

# ECO364: International Trade Theory

## Lecture 3

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- Last Class

- Heckscher-Ohlin Model - Intro
- FF Curve (Relates factor prices to factor demand)
- SS Curve (Relates good prices to factor prices)

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- Today

- Review of last lecture (FF and SS curve)
- Putting the FF and SS curve together
- Stolper-Samuelson Theorem
- Rybczynski Theorem (Edgeworth Box and PPF)
- Heckscher-Ohlin Theorem

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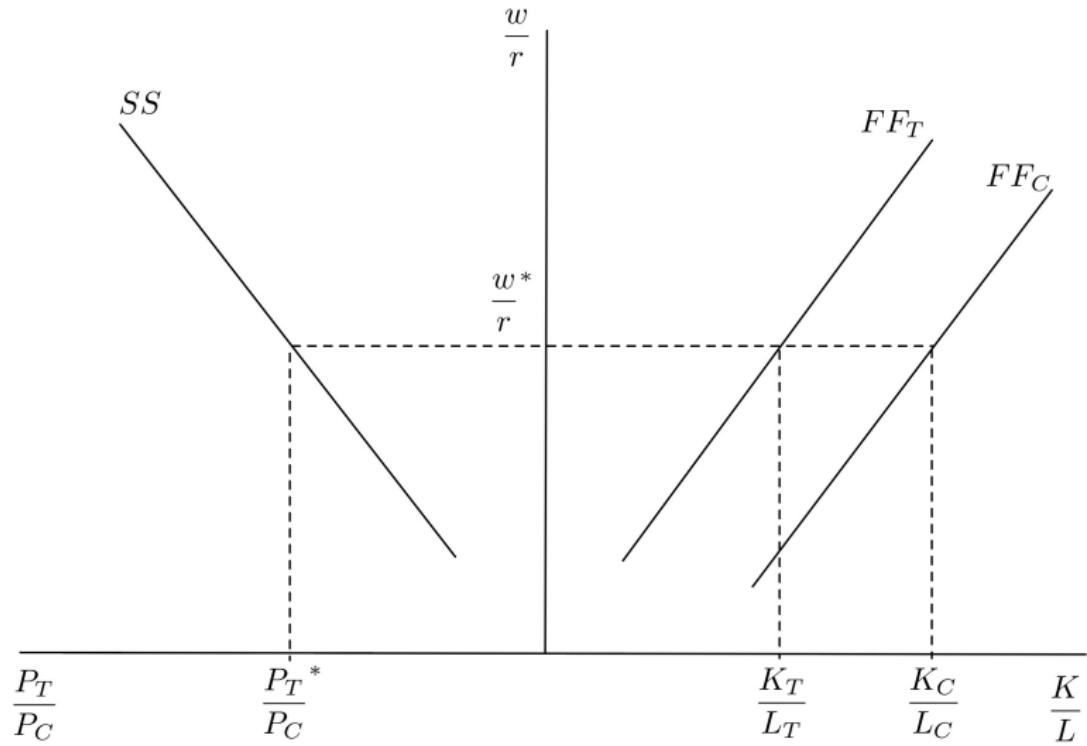
- Readings

- None!

# Last Lecture...

- Derived the FF curve
  - Relates relative factor prices to relative input demands ( $K/L$ )
  - The position of the curves relative to each other depends on the relative input intensity of each good (see FF curve derivation with numbers)
- Derived the SS curve
  - Relates relative good prices with relative factor prices
  - Started with the Lerner Diagram
  - Thought experiment

# FF and SS Curves Together



# FF and SS Curves Together

- Suppose  $P_T$  increases and  $P_C$  stays constant
  - Remember the thought experiment in lecture 2b?
  - New firms enter textile because of short-term positive profits
  - Capital and labour flows into textiles
  - Since textile is labour-intensive, increase in demand for labour increases wages
  - But for each unit of labour moving from computers to textiles, more capital is being released
    - this is because computers are relatively capital intensive
  - New, unemployed capital causes a decrease in  $r$  (the return to capital)
  - Therefore,  $w/r$  increases

# FF and SS Curves Together

- Because labour is now more expensive relative to capital, firms in both sectors reoptimize to include more capital in their production (this reduces their cost)
- Thus,  $K/L$  rises in both sectors
  - This mapping between relative factor prices and the capital-labour ratio is characterized by the FF curve
- EXERCISE: Suppose  $P_T$  decreases and  $P_C$  stays constant

# Three Theorems in the HO Model

- What happens to the returns to factors when the price of goods changes?
  - **Stolper-Samuelson Theorem**
  - Trade shocks through goods prices could result in welfare losses
- What happens to the structure of production when the distribution of factor endowments changes?
  - **Rybczynski Theorem**
  - Allows predictions for how migration might affect industrial structure
- In what goods do countries specialize in given their factor endowments following trade liberalization?
  - **Heckscher-Ohlin Theorem**
  - Makes predictions on how factor endowment might affect the goods in which countries might specialize in

# Stolper-Samuelson Theorem

# Stolper-Samuelson Theorem

- What happens to the returns to factors when the price of goods changes?
- We got a preview of the answer to this question in our study of the FF and SS curves
- We'll add to these results by looking at real returns

# Stolper-Samuelson Theorem

## Theorem (Stolper-Samuelson)

*A rise in the relative price of a good will lead to a rise in the return to the factor used most intensively in the production of that good. There will also be a fall in the return to the other factor*

# Stolper-Samuelson Theorem

## Theorem (Stolper-Samuelson)

*A rise in the relative price of a good will lead to a rise in the return to the factor used most intensively in the production of that good. There will also be a fall in the return to the other factor*

- If the price of textiles increases, the model predicts that wage increases whereas the return to capital decreases
  - Wages increases because labour is the input used most intensively in textiles

# What about *real* returns?

- What we care about is the purchasing power of our workers
  - Which means we must look at real returns:  $w/p$  and  $r/p$
- Note, when a person buys both computers and textiles, her real return is wages  $w$  normalized by a price index  $P$  (i.e.  $w/P$ )
  - $P$  is a function of the price of both textiles and computers

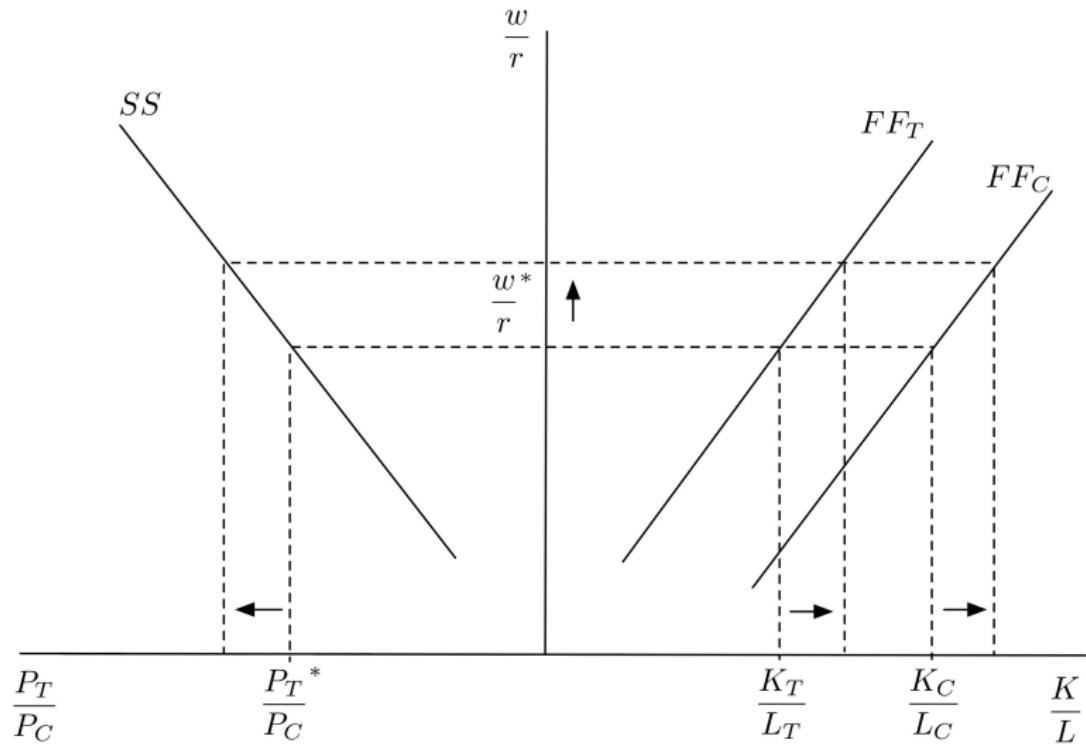
## Real returns to capital

- Suppose the price of textiles rises while the price of computers stays the same
- We demonstrated that  $w$  rises and  $r$  falls
- Since  $P_T$  increased and  $P_C$  did not change,  $r/P_C$  and  $r/P_T$  both decrease
- Therefore, the overall real return to capital falls

## Real returns to labour

- Since the price of computer did not change,  $w/P_C$  increases
- But it is not clear if  $w/P_T$  increased since both  $w$  and  $P_T$  increased
- From the FF-SS Curves, a rise in  $w/r$  results in a rise of  $K/L$  in both industries
  - This can be interpreted as firms substituting towards the more inexpensive factor, capital

# Real returns to labour



# Real returns to labour

- The increase in  $K/L$  raises the marginal product of labour
  - Each worker is working with more capital, so their individual output increases
- From perfect competition,  $w/P_T = MPL_T$ 
  - $MPL_T = \frac{\partial F_T(K, L)}{\partial L}$ , marginal product of labour
  - e.g.  $F_T(K, L) = K^{1/3}L^{2/3} \implies MPL_T = \frac{2}{3} \left(\frac{K}{L}\right)^{1/3}$
- The increase in the marginal product of labour increases  $w/P_T$

## Argument applies to returns to capital

- Each unit of capital is now working with less labour, thus the marginal product of capital falls which means the purchasing power of  $r$  in terms of both goods fall
  - $r/P_T = MPK_T$

# Rybczynski Theorem

# Rybczynski Theorem

- What happens to structure of production when the distribution of factor endowments changes?
  - Changes in stock of capital and labour:  $\bar{K}$  and  $\bar{L}$
  - Can also give insight on how factor endowments determine a country's industrial composition
- Dutch Disease
  - Commodity booms (such as the discovery of oil) tend to cause industrial restructuring, most of the time the type that is harmful to the long-term development of the country

# Rybczynski Theorem

- Given a set of goods prices, the SS curve give the corresponding relative factor price
- Given this relative factor price, the FF curves gives us the capital-labour ratio in each sector
- Along with the resource constraint, we can use this information to solve for factor allocation within this country
  - These factor allocations are  $K_C, K_T, L_C, L_T$

## Example

- Let's go back to the numerical example from Lecture 2b

$$Q_C = K_C^{2/3} L_C^{1/3}$$

$$Q_T = K_T^{1/3} L_T^{2/3}$$

- These production functions implied the following FF curves

$$\frac{w}{r} = 2 \frac{K_T}{L_T} \quad \frac{w}{r} = \frac{1}{2} \frac{K_C}{L_C}$$

# Example

$$\frac{w}{r} = 2 \frac{K_T}{L_T} \quad \frac{w}{r} = \frac{1}{2} \frac{K_C}{L_C}$$

