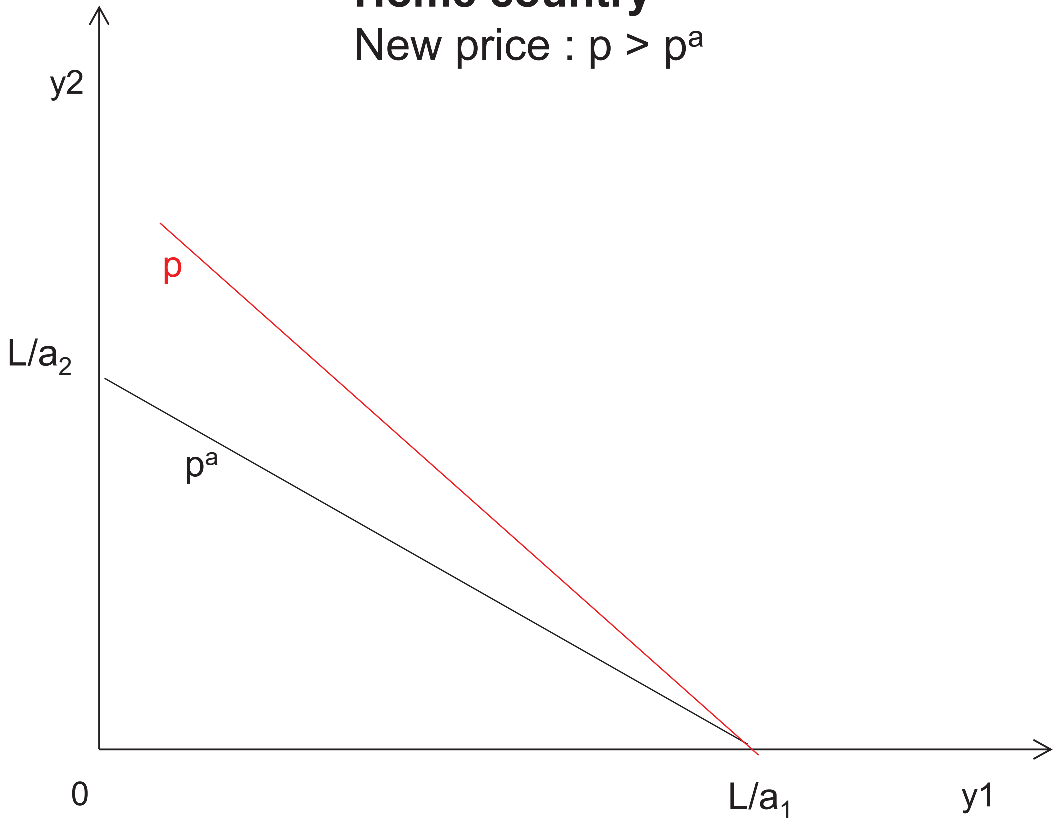

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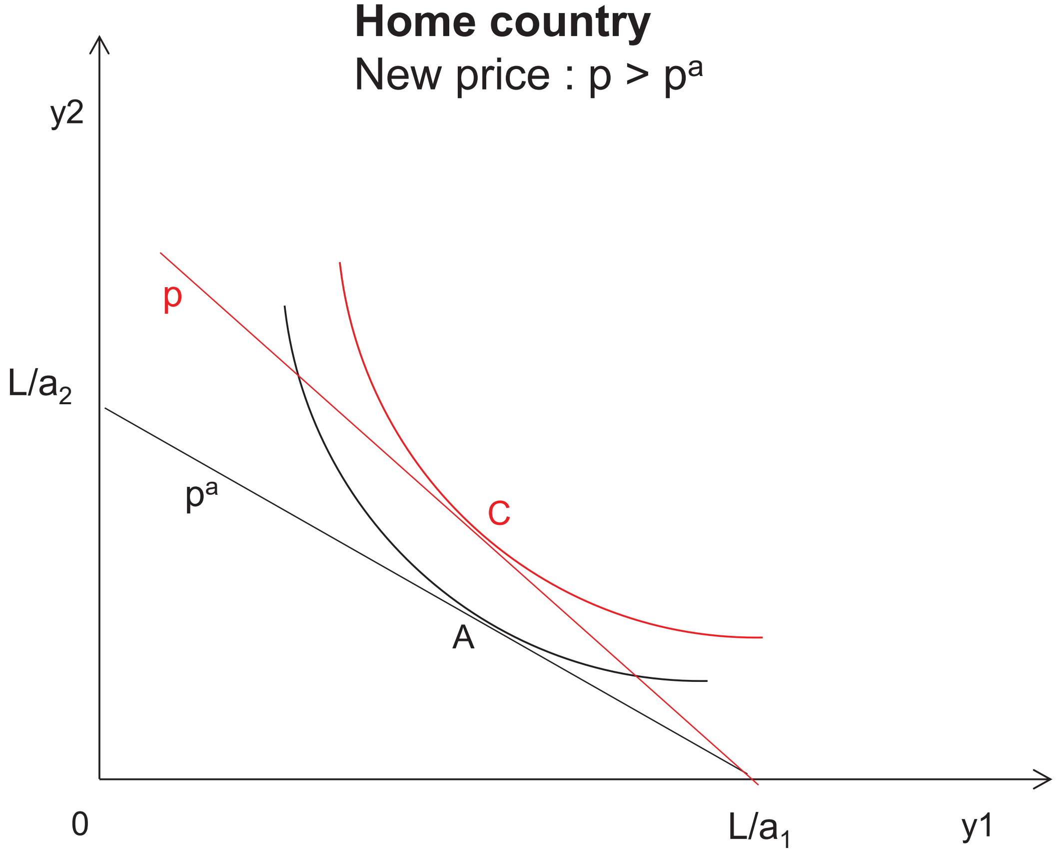
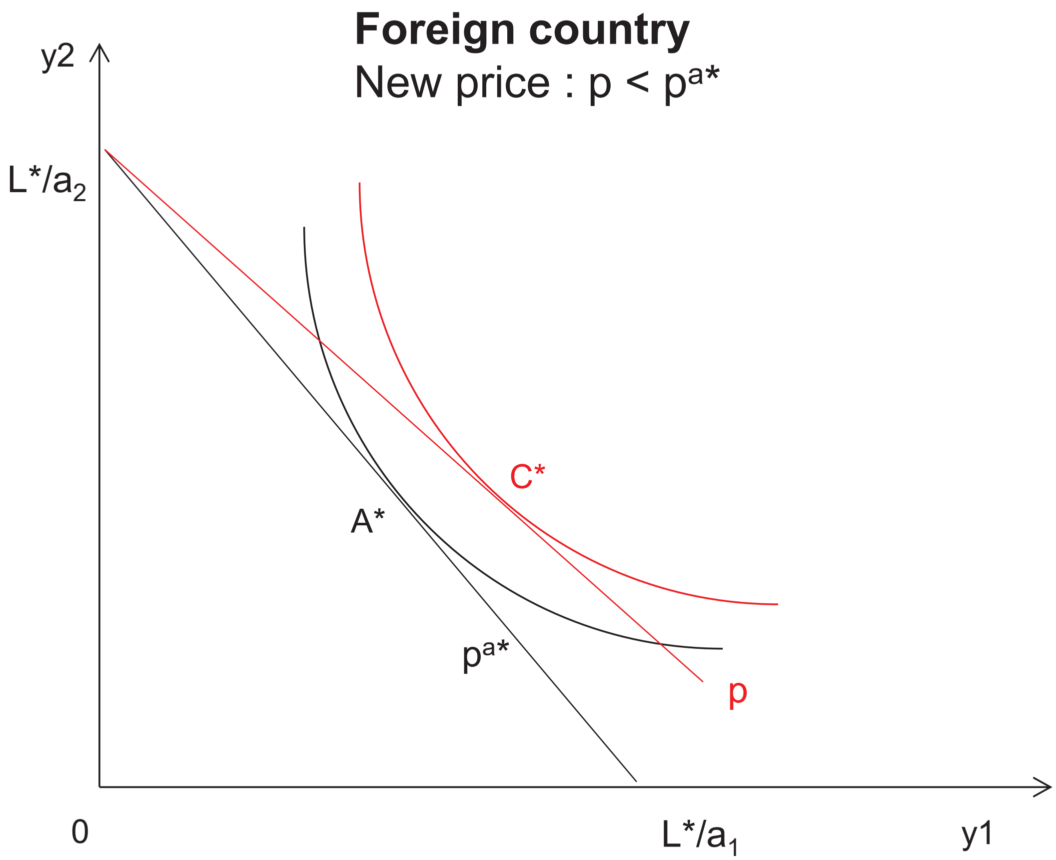




