

ECO364H1S: International Trade Theory

Lecture 4

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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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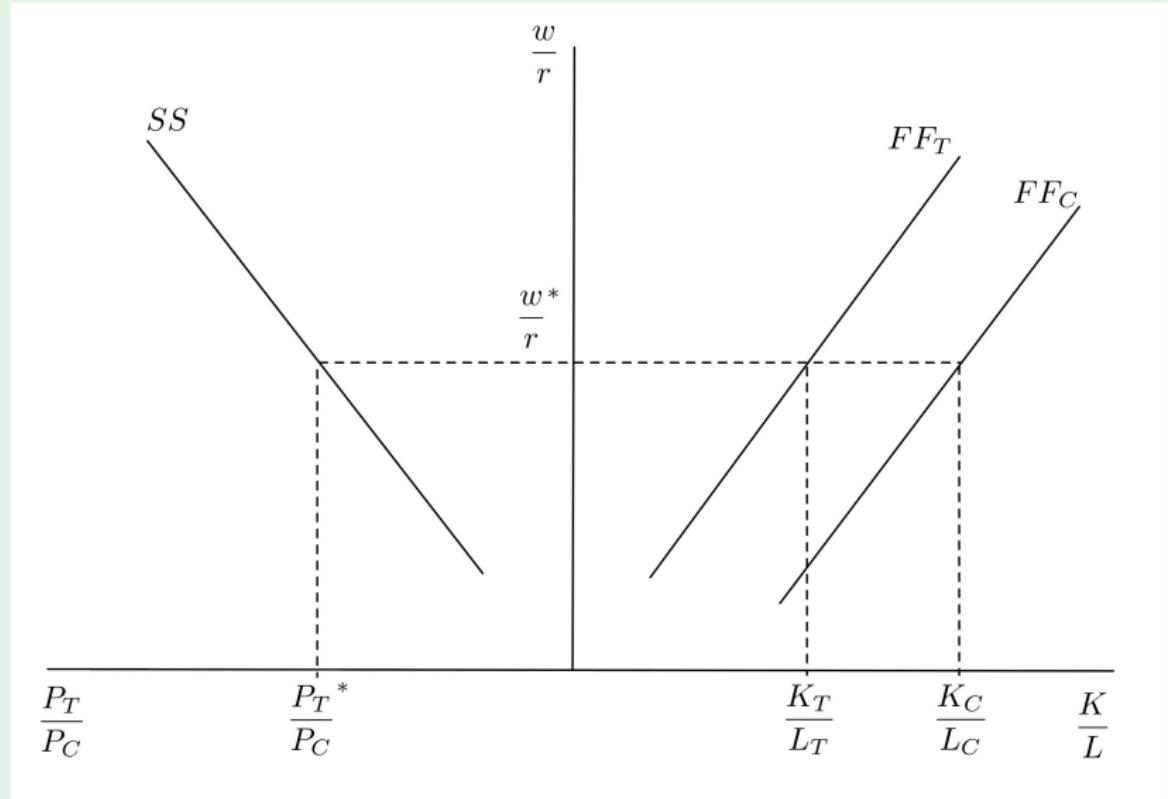
- ▶ Today
 - Putting the FF and SS curve together
 - Three Theorems:
 - Stolper-Samuelson Theorem
 - Rybczynski Theorem (Edgeworth Box and PPF)
 - Heckscher-Ohlin Theorem

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 - Rybczynski Theorem (Edgeworth Box and PPF)
 - Heckscher-Ohlin Theorem
- ▶ Readings
 - KOM, Ch. 5

Previous Lecture

- ▶ Derived the FF curve
 - Relates relative factor prices to relative input factors (K/L)
 - The position of the curves relative to each other depends on the relative input intensity of each good
- ▶ 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
- ▶ What are the long-run impact on relative factor prices and relative factor demand?
 - 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
 - Why? Because computers are relatively capital intensive
 - New, unemployed capital enables producers to bid down r (the return to capital) resulting in an increase in w/r

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)
- ▶ By the FF curves, K/L rises in both sectors
- ▶ EXERCISE: Suppose P_T decreases and P_C stays constant

Three Theorems in the HO Model

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- ▶ 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

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 - **Rybczynski Theorem**
 - Allows predictions for how migration might affect industrial structure

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- ▶ 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 real return to the factor used most intensively in the production of that good. In addition, the real return to the other factor will fall.

Stolper-Samuelson Theorem

Theorem (Stolper-Samuelson)

A rise in the relative price of a good will lead to a rise in the real return to the factor used most intensively in the production of that good. In addition, the real return to the other factor will fall.

- ▶ If the price of textiles increases (input used most intensively in textiles), the model predicts that real wage increases whereas the real return to capital decreases

Real Returns

- ▶ What we care about is the purchasing power of our workers:
 w/p and r/p
- ▶ Note, when a person buys both computers and textiles, her real return can be measured by wages w normalized by a price index P (i.e. w/P)
 - The **Consumer Price Index** is one example

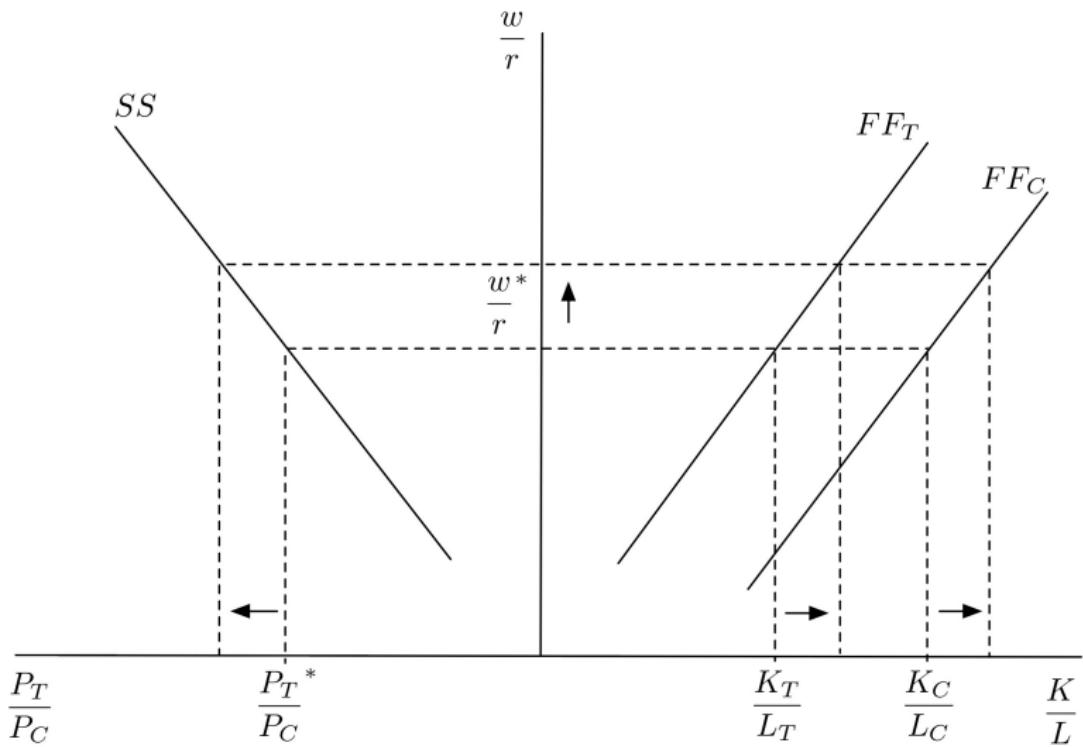
Real returns to capital

- ▶ 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, 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 how w/P_T changes because 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
 - Firms are substituting towards cheaper 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. $F_T(K, L) = K^{1/3}L^{2/3} \implies MPL_T = \frac{2}{3} \left(\frac{K}{L}\right)^{1/3}$
- ▶ Therefore, the increase in the marginal product of labour increases w/P_T
- ▶ Overall real returns to labour increased

Argument applies to returns to capital

- ▶ Argument using MPK also 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 the 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, that may be harmful to the long-term development of the country

Rybczynski Theorem

- ▶ Goods Prices \rightarrow SS Curve \rightarrow Factor Prices \rightarrow FF Curves \rightarrow $\frac{K}{L}$ in each sector
- ▶ Along with the resource constraint, we can use this information to solve for factor allocation within a country
 - These factor allocations are K_C, K_T, L_C, L_T

Example

- ▶ Let's use the same example from Lecture 3

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

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

- ▶ These production functions result in the following equations describing an 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 $\frac{w}{r} = 1$
- ▶ Simplifying the equations

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

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

- ▶ In optimum, all resources in a country will be employed (market clearing conditions):

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

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

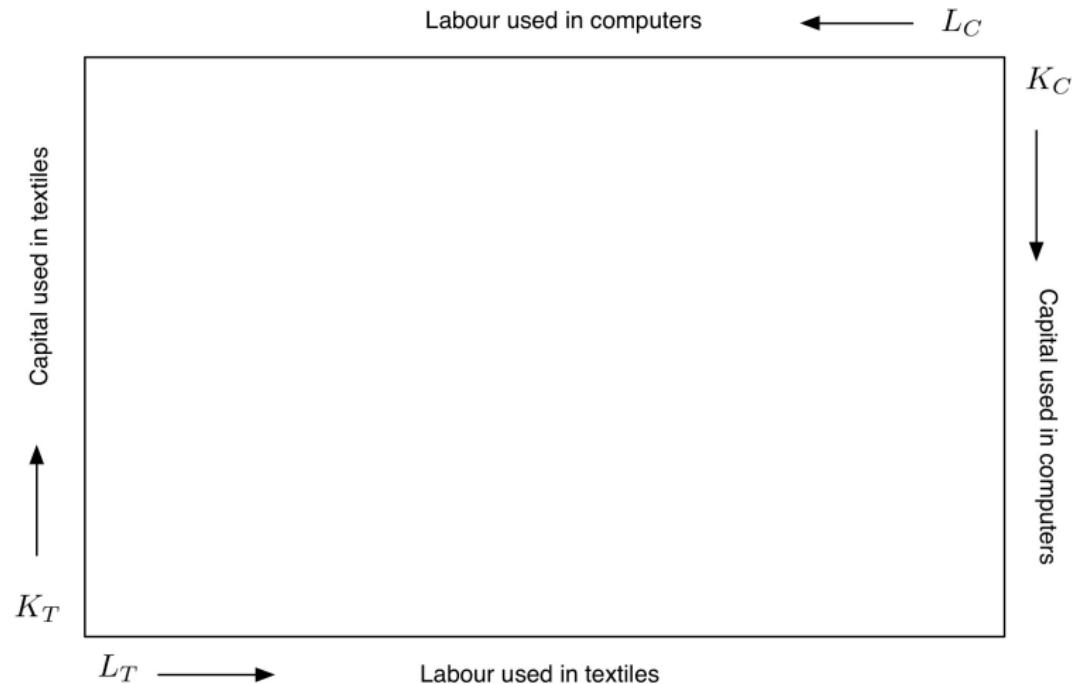
Example

- ▶ Equations (1)-(4) gives us four equations and four unknowns
- ▶ We can solve for optimal capital and labour in each industry:
 K_C^* , K_T^* , L_C^* , L_T^*
- ▶ K_C^* , K_T^* , L_C^* , L_T^* each will be a function of \bar{K} and \bar{L}
 - The solutions describes how factor endowments determine structure of production