- Now suppose relative goods prices are such that the SS curves gives us  
 $\frac{w}{r} = 1$
- Thus,

$$2K_T = L_T \tag{1}$$

$$K_C = 2L_C \tag{2}$$

- In optimum, all resources in a country will be employed
- This gives us the following equations

$$K_T + K_C = \bar{K} \tag{3}$$

$$L_T + L_C = \bar{L} \tag{4}$$

- $K$  and  $L$  with no subscripts are the stock of capital and labour

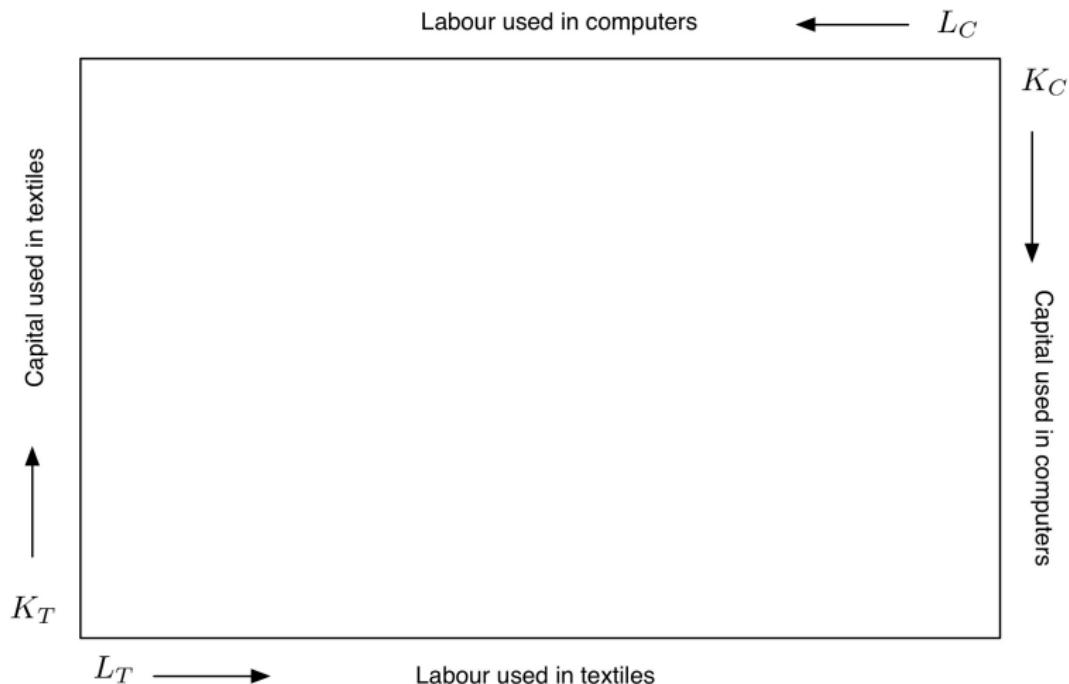
## Example

- Equations (1)-(4) gives us four equations and four unknowns
- Thus, we can solve for optimal capital and labour in each industry:  
 $K_C^*$ ,  $K_T^*$ ,  $L_C^*$ ,  $L_T^*$
- Note that the solutions will be a function of the parameters of the optimization problem
  - In particular,  $K_C^*$ ,  $K_T^*$ ,  $L_C^*$ ,  $L_T^*$  will change as the stock of capital  $\bar{K}$  and labour  $\bar{L}$  changes

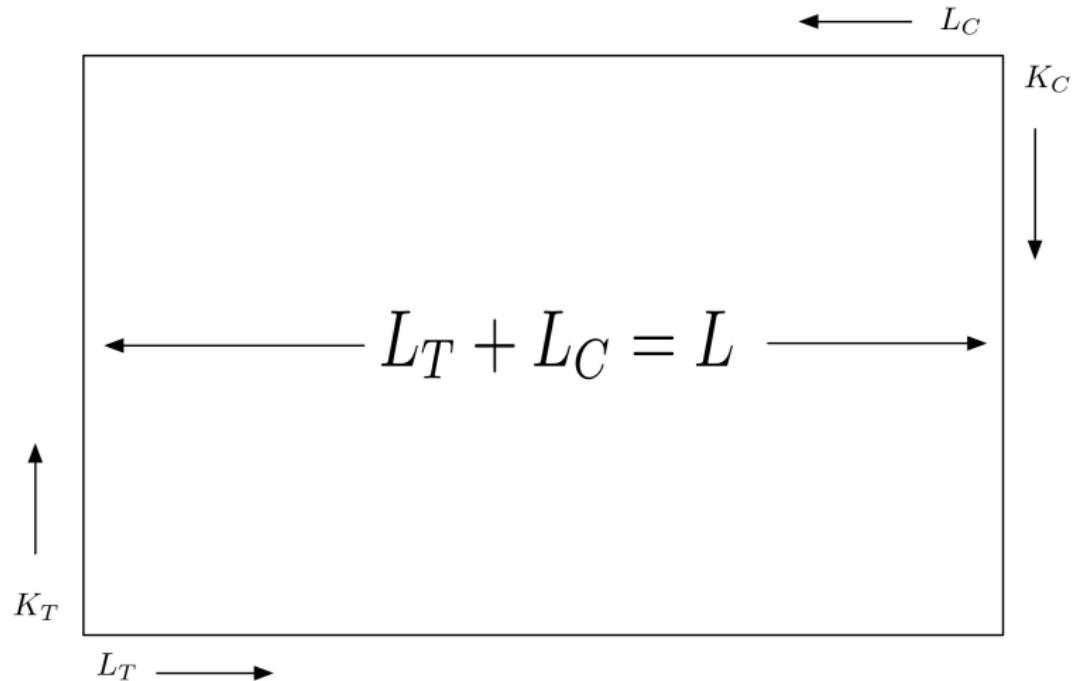
# Edgeworth Box

- Let's see how this can be done using the Edgeworth Box
  - Allows us to visualize how changes in endowment affect input use in each industry and, subsequently, their level of output

