

Lecture 4b:

# Stolper-Samuelson Theorem

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C181 – International Trade

Fall 2024

### 3- Effect of trade on factor prices

#### IN THE SPECIFIC-FACTOR MODEL

Assume that capital is used **only** in the computer industry; labor is used **only** in the shoe industry.

If the price of computers increases with trade:

- a) Workers and capital owners **all gains** from trade but **capital owners gain more**
- b) Workers and capital owners **all gains** from trade but **workers gain more**
- c) Capital owners gain from trade and **workers lose**
- d) Workers gain from trade and **capital owners lose**

= short  
run

### 3- Effect of trade on factor prices

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#### IN THE H-O MODEL

**Now, today the key question is:**

Does the same result hold when both industries use K and L and factors are mobile? (=HO model)

~~YES!~~

### 3- Effect of trade on factor prices

#### Stolper-Samuelson Theorem

Within the Heckscher-Ohlin framework:

- What is the effect of trade on wages?
- What is the effect of trade on the rental rate?  
(adjusting for prices, i.e. looking at welfare)

$$\frac{w}{P_s} = \pi_{PL_s}$$
$$\frac{w}{P_c} = \pi_{PL_c}$$

$$\frac{R}{P_c} & \text{ and } \frac{R}{P_s} \\ \Delta P_k & \pi_{PK_c} \quad \pi_{PK_s}$$

### 3- Effect of trade on factor prices

#### Stolper-Samuelson Theorem

Within the Heckscher-Ohlin framework:

- What is the effect of trade on wages?
- What is the effect of trade on the rental rate?  
(adjusting for prices, i.e. looking at welfare)

in each industry

As in the previous model, we want to understand:

- What happens to MPL and MPK?
- hence what happens to  $L_x/K_x$  in each industry  $x$ ?

E depends on  
Technology +  $V/R$

### 3- Effect of trade on factor prices

#### **Stolper-Samuelson Theorem**

Within the Heckscher-Ohlin framework:

- What is the effect of trade on wages?
- What is the effect of trade on the rental rate?  
(adjusting for prices, i.e. looking at welfare)

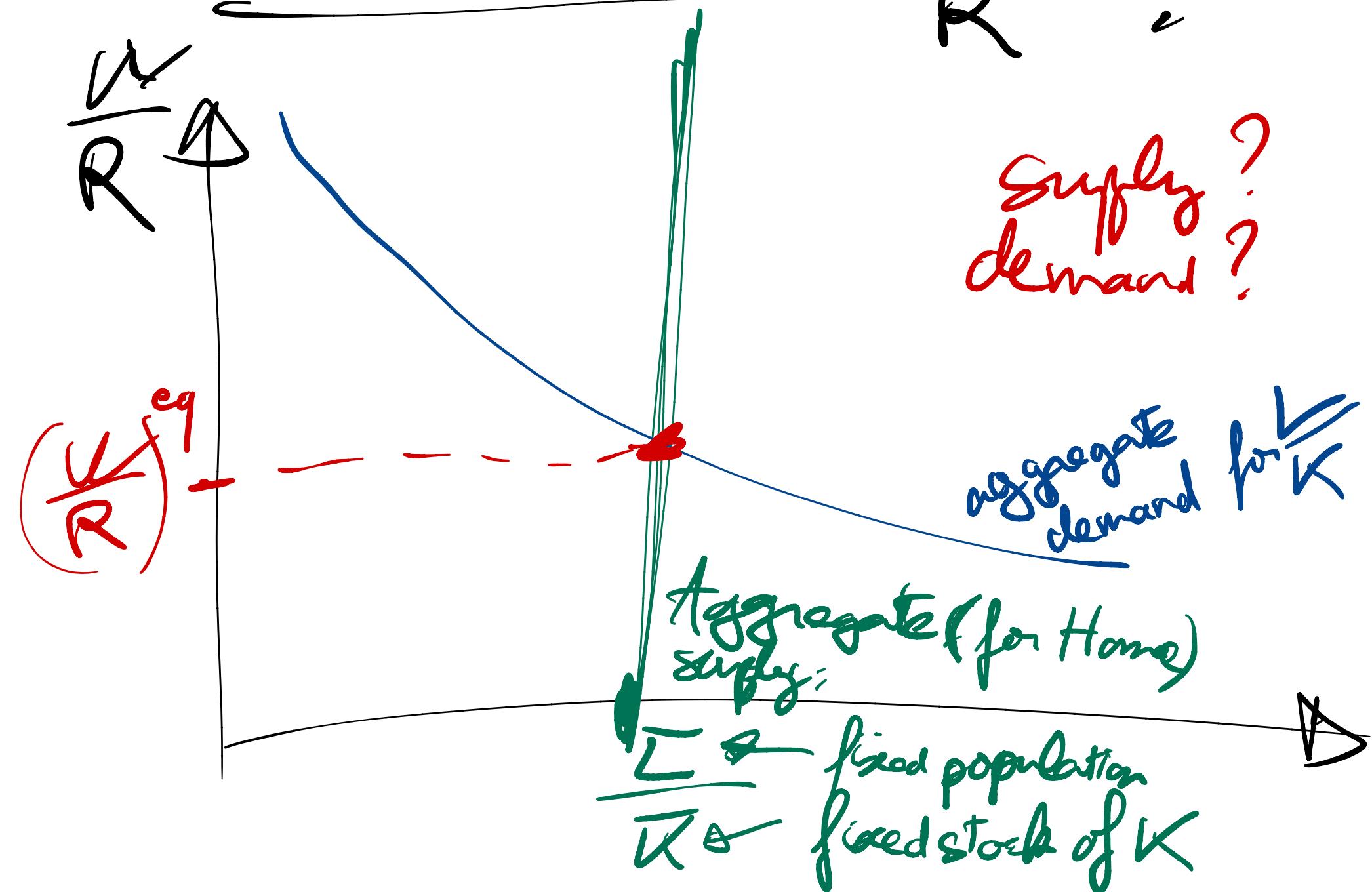
As in the previous model, we want to understand:

- What happens to MPL and MPK?
- hence what happens to  $L_x/K_x$  in each industry  $x$ ?

#### → GOAL:

*For this, we will need to understand what happens to the relative demand for labor  $L_x/K_x$ , the relative supply, and the relative cost of labor w/r in equilibrium.*

Q: what determines  $\frac{K}{R}$ ?



### 3- Effect of trade on factor prices

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Relative demand for Capital and Labor:

What is the relative *supply* of labor at Home?

### 3- Effect of trade on factor prices

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Relative demand for Capital and Labor:

What is the relative *supply* of labor at Home?