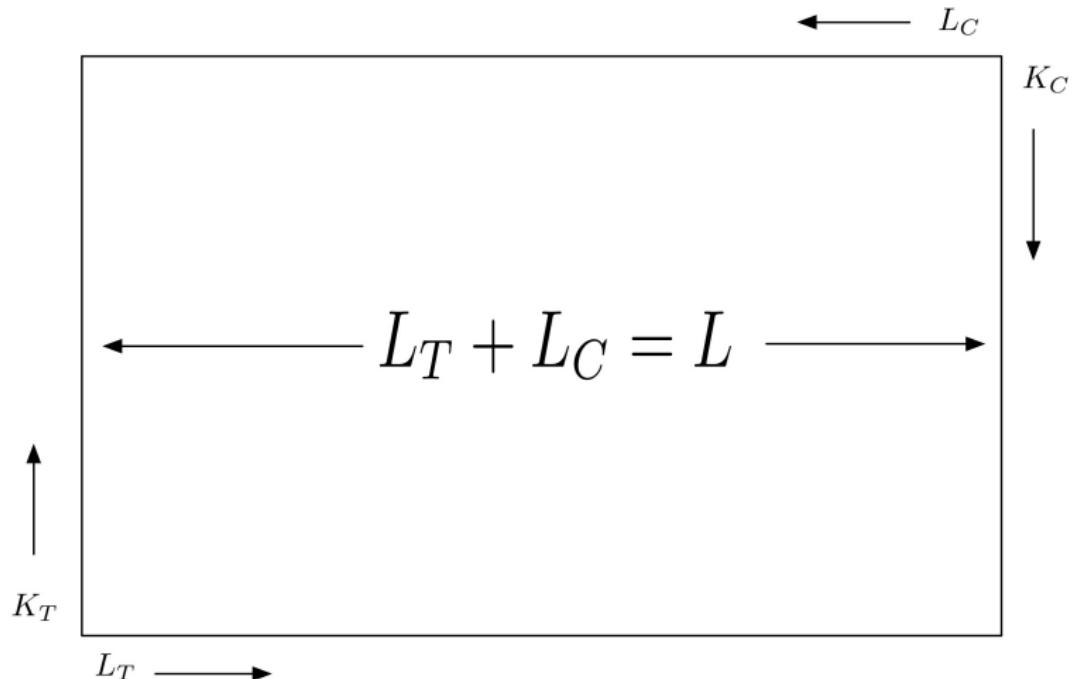
Edgeworth Box

- ▶ Let's see how this can be done using an **Edgeworth Box**
 - A visualization tool used for studying resource distribution in a general equilibrium model setting