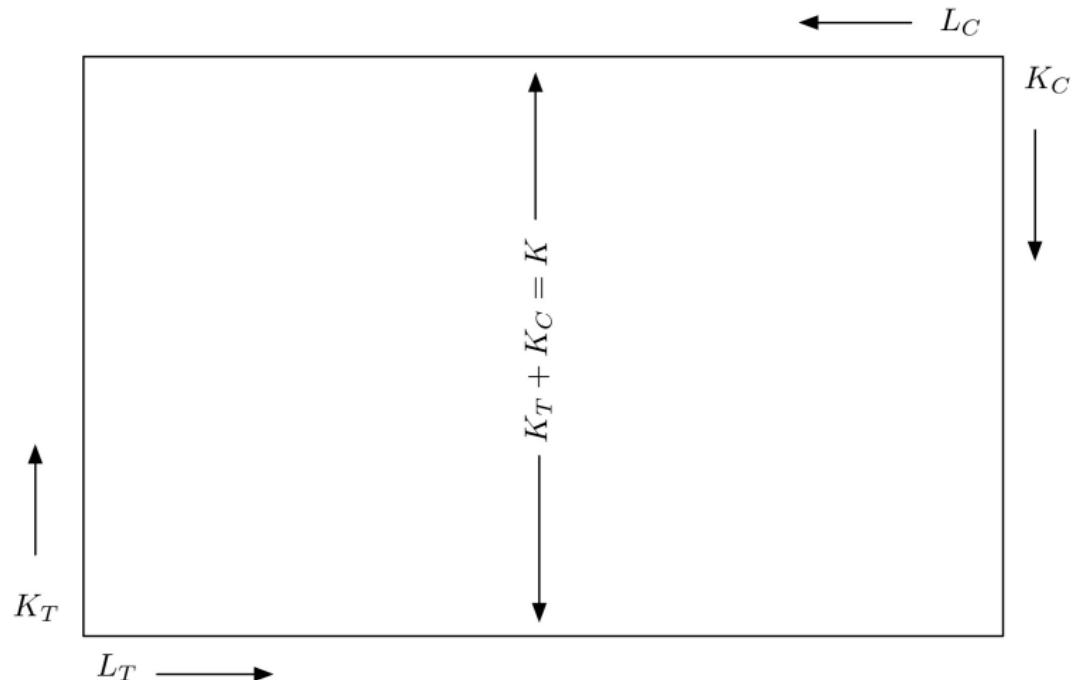
# Edgeworth Box



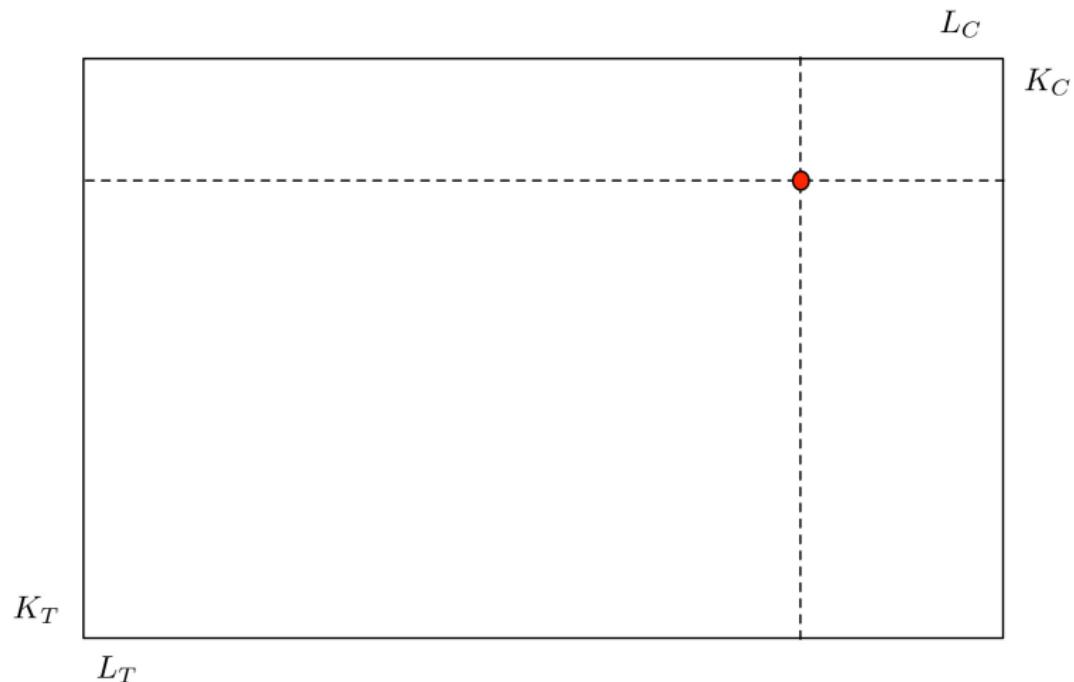
# Stock of Labour



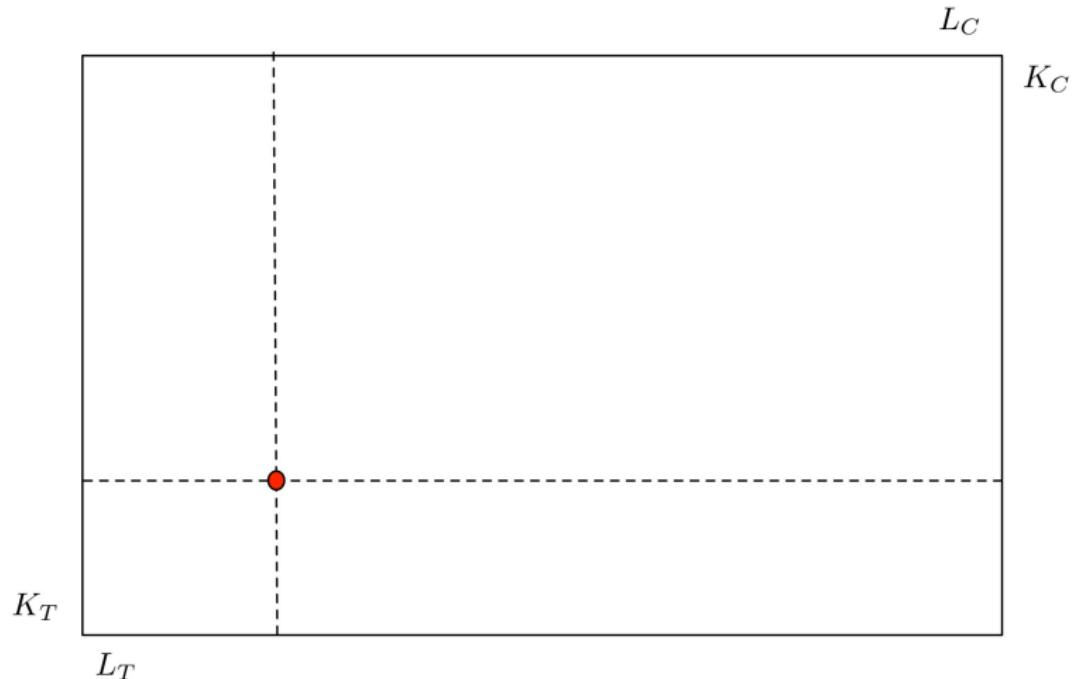
# Stock of Capital



# Large Textile Industry

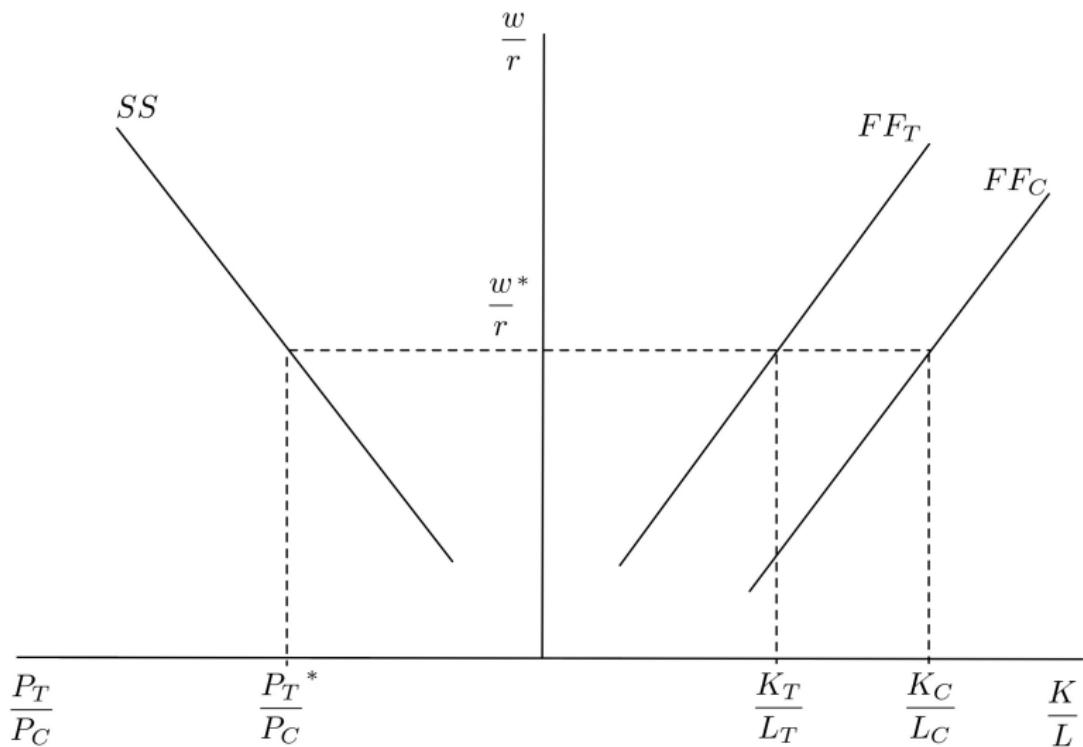


# Large Computer Industry



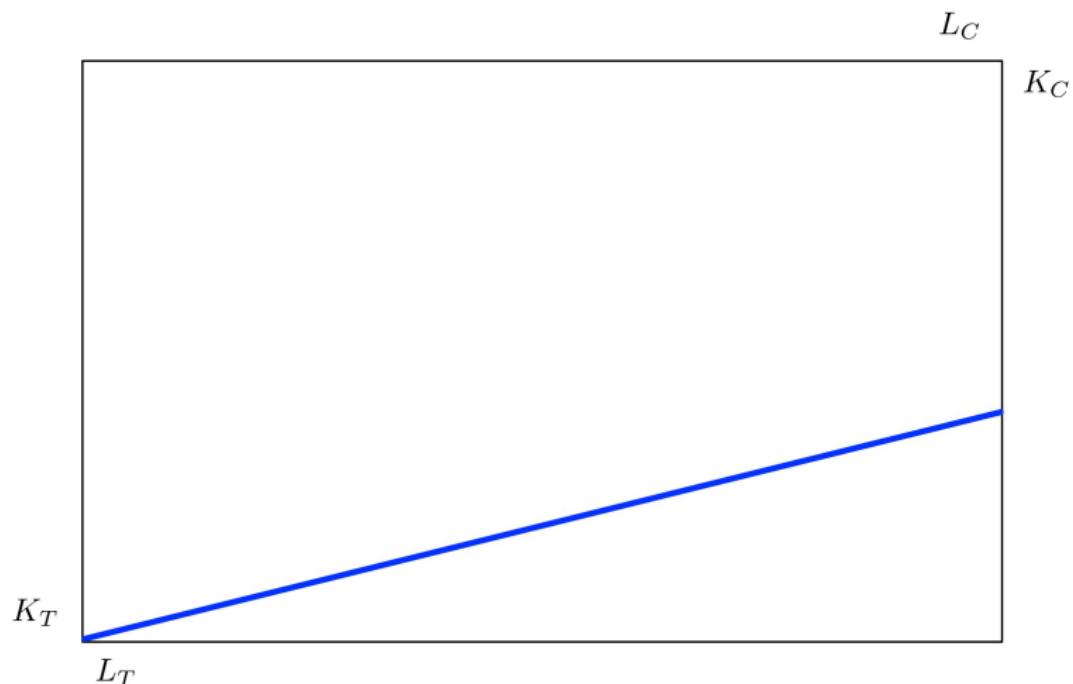
# Ray from Origin

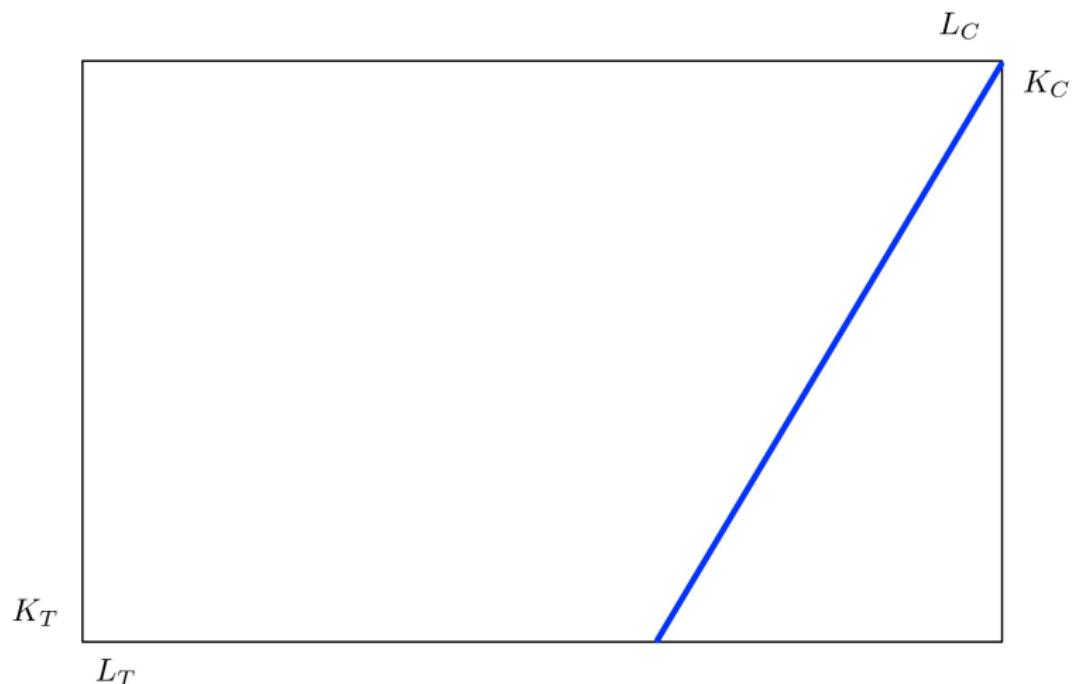
- From the FF-SS curves, we are given the capital-labour ratio for a given relative goods prices and relative factor prices
  - These capital-labour ratios tell us how relatively capital intensive an industry will be for a given relative goods price,  $P_T/P_c$



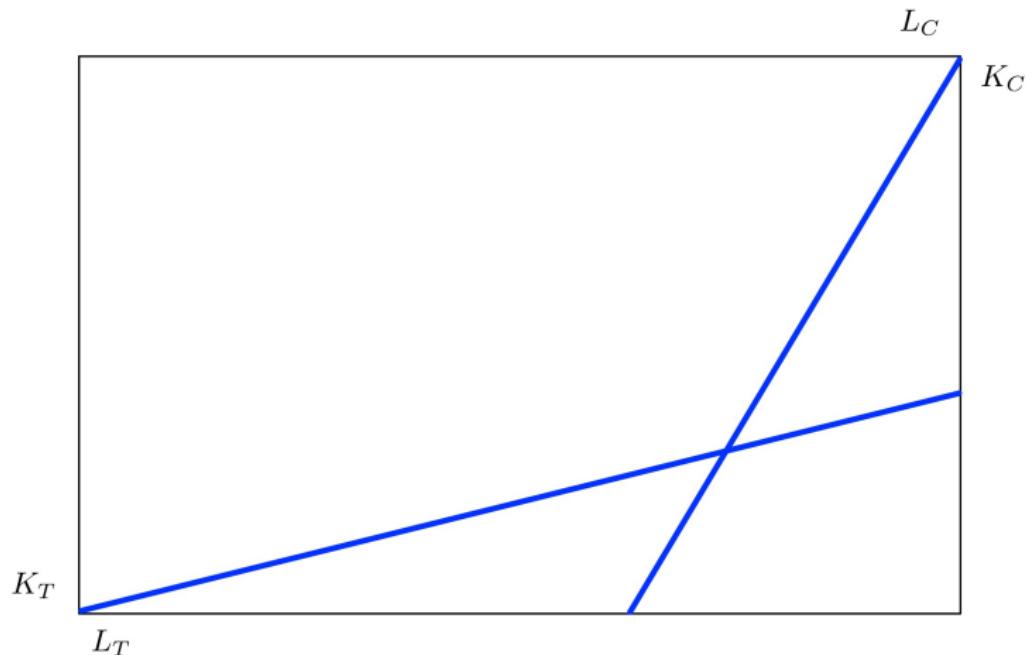
# Output Expansion Path

- The prevailing capital-labour ratios for a given set of prices is the slope of the ray from the origin in the Edgeworth box
  - These rays from the origins are also called the Output Expansion Path
  - We saw this in our study of the Lerner diagram in lecture 2b
- By our assumption that the computer industry is more capital intensive than textiles, this line will be steeper for computers
  - We can see that this is the case by comparing each industry's FF curves