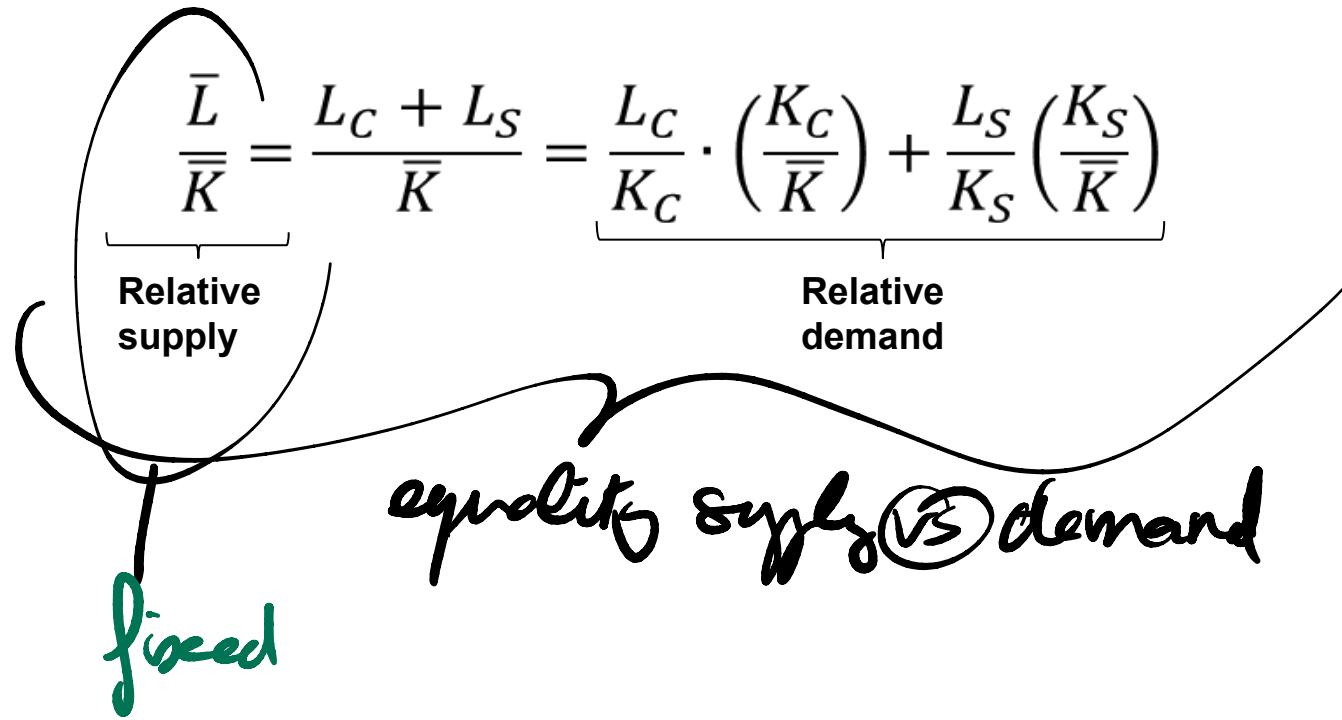
What is the relative *demand* for labor at Home?

### 3- Effect of trade on factor prices

Relative demand for Capital and Labor:

What is the relative **supply** of labor at Home?

What is the relative **demand** for labor at Home?



Demand for  $\frac{L_s}{K_s}$  in an industry?



### 3- Effect of trade on factor prices

Relative demand for Capital and Labor:

$$\frac{\bar{L}}{\bar{K}} = \frac{L_C + L_S}{\bar{K}} = \underbrace{\frac{L_C}{K_C} \cdot \left( \frac{K_C}{\bar{K}} \right)}_{\text{Relative supply}} + \underbrace{\frac{L_S}{K_S} \left( \frac{K_S}{\bar{K}} \right)}_{\text{Relative demand}}$$

Relative **demand** for labor determined by:

- Labor intensity in each industry:  $L_C/K_C$  and  $L_S/K_S$
  - Industry shares in capital use:  $K_C/K_{\text{tot}}$  and  $K_S/K_{\text{tot}}$
- Relative demand for labor = Average of labor intensities, weighted by the share of each industry in capital use.

## Relative demand for Capital and Labor:

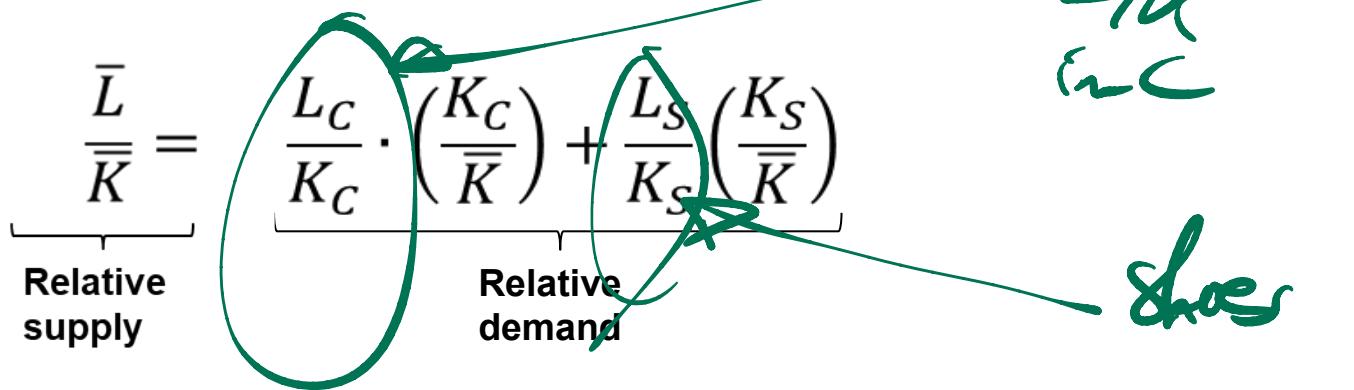
$$\frac{\bar{L}}{\bar{K}} = \underbrace{\frac{L_C}{K_C} \cdot \left( \frac{K_C}{\bar{K}} \right)}_{\text{Relative supply}} + \underbrace{\frac{L_S}{K_S} \cdot \left( \frac{K_S}{\bar{K}} \right)}_{\text{Relative demand}}$$

*depend on  $\frac{K}{R}$*

*Depend on specialization*

- $L_C/K_C$  and  $L_S/K_S$ : Labor intensity in each industry  
(correspond to each light-blue curve)
  - $K_C/K_{\text{tot}}$ : Share of Computer industry total K use  
= weight put on Computer industry
  - $K_S/K_{\text{tot}}$ : Share of Computer industry total K use  
=  $1 - (K_C/K_{\text{tot}})$
- Relative demand for labor = Average of labor intensities,  
weighted by the share of each industry in capital use.