Welfare implications:

• As equilibrium consumptions C and C* are both above equilibrium consumption points A and A*:

➔ trade improve welfare in both countries

Trade patterns:

• Comparative advantage (whether a1/a2 is larger than a*1/a*2) determines the direction of trade

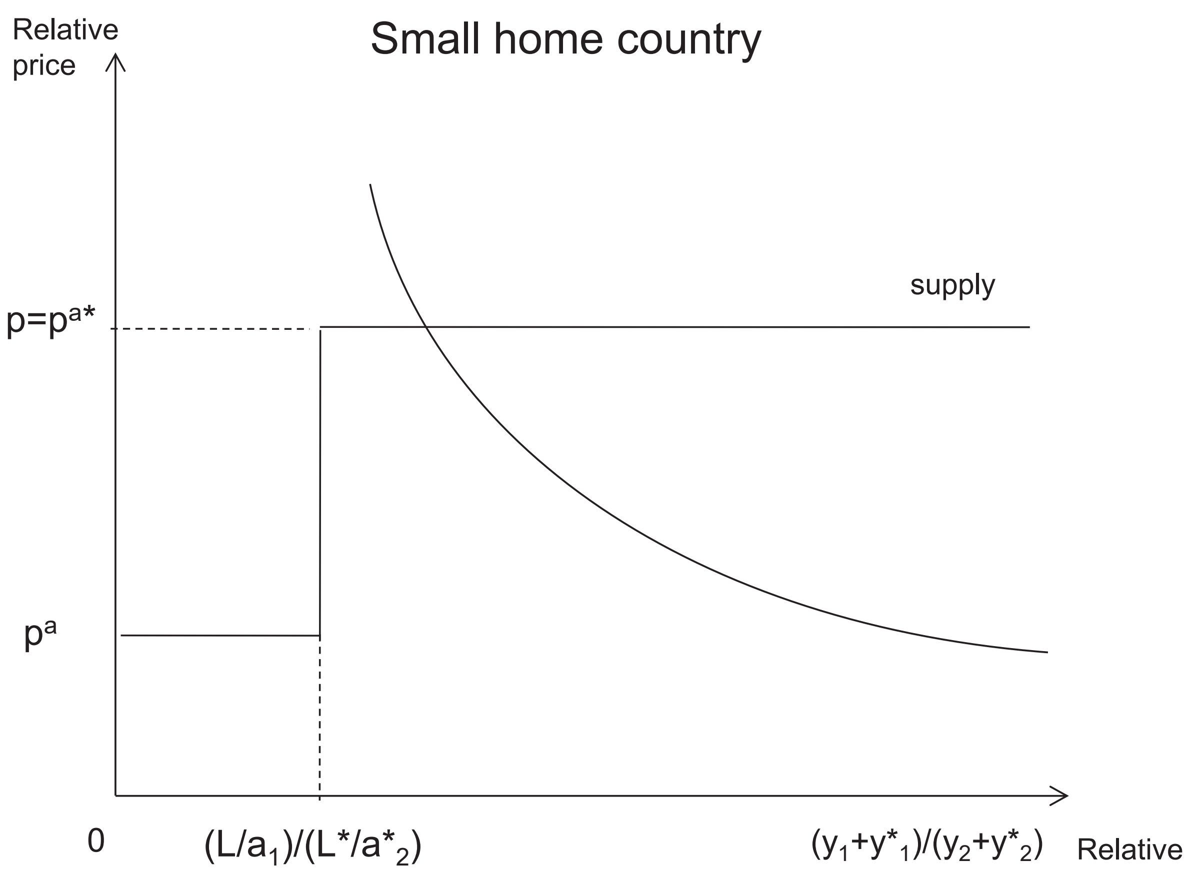
• At equilibrium, trade does not depend on absolute advantage (whether a_i is larger than a_i^*)

Terms of trade effects

- Which country gains the most?

- What happens when the foreign country becomes larger?

- What happens when the foreign country becomes more productive?



Terms of trade effects

- Which country gains the most?

  → *Small country gains most, large country less*

- What happens when the foreign country becomes larger?

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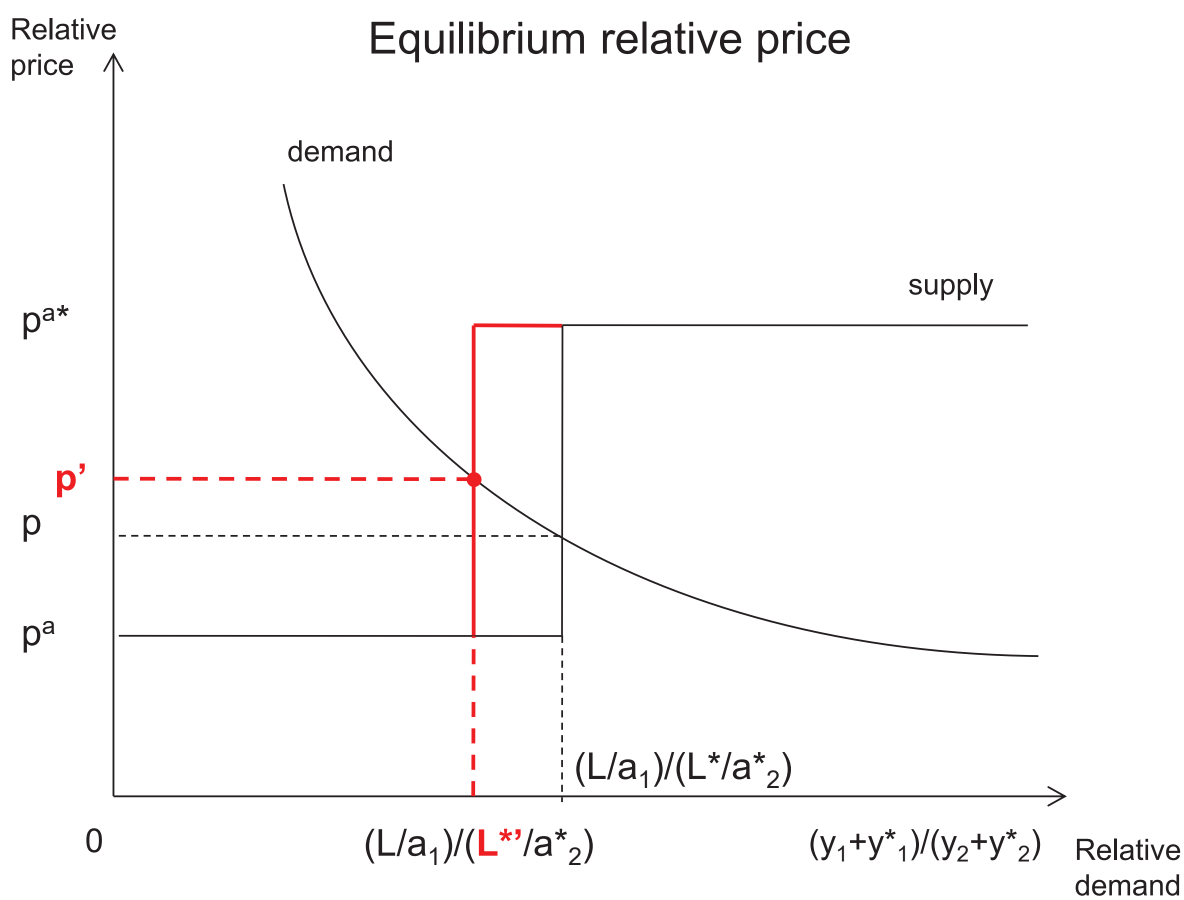
Equilibrium relative price