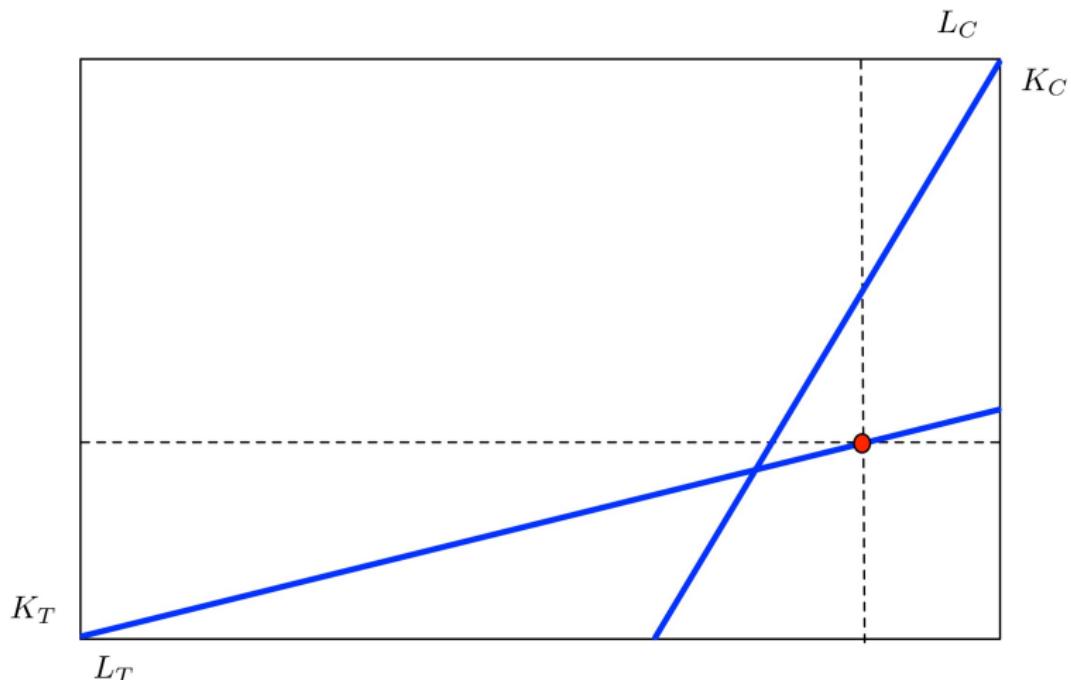




The resulting factor allocation equilibrium values of capital and labour in each industry is the point where the Output Expansion Paths cross

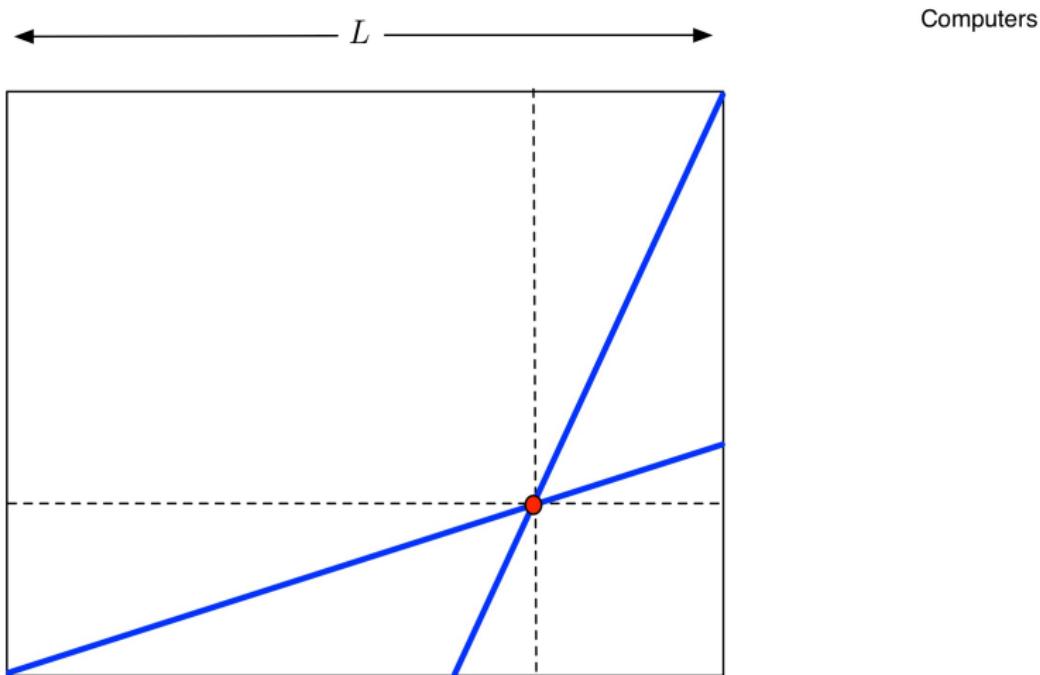


# Not an Equilibrium

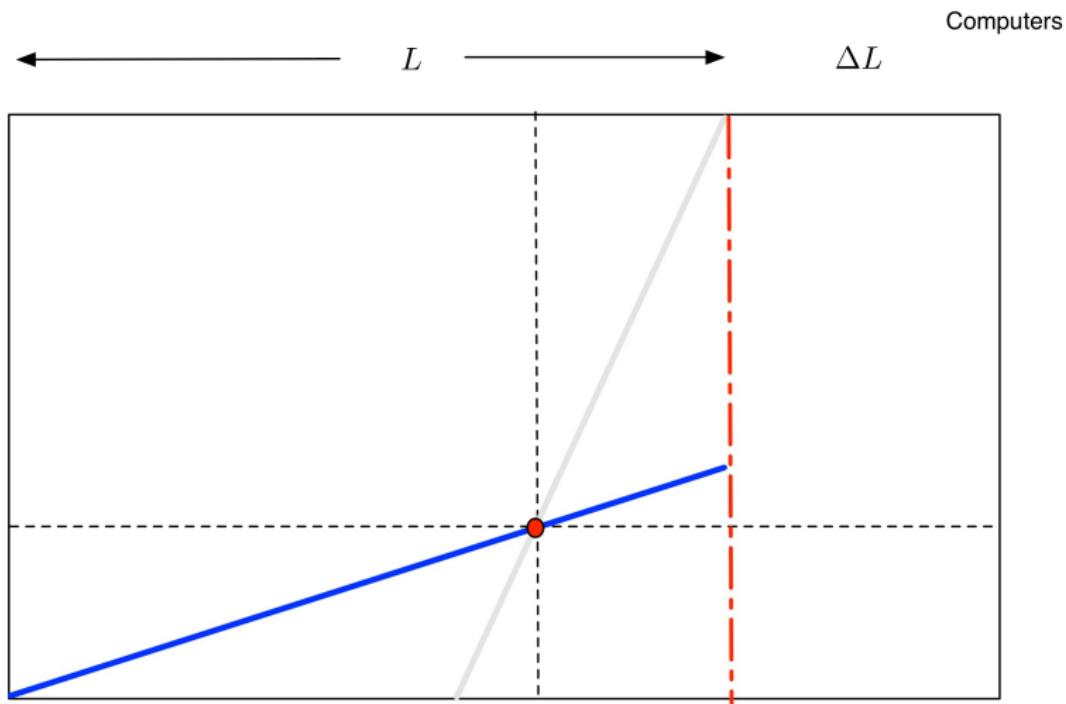


# Change in Factor Endowment

- Now we can ask How do production patterns change if we increase the stock of one of the endowments?
- Suppose the stock of labour,  $\bar{L}$ , were to increase but relative good prices and, as a result, relative factor prices stayed the same
  - Relative factor intensity in each industry have not changed

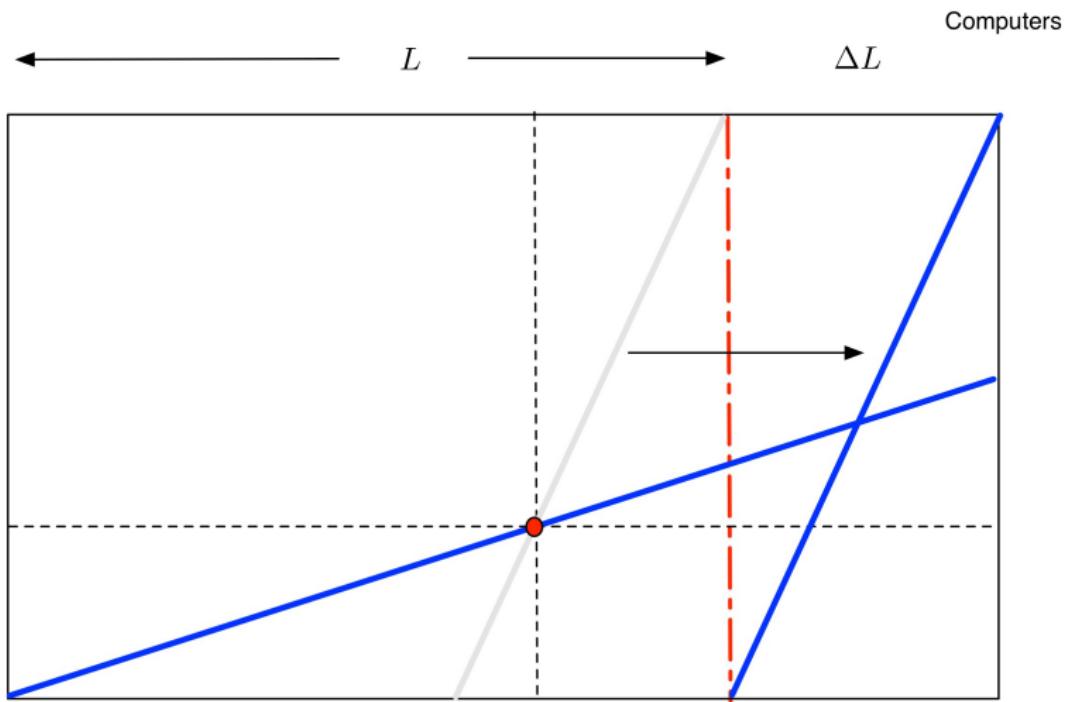
$\bar{L} \uparrow$ 

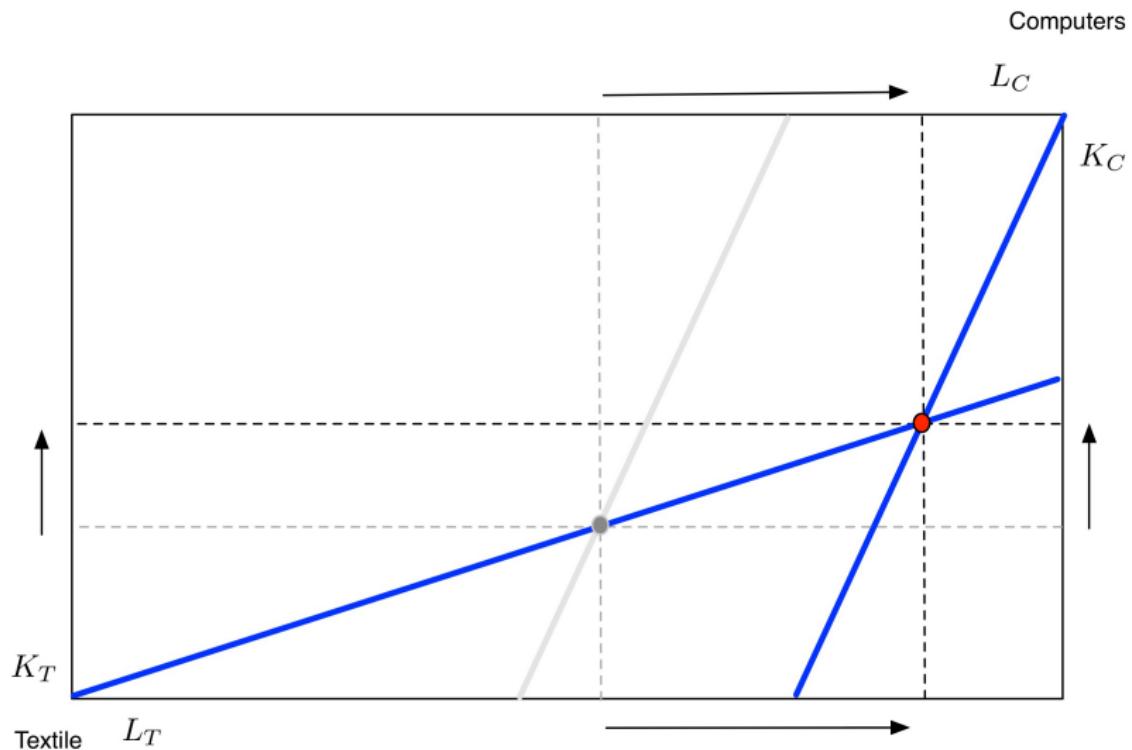
Textile

$\bar{L} \uparrow$ 

# Output Expansion Path Slope

- Because relative good and factor prices did not change, the relative factor intensity in each industry does not change
- Therefore, slope of Output Expansion Path (rays from origin) does not change