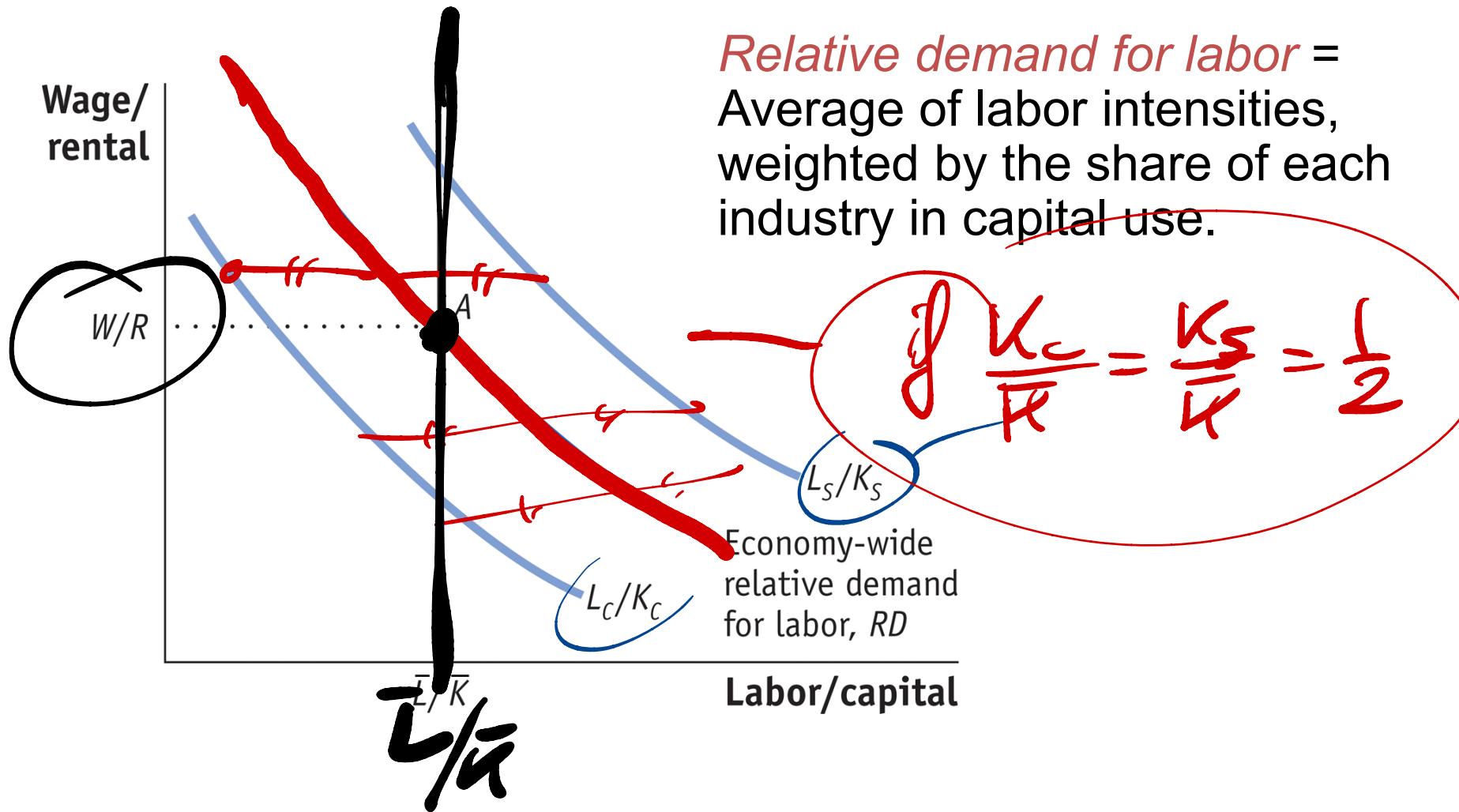
## Relative demand for Capital and Labor:



- $L_C/K_C$  and  $L_S/K_S$ : Labor intensity in each industry (correspond to each light-blue curve)
  - $K_C/K_{\text{tot}}$ : Share of Computer industry total K use  
 $\frac{\checkmark}{K}$  = weight put on Computer industry Weights
  - $K_S/K_{\text{tot}}$ : Share of Computer industry total K use  
 $= 1 - (K_C/K_{\text{tot}})$
- Relative demand for labor = Average of labor intensities, weighted by the share of each industry in capital use.

