

## Chapter 5

### Resources and Trade: The Heckscher-Ohlin Model



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## Preview

- Factor constraints and production possibilities
- How factor endowments affect output
- Comparative advantage and trade
- Changing the mix of inputs
- How prices of goods affect the incomes of factors
- Factor price equalization
- Trade and income distribution
- Empirical evidence

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## Introduction

- In addition to differences in labor productivity, trade occurs due to differences in resources across countries.
- The Heckscher-Ohlin theory argues that trade occurs due to differences in labor, labor skills, physical capital, capital, or other factors of production across countries.
  - Countries have different *relative abundance* of factors of production.
  - Production processes use factors of production with different *relative intensity*.

## Two Factor Heckscher-Ohlin Model

1. Two countries: home and foreign.
2. Two goods: cloth and food.
3. Two factors of production: labor and capital.
4. Mix of labor and capital used varies across goods.
5. The supply of labor and capital in each country is constant and varies across countries.
6. Both labor and capital can move across sectors, equalizing their returns (wage and rental rate) across sectors.
7. Countries have the same technology and the same consumer tastes.

## Production Possibilities

- Fixed mix of capital and labor in each sector:  
To produce one yard of cloth, need  $a_{KC} = 2$  capital  
AND  $a_{LC} = 2$  labor;  
To produce one pound of food, need  $a_{KF} = 3$   
capital AND  $a_{LF} = 1$  labor.
- Fixed amount of capital and labor available for  
production in each country:  
 $K = 3,000$  units of capital and  $L = 2,000$  hours of  
labor available for production in home country.  
 $K^* = 4,000$  and  $L^* = 2,000$  available for  
production in foreign country.

## Production Possibilities

- **Relative Factor Intensity**
  - Cloth production is labor-intensive relative to  
food production if cloth production uses more  
labor for each unit of capital than food  
production.

$$1 = \frac{2}{2} = \frac{a_{LC}}{a_{KC}} > \frac{a_{LF}}{a_{KF}} = \frac{1}{3}$$

- In the example, cloth uses one hour of labor for  
every unit of capital while food uses 1/3 hour of  
labor for every unit of capital in production.

## Production Possibilities

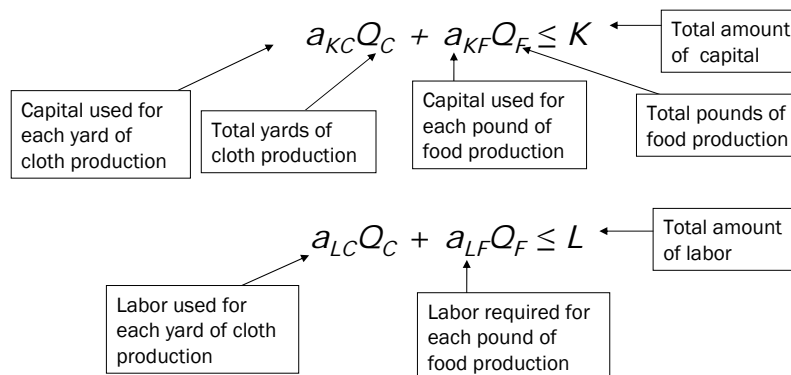
- Implies that food production uses capital relatively intensively:

$$3 = \frac{3}{1} = \frac{a_{KF}}{a_{LF}} > \frac{a_{KC}}{a_{LC}} = \frac{2}{2} = 1$$

- So each factor is used relatively intensively in the production of a good and each good uses a factor relatively intensively (no ties).

## Production Possibilities

- Production possibilities are influenced by *both* capital and labor:



## Production Possibilities

- Slope-intercept formats
  - Capital

$$Q_F = \frac{K}{a_{KF}} - \frac{a_{KC}}{a_{KF}} Q_C$$

- Labor

$$Q_F = \frac{L}{a_{LF}} - \frac{a_{LC}}{a_{LF}} Q_C$$

- Labor constraint steeper than capital constraint because cloth is relatively labor intensive.