$\bar{L} \uparrow$ 

$\bar{L} \uparrow$ 

# What Happened?

- $K_T, L_T$  increases  $\implies Q_T$  increases
- $K_C, L_C$  falls  $\implies Q_C$  falls
- These results summarizes the prediction made by the Rybczynski theorem

# Rybczynski Theorem

## Theorem (Rybczynski Theorem)

*An increase in a factor endowment will increase the output of the industry using it intensively, and a decrease in the output of the other industry*

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- Labour is used more intensively in textiles than in computers
- Therefore, an increase in the stock of labour increased output in textiles
- and decreased output in computers

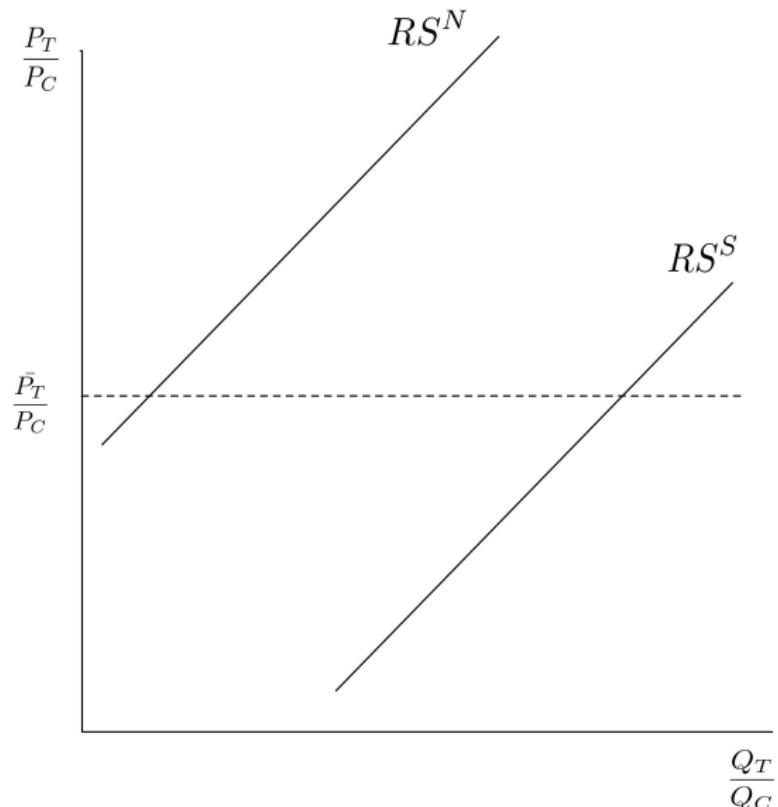
# Rybczynski Theorem

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*An increase in a factor endowment will increase the output of the industry using it intensively, and a decrease in the output of the other industry*

- An alternative interpretation is that countries will produce more of the good that intensively uses its more abundant factor
- E.g. Mexico will produce more textiles than computers relative to Canada because:
  - ① it has relatively more labour than capital compared with Canada
  - ② textiles is more labour intensive than computers
- This can be shown in each countries relative supply curve

# Relative Supply Curve



# Relative Supply Curve

- For a given relative goods price, South—the labour abundant country—produces more textiles relative to computers than North—the capital abundant country
- What underlie the difference in these two supply curve is the fact that we have assumed that goods and factor prices remain constant when we changed the labour stock in the Edgeworth Box
  - This is why the slopes of the Output Expansion Paths did not change as the stock of labour endowments increased

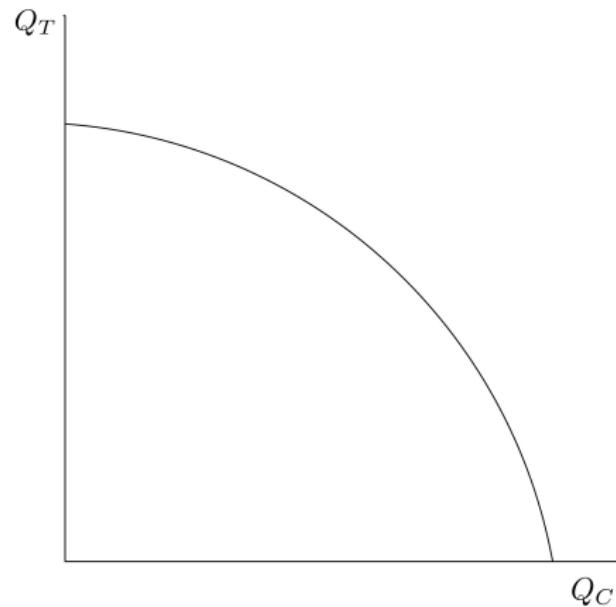
# Relative Supply Curve

- So for each  $P_T/P_C$ , the difference in  $Q_T/Q_C$  in the relative supply curves between the two countries are just the result of changes in labour endowment as seen in the Edgeworth Box
- We can also derive these relative supply curves using PPFs

# PPFs in the HO Model

- Unlike the Ricardian Model, the PPF in the HO model are bowed out
- This is because of the diminishing marginal returns assumption we made on the production function,  $Q_j = F_j(K, L)$ 
  - Increasing the production of good  $j$  entails increasing usage of both capital and labour
  - But as we use more and more of these inputs, the marginal output we get is decreasing
  - This results in a bowed out PPF curve

# PPFs in the HO Model



## Isovalue Line

- Optimum output can be attained by maximizing the value of output

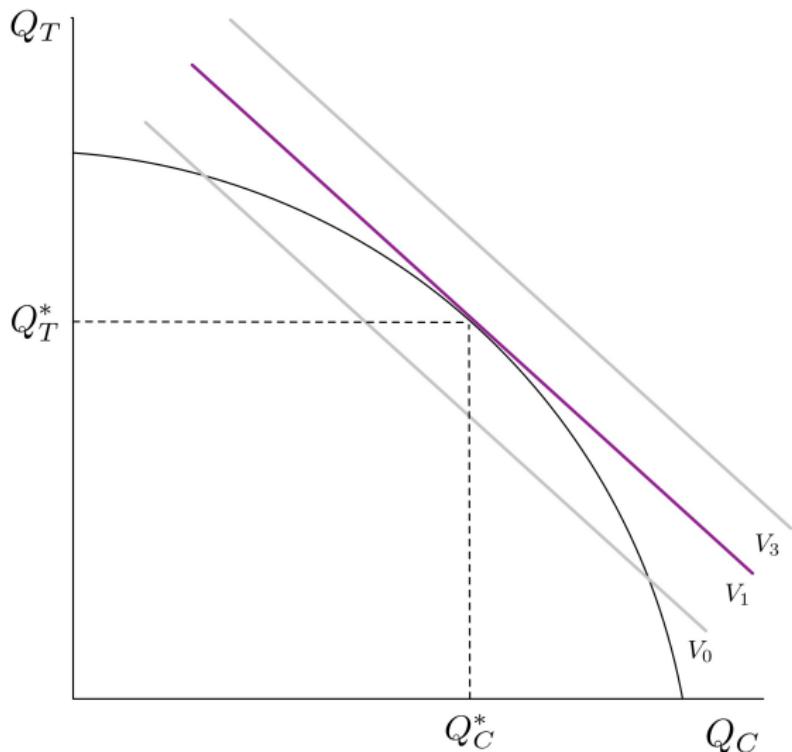
$$V = P_C Q_C + P_T Q_T$$

- Rewrite this as

$$Q_T = \frac{V}{P_T} - \frac{P_C}{P_T} Q_C$$

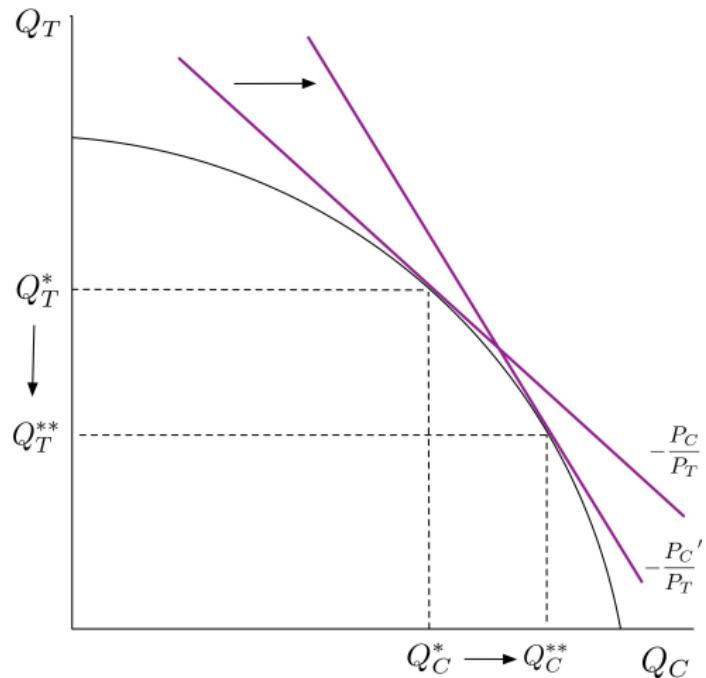
- This gives us all the combination of  $Q_T$  and  $Q_C$  that attains the value of output  $V$
- Call this line the **isovalue line**
  - This is not the same as the **isovalue curve** in the Lerner Diagram

## Isovalue Line



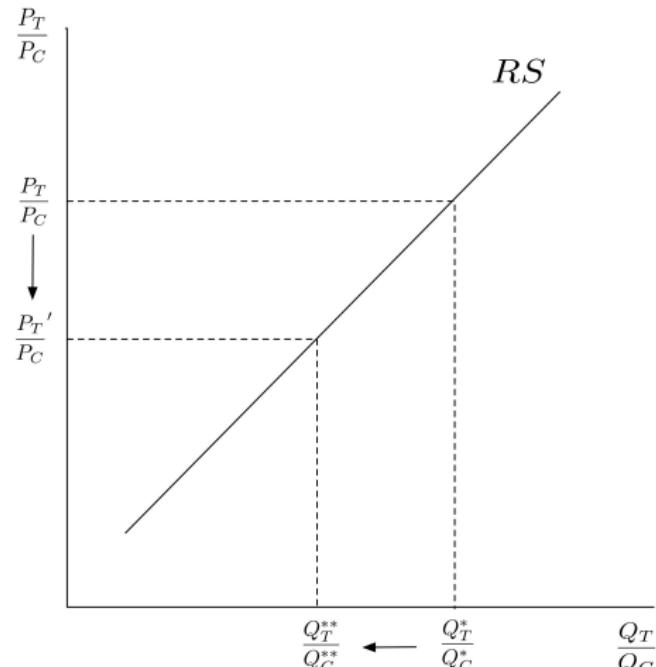
# Isovalue Line and changes in Prices

As prices change, firms reoptimize and a new tangency point is attained



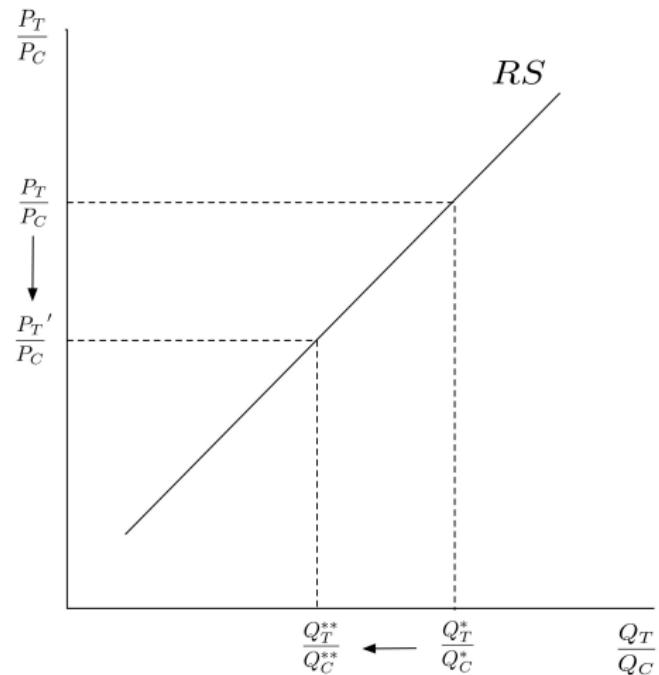
# Relative Supply Curves

The sequence of optimum output as prices change map out the relative supply curves