# 3- Effect of trade on factor prices

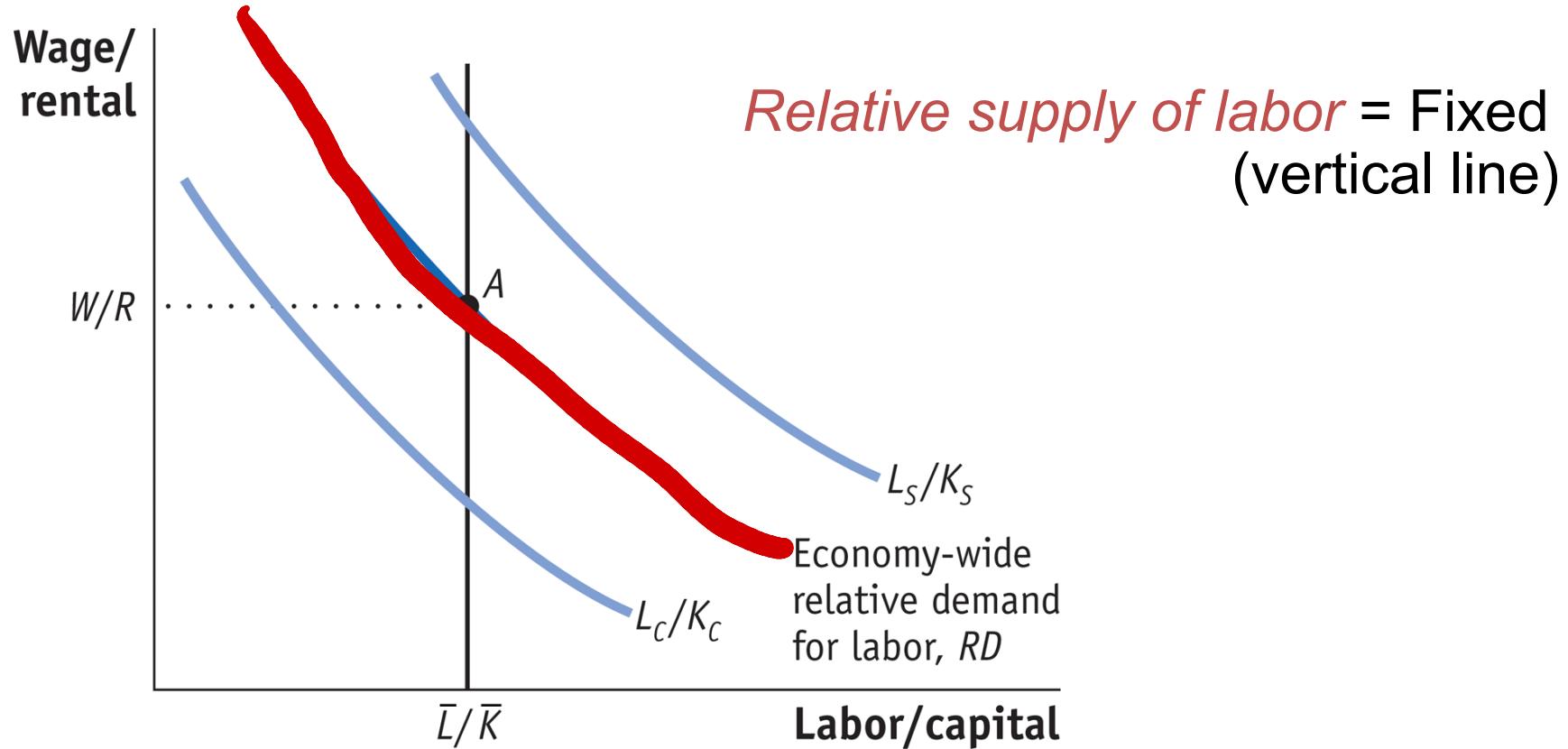
## Relative demand for Capital and Labor:



- black;  $\sum \frac{L}{K}$  supply
  - blue;  $L_c/K_c$  &  $L_s/K_s$  in each industry
  - red: aggregate;
- $$= \left( \frac{L_c}{K_c} \right) \times \left( \frac{K_c}{R} \right) + \left( \frac{L_s}{K_s} \right) \times \left( \frac{K_s}{R} \right)$$
- $\downarrow (W/R)$
- $\downarrow (W/R)$
- shares as weights

### 3- Effect of trade on factor prices

Relative supply of Capital and Labor:

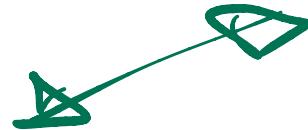
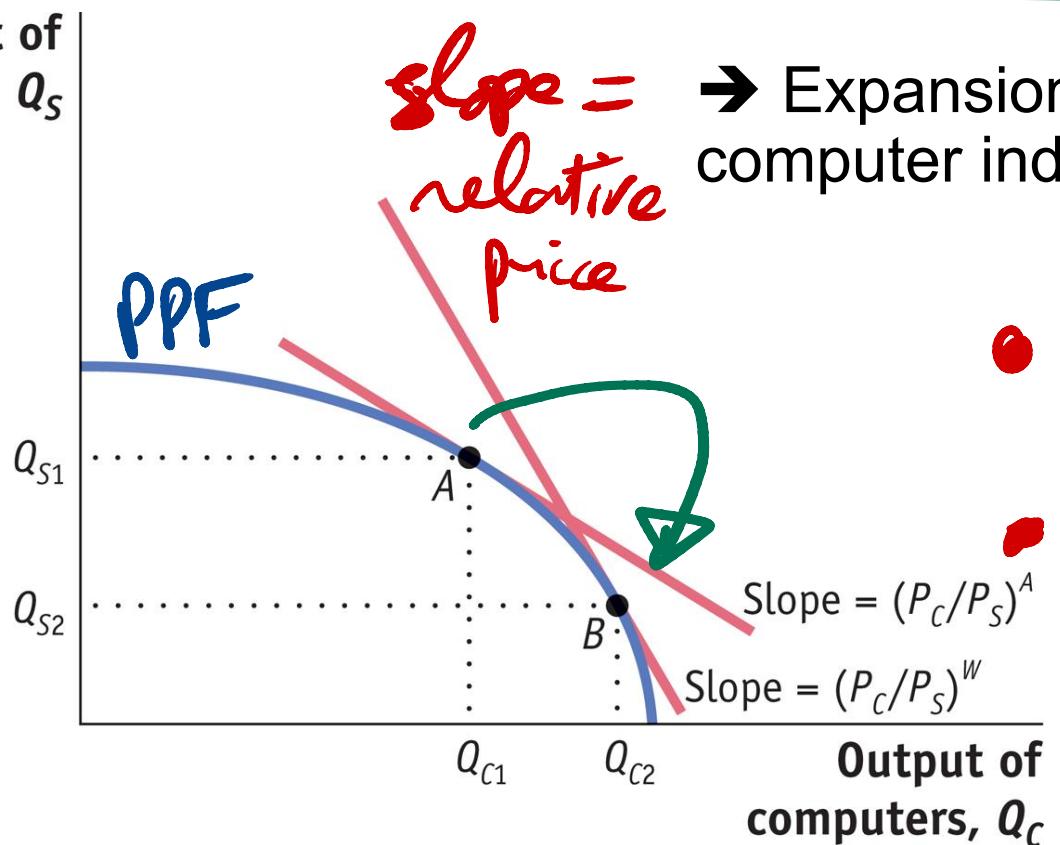


### 3- Effect of trade on factor prices

Effect of trade

(Effect of an increase in the Relative Price of Computers)

Output of  
shoes,  $Q_S$



= comparative advantage  
in computers

→ Expansion of the  
computer industry (at Home)

$$\bullet \frac{K_C}{K} \uparrow$$

$$\bullet \frac{K_S}{K} = 1 - \frac{K_C}{K}$$

### 3- Effect of trade on factor prices

Relative demand for Capital and Labor:

$$\frac{\bar{L}}{\bar{K}} = \frac{L_C + L_S}{\bar{K}} = \underbrace{\frac{L_C}{K_C} \cdot \left( \frac{K_C}{\bar{K}} \right)}_{\text{Relative supply}} + \underbrace{\frac{L_S}{K_S} \left( \frac{K_S}{\bar{K}} \right)}_{\text{Relative demand}}$$

A shift towards the computer industry leads to:

- An increase in computer industry capital share  $K_C/\bar{K}$
- A decrease in shoe industry capital share  $K_S/\bar{K}$