## Production Possibilities

- Endpoints of capital and labor constraints
  - Cloth endpoints: have enough capital to produce 1,500 yards of cloth but only enough labor to produce 1,000 yards.

$$\frac{K}{a_{KC}} = \frac{3,000}{2} = 1,500, \frac{L}{a_{LC}} = \frac{2,000}{2} = 1,000$$

- Food endpoints: have enough labor to produce 2,000 pounds of food but only enough capital to produce 1,000 pounds.

$$\frac{K}{a_{KF}} = \frac{3,000}{3} = 1,000, \frac{L}{a_{LF}} = \frac{2,000}{1} = 2,000$$

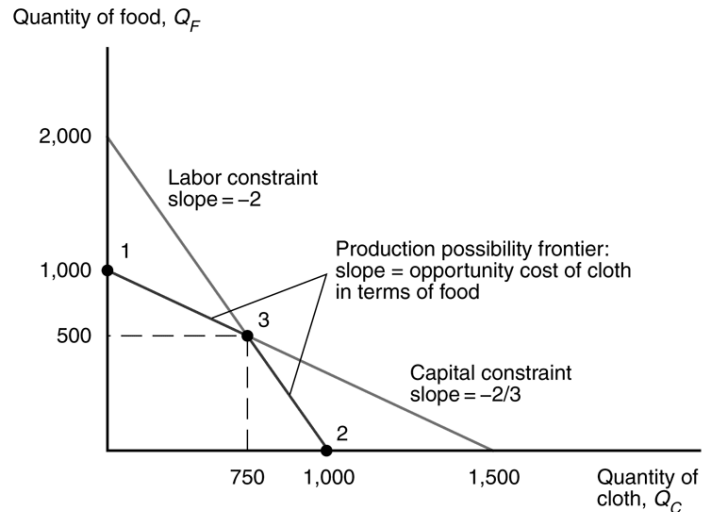
## Production Possibilities

- Max food production 1000 (point 1) fully uses capital, with excess labor.
- Max cloth 1000 (point 2) fully uses labor, with excess capital.
- Intersection of labor and capital constraints occurs at 500 pounds of food and 750 yards of cloth (point 3).

## Production Possibilities

- Economy produces subject to both constraints – must have enough capital and labor.
- Production possibilities frontier
  - Production possibilities are the interior of the factor constraints.
- Equilibrium production
  - A country produces at the intersection of the capital and labor constraints if its factors are fully employed.

**Fig. 5-1: The Production Possibility Frontier Without Factor Substitution**



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## Production Possibilities

- With more than one factor of production, the opportunity cost is no longer constant and the PPF is no longer a straight line.
- The opportunity cost of producing one more yard of cloth is:
  - *low* ( $2/3$  in example) when the economy produces a *low amount of cloth* and a high amount of food
  - *high* (2 in example) when the economy produces a *high amount of cloth* and a low amount of food
- When the economy devotes more resources towards production of one good, the marginal productivity of those resources tends to be low so that the opportunity cost is high.

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## Example 5.1 Factors and Output

- Suppose 2 hours labor and 2 units capital required to produce 1 yard of cloth, while 1 hour labor and 3 units capital required to produce 1 pound of food.
- The United States has 2,000 labor and 3,000 capital.

## Example 5.1 Factors and Output

- What is the U.S. labor constraint?

$$a_{LC}Q_C + a_{LF}Q_F = L$$

$$2Q_C + Q_F = 2000$$

$$Q_F = 2000 - 2Q_C$$

## Example 5.1 Factors and Output

- What is the U.S. capital constraint?

$$a_{KC}Q_C + a_{KF}Q_F = K$$

$$2Q_C + 3Q_F = 3000$$

$$Q_F = 1000 - \frac{2}{3}Q_C$$

## Example 5.1 Factors and Output

- What production bundle fully employs both factors?

$$2000 - 2Q_C = 1000 - \frac{2}{3}Q_C \quad Q_F = 2000 - 2Q_C$$

$$Q_F = 2000 - 2(750)$$

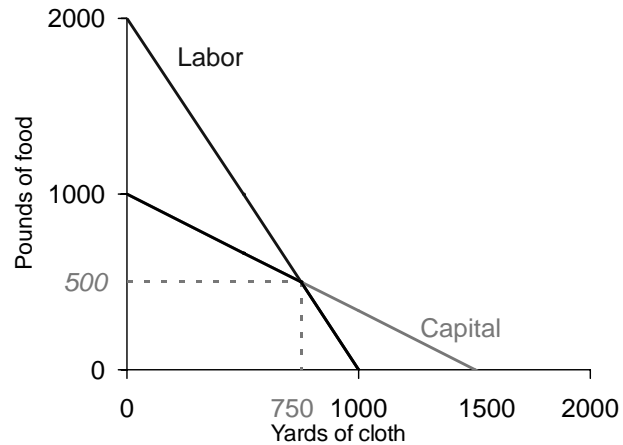
$$\left(2 - \frac{2}{3}\right)Q_C = 2000 - 1000 \quad Q_F = 2000 - 1500$$

