

The Trade Workhorse: The Heckscher-Ohlin Model

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- ▶ Last time
 - ▶ The specific factors model:
 - ▶ Analyze trade and the income distribution
 - ▶ A short-run model: some factors can only be used to produce a single good
 - ▶ Trade can hurt owners of some factors
 - ▶ As trade “grows the pie”, the right taxes can improve welfare for all
 - ▶ Political economy:
 - ▶ Trade often unpopular as losses from trade are concentrated in an industry, while benefits are diffused
 - ▶ Migration:
 - ▶ In the simplest model, migration hurts high wage labor
 - ▶ Again, the pie grows, so that taxes can compensate

- ▶ Today: The Heckscher-Ohlin Model
 - ▶ Introduction
 - ▶ The point
 - ▶ The model
 - ▶ Setup and assumptions
 - ▶ Production possibilities
 - ▶ Production and prices
 - ▶ Autarchy equilibrium
 - ▶ Trade equilibrium
 - ▶ The big four theorems
 - ▶ The problems
 - ▶ Assumptions
 - ▶ Evidence
 - ▶ Moving forward

- ▶ But first a review!

Simplest possible model for income distributions

- ▶ Two countries: Home (H) and Foreign (G)
- ▶ Two goods: Clothes (C) and Food (F)
- ▶ Two factors: Land (t) and Capital (k)
- ▶ Different from textbook (three factors)!
- ▶ Home endowment of land T less than foreign T^*
- ▶ Home endowment of capital K greater than foreign K^*

Two factor model

- ▶ Specific factors
 - ▶ Income dist.: different people own Land and Capital
 - ▶ Capital is used *only* to make clothes
 - ▶ Land is used *only* to make food
- ▶ Production technology
 - ▶ Clothes: $f_C(k) = \frac{k}{a_C}$
 - ▶ Food: $f_F(t) = \frac{t}{a_F}$
 - ▶ Same technology in both countries

Production Possibilities Sets

Payments to factor owners

- ▶ Like wages last time
- ▶ Capital gets $r_k = \frac{P_C}{a_C}$
- ▶ Land gets $r_t = \frac{P_F}{a_F}$

Equilibrium prices

- ▶ As last time, relative demand and supply

Equilibrium Gains from Trade

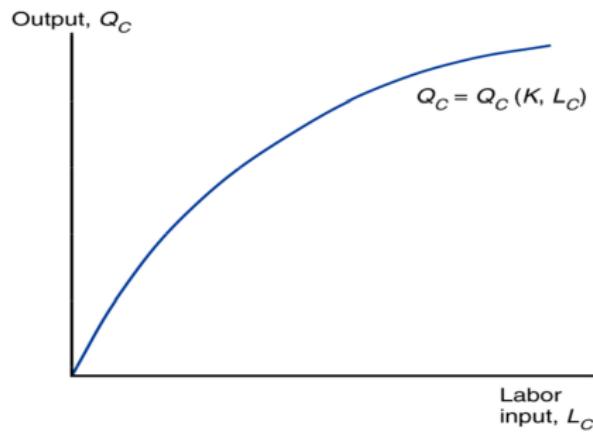
- autarchy home price ratio $< \frac{P_C^e}{P_F^e} <$ autarchy foreign price ratio

	Input	Clothes	Food
Home capital owner	One unit of capital	$\frac{1}{a_C}$	$\frac{P_C^e}{P_F^e} \frac{1}{a_C}$
Home land owner	One unit of land	$\frac{P_F^e}{P_C^e} \frac{1}{a_F}$	$\frac{1}{a_F}$

- Home capital owner gains from trade, but home land owner is hurt!