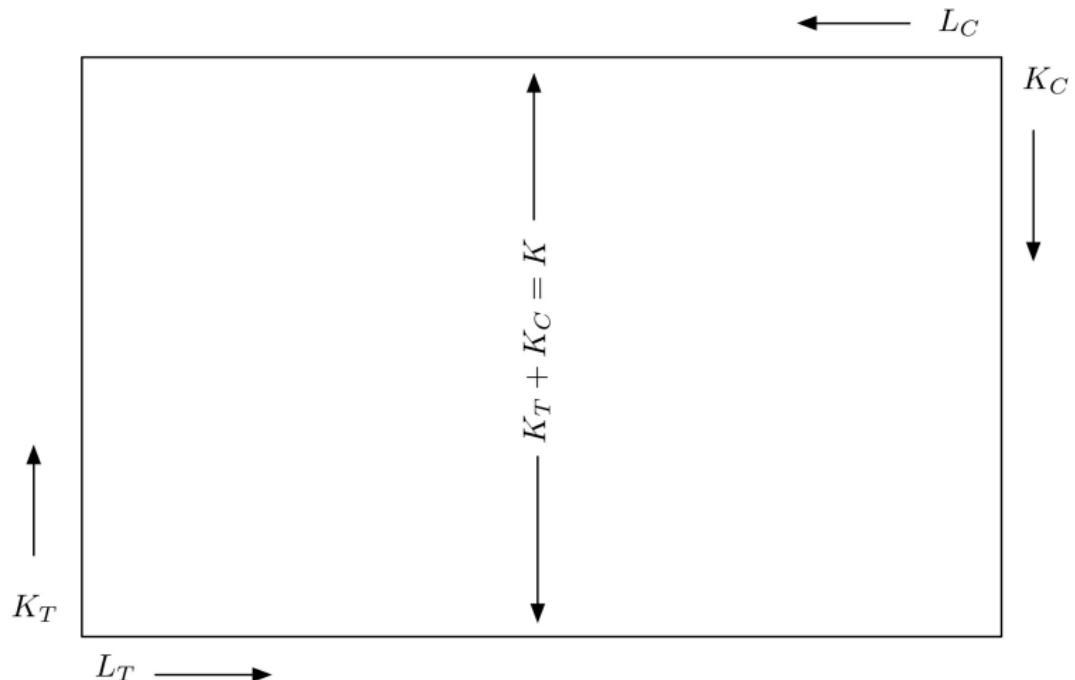
Edgeworth Box



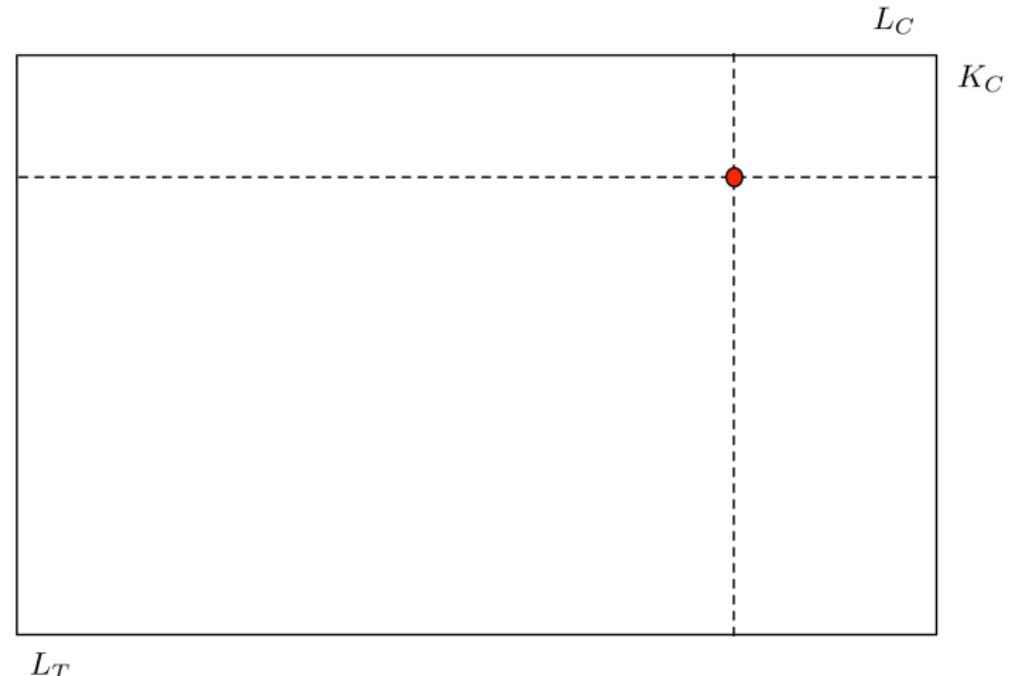
Stock of Labour



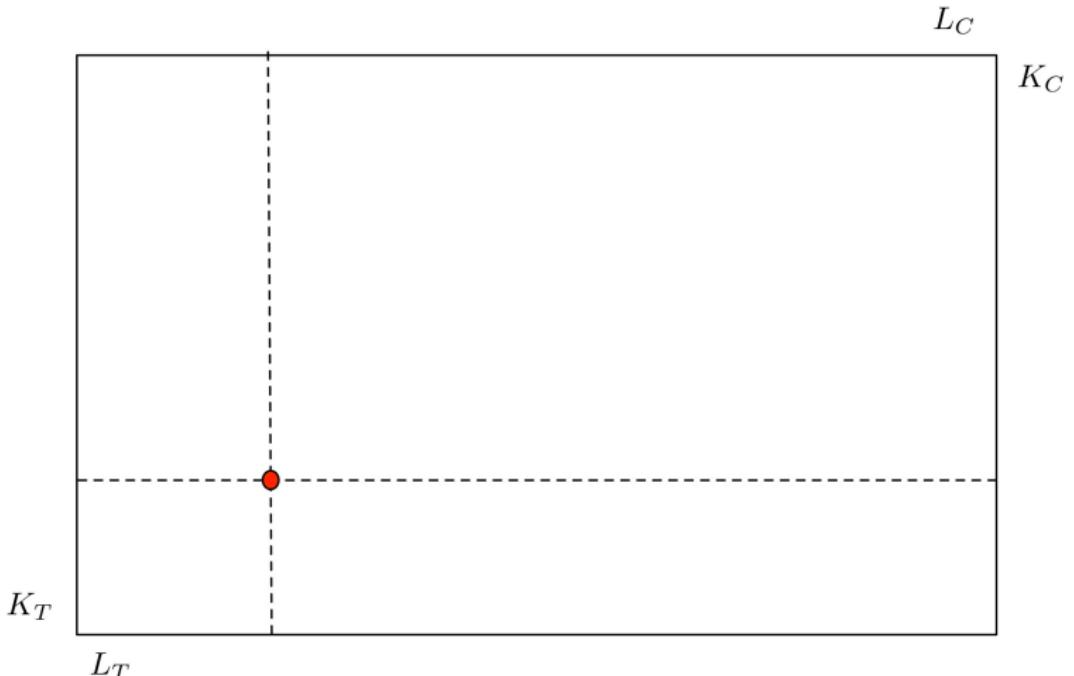
Stock of Capital



Large Textile Industry

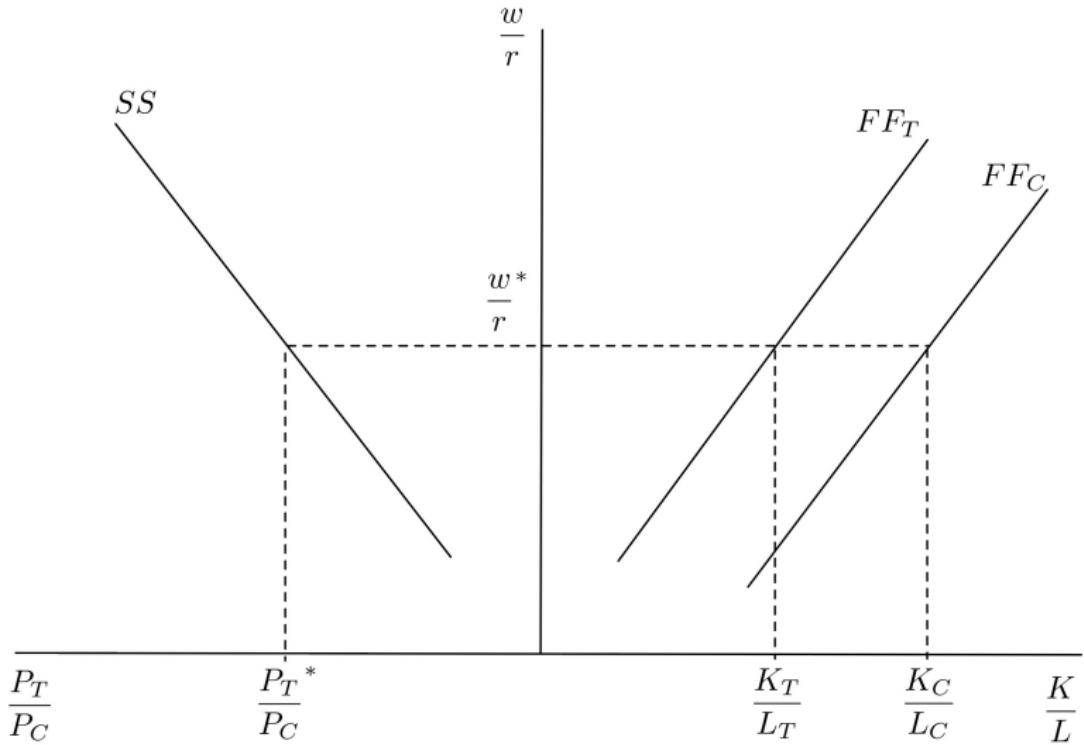


Large Computer Industry



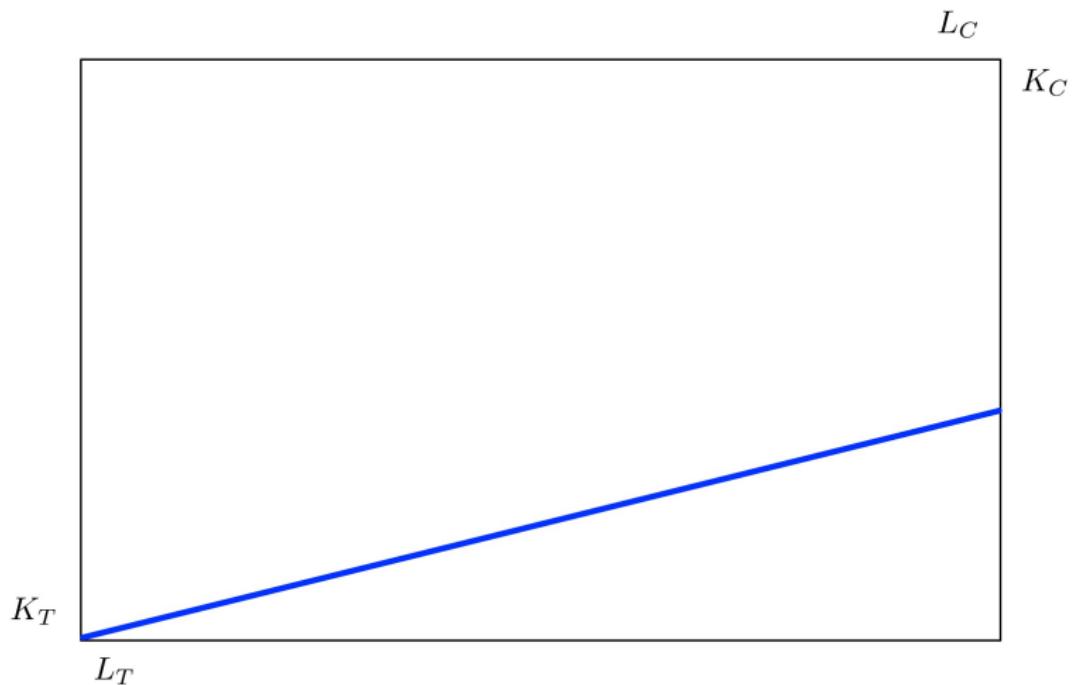
Ray from Origin

- ▶ From the FF-SS curves, we are given the capital-labour ratio for a given relative goods prices
- ▶ 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 (introduced in the Lerner diagram in lecture 3)
 - In the numeric example above, we derived these to be $\frac{w}{2r}$ and $\frac{2w}{r}$ for textiles and cloth, respectively
- ▶ 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



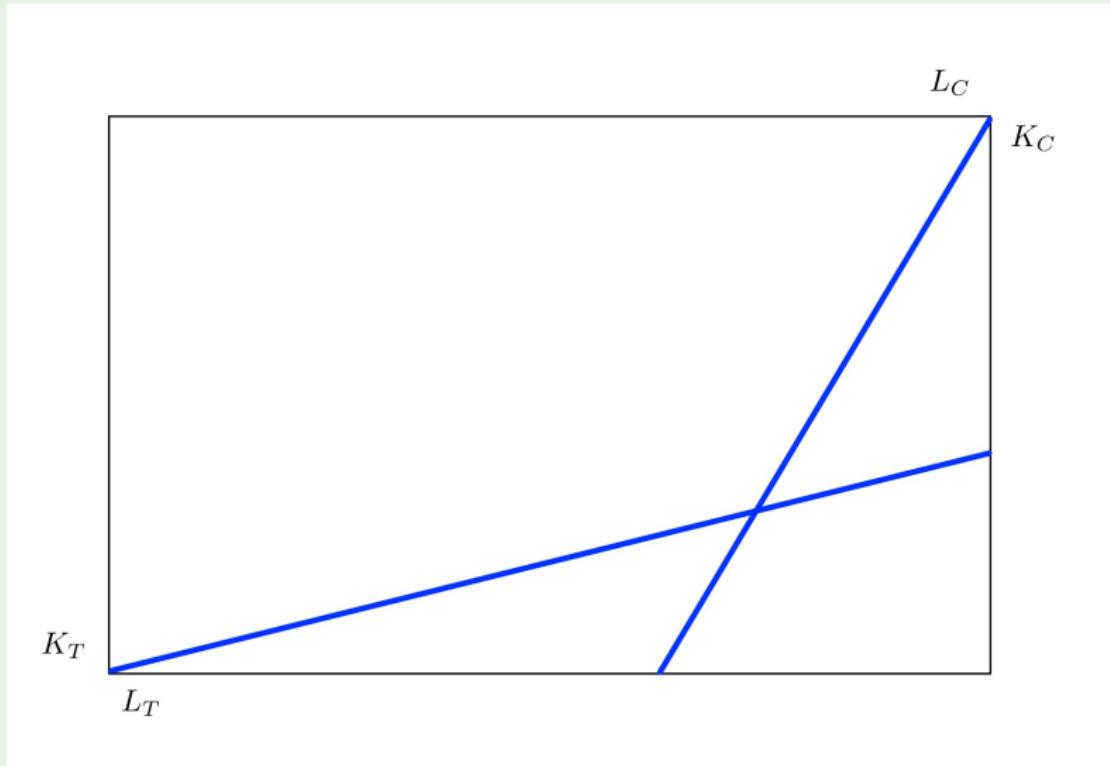
L_C

K_C

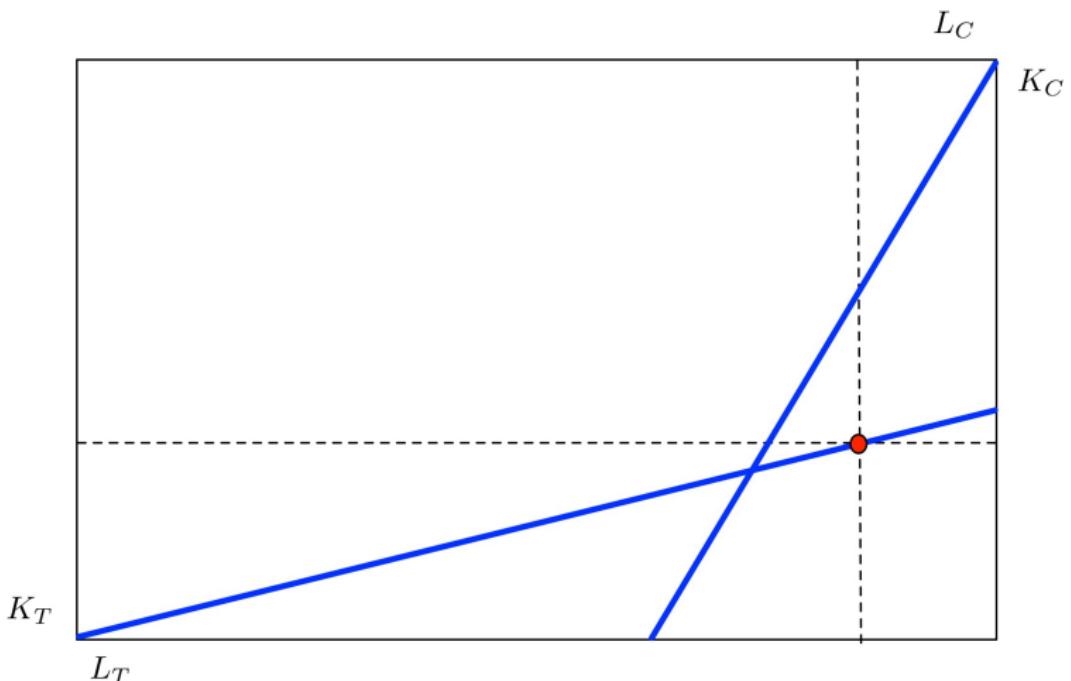
K_T

L_T

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



Equilibrium at Cross Point

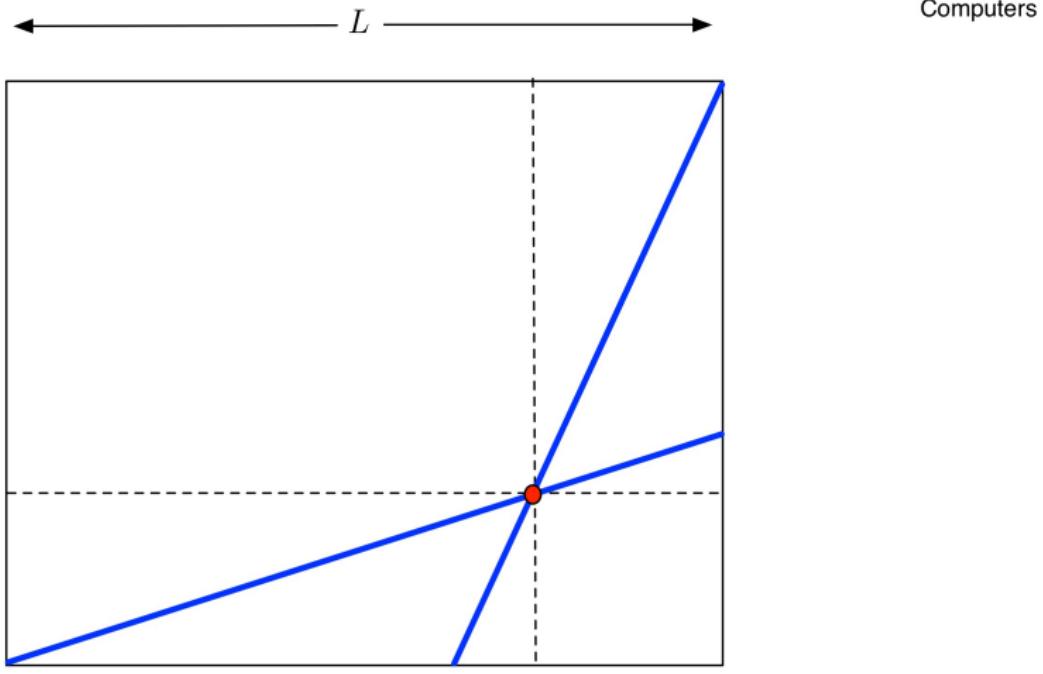
- ▶ Note that the point where the output expansion path (the two blue lines) cross determines the equilibrium
- ▶ This is because it is only at this point where the FOC from the profit maximization problem and the market clearing conditions are satisfied
- ▶ In the numeric example, the FOCs were