$$Q_F = 500$$

$$\frac{4}{3}Q_C = 1000$$

$$Q_C = 750$$

## Example 5.1 Factors and Output



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## Exercise 5.1 US Output

- In either country, producing one yard of cloth uses 4 hours of labor and 2 units of capital, while producing one pound of food uses 1 hour of labor and 3 units of capital. The United States has 200 labor and 300 capital.
- What is the U.S. labor constraint?
- What is the U.S. capital constraint?
- What U.S. production bundle fully employs both factors?

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## Exercise 5.1 Solutions

- What is the U.S. labor constraint?

$$a_{LC}Q_C + a_{LF}Q_F = L$$

$$4Q_C + Q_F = 200$$

$$Q_F = 200 - 4Q_C$$

## Exercise 5.1 Solutions

- What is the U.S. capital constraint?

$$a_{KC}Q_C + a_{KF}Q_F = K$$

$$2Q_C + 3Q_F = 300$$

$$Q_F = 100 - \frac{2}{3}Q_C$$

## Exercise 5.1 Solutions

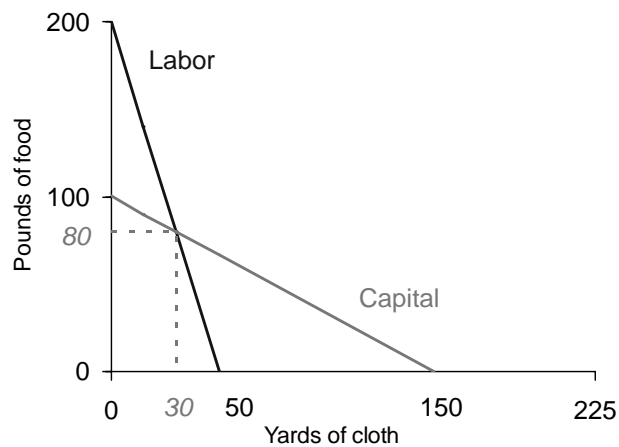
- What production bundle fully employs both factors?

$$\begin{aligned}200 - 4Q_C &= 100 - \frac{2}{3}Q_C & Q_F &= 200 - 4Q_C \\ \left(4 - \frac{2}{3}\right)Q_C &= 200 - 100 & Q_F &= 200 - 4(30) \\ \frac{10}{3}Q_C &= 100 & Q_F &= 200 - 120 \\ Q_C &= 30 & Q_F &= 80\end{aligned}$$

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## Exercise 5.1 Solutions



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## Factor Levels and Output Levels

- **Relative factor abundance**

- **Home is abundant in labor relative to capital** compared to Foreign if Home has more labor per unit of capital than Foreign

$$\frac{2}{3} = \frac{2000}{3000} = \frac{L}{K} > \frac{L^*}{K^*} = \frac{2000}{4000} = \frac{1}{2}$$

- In the example, Home has 2/3 labor per unit of capital while Foreign has less (1/2).
- **Foreign is scarce in labor relative to capital.**

## Factor Levels and Output Levels

- **Relative factor abundance**

- Implies that **Foreign is abundant in capital relative to labor** compared to Home because Foreign has more capital per unit of labor than Home.

$$2 = \frac{4000}{2000} = \frac{K^*}{L^*} > \frac{K}{L} = \frac{3000}{2000} = \frac{3}{2}$$

- In the example, Foreign has 2 capital per labor while Home has less (3/2).
- Home is scarce in capital relative to labor.

## Factor Levels and Output Levels

- Suppose capital endowment increases.
  - Capital constraint shifts out parallel - slope unchanged.
  - Both endpoints of the capital constraint larger.
- How do output levels reflect available resources?
- New equilibrium with more capital represents the foreign (relatively capital abundant) country.
  - Assuming same technologies across countries.