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  → *Home country welfare increases,*
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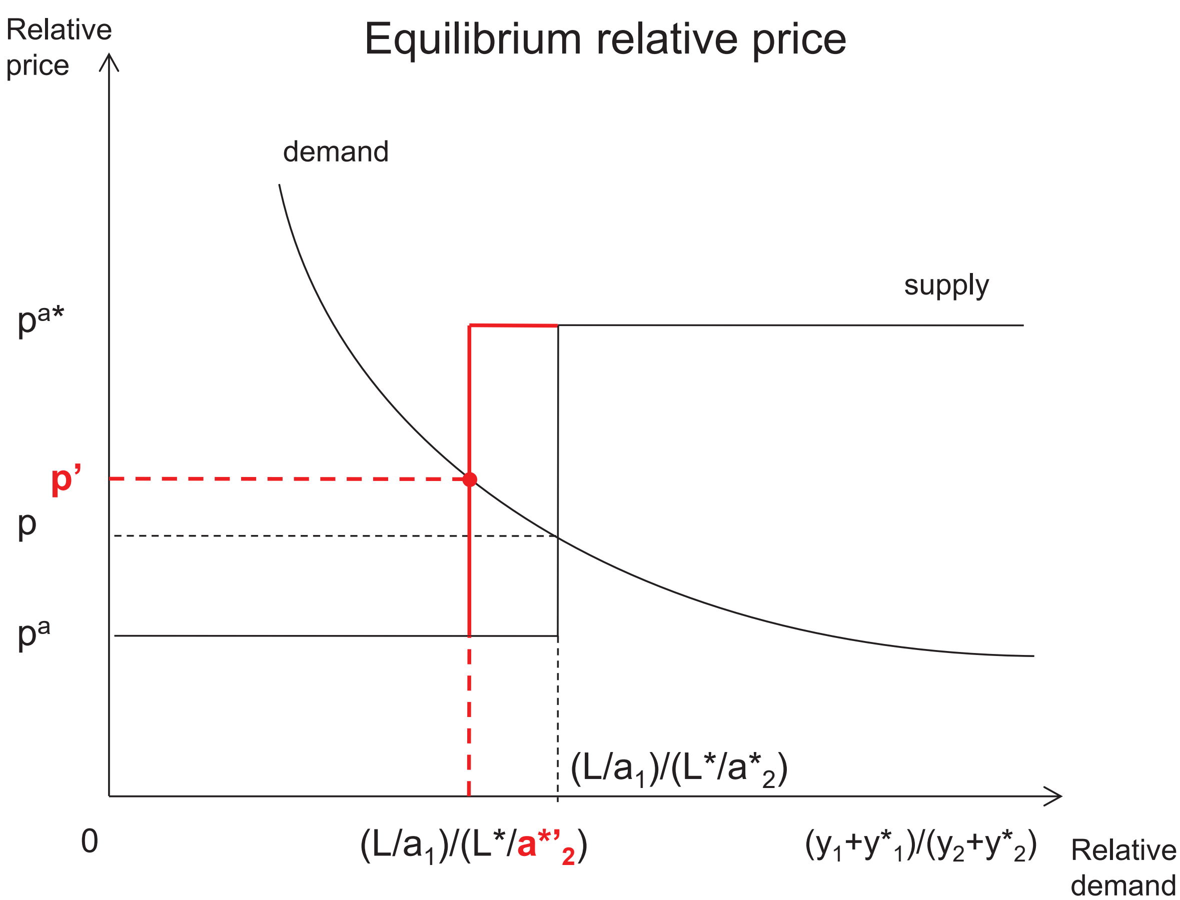
Equilibrium relative price



Terms of trade effects

• Which country gains the most?

→ *Small country gains most, large country less*

• What happens when the foreign country becomes larger?

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Foreign country's welfare decreases

• What happens when the foreign country becomes more productive?

→ *Home country welfare increases,*
(ambiguous impact on Foreign country's welfare)

Conclusions:

1. Trade improves welfare

2. Patterns of trade determined by comparative advantage

3. Terms of trade effects: gains from larger foreign partner

Next:

• From Ricardo to Heckscher-Ohlin:
  – H-O model endogenizes comparative advantage depending on factor endowments
  – Does not assume differences in technology
  – Illustrates how to account for adjustments on factor markets

Two-sector models

1) Ricardo

2) Now: Heckscher-Ohlin model:

- Factor price equalization
- Stolper Samuelson theorem
- Rybczynski theorem

Preamble

In autarky (closed economy), with different factors:

- Factor prices (e.g. w, r) depend both on:
  – Preferences and factor intensities of each industries
  – Factor abundance
- No scale effect if we have homothetic preferences and CRS (see problem set)

What happens with trade?

From autarky to Trade:

In autarky (closed economy):

- The country with the higher K/L ratio ("capital *abundant*") has the lower r/w ratio

- Hence, the capital-abundant country has a lower relative price in the capital-intensive industry

With trade:

- Capital-abundant country sees an increase in the relative price of the capital-intensive industry
  (inversely, the labor-abundant country sees an decrease in the relative price of the capital-intensive industry)

Heckscher-Ohlin

- 2 sectors i = 1, 2
- 2 factors: labor L and capital K (input costs: w,r)
- Exogenous prices given by international markets

Factors are mobile across industries (not countries),
Perfect competition, constant return to scale (CRS)

$c_1(w,r)$ denotes the cost to produce one unit of good 1
$c_2(w,r)$ denotes the cost to produce one unit of good 2

We denote by $a_{i,L}(w,r)$ and $a_{i,K}(w,r)$ the unit factor requirements in labor and capital in industry i

Equilibrium conditions

Price levels in both sectors are determined exogenously by international markets:

$c_1(w,r) = p_1$

$c_2(w,r) = p_2$

Factor use is limited by factor endowments:

$y_1 \,.\, a_{1,L}(w,r) \;+\; y_2 \,.\, a_{2,L}(w,r) \;=\; L$

$y_1 \,.\, a_{1,K}(w,r) \;+\; y_2 \,.\, a_{2,K}(w,r) \;=\; K$

→**4** unknowns: (w, r, y_1, y_2), **4** equations: may be sufficient to characterize equilibrium under certain conditions

Factor price equalization

4 unknowns: (w, r, y_1, y_2), **4** equations,

But the first two equations may be sufficient to determine factor prices!