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

Change in Factor Endowment

- ▶ *How does 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

$\bar{L} \uparrow$

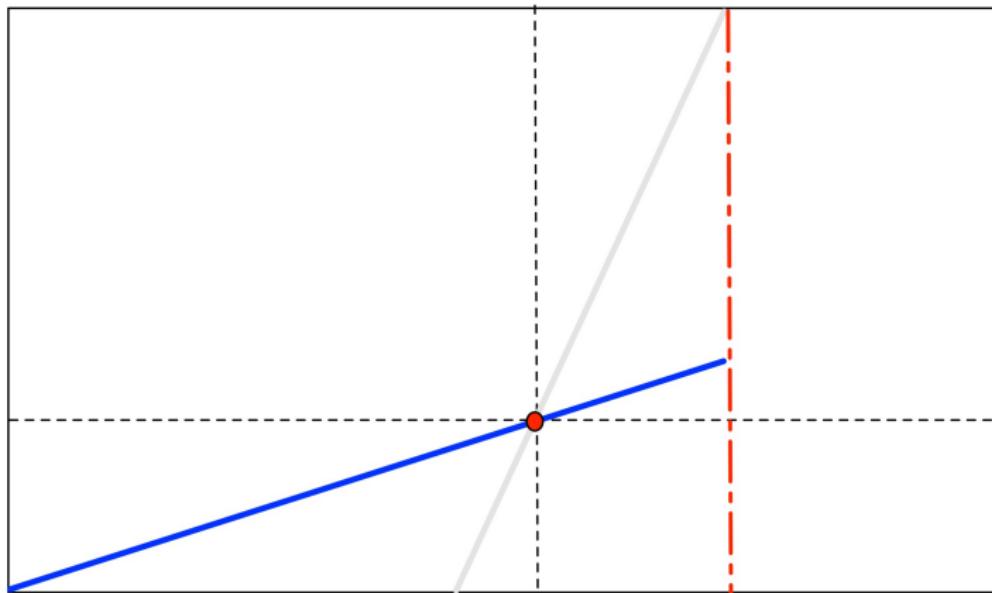


Textile

Computers

$\bar{L} \uparrow$

$$L \quad \Delta L \quad \text{Computers}$$

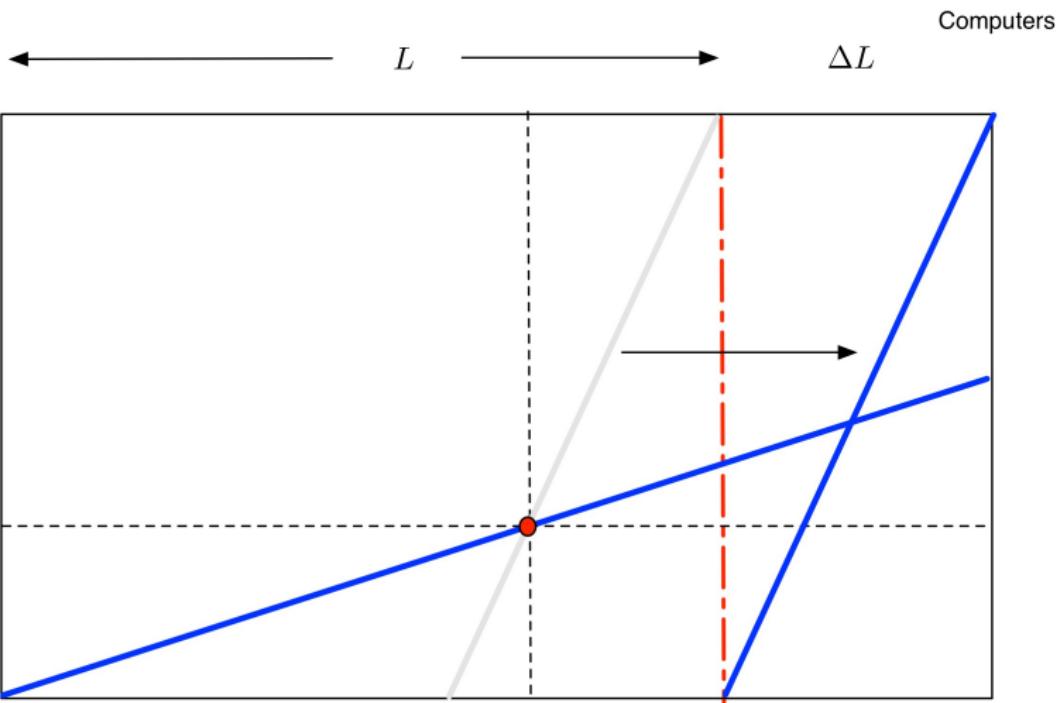


Textile

Output Expansion Path Slope

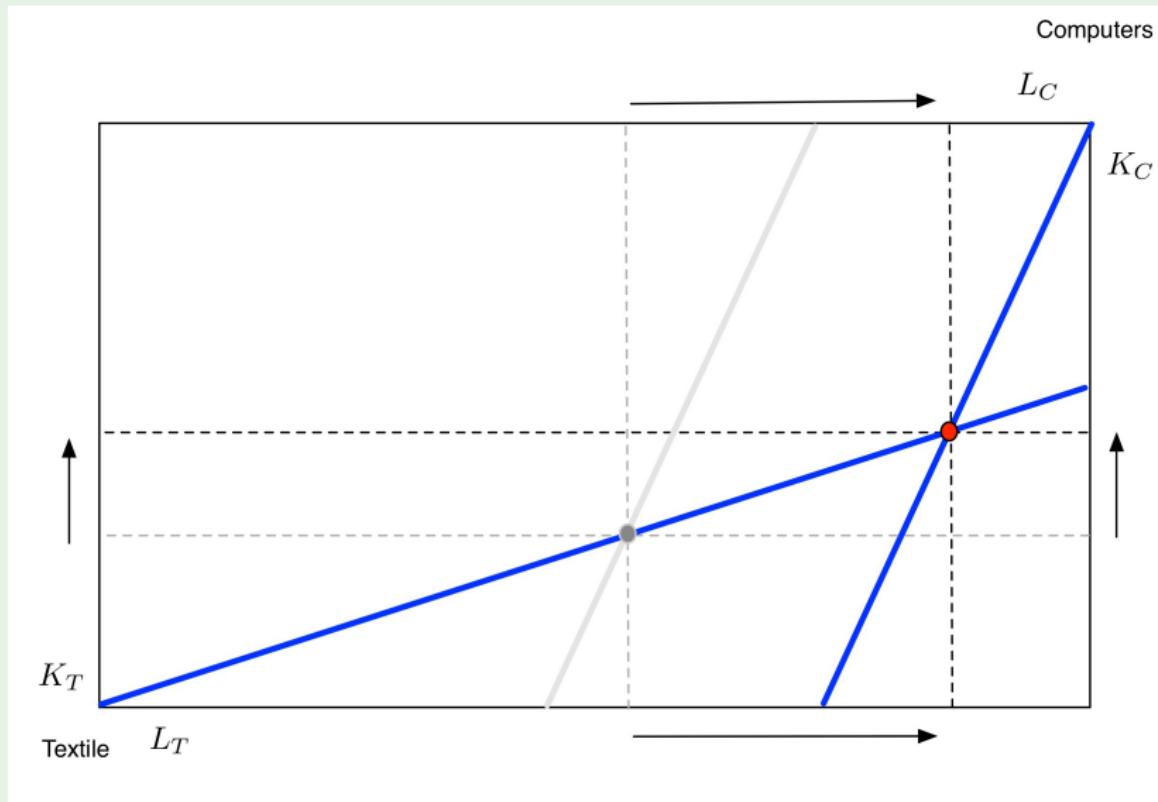
- ▶ Because relative good and factor prices did not change, the relative factor intensity in each industry does not change
- ▶ Therefore, slope of Output Expansion Path (rays from origin) does not change

$\bar{L} \uparrow$



Textile

$L \uparrow$



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

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

- ▶ 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

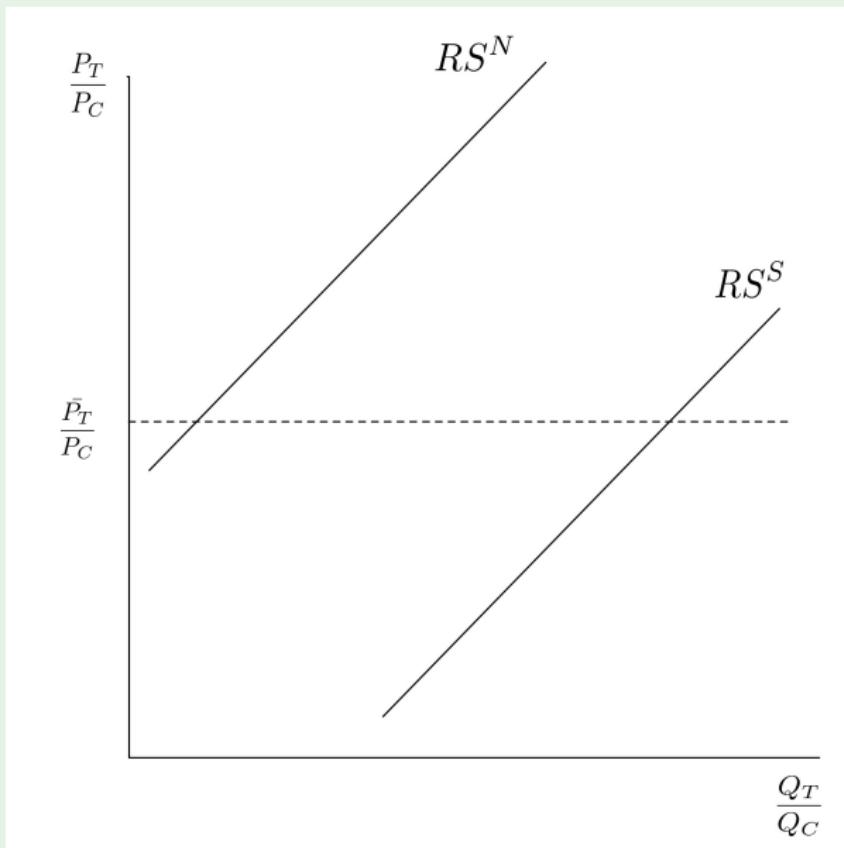
Rybczynski Theorem

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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 than 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 (as demonstrated in the Edgeworth Box)
 - This is why the slopes of the Output Expansion Paths did not change as the stock of labour endowments increased