## Factor Levels and Output Levels

- **Rybczynski theorem:** If a factor of production increases, then the supply of the good that uses this factor relatively intensively increases and the supply of *the other good decreases*.
  - An increase in capital causes the supply of food (good that relatively intensively uses capital) to increase and the supply of cloth to decrease.
  - An increase in labor causes the supply of cloth (good that relatively intensively uses labor) to increase and the supply of food to decrease.

## Example 5.2 Increase in Capital

- The new capital endowment is 4,000.
- What is new (foreign) capital constraint?

$$2Q_C + 3Q_F = 4000$$

$$Q_F = 1333 - \frac{2}{3}Q_C$$

## Example 5.2 Increase in Capital

- What new (foreign) production bundle fully employs both factors?

$$2000 - 2Q_C = 1333 - \frac{2}{3}Q_C \quad Q_F = 2000 - 2Q_C$$

$$Q_F = 2000 - 2(500)$$

$$\left(2 - \frac{2}{3}\right)Q_C = 2000 - 1333 \quad Q_F = 2000 - 1000$$

$$Q_F = 1000$$

$$\frac{4}{3}Q_C = 667$$

$$Q_C = 500$$

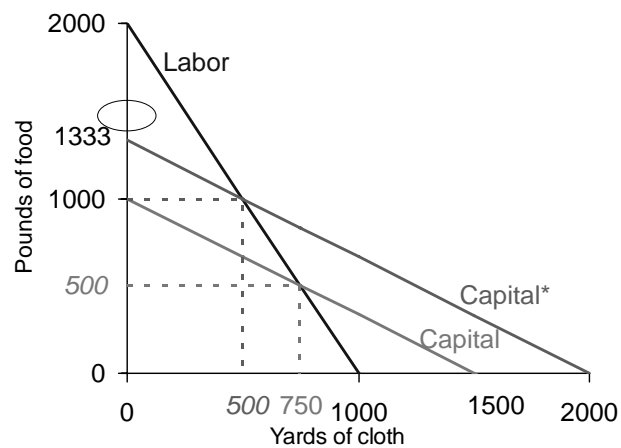
## Example 5.2 Increase in Capital

- Compare the new relative supply of cloth to food to the old.
  - The new relative supply of cloth to food is smaller.

$$\frac{3}{2} = \frac{750}{500} = \frac{Q_C}{Q_F} > \frac{Q_C^*}{Q_F^*} = \frac{500}{1000} = \frac{1}{2}$$

- Home produces more cloth per pound of food (3/2) than foreign (1/2).

## Example 5.2 Increase in Capital



## Example 5.2 Increase in Capital

- Determine comparative advantage and the pattern of trade.
  - Home has comparative advantage in cloth; Foreign has comparative advantage in food.
  - Home exports cloth and imports food; Foreign exports in food and imports cloth.

## Exercise 5.2 Canadian Output

- Canada has 200 labor and 450 capital.
- What is the Canadian capital constraint?
- What Canadian production bundle fully employs both factors?
- Compare the two countries' supply of cloth relative to food.

## Exercise 5.2 Canadian Output

- Determine and compare the relative abundance of factors across countries.
- Determine and compare the relative intensity of factor use across goods.
- Determine the pattern of comparative advantage and the pattern of trade.

## Exercise 5.2 Solutions

- What is the Canadian capital constraint?

$$2Q_C^* + 3Q_F^* = 450$$

$$Q_F^* = 150 - \frac{2}{3}Q_C^*$$

## Exercise 5.2 Solutions

- What Canadian production bundle fully employs both factors?