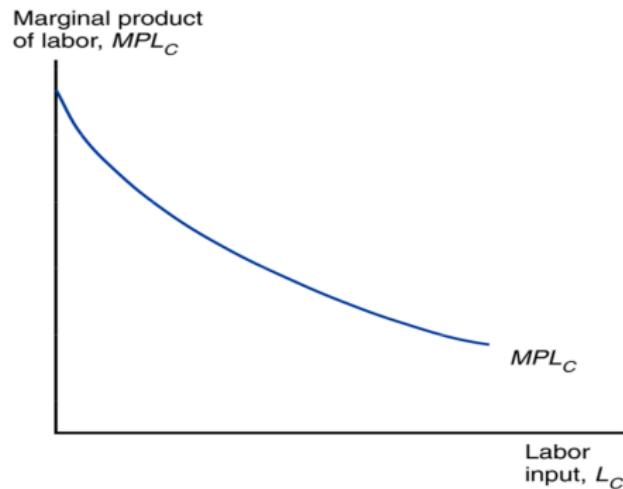
Production function

- ▶ Clothing, fix capital at K

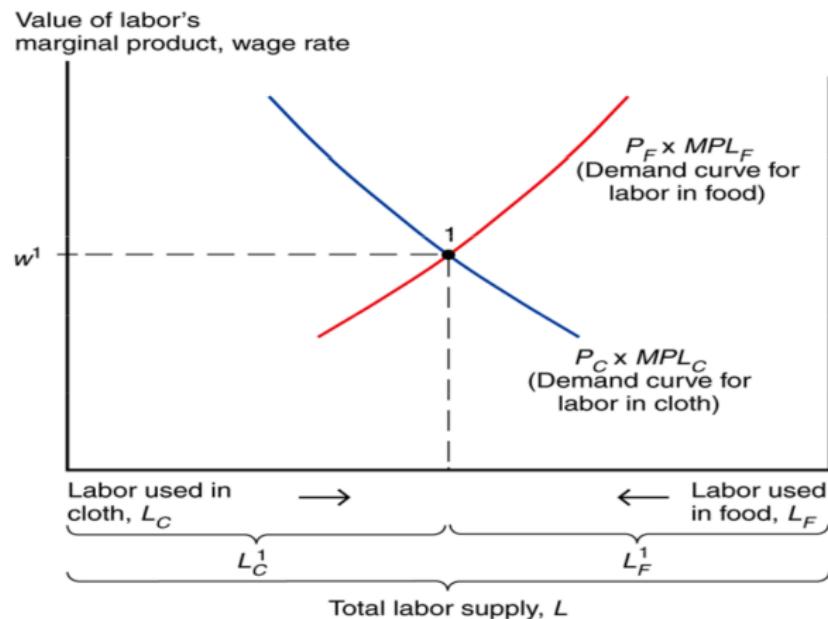


Decreasing MPL

- ▶ Clothing, fix capital at K

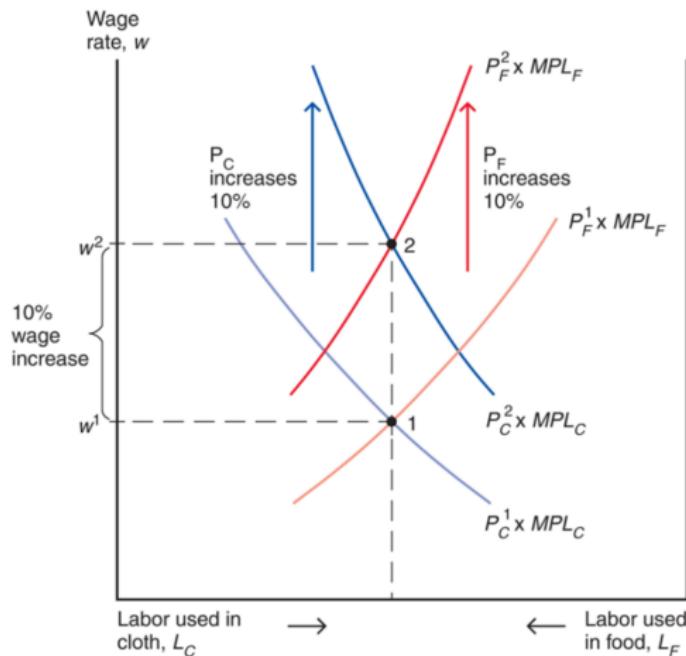


Graphical Autarchy wage



Price changes, labor allocation, and wages

- ▶ Proportional increase in wage, no labor allocation change

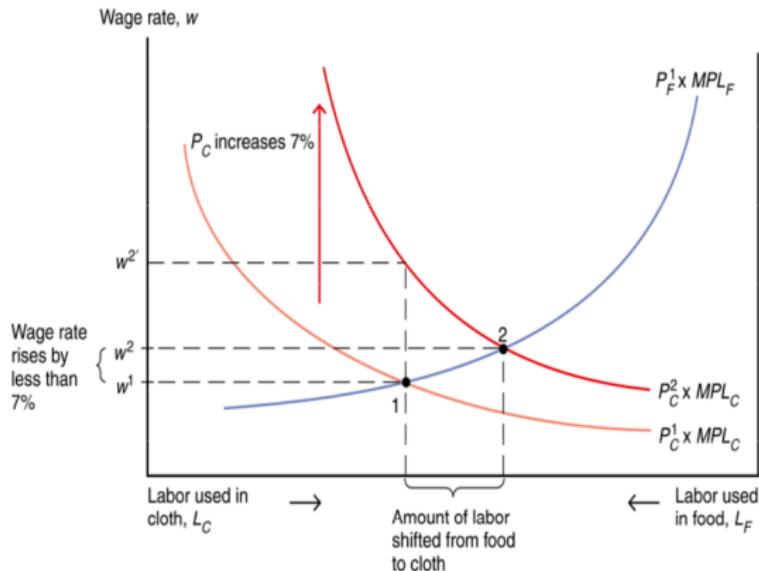


Price changes, labor allocation, and wages

- ▶ Proportional price changes
 - ▶ No one hurt, as all returns rise proportionally to price

Price changes, labor allocation, and wages

- Less than proportional increase in wage due to falling MPL

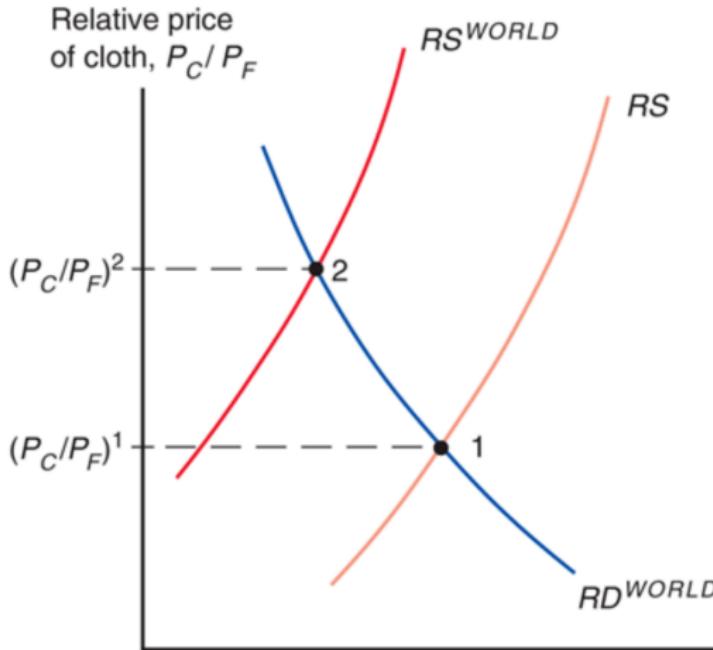


Price changes, labor allocation, and wages

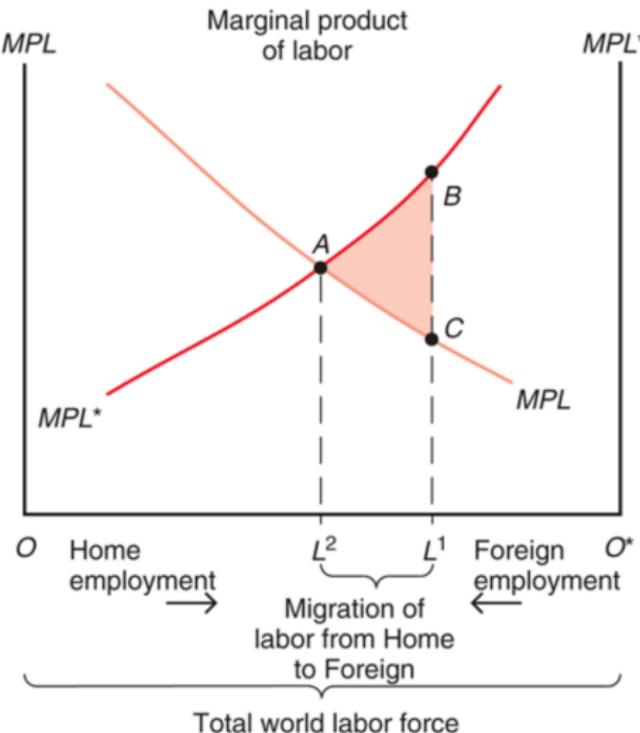
- ▶ Rise in price of clothes relative to food
- ▶ Begin waving of hands
 - ▶ Labor
 - ▶ Wage rises, but price of clothes rises more!
 - ▶ Workers can afford more food, but less clothes
 - ▶ Indeterminant effect on welfare
 - ▶ Capital
 - ▶ Price of clothes rises → pushes r_k up.
 - ▶ What happens to the marginal product of capital when L_c increases?
 - ▶ Good reason to think that marginal product of capital should increase
 - ▶ However what if $Q_C(K, L_C) = (K - L)^2$?
 - ▶ Land
 - ▶ Price of food stays constant, but clothes now more expensive!
 - ▶ Textbook assumes that marginal product of land goes down as L_F decreases
 - ▶ Thus r_t goes down, and price of clothes goes up, so land owners hurt.

Trade equilibrium

- We can think of opening up to trade as a change in relative prices, in one direction or the other



International Migration



- ▶ End review

- ▶ Quick note on this Chapter 5 of the textbook.