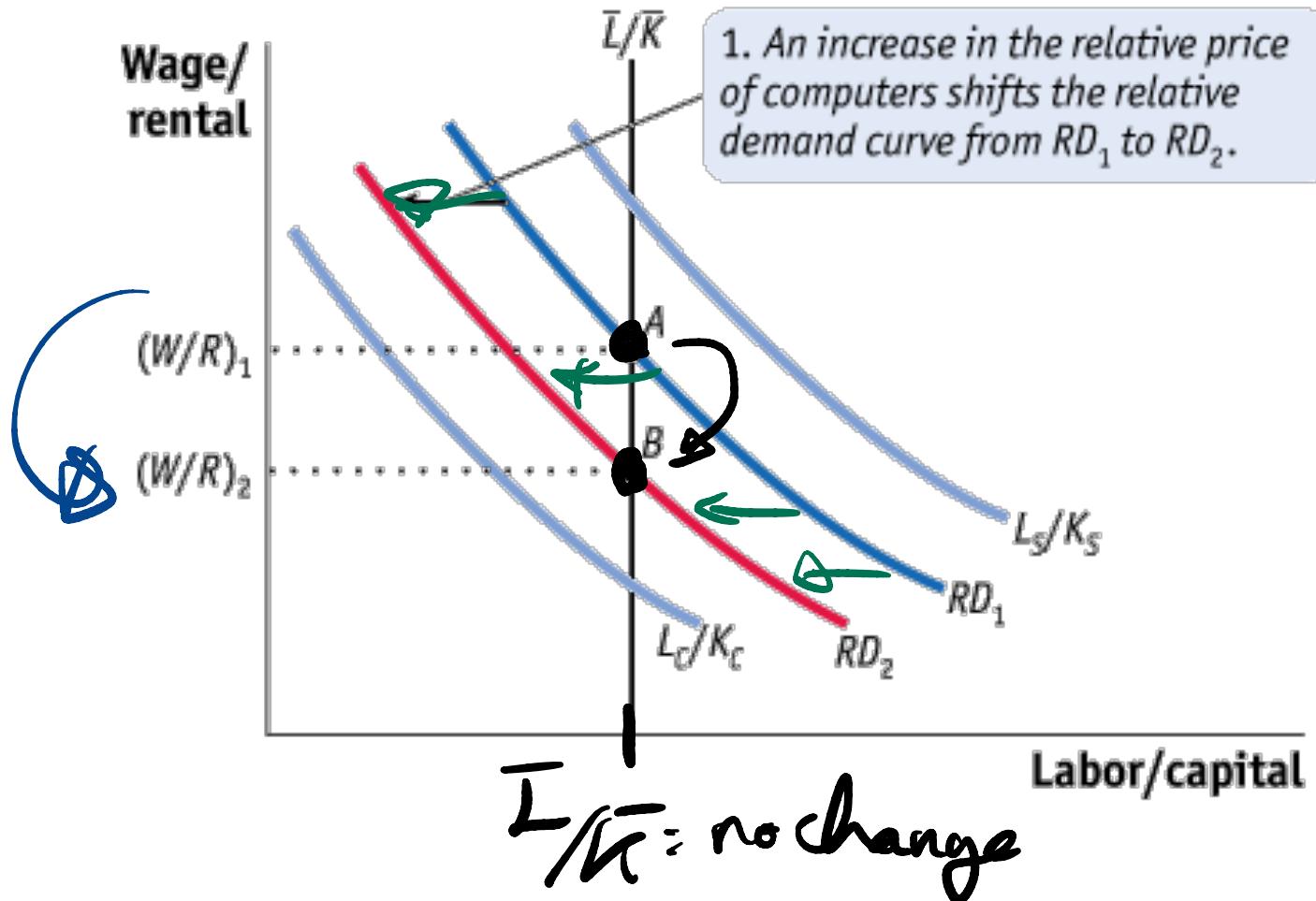
→ Decrease in relative demand for labor

→ Closer to the one in the computer industry

### 3- Effect of trade on factor prices

#### Effect of Trade

(Effect of an increase in the Relative Price of Computers)