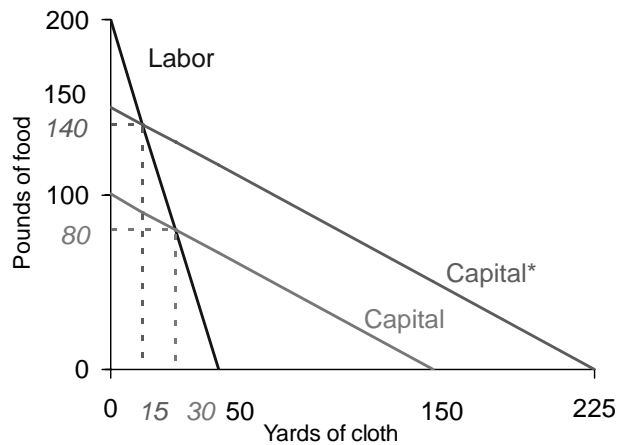
$$\begin{aligned}200 - 4Q_C^* &= 150 - \frac{2}{3}Q_C^* & Q_F^* &= 200 - 4Q_C^* \\ \left(4 - \frac{2}{3}\right)Q_C^* &= 200 - 150 & Q_F^* &= 200 - 4(15) \\ \frac{10}{3}Q_C^* &= 50 & Q_F^* &= 200 - 60 \\ Q_C^* &= 15 & Q_F^* &= 140\end{aligned}$$

## Exercise 5.2 Solutions

- Compare the two countries' supply of cloth relative to food.
  - *The United States produces more cloth relative to food than Canada.*

$$\frac{30}{80} = \frac{Q_C}{Q_F} > \frac{Q_C^*}{Q_F^*} = \frac{15}{140}$$

## Exercise 5.2 Solutions



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## Exercise 5.2 Solutions

- Determine and compare the relative abundance of factors across countries.
  - *The United States is relatively abundant in labor, and Canada is relatively abundant in capital.*

$$\frac{200}{300} = \frac{L}{K} > \frac{L^*}{K^*} = \frac{200}{450}$$

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## Exercise 5.2 Solutions

- Determine and compare the relative intensity of factor use across goods.
  - *Cloth is relatively intensive in labor, and food is relatively intensive in capital.*

$$2 = \frac{4}{2} = \frac{a_{LC}}{a_{KC}} > \frac{a_{LF}}{a_{KF}} = \frac{1}{3}$$

## Exercise 5.2 Solutions

- Determine the pattern of comparative advantage and the pattern of trade.
  - *The United States has comparative advantage in cloth; Canada has comparative advantage in food.*
  - *The United States exports cloth and imports food; Canada exports in food and imports cloth.*

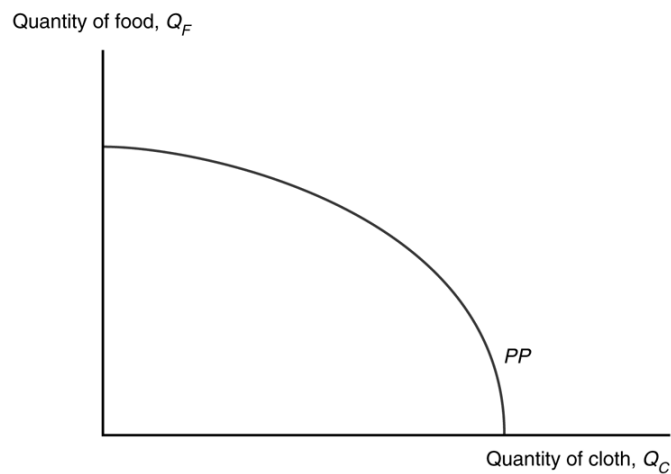
## Production Possibilities

- The above PPF equations do not allow substitution of capital for labor in production.
  - Unit factor requirements are constant along each line segment of the PPF.
- If producers can substitute one input for another in the production process, then the PPF is curved (bowed).
  - Opportunity cost of cloth increases as producers make more cloth.

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## Fig. 5-2: The Production Possibility Frontier with Factor Substitution



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## Production Possibilities

- What does the country produce?
- The economy produces at the point that maximizes the value of production,  $V$ .
- An **isovalue** line is a line representing a constant value of production,  $V$ :

$$V = P_C Q_C + P_F Q_F$$

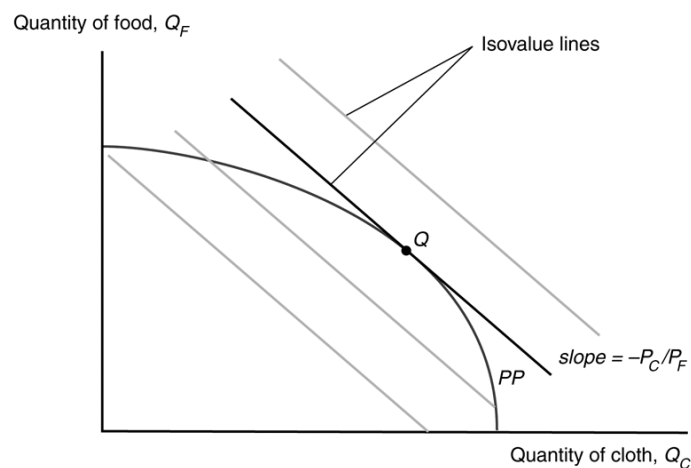
– where  $P_C$  and  $P_F$  are the prices of cloth and food.