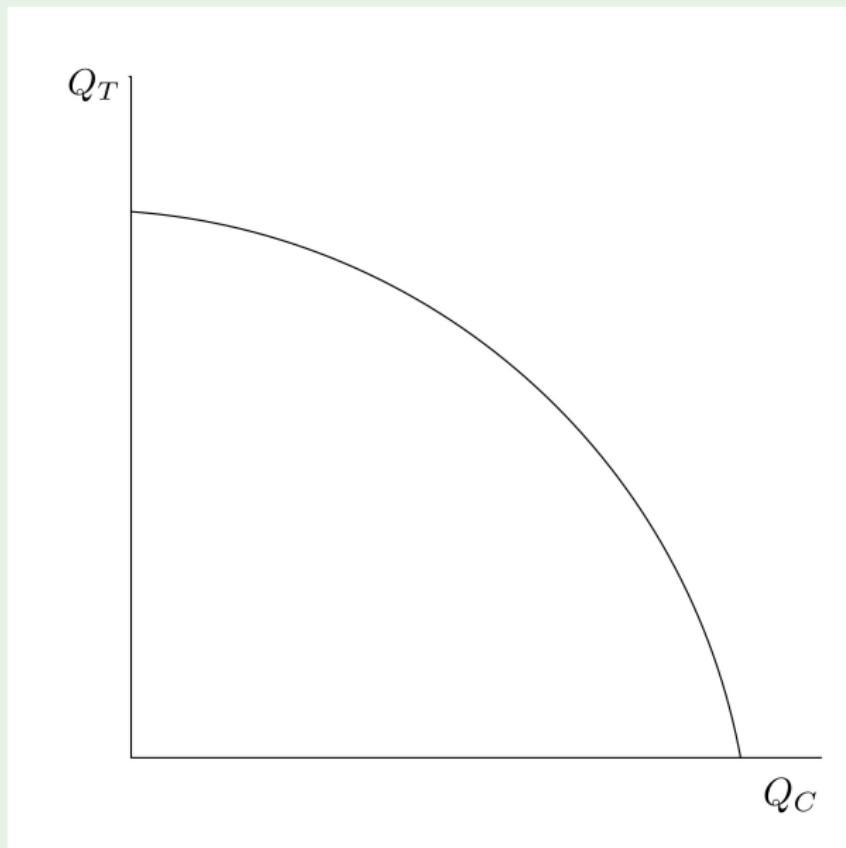
Relative Supply Curve

- ▶ 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 shown in the Edgeworth Box)
- ▶ In other words, changes in the labour endowments causes shifts in the relative supply curve

PPFs in the HO Model

- ▶ Unlike the Ricardian Model, the PPF in the HO model are bowed out
- ▶ This follows from 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 decreases
 - 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 (i.e revenue) subject to the PPF:

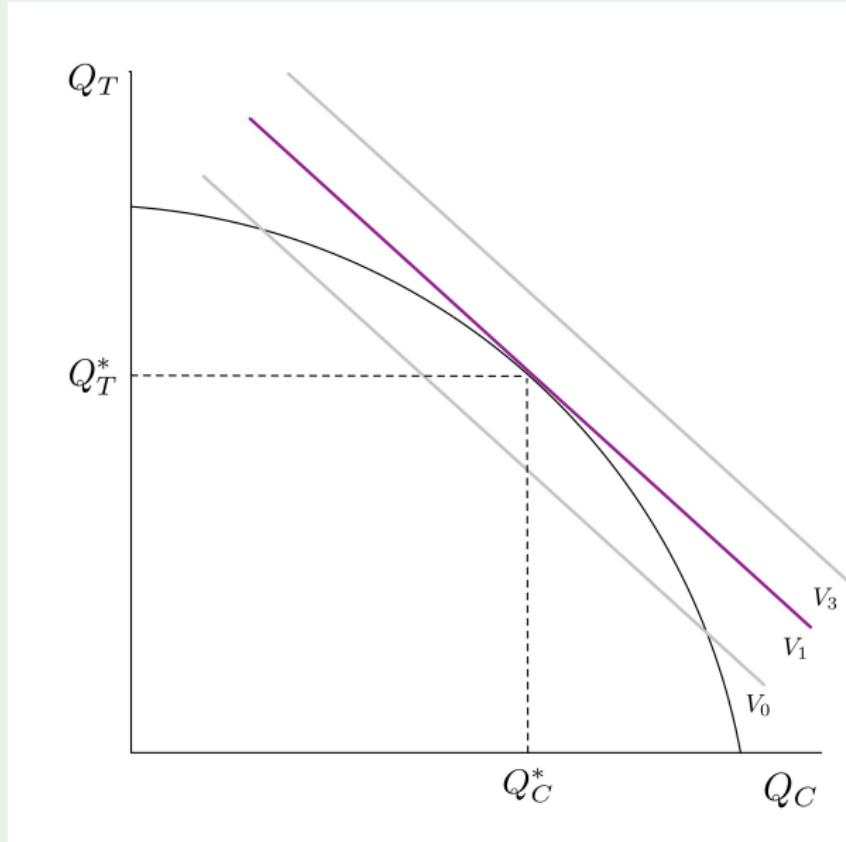
$$V = P_C Q_C + P_T Q_T$$

- ▶ Rewrite as

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

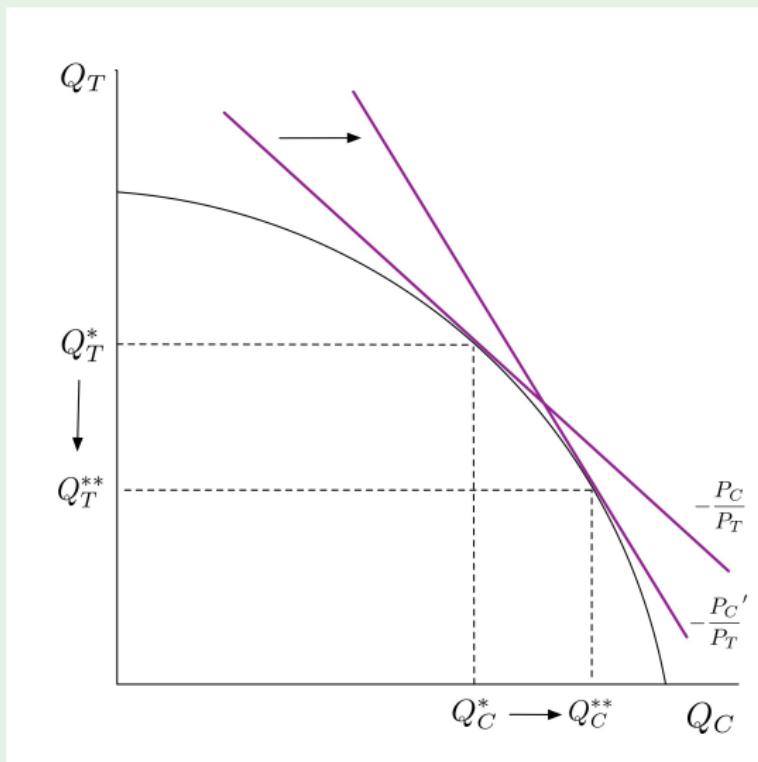
- ▶ This gives us all the combination of Q_T and Q_C that attains the value of output V
- ▶ Call this line the **isovalue line**
 - This is not the same as the **isovalue curve** in the Lerner Diagram (which can also be called the **isoquant**)

Isovalue Line



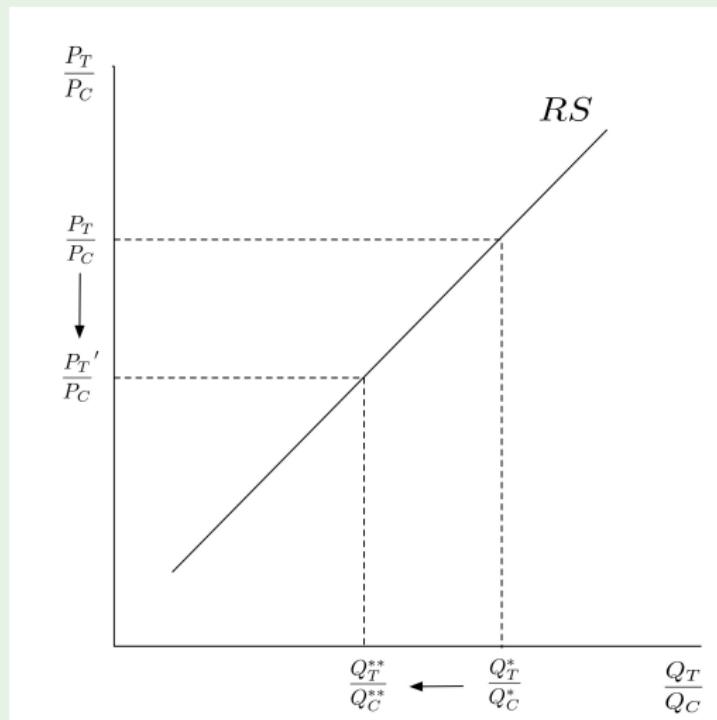
Isovalue Line and changes in Prices

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



Relative Supply Curves

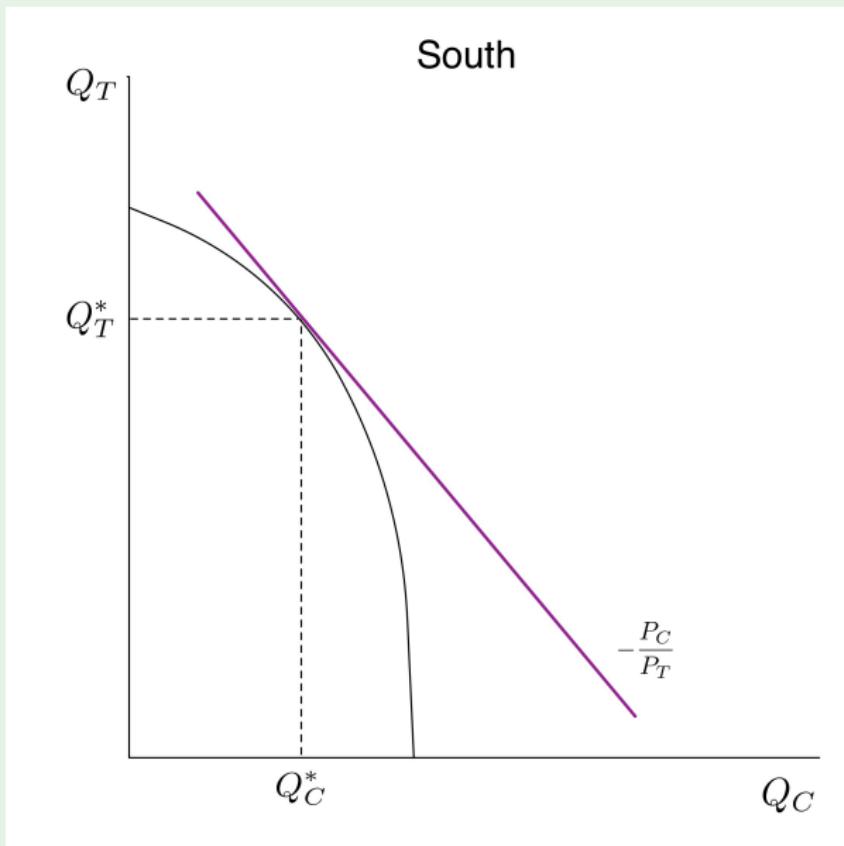
The sequence of optimum output as prices change map out the relative supply curves