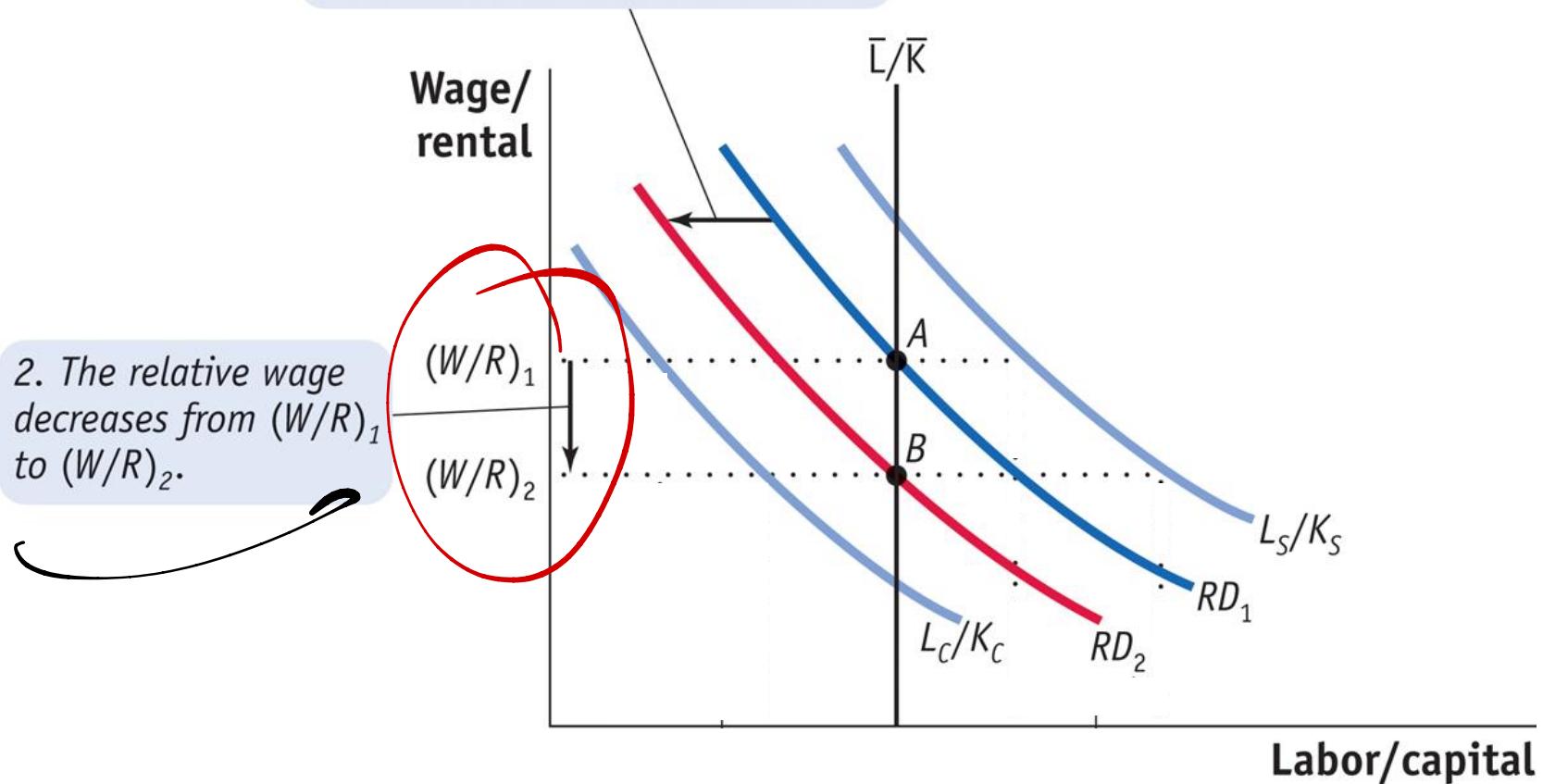


# 3- Effect of trade on factor prices

## Effect of Trade

(Effect of an increase in the Relative Price of Computers)

1. An increase in the relative price of computers shifts the relative demand curve from  $RD_1$  to  $RD_2$ .



### 3- Effect of trade on factor prices

#### Effect of trade

At Home, opening to trade induces:

- An increase in the relative price of computers

- An expansion of the computer industry

$$K_c / \bar{K}$$

- A decrease of the demand for labor

(on aggregate)

- A decrease in the wage/rental-rate ratio

$$W/R$$

(in equilibrium,  
intersection supply  
and demand)

Example: with  $\beta = 2/3 > \alpha = 1/3$

- Shoe:  $\frac{L_S}{K_S} = 2\left(\frac{w}{r}\right)^{-1}$
- computer:  $\frac{L_C}{K_C} = \frac{1}{2}\left(\frac{w}{r}\right)^{-1}$

Effect of trade on rental rate / w ratio.

- Equilibrium:  $\frac{\bar{L}}{\bar{K}} = \frac{L_C}{K_C} \cdot \left(\frac{K_C}{\bar{K}}\right) + \frac{L_S}{K_S} \cdot \left(\frac{K_S}{\bar{K}}\right)$

→ implies:  $\frac{\bar{L}}{\bar{K}} = \frac{1}{2}\left(\frac{w}{r}\right)^{-1} \cdot \left(\frac{K_C}{\bar{K}}\right) + 2\left(\frac{w}{r}\right)^{-1} \cdot \left(\frac{K_S}{\bar{K}}\right)$

→ And thus:  $\frac{w}{r} = \frac{\bar{K}}{\bar{L}} \cdot \left( \frac{1}{2} \frac{K_C}{\bar{K}} + 2 \frac{K_S}{\bar{K}} \right)$

$\frac{w}{r}$  decreases as  $K_C$  increases and  $K_S$  decreases

*"labor intensity"*

Example: with  $\beta = 2/3 > \alpha = 1/3$

• Shoe:  $\frac{L_S}{K_S} = 2\left(\frac{w}{r}\right)^{-1}$

computer:  $\frac{L_C}{K_C} = \frac{1}{2}\left(\frac{w}{r}\right)^{-1}$

Effect of trade on rental rate / w ratio:

• Equilibrium:  $\frac{\bar{L}}{\bar{K}} = \frac{L_C}{K_C} \cdot \left(\frac{K_C}{\bar{K}}\right) + \frac{L_S}{K_S} \cdot \left(\frac{K_S}{\bar{K}}\right)$

→ implies:  $\frac{\bar{L}}{\bar{K}} = \frac{1}{2}\left(\frac{w}{r}\right)^{-1} \cdot \left(\frac{K_C}{\bar{K}}\right) + 2\left(\frac{w}{r}\right)^{-1} \cdot \left(\frac{K_S}{\bar{K}}\right)$

→ And thus:  $\frac{w}{r} = \frac{\bar{K}}{\bar{L}} \cdot \left(\frac{1}{2} \frac{K_C}{\bar{K}} + 2 \frac{K_S}{\bar{K}}\right)$

$\frac{w}{r}$  decreases as  $K_C$  increases and  $K_S$  decreases

### 3- Effect of trade on factor prices

What's next?

- We have yet to examine whether workers actually gain or lose from trade.
- As for the Specific-Factor Model, we examine how ~~MPK~~ and MPL evolve. (~~FLPL<sub>C</sub>, FPL<sub>S</sub>~~)
- As for the Specific-Factor Model, this depends crucially on how  $L_C/K_C$  and  $L_S/K_S$  change in each industry.

### 3- Effect of trade on factor prices

Clicker question

$$\frac{L_c}{L_s} \text{ & } \frac{K_c}{K_s}$$



Assume that computers are more capital intensive than shoes. If the price of computers increases with trade:

- a)  Labor intensity increases in the Shoe industry and decreases in the Computer industry
- b)  Labor intensity decreases in the Shoe industry and increases in the Computer industry
- c)  Labor intensity increases in both industries
- d)  Labor intensity decreases in both industries

### 3- Effect of trade on factor prices

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Answer:

### 3- Effect of trade on factor prices

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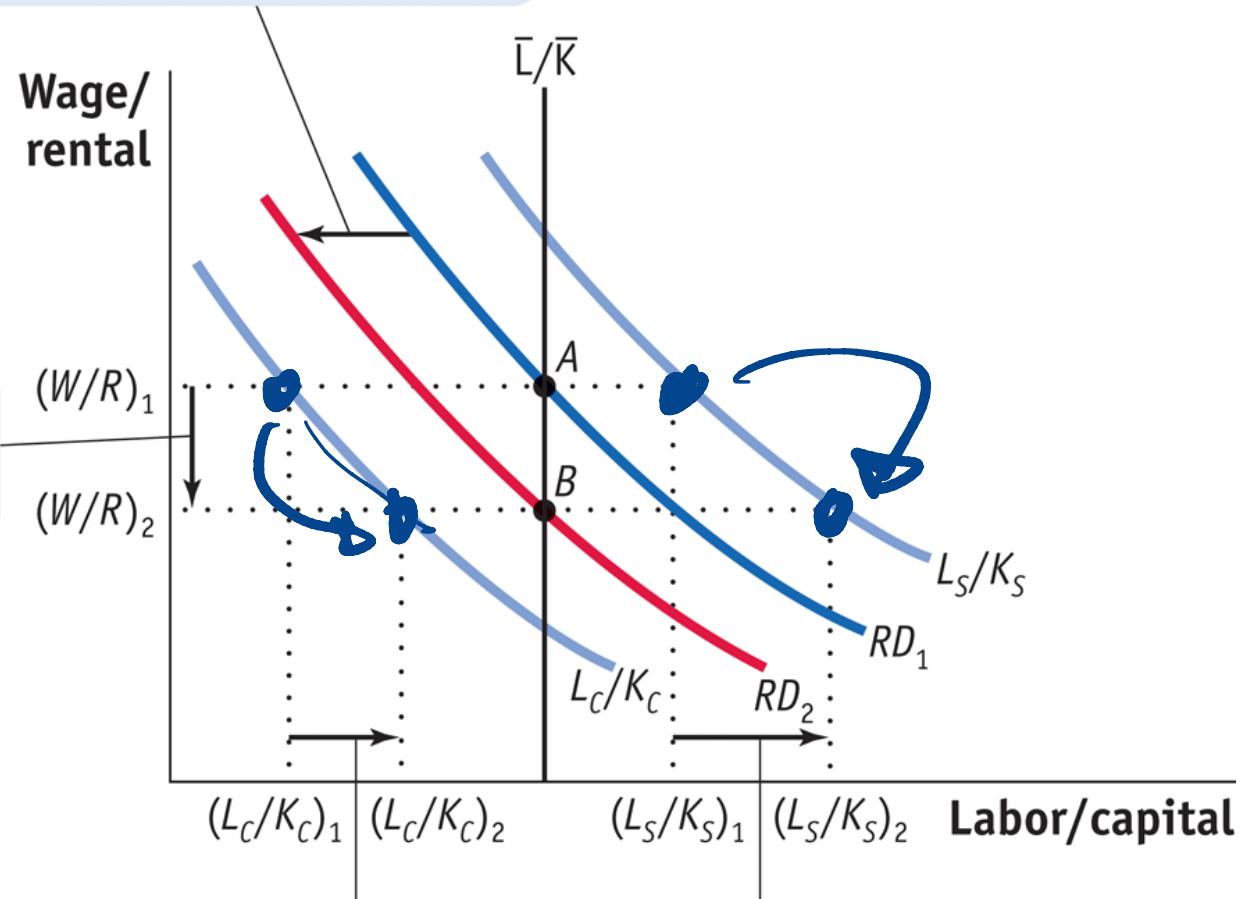
Answer:

On the graph:

- Moving to the right for the demand curve in each industry (light-blue curves).
- Notice that the curves specific to each industry do not move, it's just a movement along these curves.

1. An increase in the relative price of computers shifts the relative demand curve from  $RD_1$  to  $RD_2$ .

2. The relative wage decreases from  $(W/R)_1$  to  $(W/R)_2$ .



3. At the new relative wage, the labor/capital ratio in each industry increases.

### 3- Effect of trade on factor prices

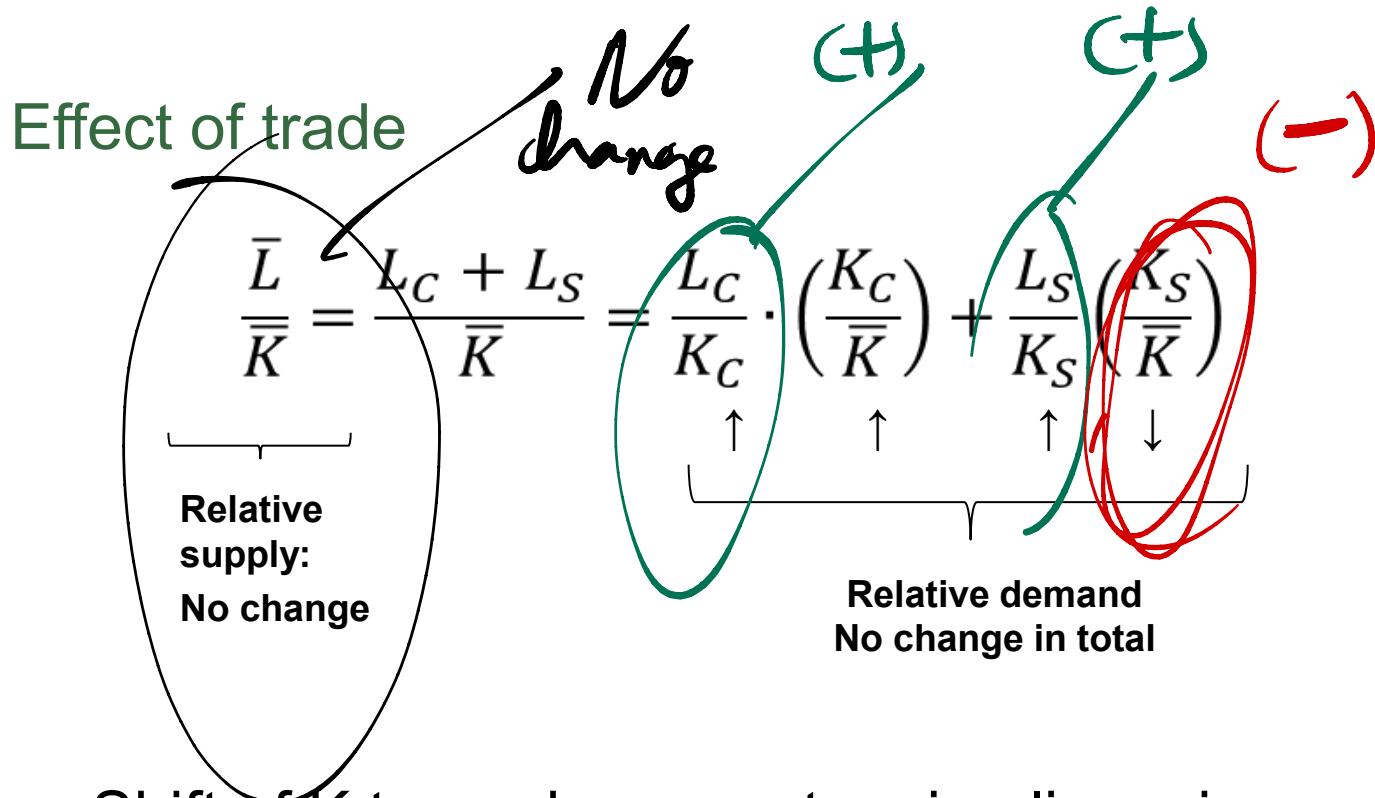
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#### Effect of trade

At Home, opening to trade induces:

- An increase in the relative price of computers
- An expansion of the computer industry
- A decrease of the demand for labor
- A decrease in the wage/rental-rate ratio
- *increase in labor intensity  $L_C/K_C$  and  $L_S/K_S$  in each industry*

### 3- Effect of trade on factor prices



- Shift of K towards computers implies a increase in labor intensity in each industry
- On aggregate, the relative demand remains unchanged

Q: how can labor intensity increase in all industries, while the supply of labor & capital stays fixed??