# Relative Supply Curves

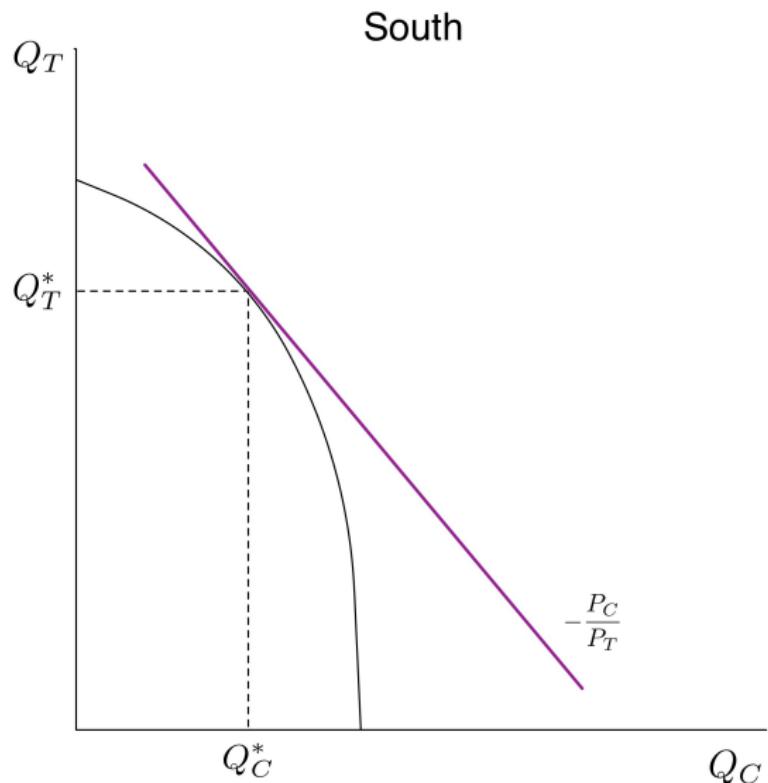
Note the ratio of prices in the y-axis



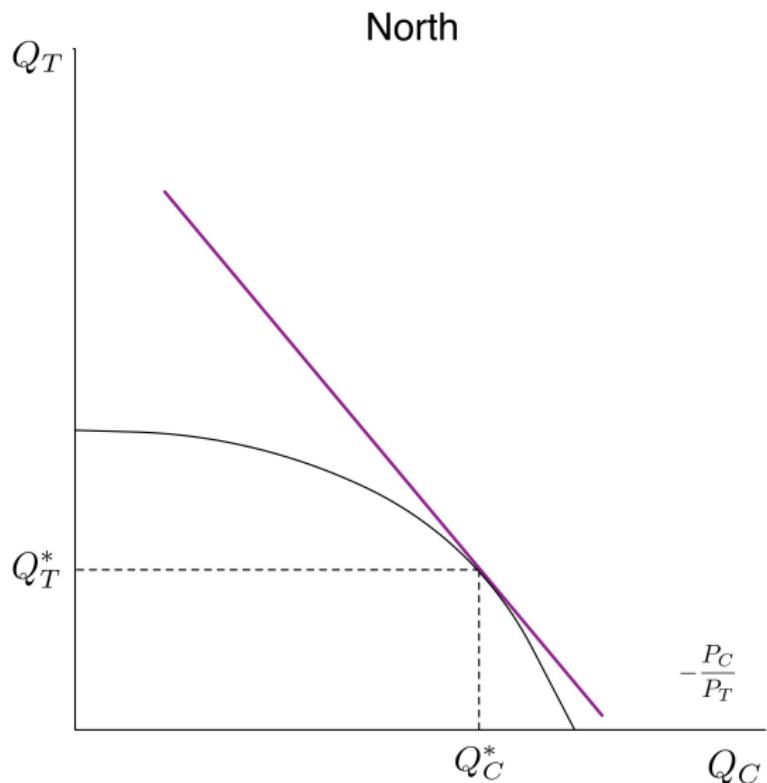
# Relative Supply Curves

- The shape of the PPF curves depend on the labour and capital endowment in each country
  - $Q_T = h(\bar{Q}_C, \bar{K}, \bar{L})$
- Consider South, is relatively more abundant in labour
  - For a given  $Q_C$ , South can create more textiles than North
- North, on the other hand, is relatively more abundant in capital
  - For a given  $Q_T$ , North can create more computers than South

## Country PPF



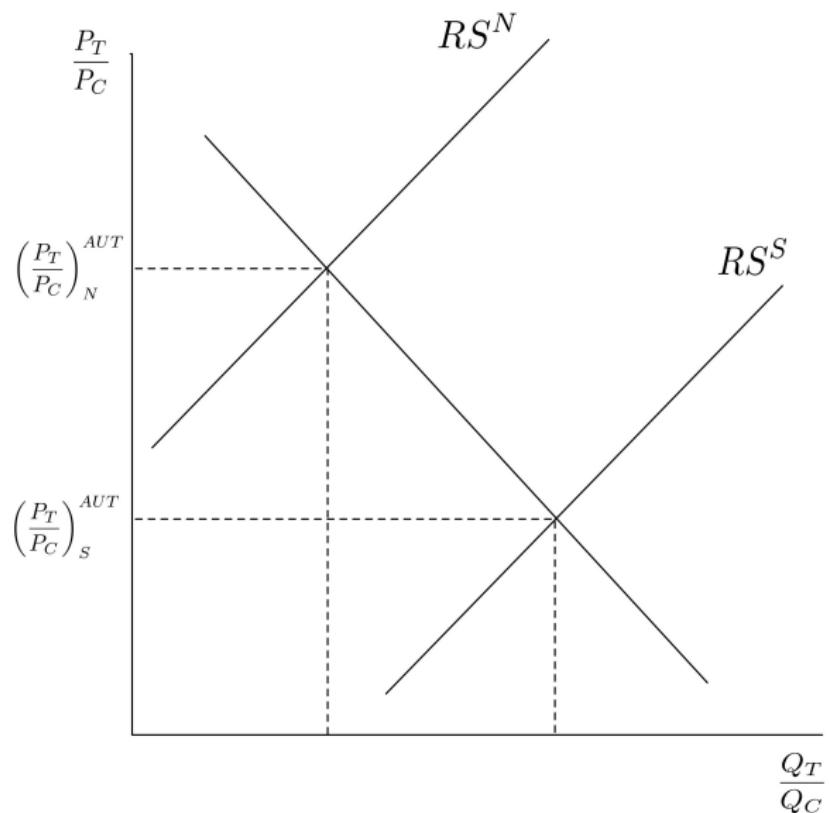
## Country PPF



## Country PPF: North and South

- For a given price, North is able to produce more computers, while South is able to produce more textile
- In other words, for the price  $P_C/P_T$  in the diagram,  $Q_T/Q_C$  is higher for South
- This means that North's relative supply curve is to the left of South's

# Country PPF: North and South



# Free Trade

- Let's now study what happens when we allow countries to trade
- Recall, preference is homothetic and identical across the two countries
  - Countries face the same relative demand (RD) curve
  - Relative demand curve derived from the utility maximization condition

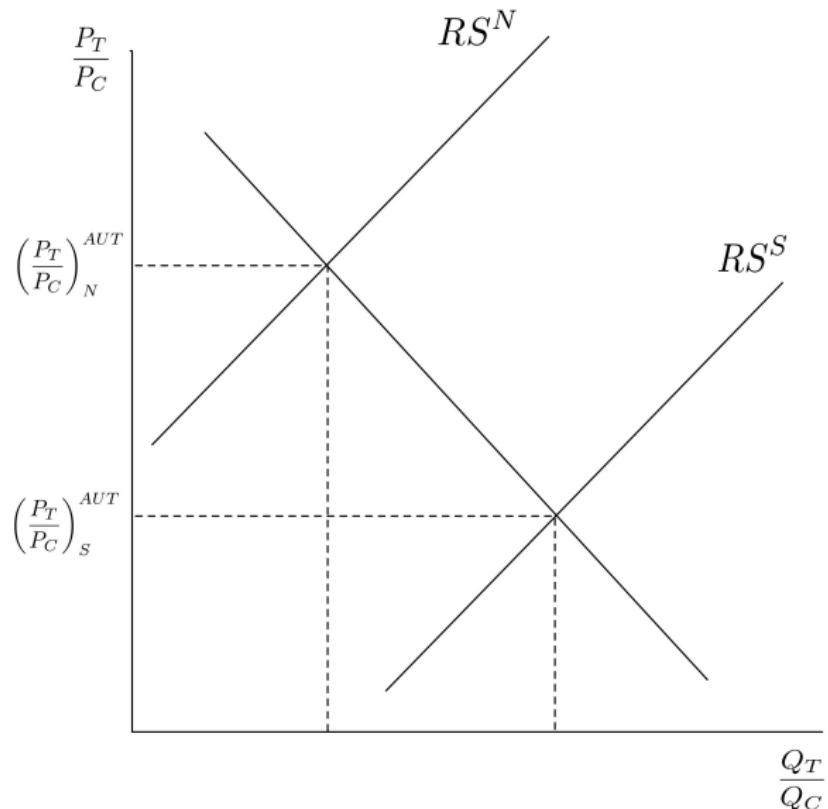
$$\frac{P_T}{P_C} = \frac{MU_T}{MU_C}$$

- It is downward sloping

# Free Trade

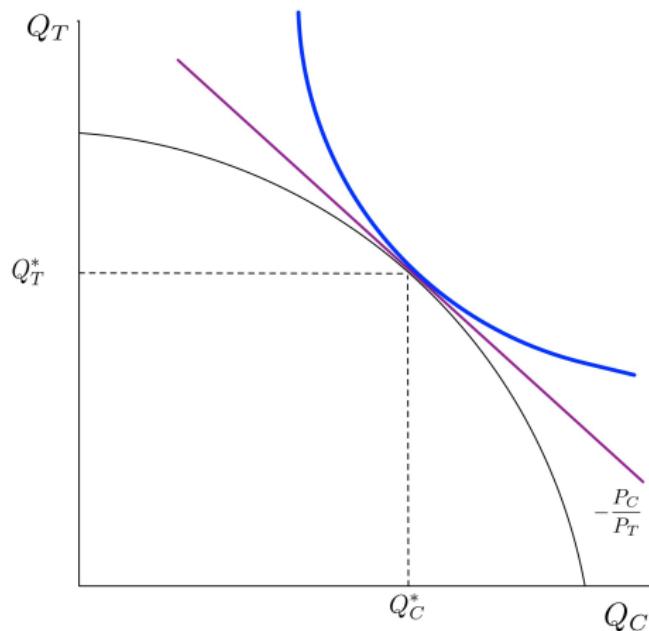
- Relative supply curve derived from the tangency points between the PPF and isovalue line
- The points where each country's relative supply curve cross the relative demand curve is their autarky equilibrium