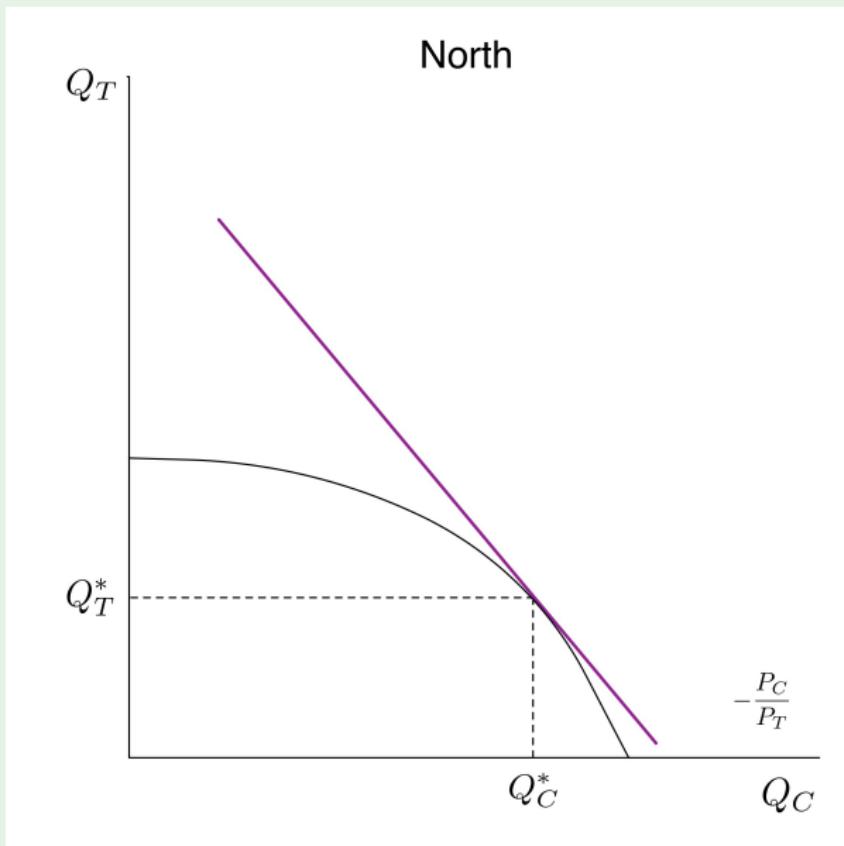
Relative Supply Curves

- ▶ The shape of the PPF curves depend on the labour and capital endowment in each country:
 - $Q_T = h(\bar{Q}_C, \bar{K}, \bar{L})$
- ▶ 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



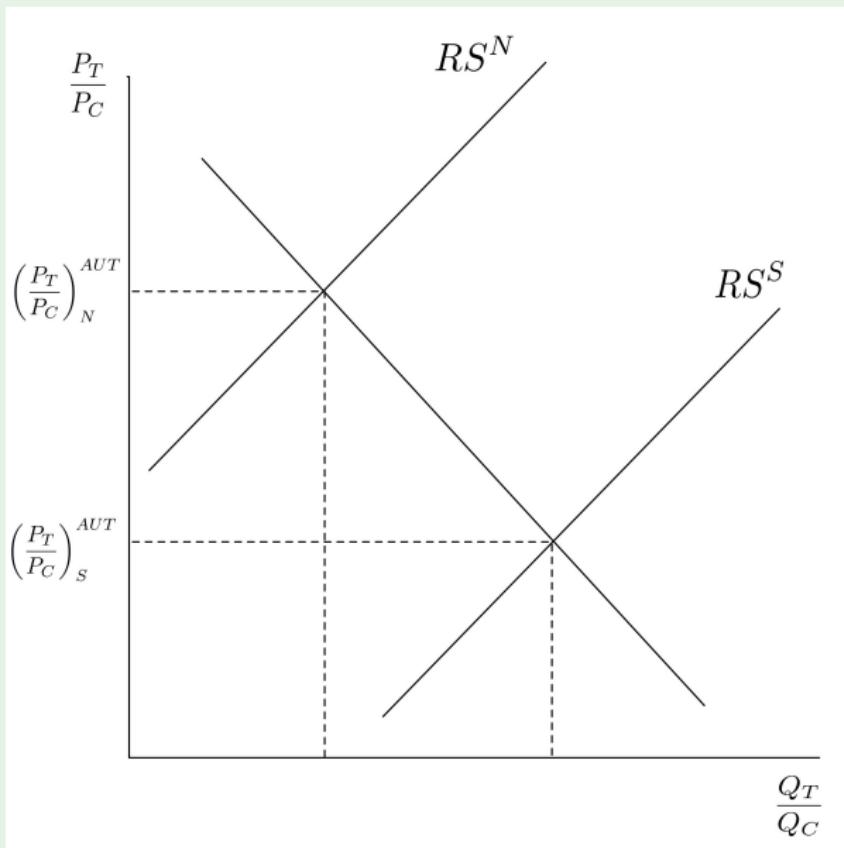
Country PPF



Country PPF: North and South

- ▶ For a given relative goods price, North is able to produce more computers, while South is able to produce more textiles
- ▶ In other words, for the price P_C/P_T in the diagram, Q_T/Q_C is higher for South
- ▶ In terms of relative supply curves, North's supply curve will be to the left of South's

Country PPF: North and South



Heckscher-Ohlin Theorem

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

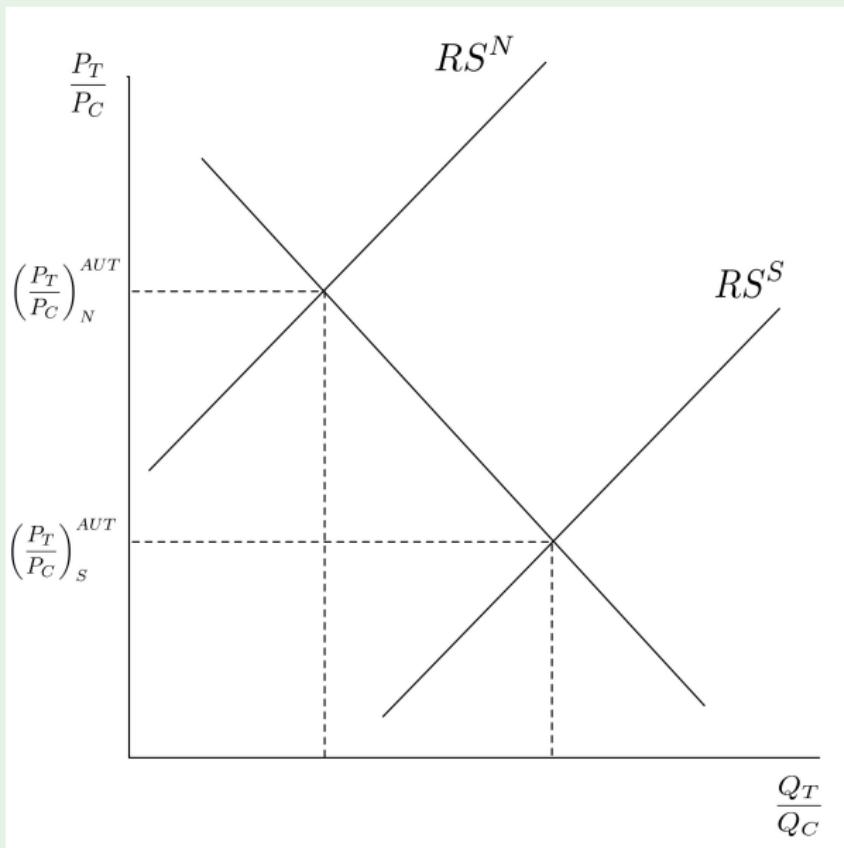
$$\frac{P_T}{P_C} = \frac{MU_T}{MU_C}$$

- It is downward sloping

Free Trade

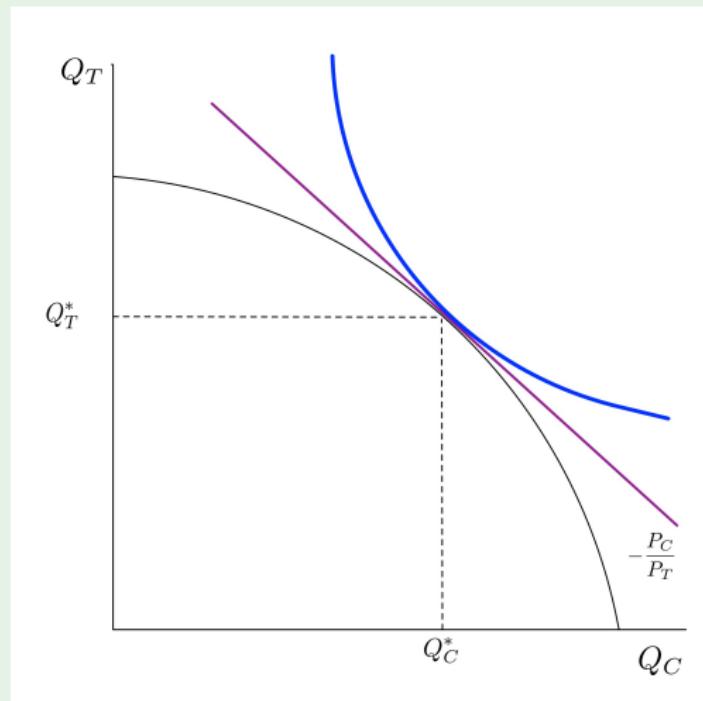
- ▶ Relative supply curve derived from the tangency points between the PPF and iso-value line
- ▶ The points where each country's relative supply curve cross the relative demand curve is their autarky equilibrium
- ▶ Under autarky, relative prices change only if
 - consumer preferences changes (indifference curves change shape or position)
 - labour endowment changes (PPFs changes shape)