Heckscher-Ohlin: Rise of a theory

- ▶ From a book by Ohlin published in 1933
- ▶ Original point → trade and long-run income distribution
- ▶ Attractive model
 - ▶ Elegant: Can be analyzed graphically
 - ▶ Enough complexity to tackle many trade issues
 - ▶ Effect of trade liberalization
 - ▶ Effect of tariffs
 - ▶ Effect of technological change on trade patterns
 - ▶ Effect of technological change on income distributions
 - ▶ Clear, testable predictions
 - ▶ Developed and extended by famous economists
 - ▶ Ohlin (Nobel 1979)
 - ▶ Samuelson (Nobel 1970)

Heckscher-Ohlin: Downfall

- ▶ Some quotes:
 - ▶ *... the Heckscher-Ohlin model is hopelessly inadequate as an explanation for historical and modern trade patterns, unless we allow for technological differences across countries.*
-Robert Feenstra, Distinguished Professor of Economics at University of California, Davis, 2004
 - ▶ *It is time to declare Stolper-Samuelson [an important result of the HO model] dead. Stolper-Samuelson says that trade liberalization will raise the real income of the abundant (unskilled) labor in poor countries. Stolper-Samuelson, qua theorem, is not wrong, of course. But if we use it, as we so often have, as if it provides a reliable answer to this question of real human significance, then it is worse than wrong - it is dangerous.*
-Donald Davis, Professor of Economics at Colombia University and Prachi Mishra, Senior Economist, IMF 2007

Heckscher-Ohlin: Why the hate?

- ▶ Heckscher-Ohlin is a scientific theory: testable predictions
- ▶ Predictions have often not been backed up by data
- ▶ Assumptions also seem unusual in the modern world

The point

- ▶ Hecksher-Ohlin about long-run effects of trade
- ▶ Embodied in the idea that all factors are costlessly mobile

The point

- ▶ Famous implications are the four theorems (paraphrase):
 1. *Heckscher-Ohlin*: Countries with relatively more of a resource will export goods for which that resource is more useful in production
ex: China exports Labor-intensive manufactured goods
 2. *Rybczynski*: If country gets more of a resource, then the output of the good that uses that resource intensively will rise while the output of the other good will fall. *ex*: if Denmark got more labor, it would increase its production of textiles
 3. *Stolper-Samuelson*: A rise in the price of a final good for which a particular resource is more useful in production will increase the payments to that resource
ex: if the price of textiles goes up, Chinese workers get higher wages
 4. *Factor-price equalization*: Trade should cause resource prices to converge
ex: Danish and Chinese workers should be paid the same wages

Model - Plan of attack

- ▶ Setup and assumptions
- ▶ Production possibilities
- ▶ Production and prices
- ▶ Autarchy equilibrium
- ▶ Trade equilibrium

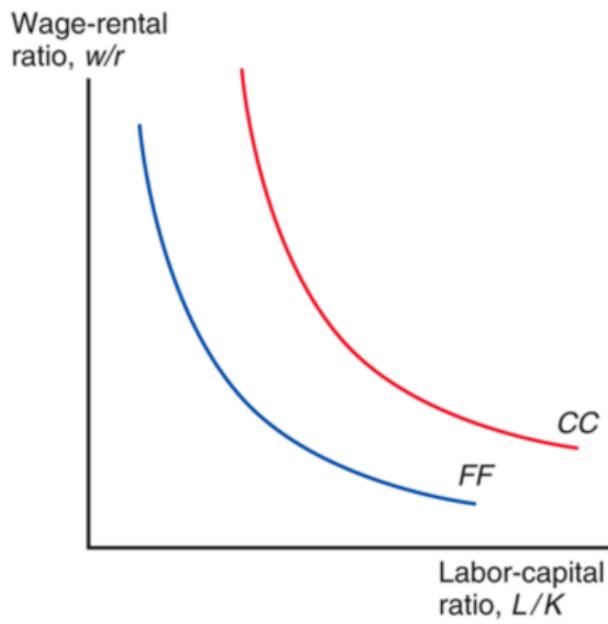
Setup

- ▶ Two countries: Home (H) and Foreign (G)
- ▶ Two goods: Clothes (C) and Food (F)
- ▶ Two factors: Labor (L) and Capital (K)
- ▶ Sometimes called the $2 \times 2 \times 2$ model

Setup

- ▶ Some terminology

- ▶ If $\frac{L}{K} < \frac{L^*}{K^*}$, then Capital is *abundant* in Home, and Labor is *scarce*
- ▶ If for *any* factor prices, relatively more Labor is used to make Clothes than Food, Clothes are *Labor-intensive*, and Food is *Capital-intensive*

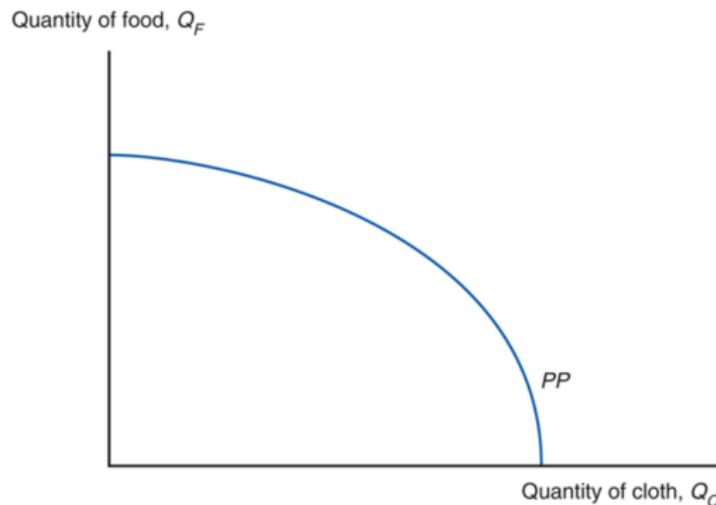


Setup

- ▶ Clothes and Food can be produced with combinations of Labor and Capital
- ▶ Both countries have the same production technology
- ▶ Production technologies are Constant Returns to Scale (double both inputs, double output)
- ▶ Each country has a different endowment of Labor and Capital
- ▶ Labor and Capital cannot move between countries, even in the long run
 - ▶ No shipping of machines allowed
 - ▶ No moving abroad
- ▶ As before, competitive firms with zero profit

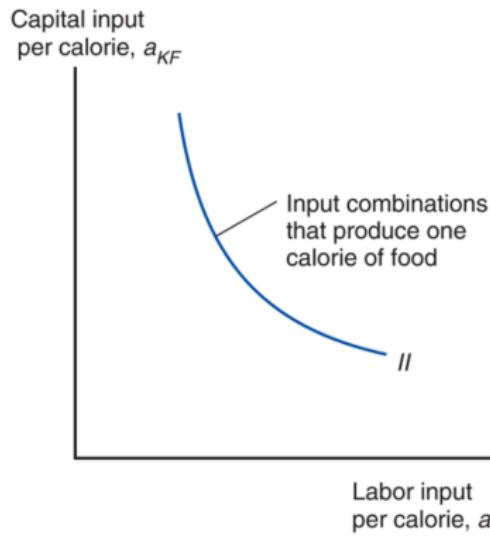
Production Possibilities Frontier

- ▶ Recall: Slope = take a bit of Labor from Food production and put it into Clothes production
- ▶ Now also: Slope = take a bit of Capital from Food production and put it into Clothes production
- ▶ In notation: Slope = $-\frac{MPL_F}{MPL_C} = -\frac{MPK_F}{MPK_C}$ (why must ratios equal?)