# Autarky Equilibrium



## Autarky Equilibrium: PPF

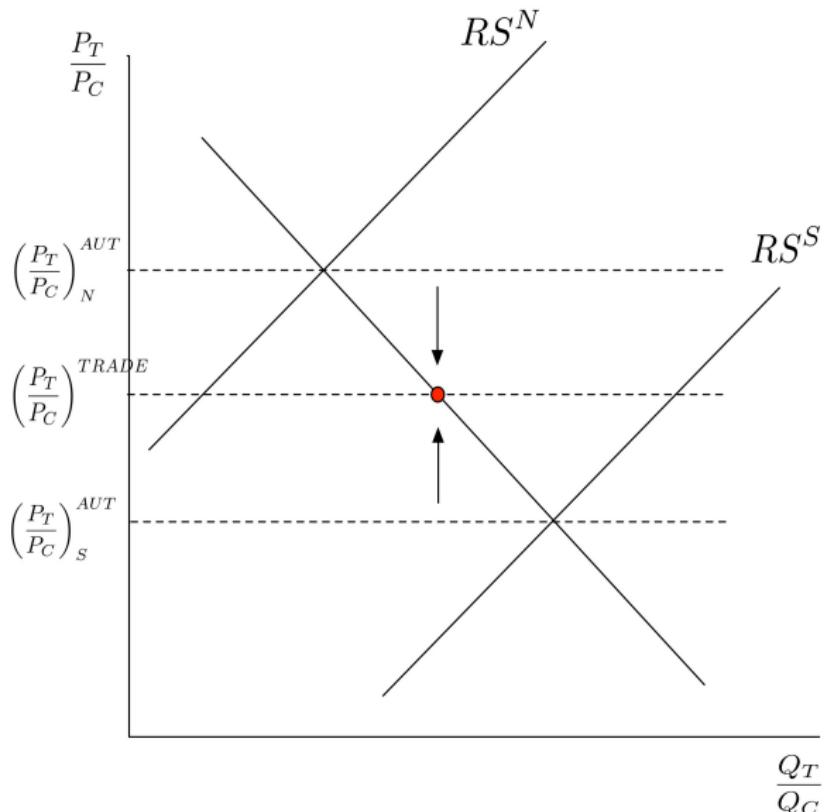
For both countries, equilibrium quantities are located where PPF is tangent to indifference curve. Consumption also equals production in autarky



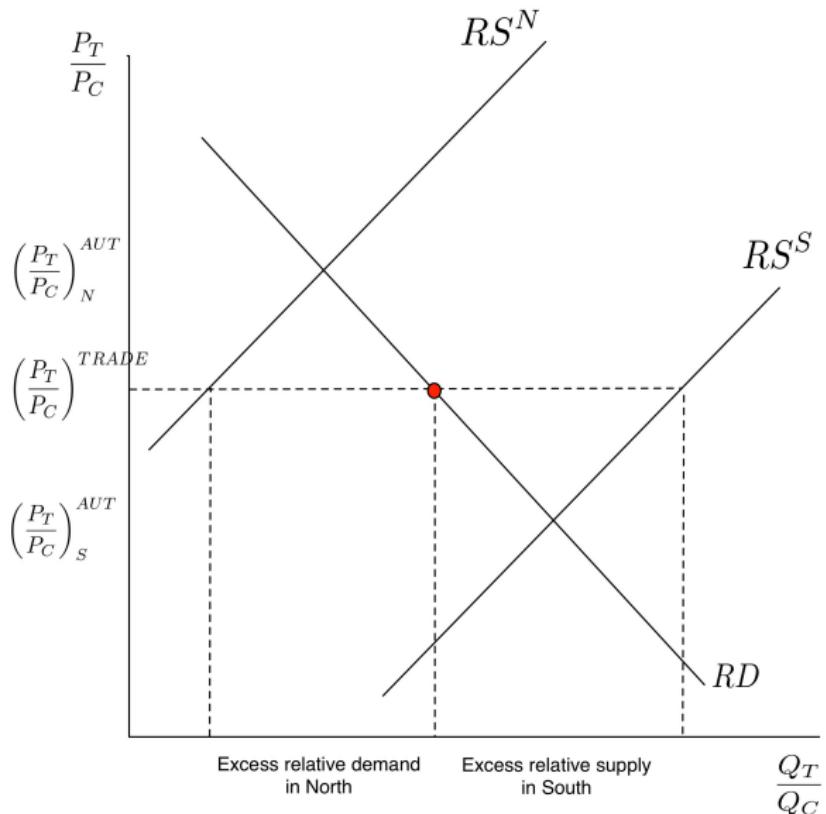
# Trade Equilibrium

- With free trade, goods are now free to flow across countries
- Differences in price for a good across countries can be arbitrated away
- This causes a convergence in the relative price of goods
  - A decrease in relative goods prices for North
  - An increase in relative goods prices for South

# Trade Equilibrium



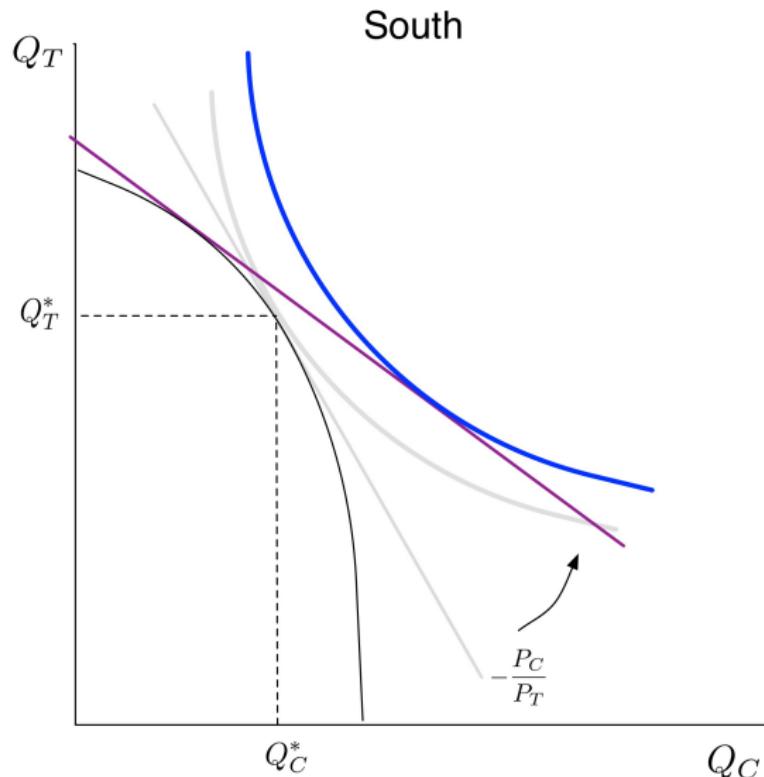
# Trade Equilibrium



# Trade Equilibrium

- At the new trade equilibrium relative good prices, production no longer equals consumption
- We can see how output changes within a country and the gains from trade from the PPF curve

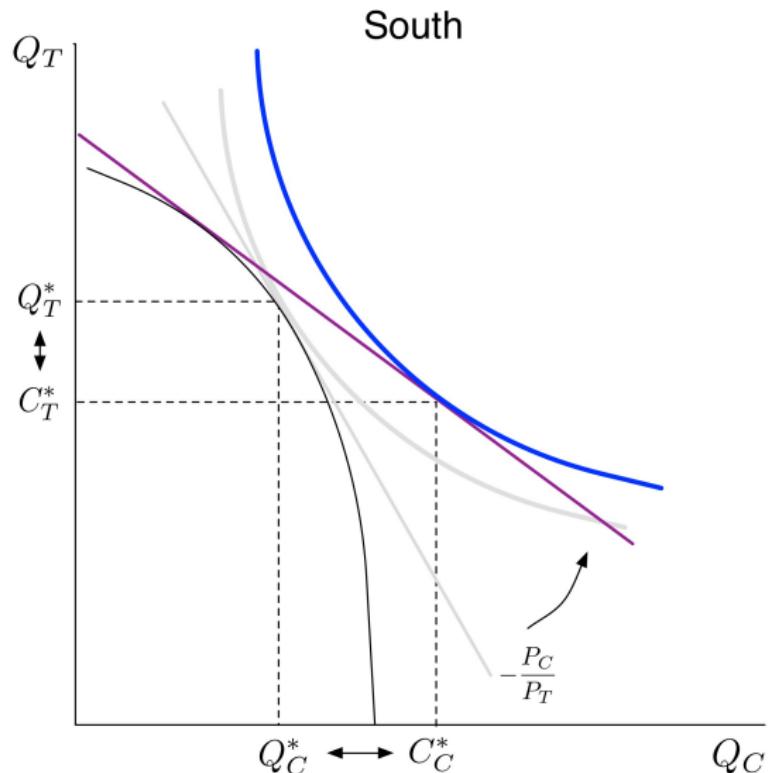
## Gains from Trade: South



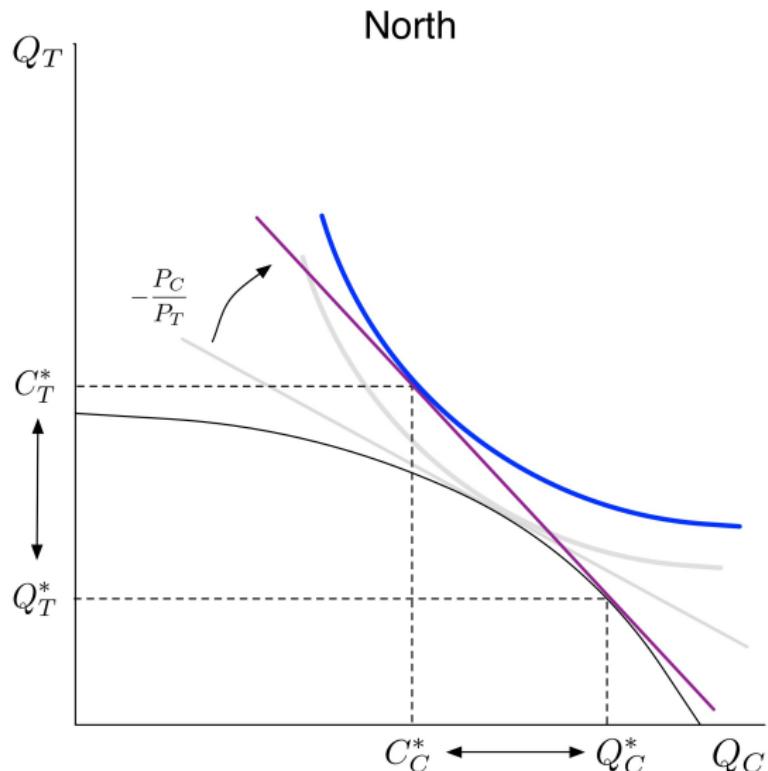
## Gains from Trade: South

- In autarky, South had to produce its own computers
- When countries are allowed to trade, prices converge and South goes from facing its autarky price  $\left(\frac{P_T}{P_C}\right)_S^{AUT}$  to a higher global market price  $\left(\frac{P_T}{P_C}\right)^{TRADE}$ 
  - Note in the PPF diagram, this is a decrease in  $\frac{P_C}{P_T}$ —which is a flatter isovalue line
- We see that following this change in relative price, South produces less computers and more textiles
- By importing the extra computers they need and exporting their surplus of textiles, they achieve a higher indifference curve