Autarky Equilibrium



Autarky Equilibrium: PPF

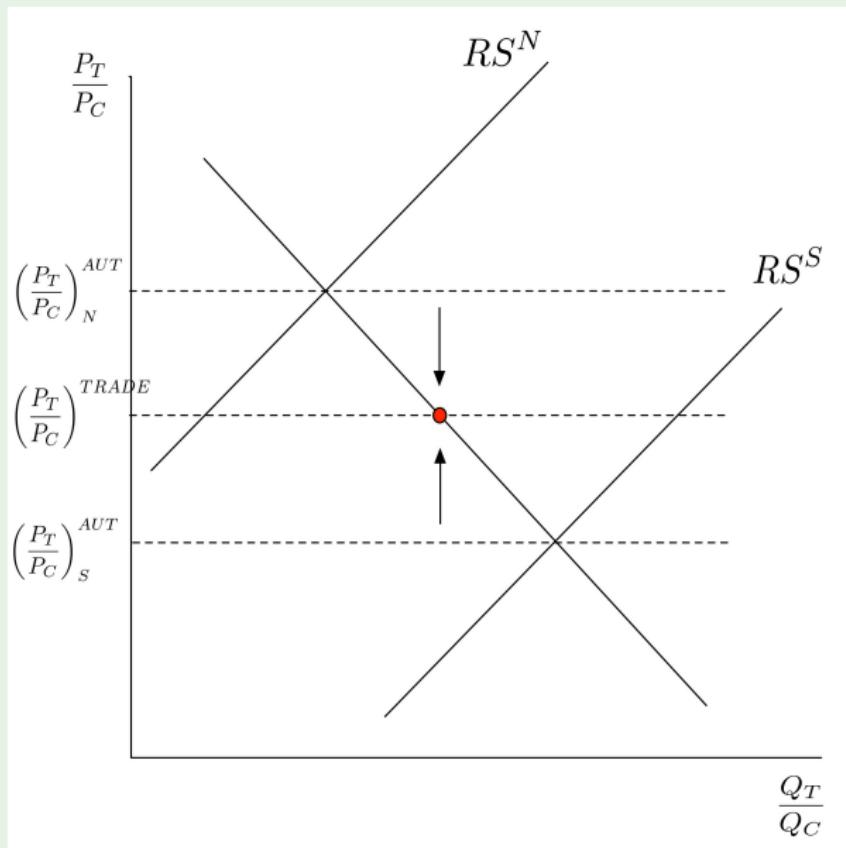
For either countries, equilibrium quantities is located where PPF is tangent to indifference curve. Consumption also equal production in autarky



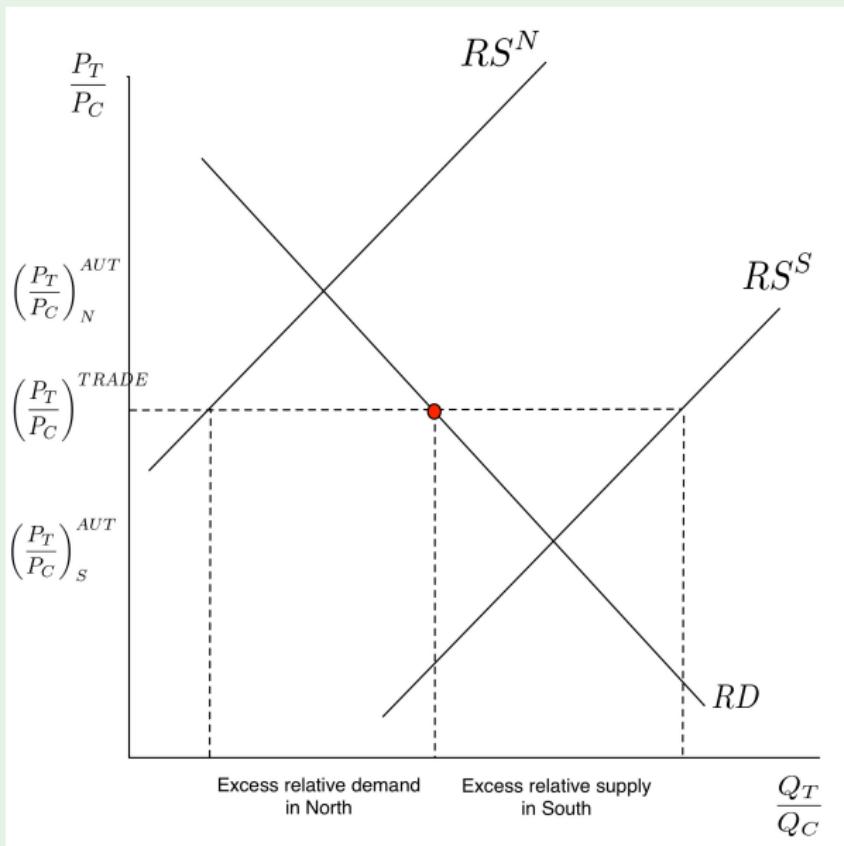
Trade Equilibrium

- ▶ With free trade, countries are now free to trade goods
- ▶ In the longrun, differences in price for a good across countries will 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



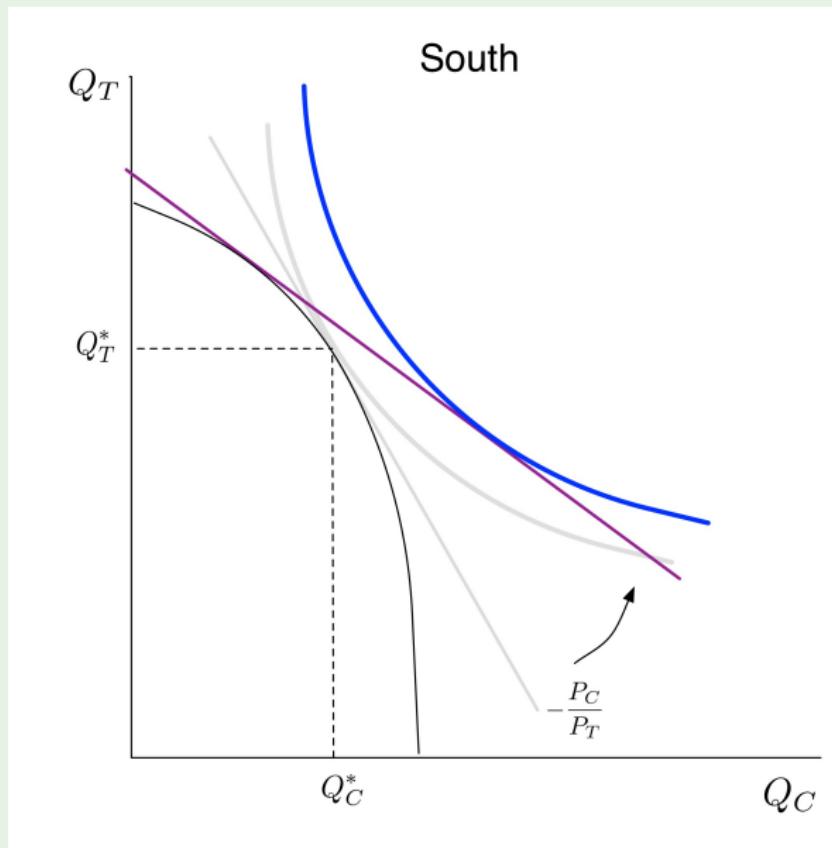
Trade Equilibrium



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

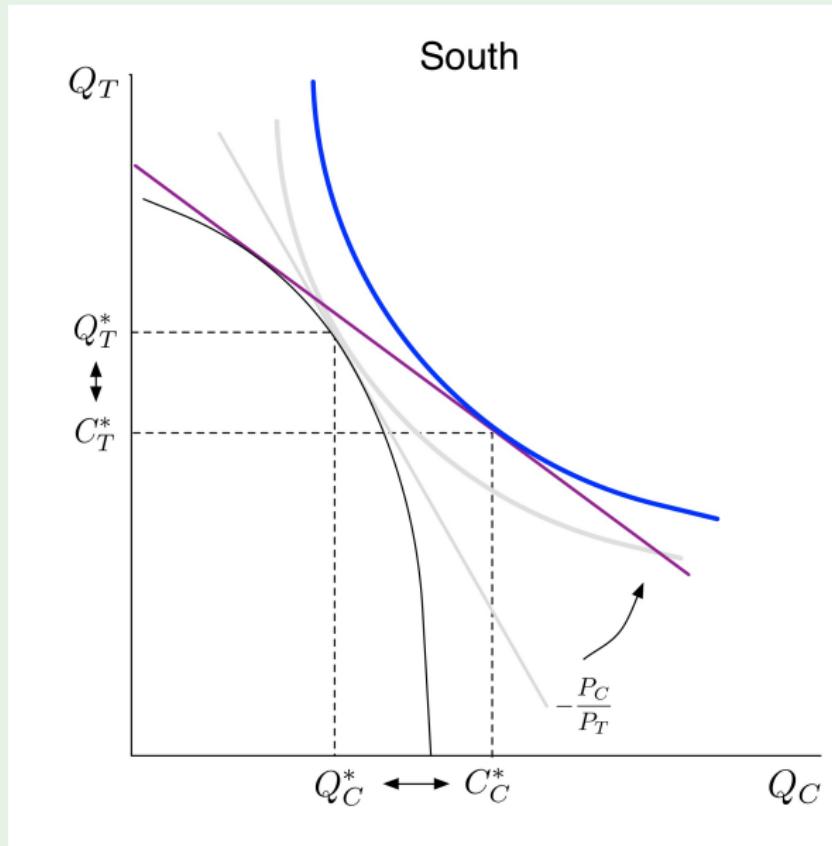
Gains from Trade: South



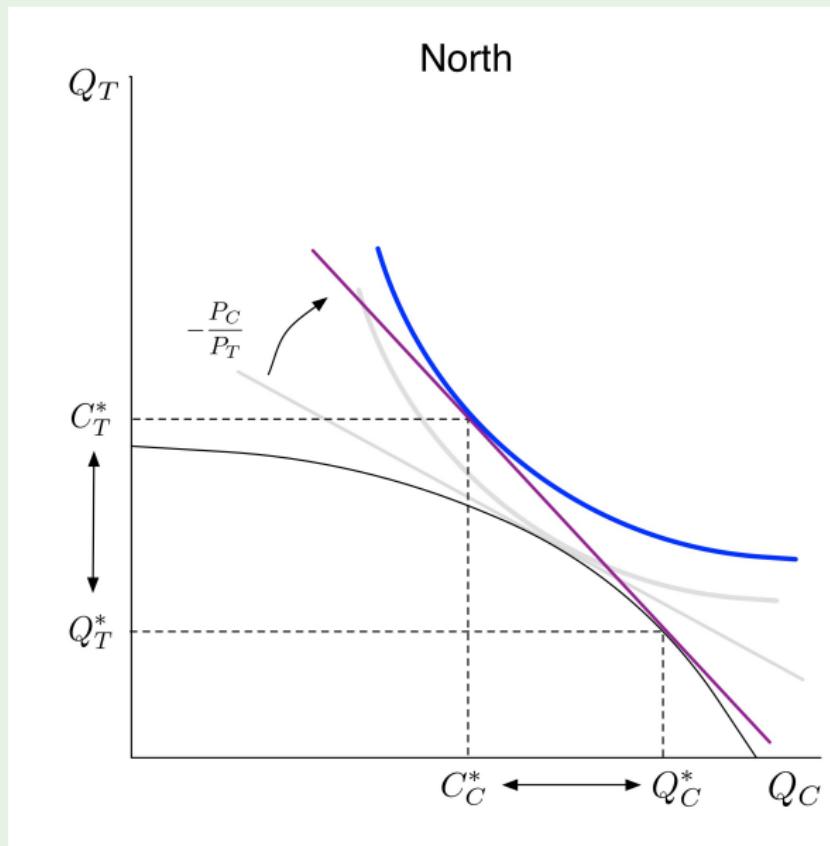
Gains from Trade: South

- ▶ 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
- ▶ 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 isovalue 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

PPFs and Gains from Trade

- ▶ We can also look at a country's balanced trade condition to understand why countries gain from trade
- ▶ Balanced trade condition:

$$P_C C_C + P_T C_T = P_C Q_C + P_T Q_T$$

- One could also think of this as a *country-level* budget constraint
- ▶ Value of goods consumed shouldn't exceed value of goods produced
- ▶ Rewrite as follows:

$$C_T - Q_T = \frac{P_C}{P_T} (Q_C - C_C)$$

PPFs and Gains from Trade

$$C_T - Q_T = \frac{P_C}{P_T} (Q_C - C_C)$$

- ▶ Under autarky, a country can only consume what it produces:
 $C_T = Q_T$ and $C_C = Q_C$
 - Tangency across PPF, balanced trade equation, and indifference curve
- ▶ But under free trade, $C_T = Q_T$ and $C_C = Q_C$ no longer needs to hold
 - Under such conditions for South, $|C_T - Q_T|$ is exports and $|C_C - Q_C|$ is imports
- ▶ Free trade allow countries to consume anywhere on their budget constraint instead of being restricted by their PPF curve!