– slope of isovalue line is  $-(P_C/P_F)$

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## Fig. 5-3: Prices and Production



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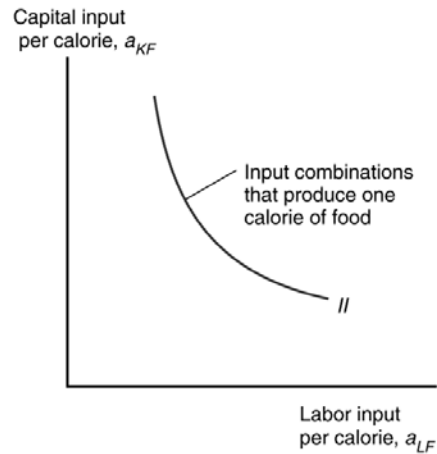
## Production Possibilities

- Given the relative price of cloth, the economy produces at the point  $Q$  that touches the highest possible isovalue line.
- At that point, the relative price of cloth equals the slope of the PPF, which equals *the opportunity cost of producing cloth*.
  - The trade-off in production equals the trade-off according to market prices.

## Choosing the Mix of Inputs

- Producers may choose different amounts of factors of production used to make cloth or food.
- Their choice depends on the wage,  $w$ , paid to labor and the rental rate,  $r$ , paid when renting capital.
- As the wage  $w$  increases relative to the rental rate  $r$ , producers use less labor and more capital in the production of both food and cloth.

## Fig. 5-4: Input Possibilities in Food Production



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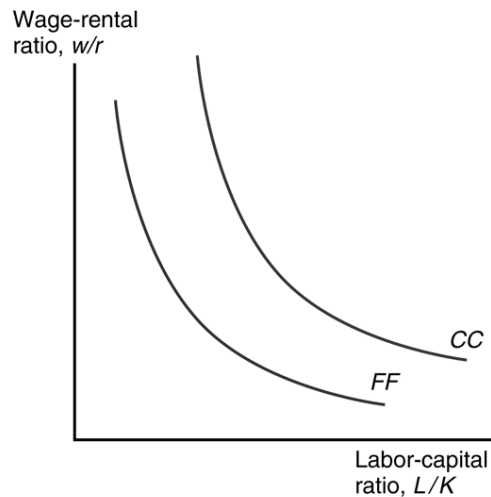
## Choosing the Mix of Inputs

- Assume that at any given factor prices, cloth production uses more labor relative to capital than food production uses:  
 $a_{LC}/a_{KC} > a_{LF}/a_{KF}$  or  $L_C/K_C > L_F/K_F$
- Production of cloth is relatively labor intensive, while production of food is relatively capital intensive.
- Relative factor demand curve for cloth  $CC$  lies outside that for food  $FF$ .

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**Fig. 5-5: Factor Prices and Input Choices**



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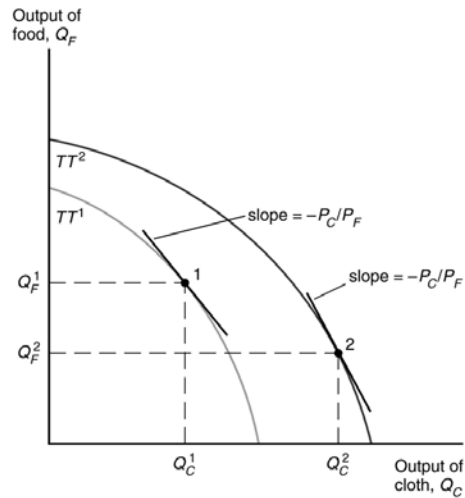
## Resources and Output

- Assume an economy's labor force grows, which implies that its ratio of labor to capital  $L/K$  increases.
- Expansion of production possibilities is biased toward cloth.
- At a given relative price of cloth, the ratio of labor to capital used in both sectors remains constant.
- To employ the additional workers, the economy expands production of the relatively labor-intensive good cloth and contracts production of the relatively capital-intensive good food.