Input Possibilities

- ▶ Fix the amount of, say, Food we want to produce
- ▶ Slope = if I want to use a bit more Labor, how much Capital is freed up?
- ▶ $\frac{dQ}{dK} = MPK_F, \frac{dK}{dQ} = \frac{1}{MPK_F}$
- ▶ Slope = $-\frac{\frac{1}{MPK_F}}{\frac{1}{MPL_F}} = -\frac{MPL_F}{MPK_F}$
- ▶ Why is the curve convex?

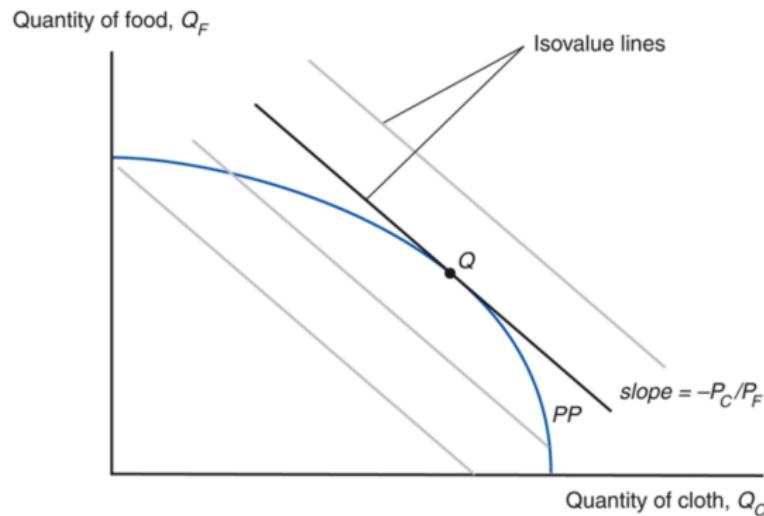


Pause

- ▶ We have described the environment
- ▶ We have described what it is possible to produce
- ▶ Now how do output prices affect production?
- ▶ How do input prices affect input choice?

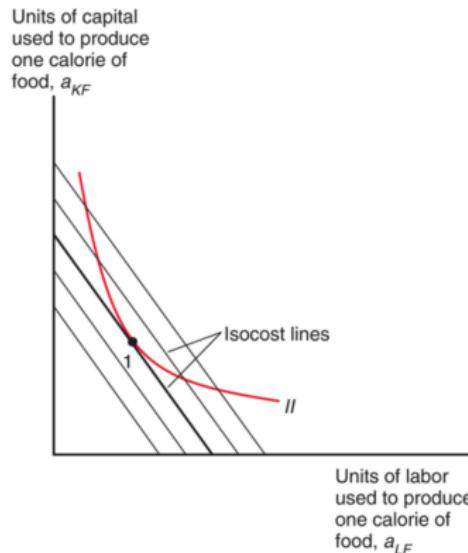
Output price ratio and production

- ▶ Suppose we have the price ratio $\frac{P_C}{P_F}$
- ▶ Then $\frac{P_C}{P_F} = \frac{MPL_F}{MPL_C} = \frac{MPK_F}{MPK_C}$ (why?)
- ▶ Production given by the point on the PPF tangent to $-\frac{P_C}{P_F}$



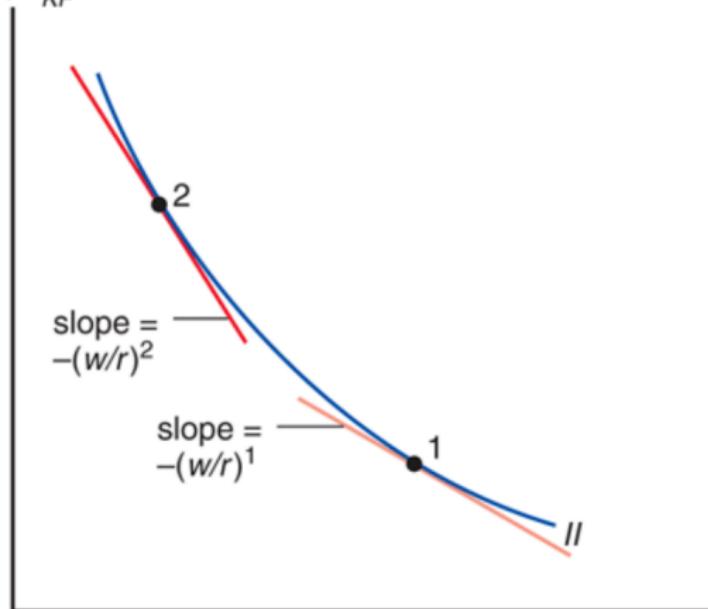
Input price ratio and production

- ▶ Suppose we have the price ratio $\frac{w}{r}$
- ▶ Then $\frac{w}{r} = \frac{MPL_F}{MPK_F} = \frac{MPL_C}{MPK_C}$ (why?)
- ▶ Input bundle given by the point on the input possibilities curve tangent to $-\frac{w}{r}$



Input price change and production

Units of capital
used to produce
one calorie of
food, a_{KF}



Units of labor
used to produce
one calorie of
food, a_{LF}

Pause

- ▶ We have now described what *can* be produced
- ▶ We have also described how output production is linked to output prices
- ▶ We have also described how input choice is linked to input prices
- ▶ Next we will heuristically describe how input and output prices are linked in equilibrium