## Gains from Trade: South



## Gains from Trade: North



## Gains from Trade: North

- Under autarky, North had to produce relatively more textiles to satisfy demand
- Trade caused a decrease of relative goods prices from autarky,  $\left(\frac{P_T}{P_C}\right)_N^{AUT}$ , to global market price,  $\left(\frac{P_T}{P_C}\right)^{TRADE}$ 
  - This is an increase in the inverse,  $P_C/P_T$ , resulting in a steeper iso-value line
- North can now specialize in computers by producing more of it relative to textiles
- By importing the extra textiles they need and exporting their surplus of computers, they achieve a higher indifference curve

# Heckscher-Ohlin Theorem

- This trading pattern is summarized by the Heckscher-Ohlin Theorem

# Heckscher-Ohlin Theorem

Theorem (Heckscher-Ohlin Theorem)

*Each country will export the good that uses its abundant factor intensively*

# Heckscher-Ohlin Theorem

Theorem (Heckscher-Ohlin Theorem)

*Each country will export the good that uses its abundant factor intensively*

- South is abundant in labour
- Textile is labour intensive
- South will export textile under free trade

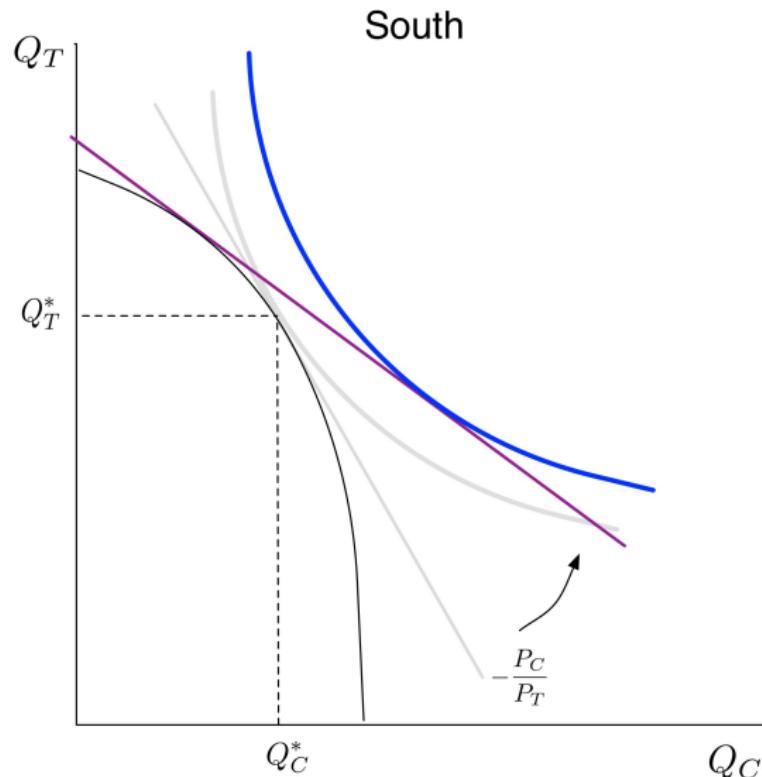
# Implications on Income Distribution

- $P_T/P_C$  rose for South and fell for North
- By the Stolper-Samuelson theorem
  - Labourers in the South real returns increase; capital owners real returns decrease
  - Labourers in the North real returns decrease; capital owners real returns increase
- Abundant factors win while scarce factors lose
- But, countries as a whole achieve a higher indifference curve
  - Those who gained outnumber those who lost welfare
  - Perhaps some sort of transfer mechanism could be implemented to share some of the gains with scarce factors

# Size and Gains from Trade

- From the PPF curves, we saw that the more different a country's autarky price is from the global market price, the greater the gain

# Size and Gains from Trade



# Size and Gains from Trade

- Under what case will a country experience a drastic change in its relative goods price when going from autarky to free trade?
- A country will experience the most drastic change in its relative goods price the more *different* it is from the integrated world (post-trade world)
  - Different in terms of its stock of factors
- The country that is most different from the integrated world are the smaller countries

# Size and Gains from Trade

- Consider the following example

Table: Country Size by Stock of Capital

	Large Canada			Large China		
	$\bar{K}$	$\bar{L}$	$K/\bar{L}$	$\bar{K}$	$\bar{L}$	$K/\bar{L}$
Canada	200	100	2	20	10	2
China	5	20	0.25	50	200	0.25
World	205	120	1.71	70	210	0.33

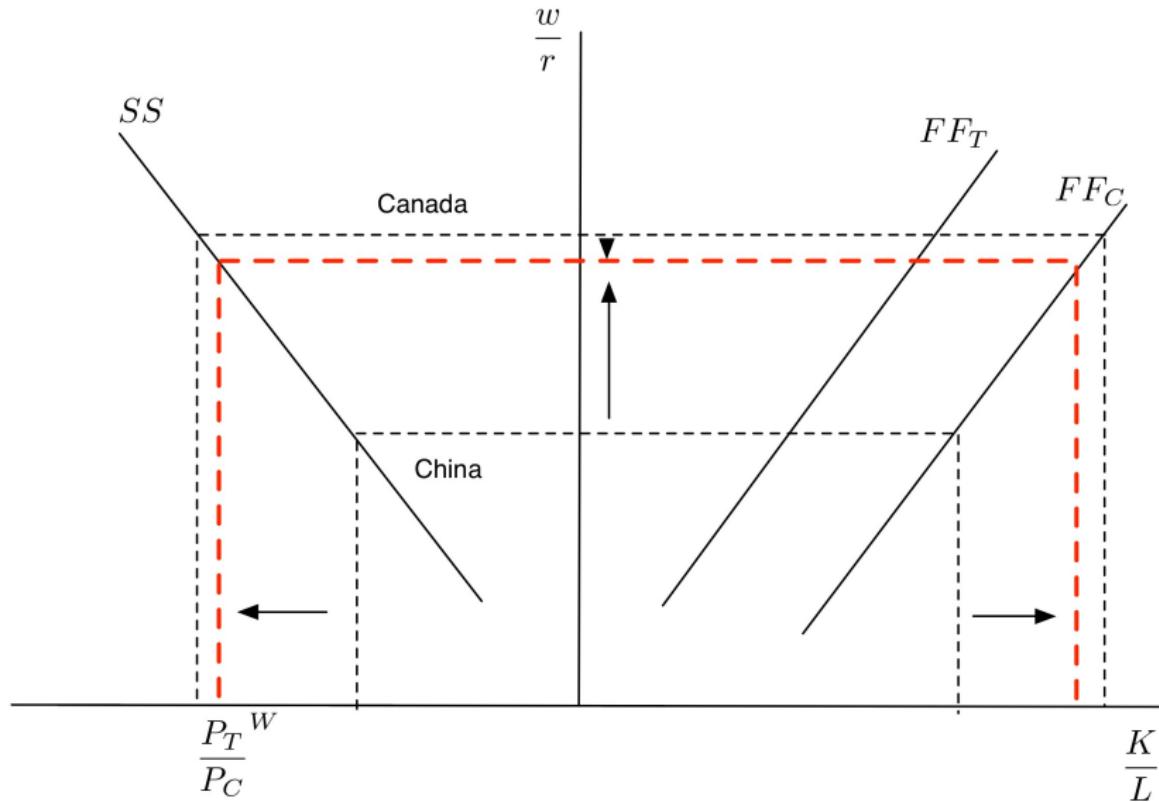
# Large Canada

Table: Country Size by Stock of Capital

	Large Canada			Large China		
	$\bar{K}$	$\bar{L}$	$K/\bar{L}$	$\bar{K}$	$\bar{L}$	$K/\bar{L}$
Canada	200	100	2	20	10	2
China	5	20	0.25	50	200	0.25
World	205	120	1.71	70	210	0.33

- Canada more closely resembles the world
  - Canada's  $K/L = 2$ ; World's  $K/L = 1.71$
- Thus, Canada's autarky price is close to world trade equilibrium price
- China will experience a more drastic change in the isovalue line, which means greater gains

# Large Canada



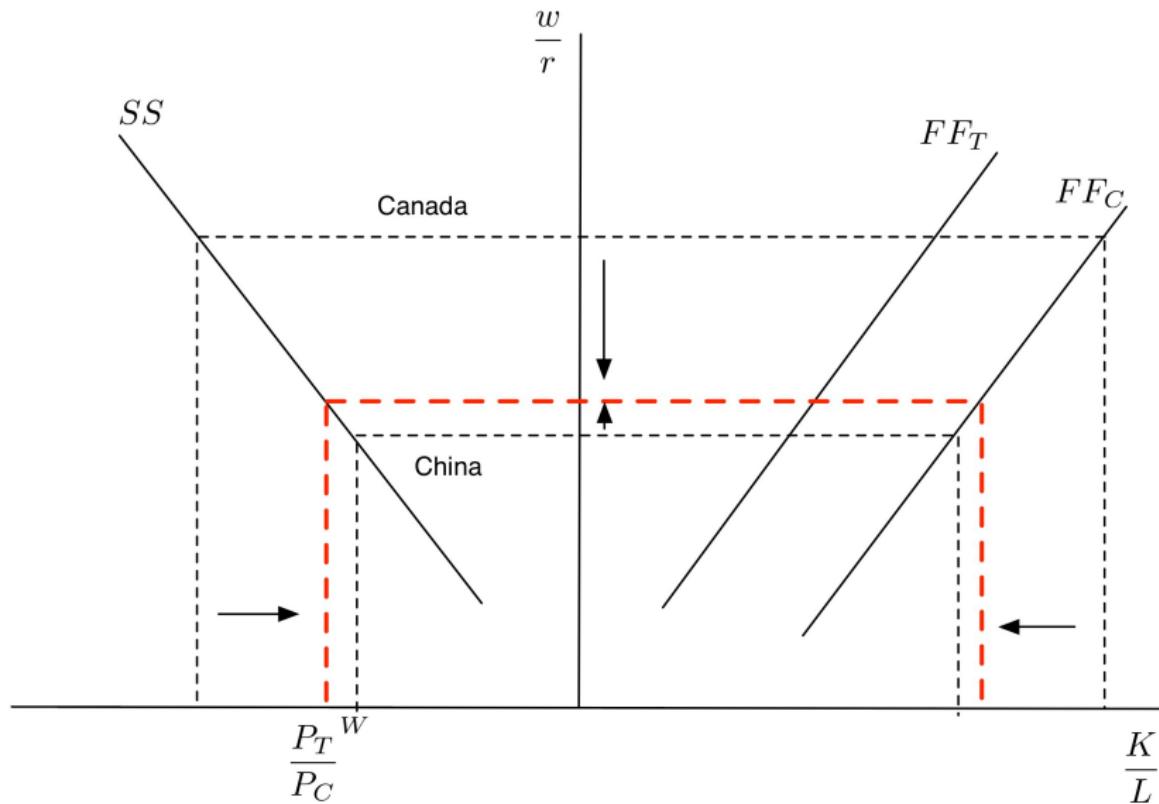
# Large China

Table: Country Size by Stock of Capital

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- China more closely resembles the world
  - China's  $K/L = 0.25$ ; World's  $K/L = 0.33$
- Thus, China's autarky price is close to world trade equilibrium price
- Canada will experience a more drastic change in the isovalue line, which means greater gains

# Large China



# Conclusion

- We have covered the three major results in the Heckscher-Ohlin Model
  - Stolper-Samuelson Theorem
  - Rybczynski Theorem
  - Heckscher-Ohlin Theorem
- Together, they allowed us to answer
  - How changes in goods prices affect the return to factors
  - How changes in the stock of factors affect industrial composition
  - and how the stock of factors determine the goods countries will trade
- Next class
  - Trade allow prices to converge, which causes factor prices to also converge
    - Why does this happen?
  - How well does the HO model hold in the data?