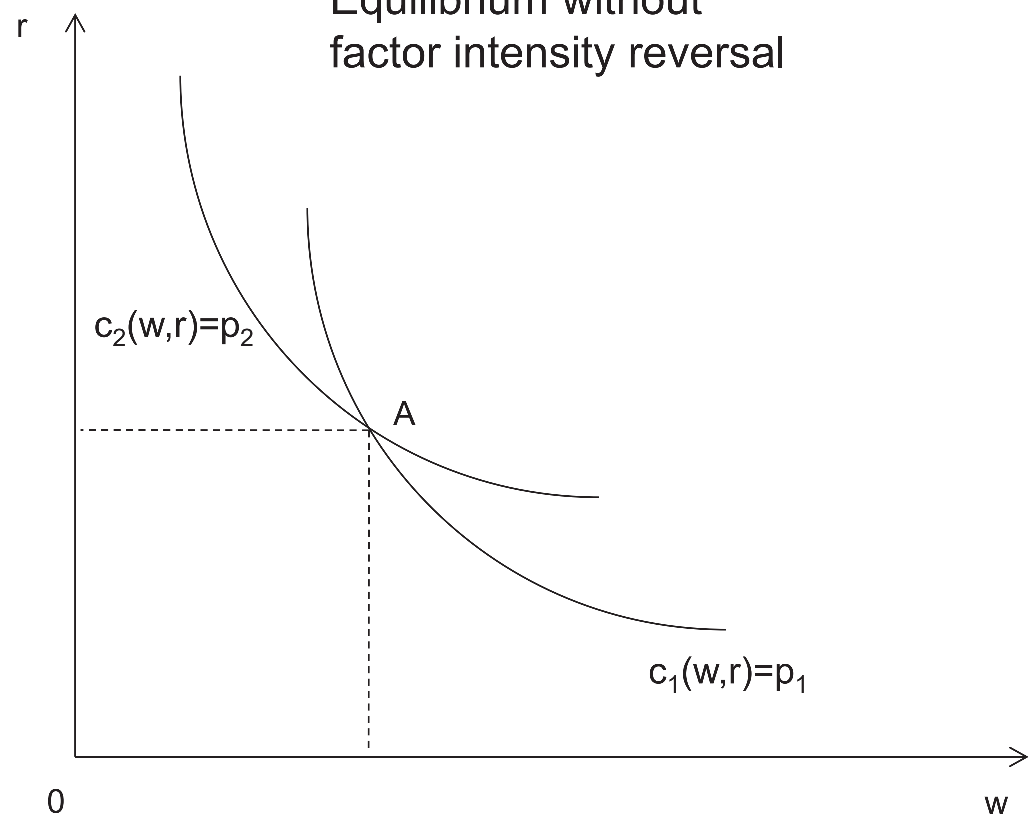
$c_1(w,r) = p_1$

$c_2(w,r) = p_2$

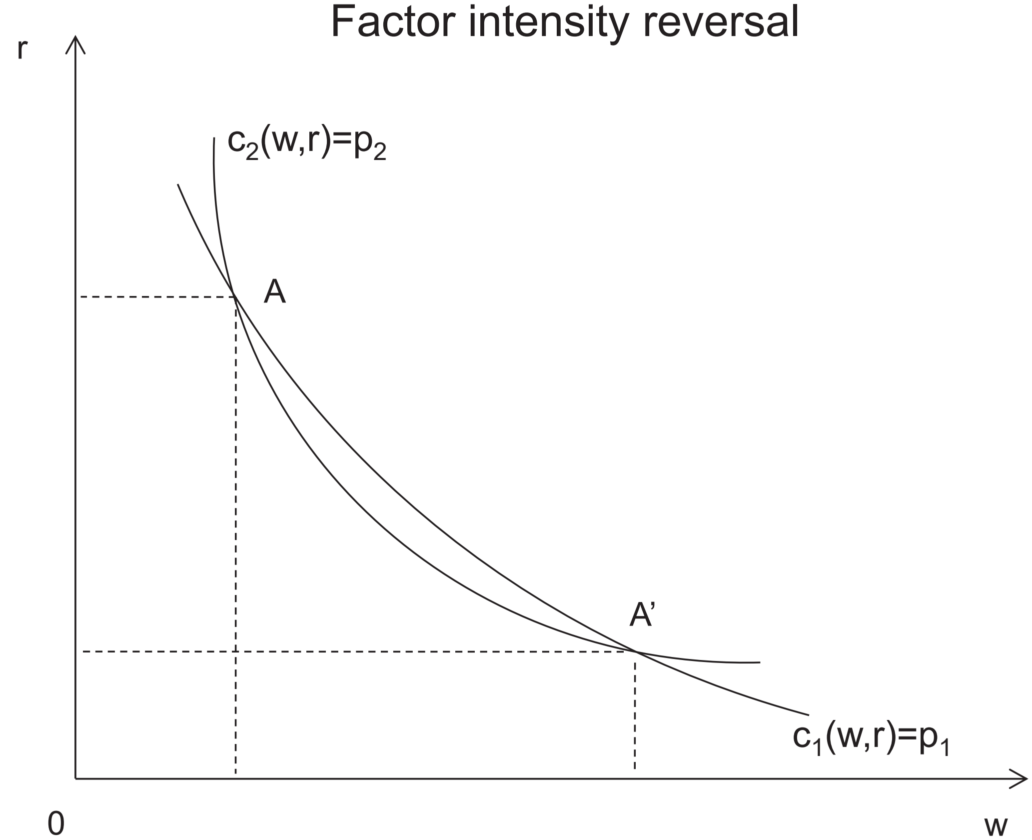
Theorem: As long as there is no "factor intensity reversal" and both countries produce both goods, factor prices are uniquely determined by p_1 and p_2

Corrollary: Under the latter conditions, factor prices do not depend on endowments

Equilibrium without factor intensity reversal



Factor intensity reversal



Next question:
How do factor prices react to changes in final good prices?

Differentiating $c_i(w,r) = p_i$, we obtain: $dp_i = a_{i,L}\ dw + a_{i,K}\ dr$

This can be rewritten (Jones' algebra): $dp_i/p_i = \Theta_{i,L}\ dw/w + \Theta_{i,K}\ dr/r$

Where $\Theta_{i,L} = a_{i,L}\ w/c_i$ and $\Theta_{i,K} = a_{i,K}\ r/c_i$ are the cost share for good i

It provides a linear system of two equations with the following solutions:

$dw/w = (\Theta_{2,K}\ dp_1/p_1 - \Theta_{1,K}\ dp_2/p_2)/(\Theta_{2,K} - \Theta_{1,K})$
$dr/r = (\Theta_{1,L}\ dp_2/p_2 - \Theta_{2,L}\ dp_1/p_1)/(\Theta_{1,L} - \Theta_{2,L})$

We now assume that sector 1 is labor-intensive: $\Theta_{1,L} > \Theta_{2,L}$
and that the relative price of 1 increases: $dp_1/p_1 > dp_2/p_2$
We obtain:

$dw/w > dp_1/p_1 > dp_2/p_2 > dr/r$

Stolper-Samuelson theorem

Magnification effect:

$dw/w > dp_1/p_1 > dp_2/p_2 > dr/r$

An increase in the relative price of a good will increase the real return of the factor used intensively in that good, and reduce the real return to the other factor.