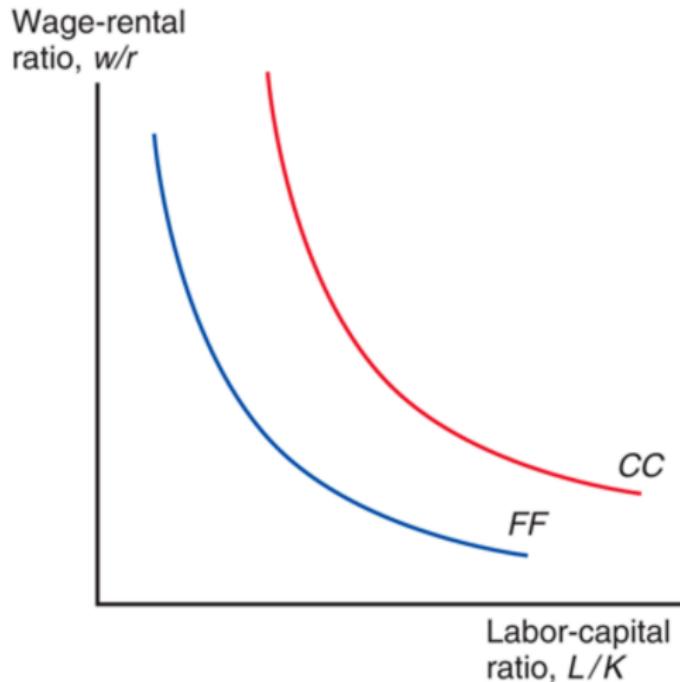
Input and Output Prices

- ▶ Setup
 - ▶ Draw input possibilities curves for both goods on the same chart
 - ▶ Curves are for production of the same value of the two goods
 - ▶ Assume that both goods are produced
 - ▶ Must be line tangent to both curves, with slope wage-rental ratio
- ▶ Food industry is *labor intensive*
 - ▶ That is, for any wage-rental ratio, Food uses a higher proportion of Labor than Clothes
- ▶ Suddenly the price of food rises
 - ▶ If wage-rental ratio doesn't change, negative profits for making clothes, clothes industry closes
 - ▶ If both industries to remain open, wage-rental ratio must rise
 - ▶ Since firms hire less labor and more capital per unit produced, MPL rises and MPK falls
 - ▶ Wages rise (clothes buy more food, and wages paid in clothes rise): $\frac{w}{P_C} = MPL_C = \frac{P_F}{P_C} MPL_F$.
 - ▶ rent falls (food buys less clothes, and rent paid in food falls): $\frac{r}{P_F} = \frac{P_C}{P_F} MPK_C = MPK_F$.

The Stolper-Samuelson Theorem

- ▶ *Stolper-Samuelson:* A rise in the price of a final good for which a particular resource is more useful in production will increase the payments to that resource
- ▶ Owners of one input are always hurt by a price change in output goods.
- ▶ Trade in outputs typically changes output prices, so some people are typically hurt by trade.

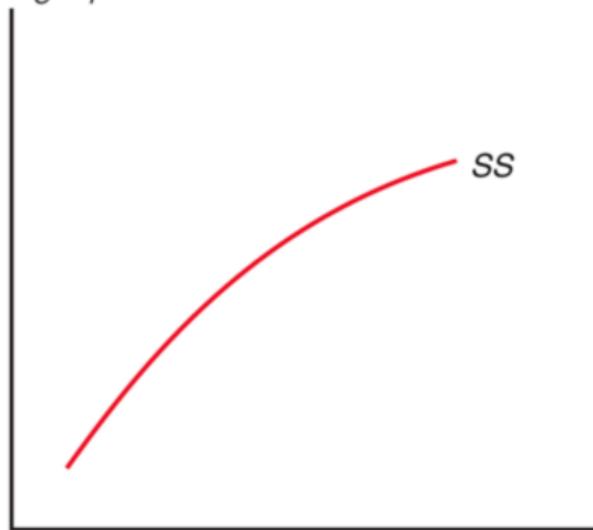
Textbook discussion of Stolper-Samuelson



Textbook discussion of Stolper-Samuelson

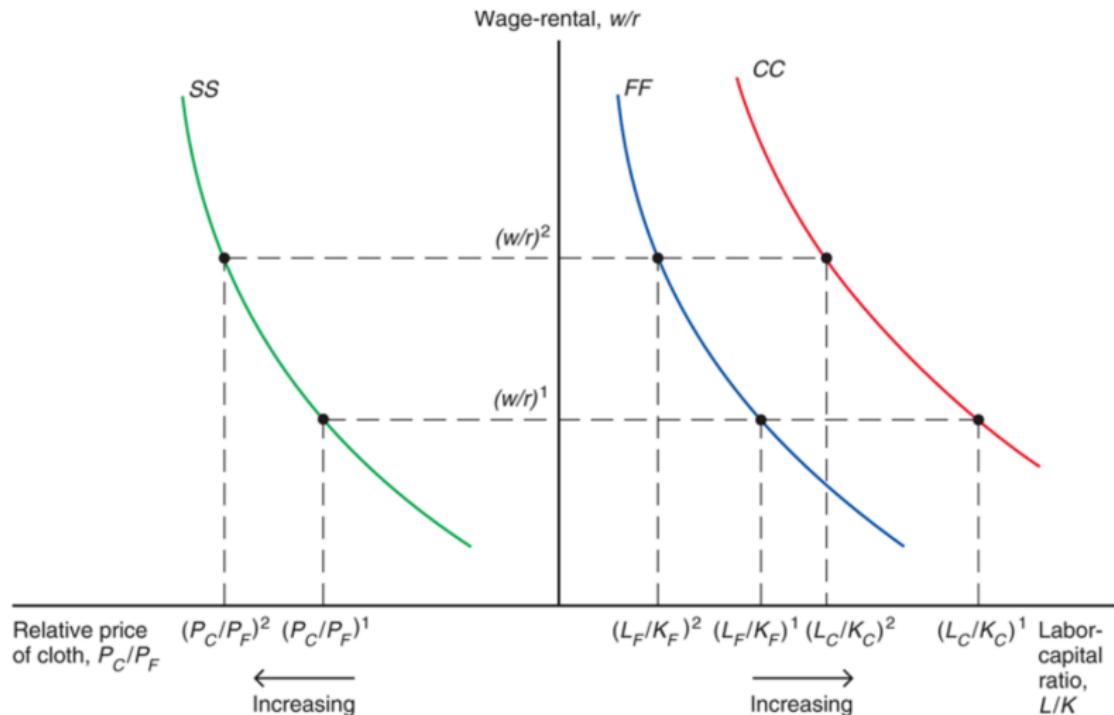
- ▶ Heuristic: Clothes use relatively more labor, so if price of labor relatively increases, $\frac{P_C}{P_F}$ increases.
- ▶ How did we derive this relationship?

Relative price of
cloth, P_C/P_F



Wage-rental
ratio, w/r

Textbook discussion of Stolper-Samuelson

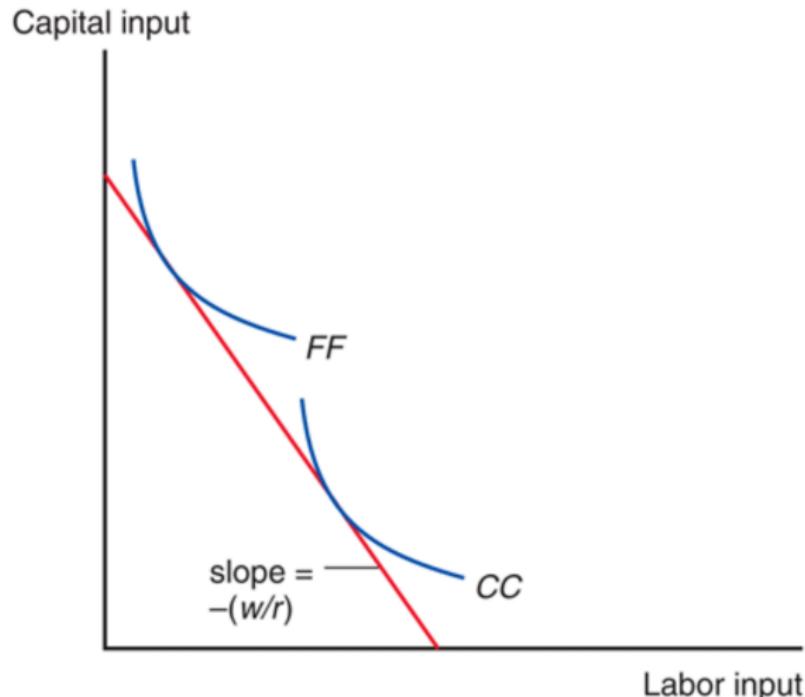


Pause

- ▶ We have now described what *can* be produced
- ▶ We have described how output production is linked to output prices
- ▶ We have described how input choice is linked to input prices
- ▶ We have described how input and output prices are linked (Stolper-Samuelson)
- ▶ Next: Fixing prices, how do changes in factor endowments affect production?