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→ balls & bins illustration:

Home has

and

	Computers	Shoes	Unemployed
Autarky	K K K L L L	K K K K K L L L L L L L L L L L L	∅
Transition (keeping $K/L_x$ fixed)	K K K K K L L L L L L	K K K L L L L L L	L L
with Trade	K K K K K L L L L L L + L	K K K L L L + L	∅

Transition: if we reallocate KK to the computer industry by keeping the same  $K/L$  ratios, two L become unemployed  
 → L intensity has to increase!

### 3- Effect of trade on factor prices

Effect of trade on MPK and MPL?

$$\frac{K}{P_C} = \pi PL_c \Delta \quad \text{depends on } L_c/K_c$$

$$\frac{K}{P_S} = \pi PL_s \Delta \quad \text{depends on } L_s/K_s$$

### 3- Effect of trade on factor prices

Effect of trade on MPK and MPL?

$MPK_C \uparrow$  because  $L_C/K_C$  increases  
(there are more workers to operate machines in the computer industry)

$MPK_S \uparrow$  because  $L_S/K_S$  increases  
(there are also more workers to operate machines in the shoe industry)

Conversely, MPL decreases in both industries

$$\pi_{PL_S}, \pi_{PL_C} \rightarrow \left( \frac{K_S}{L_S} \downarrow, \frac{K_C}{L_C} \downarrow \right)$$

### 3- Effect of trade on factor prices

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We answered:

- What is the effect of trade on the wage/rental rate ratio?

Now:

- What is the effect of trade on the rental rate?  
(in real terms, i.e. in terms of welfare)
- What is the effect of trade on wages?  
(in real terms, i.e. in terms of welfare)

### 3- Effect of trade on factor prices

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Effect on rental rate?

What about the rental rate? Welfare of K owners?

$$R = P_C \bullet MPK_C \quad \text{and} \quad R = P_S \bullet MPK_S$$

### 3- Effect of trade on factor prices

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Effect on rental rate?

What about the rental rate? Welfare of K owners?

$$R = P_C \bullet MPK_C \quad \text{and} \quad R = P_S \bullet MPK_S$$

Real rate (compared to each price):

$R/P_C = MPK_C \uparrow$  because  $L_C/K_C$  increases  
(there are more workers to operate machines in the computer industry)

### 3- Effect of trade on factor prices

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Effect on rental rate?

What about the rental rate? Welfare of K owners?

$$R = P_C \bullet MPK_C \quad \text{and} \quad R = P_S \bullet MPK_S$$

Real rate (compared to each price):

$R/P_C = MPK_C \uparrow$  because  $L_C/K_C$  increases

$R/P_S = MPK_S \uparrow$  because  $L_S/K_S$  increases  
(there are also more workers to operate machines in the shoe industry)

### 3- Effect of trade on factor prices

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Effect on rental rate?

What about the rental rate? Welfare of K owners?

$$R = P_C \bullet MPK_C \quad \text{and} \quad R = P_S \bullet MPK_S$$

Real rate (compared to each price):

$$R/P_C = MPK_C \uparrow \text{ because } L_C/K_C \text{ increases}$$

$$R/P_S = MPK_S \uparrow \text{ because } L_S/K_S \text{ increases}$$

→ **The rental rate increases faster than any price in the Home country**

### 3- Effect of trade on factor prices

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Effect on wages?

What about wages? Welfare of workers?

$$W = P_C \cdot MPL_C \quad \text{and} \quad W = P_S \cdot MPL_S$$

“Real” wage (compared to each price):

$$W/P_C = MPL_C \downarrow \text{ because } L_C/K_C \text{ increases}$$

$$W/P_S = MPL_S \downarrow \text{ because } L_S/K_S \text{ increases}$$

→ **Wages decreases faster than any price in the Home country**

### 3- Effect of trade on factor prices

Determination of the Real Wage and Real Rental  
Stolper-Samuelson Theorem:

If the Home country opens to trade, the price of computers increases (compared to the price of shoes) and:

$$\frac{\Delta W}{W} < \frac{\Delta P_S}{P_S} < \frac{\Delta P_C}{P_M} < \frac{\Delta R}{R}$$

The diagram illustrates the relative changes in factor prices. It shows four ratios arranged horizontally:  $\frac{\Delta W}{W}$ ,  $\frac{\Delta P_S}{P_S}$ ,  $\frac{\Delta P_C}{P_M}$ , and  $\frac{\Delta R}{R}$ . A green curved arrow below the first ratio points downwards, indicating a decrease in the real wage ( $\frac{W}{P_S}$ ). A red curved arrow below the last ratio points upwards, indicating an increase in the real rental ( $\frac{R}{P_C}$ ). The middle ratios,  $\frac{\Delta P_S}{P_S}$  and  $\frac{\Delta P_C}{P_M}$ , are grouped by a horizontal bracket, suggesting they are the primary factors in determining the movement of the real wage and real rental.

### 3- Effect of trade on factor prices

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Determination of the Real Wage and Real Rental  
Stolper-Samuelson Theorem:

In the long run, when all factors are mobile, an increase in the relative price of a good will increase the real earnings of the factor used intensively in the production of that good and decrease the real earnings of the other factor.

*PS: regardless of which industry employs this factor  
(HO model is about the long-run: factors are mobile)*

## Heckscher-Ohlin: Summary from Chapter 4

- We can generate trade by differences in endowments, even if technologies are the same
- **Heckscher-Ohlin Theorem:** if a country is abundant in a factor, it should exports in industries that are relatively intensive in this factor.
- The data support HO theorem only when also incorporate differences in productivity.
- **Stolper-Samuelson theorem:** An increase in the price of a good generates an increase in the real earning of the factor used intensively in the production of that good, and should decrease the real earning of the other factor

## 4- Trade and wage inequality

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- Next parts:
  - Heckscher-Ohlin-Vanek model test
  - Trade and wage inequality
  - FDI and migration (chapter 5)