• Hence, even if trade has overall a positive effect on welfare, it has negative effect on the return of the factor that is not used intensively.

• Prediction on wage inequality in developing countries: the relative wage of unskilled workers should increase.

• The effect is stronger when $(\Theta_{1,L} - \Theta_{2,L})/\Theta_{1,L}$ is small

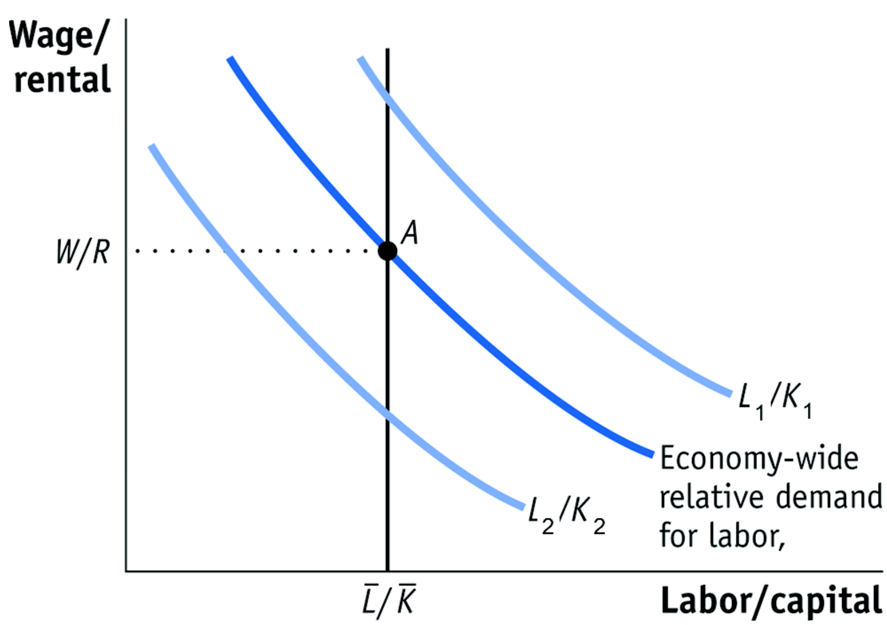
Stolper-Samuelson theorem

Another (indirect) way to prove and illustrate this result:

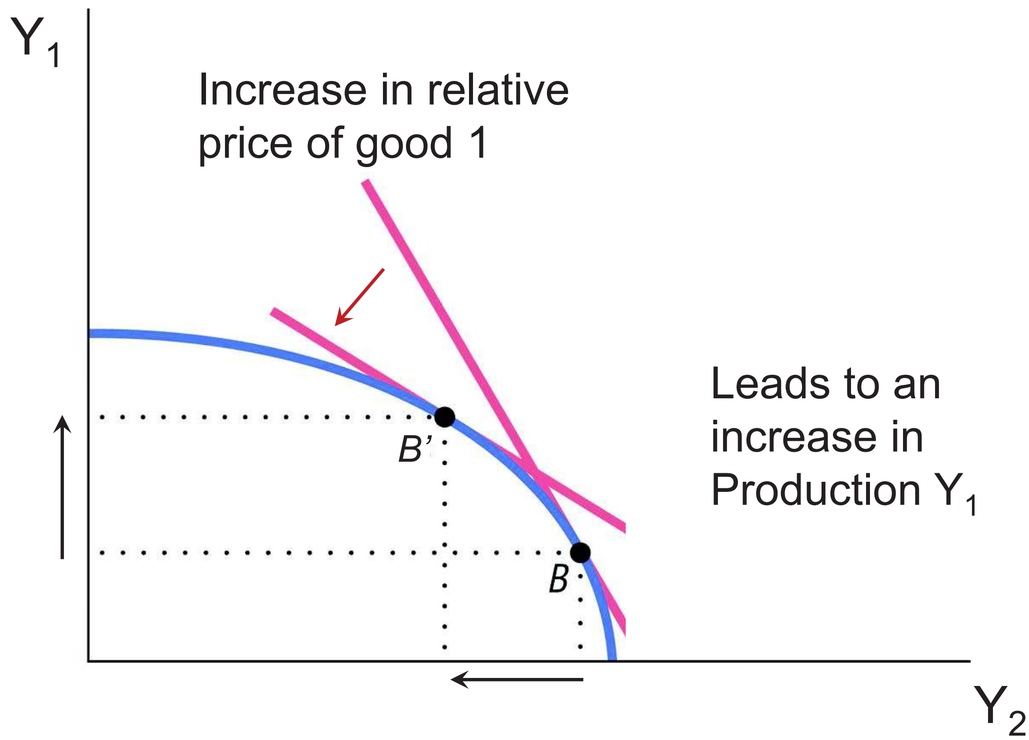
- An increase in the price of good 1 leads to an increase in the production of good 1
- If the production of good 1 is intensive in labor, this leads to an increase in the relative demand for labor
- Holding the relative supply of labor, this implies an increase in the relative cost of labor (wage/rental rate) and an increase in capital/labor ratio in each industry
- Increase in capital/labor ratios imply increases in MPL and decreases in MPK
- w/P = MPL and r/P = MPK then imply Stolper-Samuelson

Relative labor demand and supply

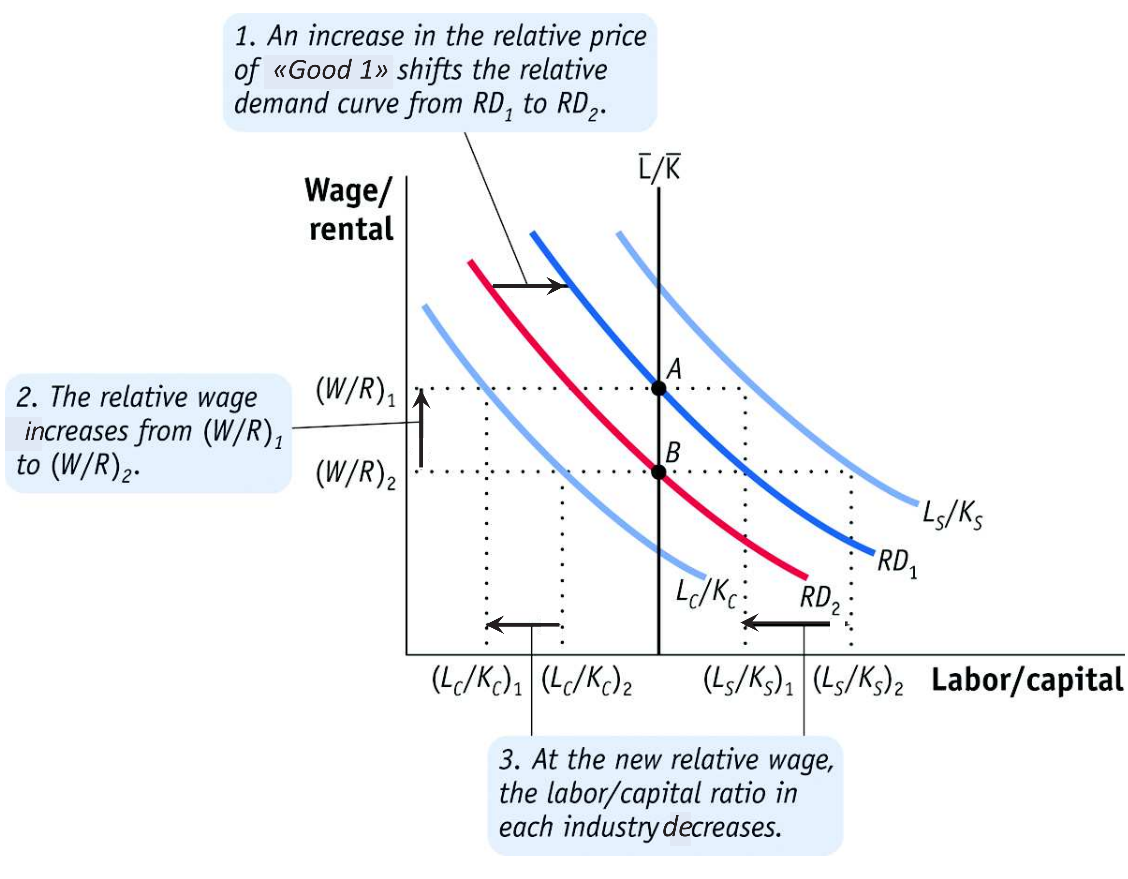
$$\underbrace{\frac{\bar{L}}{\bar{K}}}_{\textbf{Relative supply}} = \frac{L_1 + L_2}{\bar{K}} = \underbrace{\frac{L_1}{K_1} \cdot \left(\frac{K_1}{\bar{K}}\right) + \frac{L_2}{K_2}\left(\frac{K_2}{\bar{K}}\right)}_{\textbf{Relative demand}}$$