Factor endowment changes and production

- If prices do not change, industry-level Labor-Capital ratios do not depend on aggregate Labor-Capital ratios



Factor endowment changes and production

- ▶ We have the accounting identity:

$$\begin{aligned}\frac{L}{K} &= \frac{L_C}{K} + \frac{L_F}{K} \\ &= \frac{L_C}{K_C} \frac{K_C}{K} + \frac{L_F}{K_F} \frac{K_F}{K}\end{aligned}$$

- ▶ Changes in aggregate $\frac{L}{K}$ do not affect $\frac{L_C}{K_C}$ and $\frac{L_F}{K_F}$
- ▶ If $\frac{L}{K}$ increases, only way for the identity to hold is for Capital to move from the capital intensive industry to the labor intensive industry
- ▶ If Capital moves, since industry Capital-Labor ratios don't change, Labor must move as well
- ▶ That is, $\frac{L}{K}$ increases \rightarrow more Labor-intensive good, less Capital-intensive good

The Rybczynski Theorem

- ▶ *Rybczynski:* If country gets more of a factor, then the output of the good that uses that factor intensively will rise while the output of the other good will fall.

Pause

- ▶ We have now described what *can* be produced
- ▶ We have described how production and inputs linked to prices
- ▶ We have described how input and output prices are linked (Stolper-Samuelson)
- ▶ We have described how factor endowments and output is linked (Rybczynski)
- ▶ Next: Describe trade patterns in equilibrium

Trade Patterns

- ▶ Remember: Countries are identical, except for relative factor endowments
- ▶ Assume that home has relatively more Capital: $\frac{L}{K} < \frac{L^*}{K^*}$
- ▶ For any output price, Rybczynski → relatively more Capital intensive good (Clothing) produced at home:

$$\frac{Q_C}{Q_F} > \frac{Q_C^*}{Q_F^*}$$

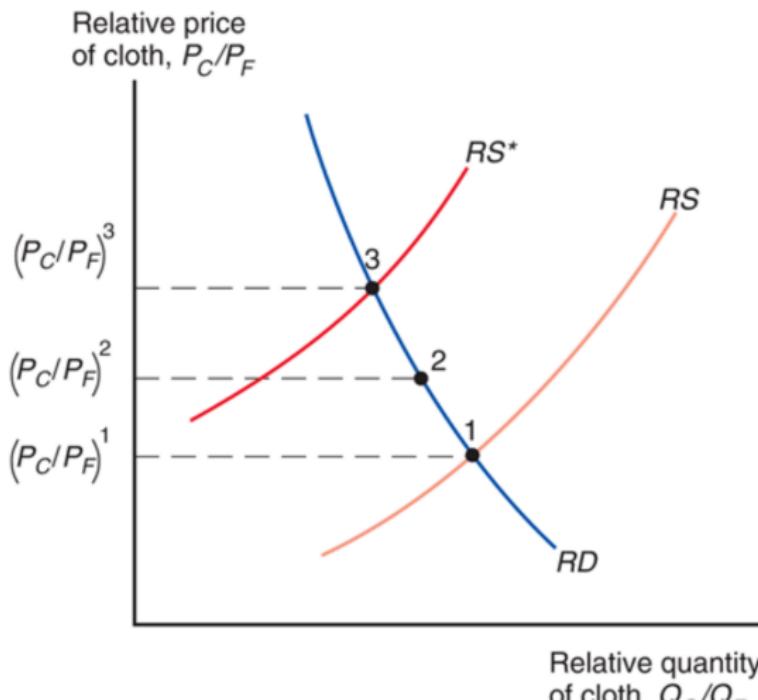
- ▶ Since consumption depends only on output price, equilibrium consumption ratio $\frac{D_C}{D_F} = \frac{D_C^*}{D_F^*}$
- ▶ (Hidden assumption: homotheticity again!)
- ▶ Must be that home exports Capital-intensive good (Clothes) and imports Labor-intensive good (Food)

The Hecksher-Ohlin Theorem

- ▶ The country with relatively more Capital exports the Capital-intensive good.
- ▶ The country with relatively more Labor exports the Labor-intensive good.
- ▶ *Heckscher-Ohlin: Countries with relatively more of a resource will export goods for which that resource is more useful in production*

The effect of trade on relative input and output prices

- ▶ Claim in the book: Trade induces convergence in relative output prices
- ▶ Notice that relative price change in favor of abundant resource in both countries



The effect of trade on relative prices

- ▶ If this (fairly reasonable) claim is true:
 - ▶ Owners of the abundant resource gain
 - ▶ Owners of the scarce resource lose
 - ▶ Reason: Stolper-Samuelson theorem
- ▶ Trade should hurt skilled Chinese labor, and unskilled Danish labor

Pause

- ▶ We have now described what *can* be produced
- ▶ We have described how production and inputs linked to prices
- ▶ We have described how input and output prices are linked (Stolper-Samuelson)
- ▶ We have described how factor endowments and output is linked (Rybczynski)
- ▶ We have described trade patterns in equilibrium (Heckscher-Ohlin)
- ▶ Next, we will describe the effect of trade on factor prices

The effect of trade on world factor prices

- ▶ In our proof of Stolper-Samuelson, we saw a graph as below showing how factor prices are determined in equilibrium
- ▶ This graph is related only to the technology available and relative price of the two goods
- ▶ This graph is *not* related to aggregate factor endowments $\frac{L}{K}$ and $\frac{L^*}{K^*}$
- ▶ Since in trade relative prices are the same, and technologies in the countries are the same:
 - ▶ So are factor prices the same in the two countries!
- ▶ Intuition: Exporting the Labor-intensive good is like exporting Labor, even though Labor cannot move between countries

The Four Theorems

- ▶ Famous implications are the four theorems:
 1. *Heckscher-Ohlin*: Countries abundant in a factor will export the good intensive in that factor
 2. *Rybczynski*: If a country's relative amount of a factor rises, then the output of the good intensive in that factor will rise while the output of the other good will fall.
 3. *Stolper-Samuelson*: A rise in the relative price of an output intensive in a factor will increase thereal returns to that factor, and decrease returns to the other factor
 4. *Factor-price equalization*: Trade causes factor prices to completely converge
- ▶ Empirical tests will be based on these four predictions

Problems - assumptions

1. Proofs of the theorems require that both goods are produced in both countries
 2. The model assumes technology is the same everywhere
 3. The model assumes that Capital cannot move
 4. Output goods have the same price everywhere
-
- ▶ In the early 20th century, these assumptions were reasonable
 - ▶ Now they seem like a poor approximation to the world

Factor price equalization

- ▶ Most obvious test
- ▶ Most obvious failure, even as an approximation

Country	Hourly Compensation of Production Workers, 2011
United States	100
Germany	133
Japan	101
Spain	80
South Korea	53
Brazil	33
Mexico	18
China*	4

*2008

Source: Bureau of Labor Statistics, *Foreign Labor Statistics Home Page*.