PPFs and Gains from Trade

- ▶ Because we can consume outside of the PPF under free trade, a given country as a whole, can consume more of both goods compared to autarky
 - They may consume less of one good under free trade, but total consumption (sum of both goods) will be greater than under autarky
- ▶ Therefore, every individual in principle should also be able consume more of both goods
- ▶ Some individuals may want more of one good and less of the other, such option is available under free trade
- ▶ See KOM, Ch. 4.3

Heckscher-Ohlin Theorem

- ▶ The trading pattern we have observed 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

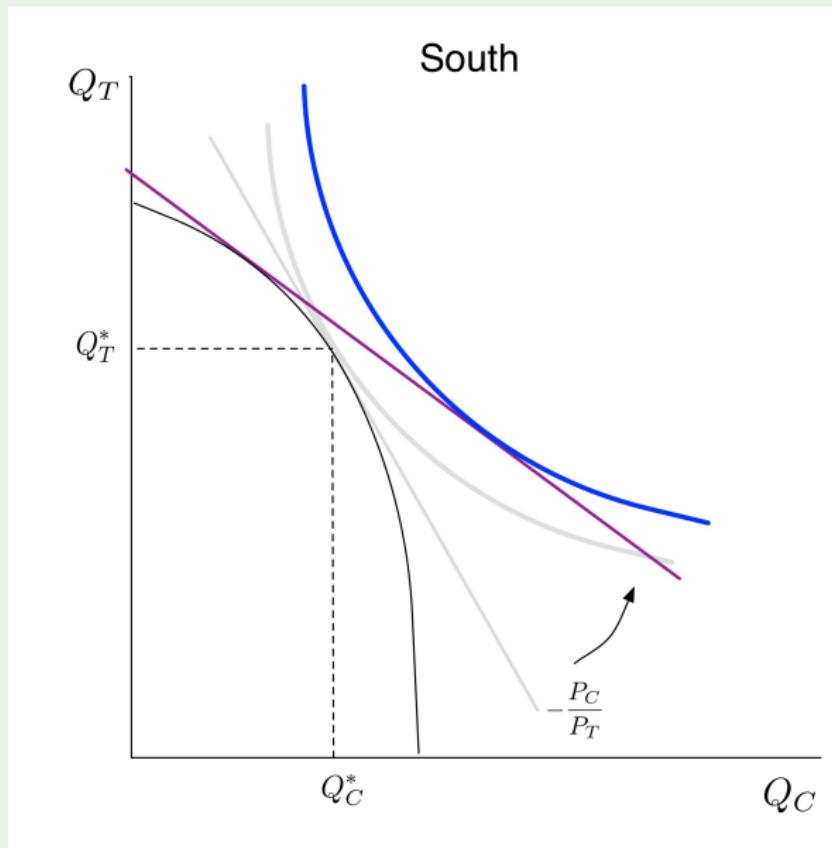
- ▶ P_T/P_C rose for South and fell for North
- ▶ By the Stolper-Samuelson theorem
 - South: Labourers real returns increase; capital owners real returns decrease
 - North: Labourers real returns decrease; capital owners real returns increase
- ▶ Abundant factors win; scarce factors lose
- ▶ But, countries 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 losing factors

Size and Gains from Trade

Size and Gains from Trade

- ▶ From the PPF curves, we saw that the greater the difference between a country's autarky price from its global market price, the greater the gain

Size and Gains from Trade



Size and Gains from Trade

- ▶ Which countries experience the most drastic change in relative goods price when going from autarky to free trade?
 - Countries with resource endowments that are most different from the integrated world
 - These tend to be economically small countries

Size and Gains from Trade

- ▶ Example:

Table: Country Size by Stock of Capital

	Large Canada			Large China		
	\bar{K}	\bar{L}	\bar{K}/\bar{L}	\bar{K}	\bar{L}	\bar{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

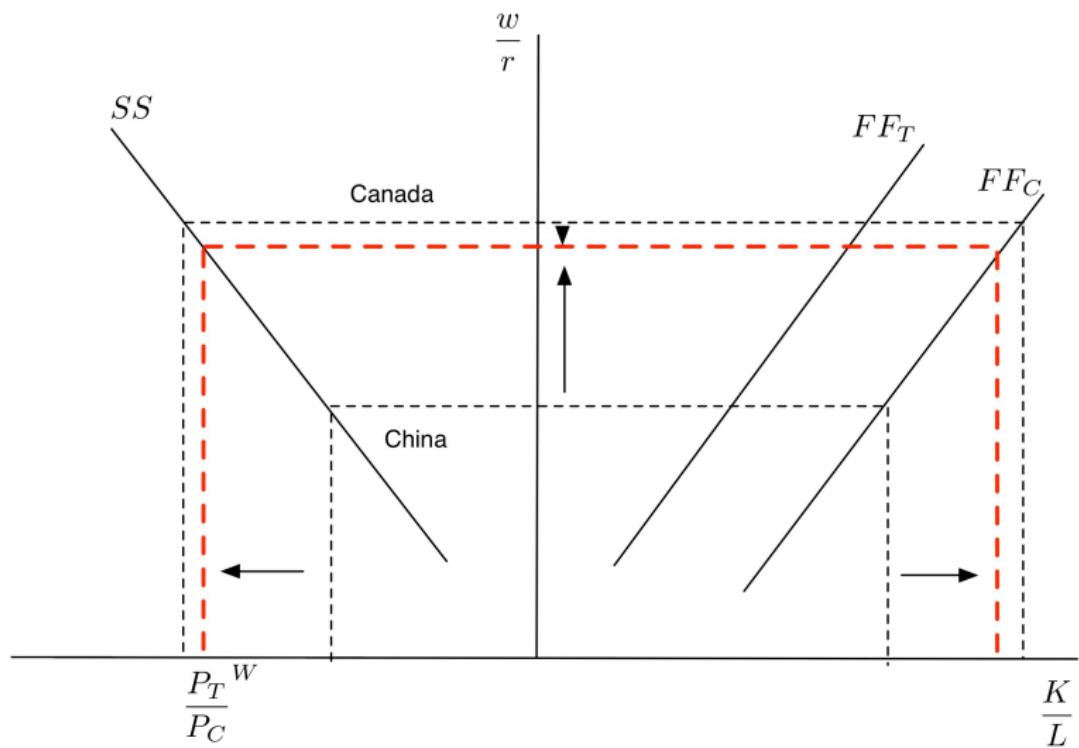
Large Canada

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

- ▶ Large 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, resulting in greater gains

Large Canada



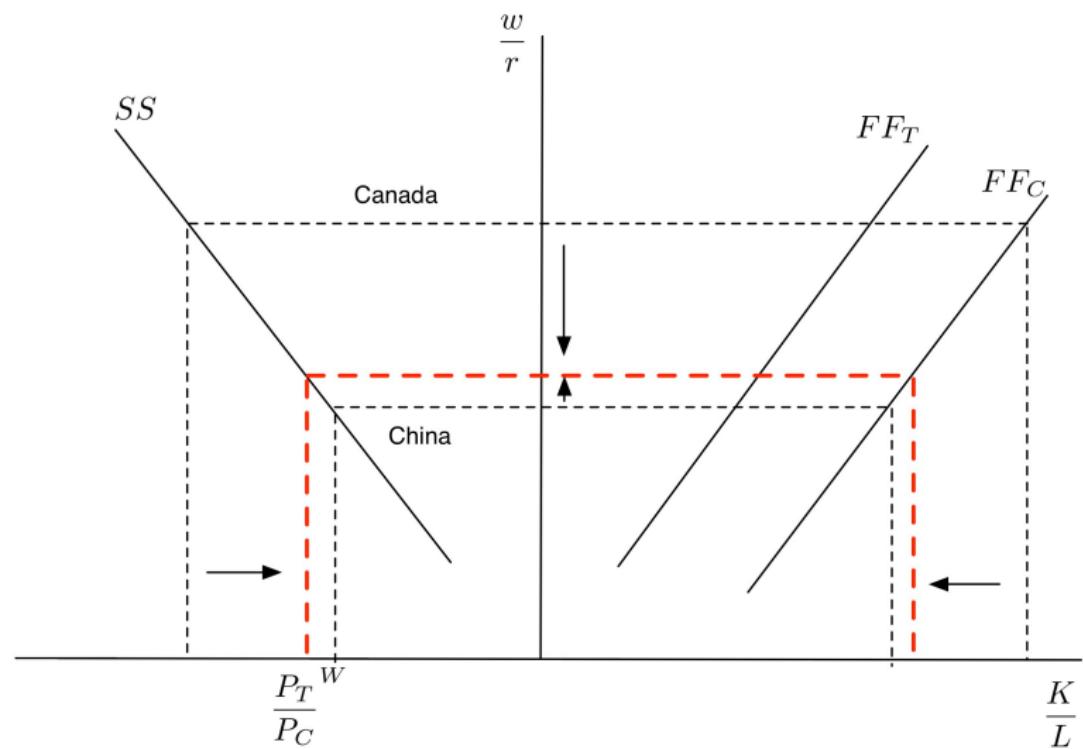
Large China

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Canada	200	100	2	20	10	2
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World	205	120	1.71	70	210	0.33

- ▶ Large 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 three important results from 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
 - How the stock of factors determine the goods countries will trade
 - Which country experience the greatest change under free trade

Conclusion

- ▶ Next class
 - Trade allow prices to converge, which causes factor prices to also converge
 - Why does this happen?
 - How well do the predictions in the HO model hold in the real world?