Changes in production



Relative labor demand and supply



Stolper-Samuelson theorem

- What happens to MPK_i and MPL_i in each industry i?

  If $Y_i = F_i(K,L)$ is CRS, then MPL and MPK are homogenous of degree zero and:

  MPL increases with K/L while MPK decreases with K/L

  → Hence MPL increases with trade and MPK decreases

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  MPL increases with K/L while MPK decreases with K/L

  → Hence MPL increases with trade and MPK decreases

- $w = P_i \,.\, MPL_i$ and $r = P_i \,.\, MPK_i$ hence:

  - wages growh faster than any price
  - rental rates r growth slower than any price

  This is Stolper-Samuelson Theorem

Changes in endowments

- Suppose that endowments for a factor increases, e.g. Syrian refugees in Germany (increase in L) or FDI in China (increase in K):
  - How does it affect returns to each factor?
  - How does it affect the composition of output?

Changes in endowments

- Suppose that endowments for a factor increases, e.g. Syrian refugees in Germany (increase in L) or FDI in China (increase in K):
  - How does it affect returns to each factor?
  - How does it affect the composition of output?

- What we have already shown:
  - Returns to factors do not actually depend on factor supply when prices are held constant (small open economy)

How do the production of goods react to changes in endowments? (holding prices constant)

Similar algebra:

Differentiating $y_1.a_{1,X} + y_2.a_{2,X} = X$ (with X=K or L), we obtain:

$dX/X = \lambda_{1,X}\, dy_1/y_1 + \lambda_{2,X}\, dy_2/y_2$

Where $\lambda_{i,X} = y_i\, a_{i,X} /X$ is the share of input X used for good i

We assume that sector 1 is labor-intensive: $\lambda_{1,L} > \Theta\, \lambda_{1,K}$
and that relative endowments in labor increase: $dL/L > dK/K$
After solving the linear system, we obtain:

$dy_1/y_1 > dL/L > dK/K > dy_2/y_2$

Rybzcynski theorem

Magnification effect:

$dy_1/y_1 > dL/L > dK/K > dy_2/y_2$

An increase in a factor endowment will increase the output of the sector using it intensively, and reduce the output of the other sector.

• Specialization

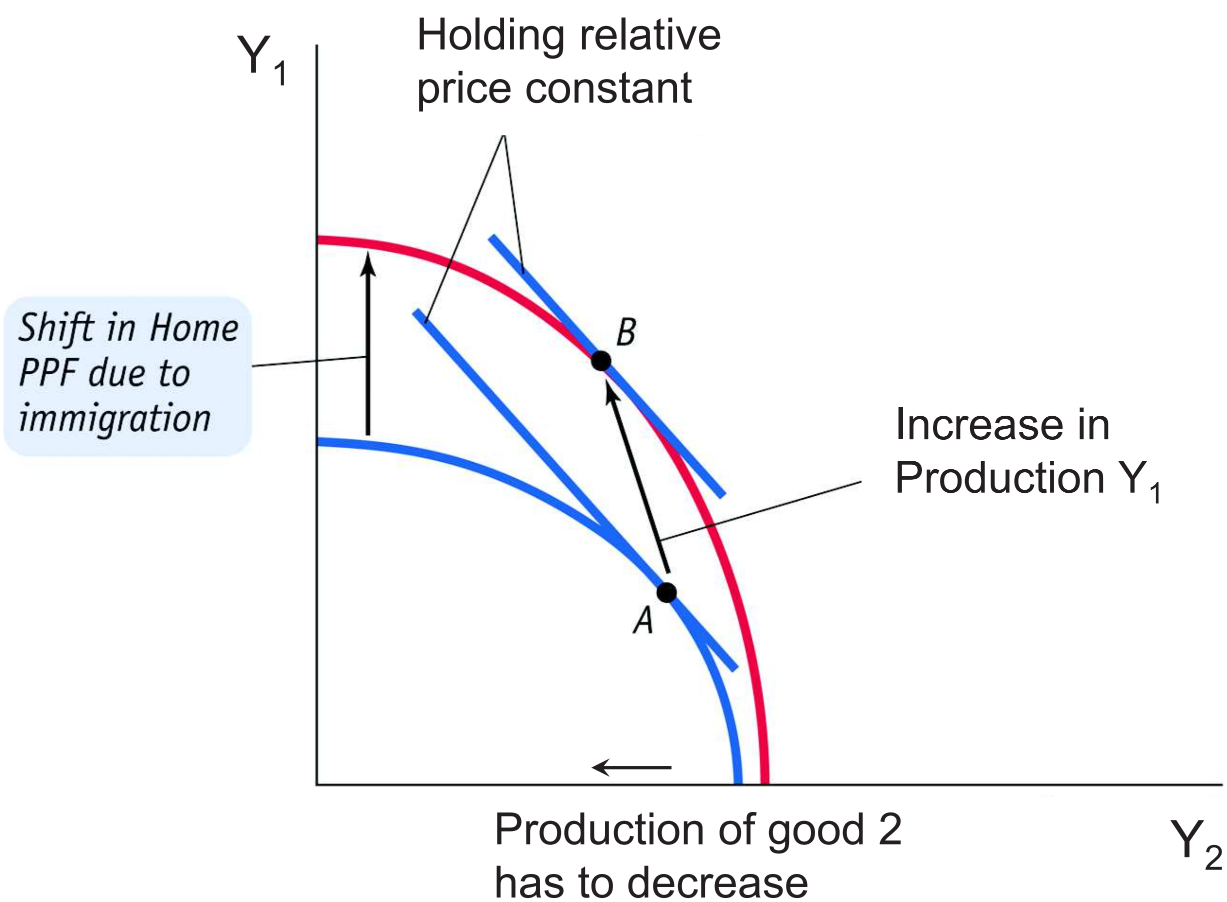
• Example: “Dutch disease”.