Reduction in developing country inequality

- ▶ Suppose our two factors were skilled and unskilled Labor
- ▶ China is abundant in unskilled Labor, Denmark in skilled
- ▶ Trade liberalization should cause China to export goods intensive in unskilled Labor (Heckscher-Ohlin)
- ▶ This should cause the relative price of goods intensive in unskilled Labor to rise in China
- ▶ That should increase the returns to unskilled Labor relative to skilled labor (Stolper-Samuelson)
- ▶ Less wage inequality predicted!

Reduction in developing country inequality

Table 5
Baseline results.

	1995		2002	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
College premium	0.231*** (0.026)	0.378*** (0.071)	0.511*** (0.028)	0.879*** (0.110)
No. of obs.	5629	5629	4980	4980
Shea partial R ²		0.051		0.051
F-test		126.348		278.859
p-value		0.000		0.000

1. Notes: Robust standard errors in brackets (clustered at provincial level). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

2. All the estimation includes age, age squared, a dummy variable indicating an individual's minority status, gender, and a set of provincial dummy variables (refer to the text for detail).

3. Shea Partial R² and F-test are test statistics for weak instrument variable tests.

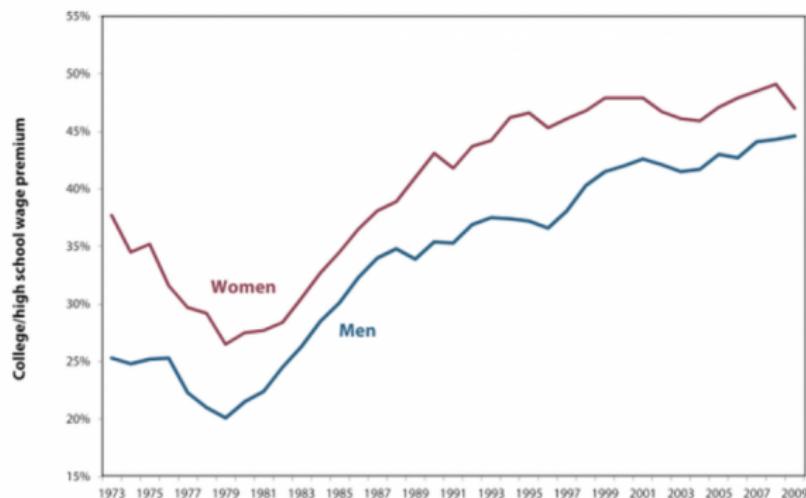
Source:

Wang, L. Economic Transition and College Premium in Urban China, China Economic Review, 2012

The flip side

- ▶ Of course, we should also expect the college premium to go up in developed countries

Those with college degrees see relative, though slowing, gains College/high school wage premium, 1973–2009



Source: EPI analysis of Current Population Survey, Outgoing Rotations Group.

The Leontief Paradox

- ▶ Heckscher Ohlin Theorem says that the United States should export Capital intensive goods, and import Labor intensive goods
- ▶ Leontief pointed out that the opposite is true, that is the sign of trade is incorrect
- ▶ More recently, Davis and Weinstein find that trade patterns fail the HO sign test for 64% of countries
- ▶ The HO predictions are worse than random!

Missing trade

- ▶ The United States and Europe have a very large share of world Capital, but a very small share of world Labor
- ▶ The opposite is true for developing countries
- ▶ We should see massive trade flows between the developed and developing world
- ▶ In reality we see very little trade relative to developing developing trade

- ▶ If we start dropping assumptions, the HO predictions to better
1. Common technologies across countries
 2. Countries produce the same set of goods
 3. Costless trade, equalized output prices

	Assumptions Dropped*			
	None	Drop (1)	Drop (1)–(2)	Drop (1)–(3)
Predictive Success (sign test)	0.32	0.50	0.86	0.91
Missing Trade (observed/ predicted)	0.0005	0.008	0.19	0.69

*Assumptions: (1) common technologies across countries; (2) countries produce the same set of goods; and (3) costless trade equalizes goods prices.

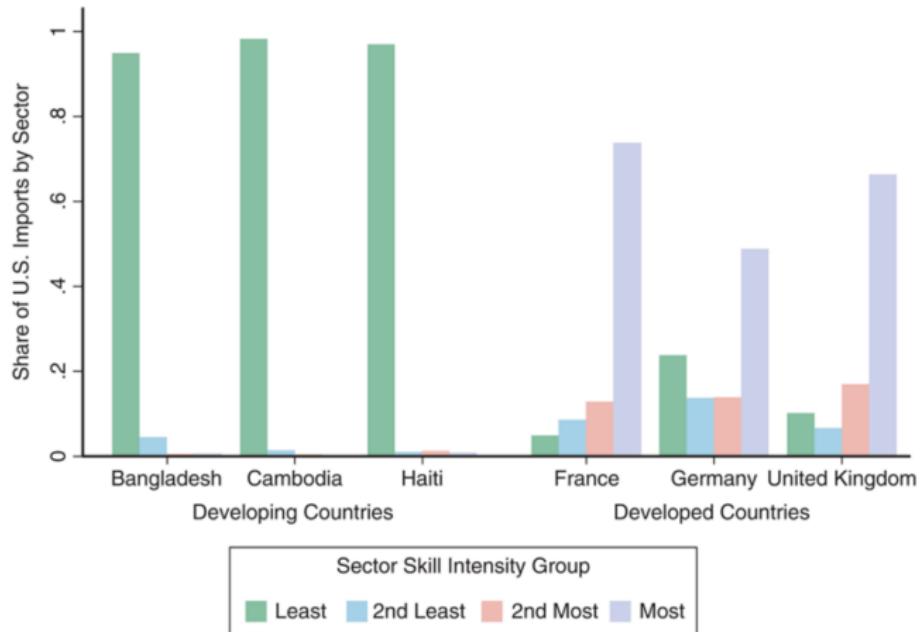
Source: Don R. Davis and David Weinstein, “An Account of Global Factor Trade,” *American Economic Review* (2001), pp. 1423–1453.

My view

- ▶ We used these assumptions to prove the theorems
- ▶ Without the theorems, the model does not have predictions
- ▶ Therefore, if we drop the assumptions, we do not really have a test

Where the HO model does better

- ▶ Skill intensity in developed and developing country exports



Source: NBER-CES U.S. Manufacturing Productivity Database, U.S. Census Bureau, and Peter K. Schott, "The Relative Sophistication of Chinese Exports," *Economic Policy* (2008), pp. 5–49.

where the HO model does better



Source: NBER-CES U.S. Manufacturing Productivity Database, U.S. Census Bureau, and Peter K. Schott, "The Relative Sophistication of Chinese Exports," *Economic Policy* (2008), pp. 5–49.

where the HO model does better

- ▶ Then again, hard to imagine a world were Haiti exports microprocessors and Denmark buttons.