Rybzcynski theorem

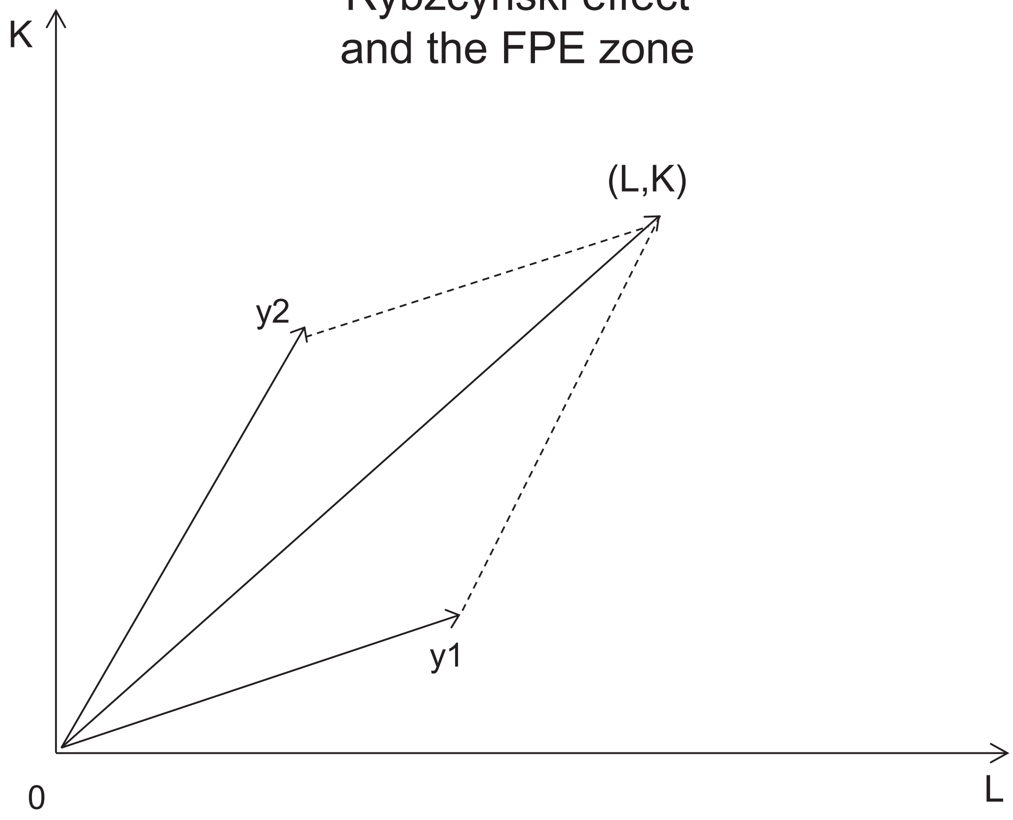
Two other ways to prove and illustrate this result:

2- Changes in the PPF

3- Edgeworth box for factors of production



Rybzcynski effect and the FPE zone



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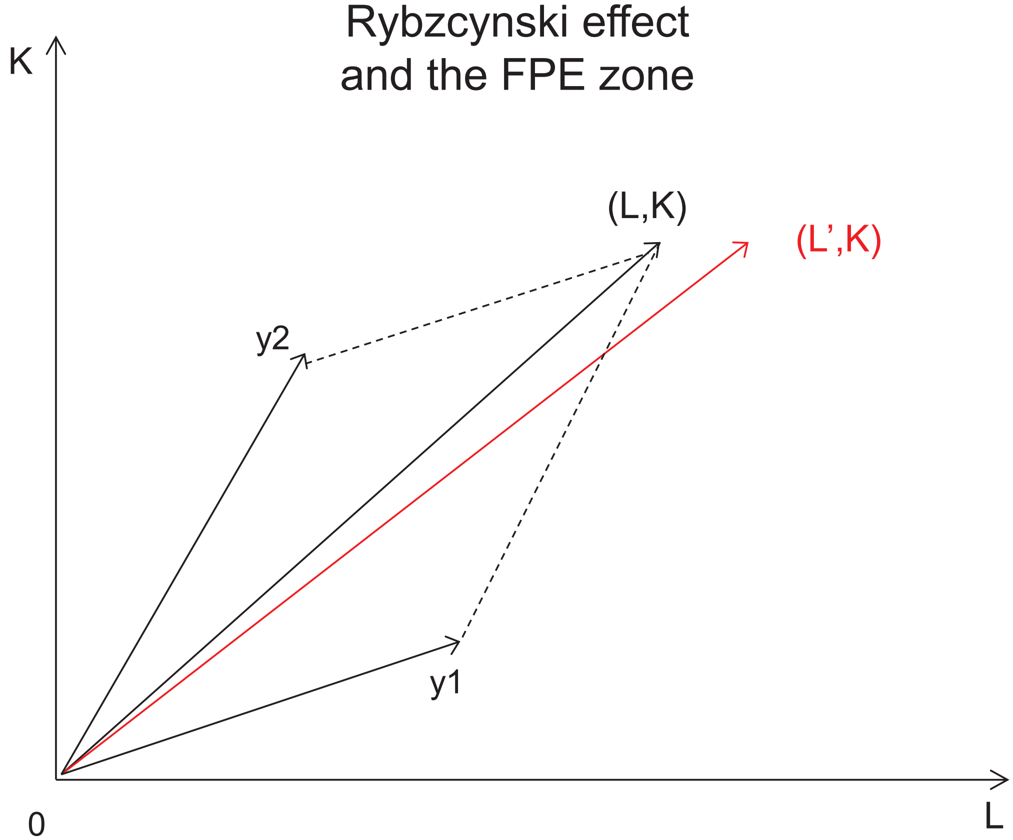
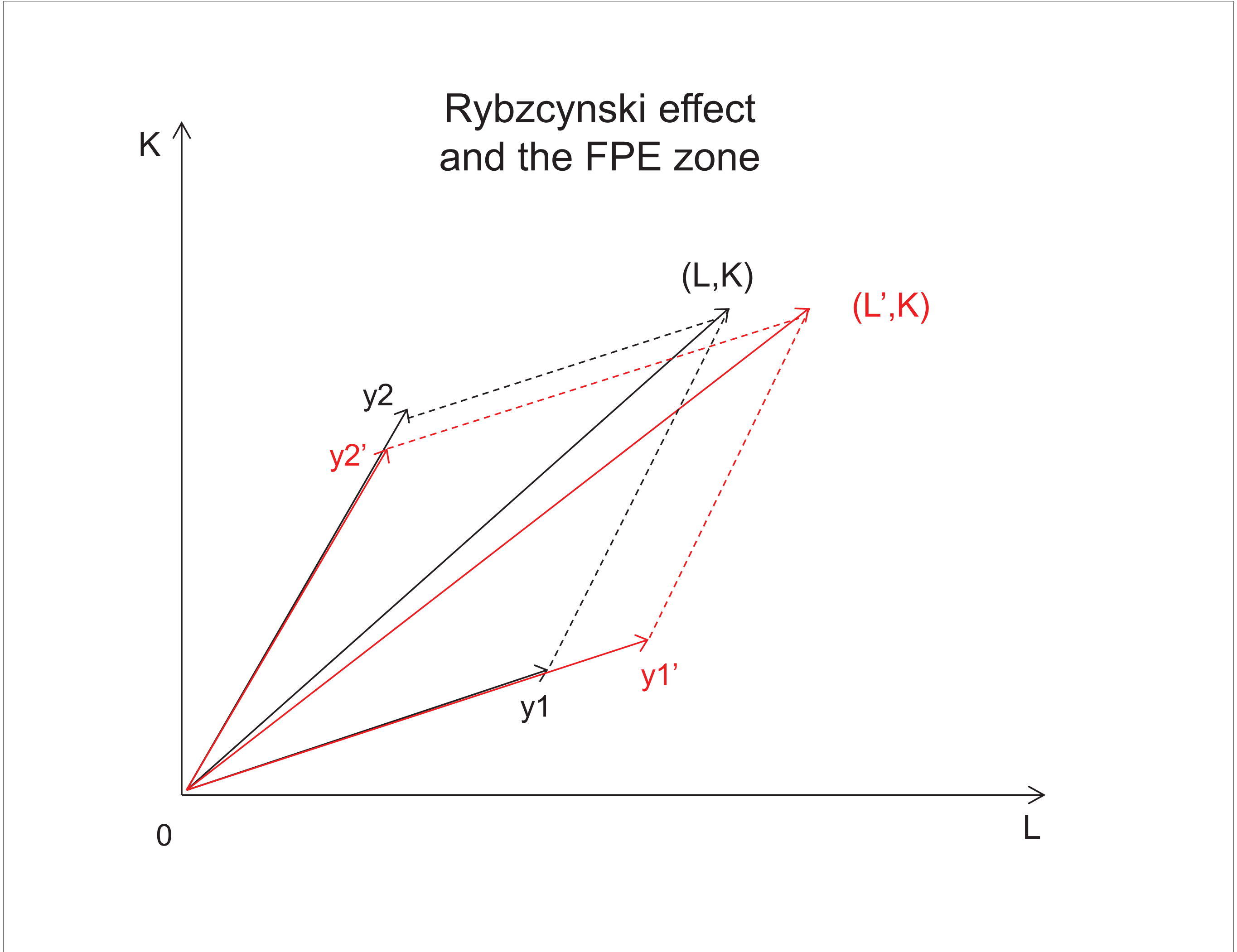
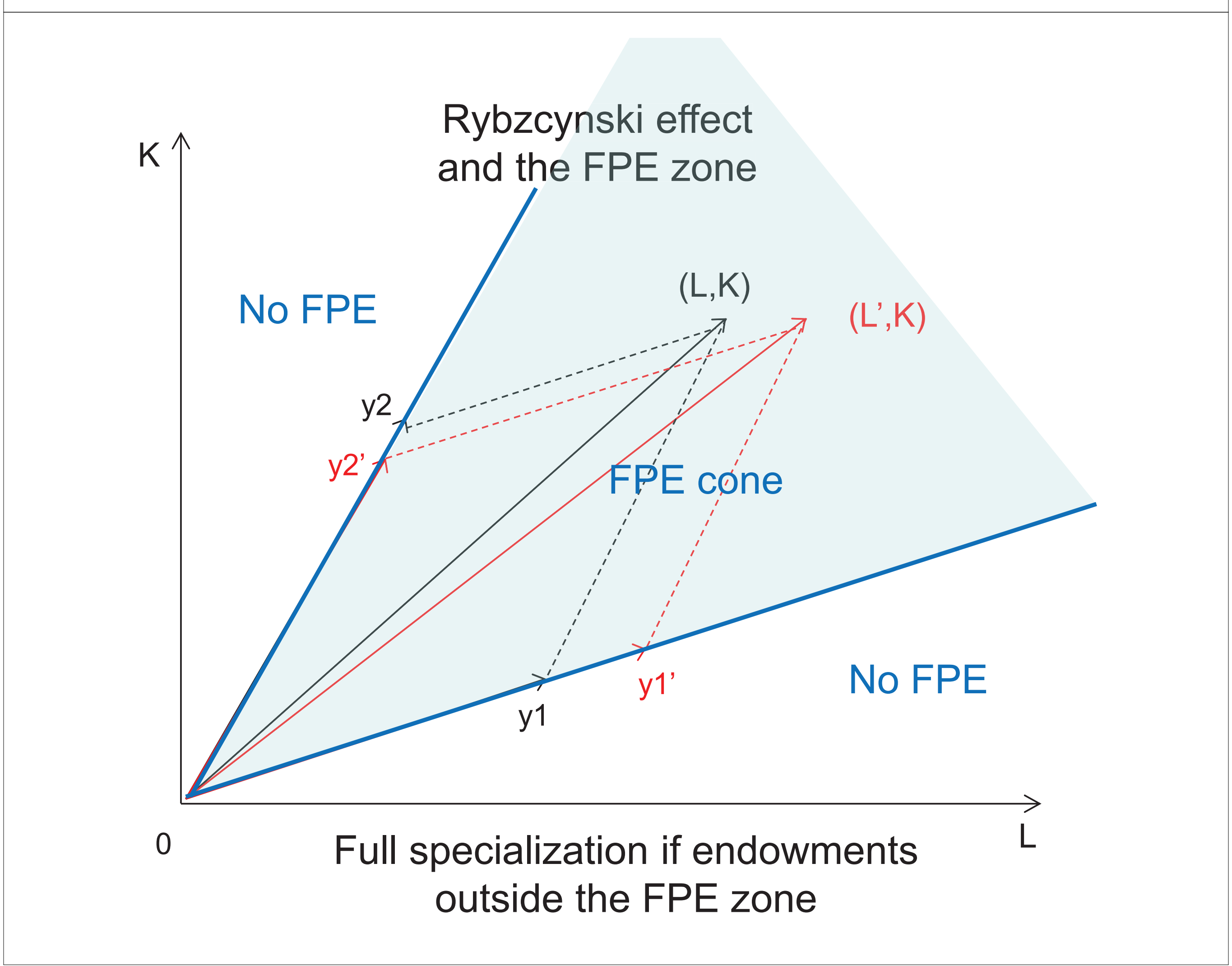



Rybzcynski effect
and the FPE zone
K
(L,K)
(L',K)
y2
y2'
y1'
y1
0
L


Rybzcynski effect
and the FPE zone
K
No FPE
(L,K)
(L',K)
y2
y2'
FPE cone
y1'
No FPE
y1
0
L
Full specialization if endowments
outside the FPE zone

Conclusion

- Differences in endowments generates trade
- Leads towards factor price equalization
- Unequal effects of trade opening:
  - welfare gains for owners of a factor of production if exporting industry is intensive in this factor
  - welfare loss for owners of factor of production if importing industry is intensive in this factor
- Change in factor endowments:
  - Heterogeneous effects of trade on industrial composition
  - But surprisingly no effect on factor prices under FPE

PS5 – Krugman model with CES

- 2 symmetric countries (unlike Ricardo or HO):
  - Same technology, preferences and factors of production
  - Just different size (not needed)
- Monopolistic competition with many firms:
  - Markups equal 1/elasticity
- Equilibrium with free entry
  - With CES, size of firms remains constant
  - Number of producers in each country remains constant (since number = labor force / employment in each firm)
- Gains from trade:
  - Consumer access more varieties foreign + domestic varieties
  - Simple formula to be proven in PS5