Summary

- ▶ Heckscher-Ohlin Theory extremely important in the history of economic thought on trade
- ▶ Point: Trade has long-run effects on the distribution of income
- ▶ Main predictions relate to the four theorems
 1. Heckscher-Ohlin
 2. Rybczynski
 3. Stolper-Samuelson
 4. Factor Price Equalization
- ▶ In the last 20 years, theory has become less popular as it has failed to match trade data, even as an approximation

Moving forward

- ▶ Next time: “The Standard Trade Model”
- ▶ We have seen that HO does better when combined with technology differences
- ▶ Unifying trade framework with elements from Ricardo, specific factors, and HO.
- ▶ Use this model to analyze effect of tariffs, changes in exchange rates, etc



North-South Trade and Income Inequality

- Over the last 40 years, countries like South Korea, Mexico, and China have exported to the U.S. goods intensive in unskilled labor (ex., clothing, shoes, toys, assembled goods).
- At the same time, income inequality has increased in the U.S., as wages of unskilled workers have grown slowly compared to those of skilled workers.
- Did the former trend cause the latter trend?



North-South Trade and Income Inequality (cont.)

- The Heckscher-Ohlin model predicts that owners of relatively abundant factors will gain from trade and owners of relatively scarce factors will lose from trade.
 - Little evidence supporting this prediction exists.
- 1. According to the model, a change in the distribution of income occurs through changes in output prices, but there is no evidence of a change in the prices of skill-intensive goods relative to prices of unskilled-intensive goods.



North-South Trade and Income Inequality (cont.)

2. According to the model, wages of unskilled workers should increase in unskilled labor abundant countries relative to wages of skilled labor, but in some cases the reverse has occurred:
 - Wages of skilled labor have increased more rapidly in Mexico than wages of unskilled labor.
 - But compared to the U.S. and Canada, Mexico is supposed to be abundant in unskilled workers.



North-South Trade and Income Inequality (cont.)

3. Even if the model were exactly correct, trade is a small fraction of the U.S. economy, so its effects on U.S. prices and wages should be small.
 - The majority view of trade economists is that the villain is not trade but rather new production technologies that put a greater emphasis on worker skills (such as the widespread introduction of computers and other advanced technologies in the workplace).



Skill-Biased Technological Change and Income Inequality

- Even though skilled labor becomes relatively more expensive, in panel (b) producers in both sectors respond to the skill-biased technological change by *increasing* their employment of skilled workers relative to unskilled workers.
 - The trade explanation in panel (a) predicts an opposite response for employment in both sectors.
- A widespread increase in the skilled labor ratios for most sectors in the U.S. economy points to the skill-biased technological explanation.



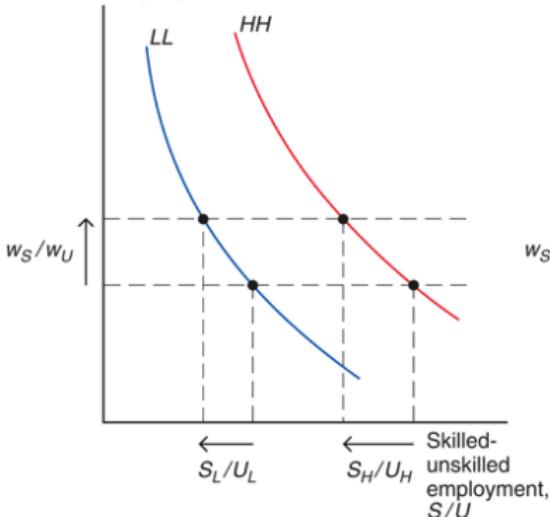
Skill-Biased Technological Change and Income Inequality (cont.)

- Trade likely has been an indirect contributor to increases in wage inequality, by accelerating the process of technological change.
 - Firms that begin to export may upgrade to more skill-intensive production technologies.
 - Trade liberalization can then generate widespread technological change by inducing a large proportion of firms to make such technology-upgrade choices.
- Breaking up the production process across countries can increase the relative demand for skilled workers in developed countries similar to skill-biased technological change.



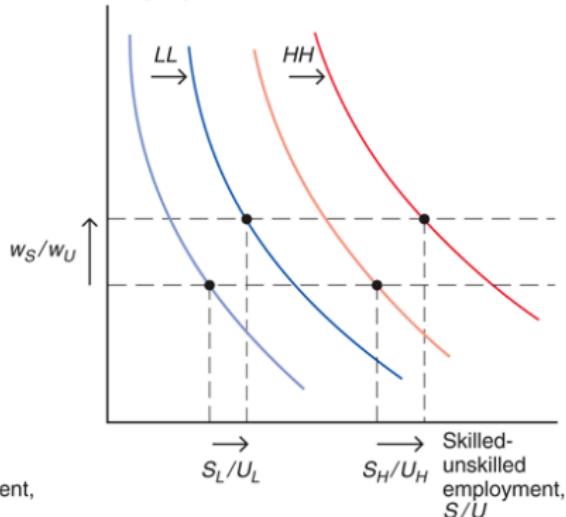
**Fig. 5-10: Increased Wage Inequality:
Trade or Skill-Biased Technological Change?**

Skilled-unskilled
wage ratio, w_S/w_U



(a) Effects of trade

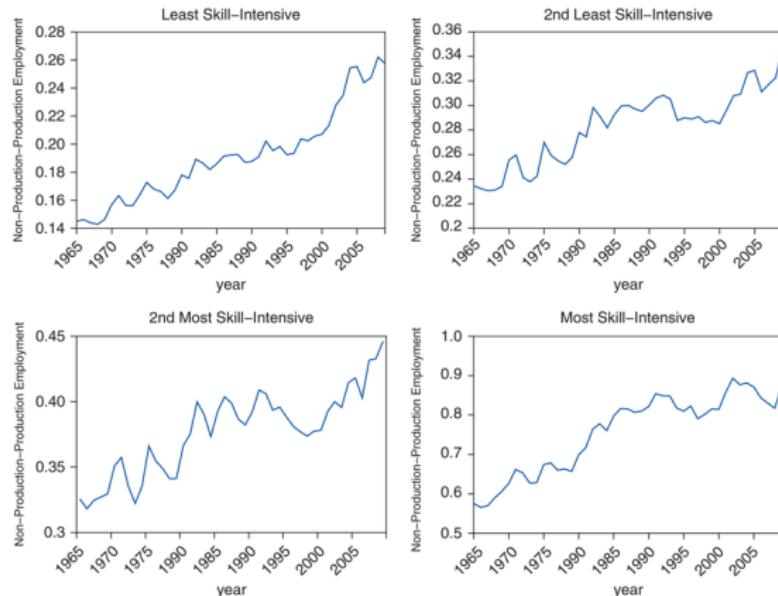
Skilled-unskilled
wage ratio, w_S/w_U



(b) Effects of skill-biased technological change



Fig. 5-11: Evolution of U.S. Non-Production-Production Employment Ratios in Four Groups of Sectors



Source: NBER-CES Manufacturing Productivity Database