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**Fig. 5-8: Resources and Production Possibilities**



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## Trade in the Heckscher-Ohlin Model

- The countries are assumed to have the same technology and the same tastes.
  - With the same technology, each economy has a comparative advantage in producing the good that relatively intensively uses the factors of production in which the country is relatively well endowed.
  - With the same tastes, the two countries will consume cloth to food in the same ratio when faced with the same relative price of cloth under free trade.

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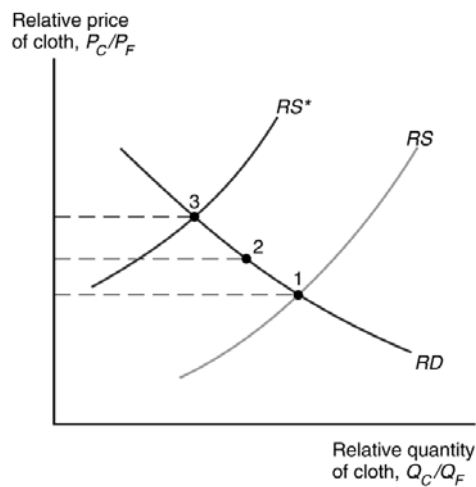
## Trade in the Heckscher-Ohlin Model

- Since cloth is relatively labor intensive, at each relative price of cloth to food, Home will produce a higher ratio of cloth to food than Foreign.
  - Home will have a larger relative supply of cloth to food than Foreign.
  - Home's relative supply curve lies to the right of Foreign's.

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## Fig. 5-9: Trade Leads to a Convergence of Relative Prices



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## Trade in the Heckscher-Ohlin Model

- Like the Ricardian model, the Heckscher-Ohlin model predicts a convergence of relative prices with trade.
- With trade, the relative price of cloth rises in the relatively labor abundant (home) country and falls in the relatively labor scarce (foreign) country.

## Trade in the Heckscher-Ohlin Model

- Relative prices and the pattern of trade: In Home, the rise in the relative price of cloth leads to a rise in the relative production of cloth and a fall in relative consumption of cloth.
  - Home becomes an exporter of cloth and an importer of food.
- The decline in the relative price of cloth in Foreign leads it to become an importer of cloth and an exporter of food.

## Trade in the Heckscher-Ohlin Model

- **Heckscher-Ohlin theorem:** An economy has a comparative advantage in producing, and thus will export, goods that are relatively intensive in using its relatively abundant factors of production,
  - and will import goods that are relatively intensive in using its relatively scarce factors of production.

## Cloth and Food Pricing Equations

- Under competition, the price of a good equals the cost of production.
- Cost of production depends on the wage paid to labor and the rent paid to capital
  - as well as how many units of labor and capital are used.

## Cloth and Food Pricing Equations

- Cloth Pricing

$$a_{LC}w + a_{KC}r = P_C$$

- Food Pricing

$$a_{LF}w + a_{KF}r = P_F$$

## Cloth and Food Pricing Equations

- Slope-intercept forms
  - Cloth

$$r = \frac{P_C}{a_{KC}} - \frac{a_{LC}}{a_{KC}} w$$

- Food

$$r = \frac{P_F}{a_{KF}} - \frac{a_{LF}}{a_{KF}} w$$

- Cloth pricing line steeper than food pricing line because cloth is relatively labor intensive.

## Cloth and Food Pricing Equations

- Factor price frontier
  - The outer envelope of the pricing equations gives possible factor price combinations.
  - Price of a good cannot exceed cost.
- Equilibrium prices of goods
  - The intersection of the two pricing equations gives factor prices if both goods are produced.

## Example 5.3 Goods and Factor Prices

- What is the U.S. pricing equation for cloth if the price of cloth is \$4/yard?

$$a_{LC}w + a_{KC}r = P_C$$

$$2w + 2r = 4$$

$$r = 2 - w$$

### Example 5.3 Goods and Factor Prices

- What is the U.S. pricing equation for food if the price of food is \$4/pound?

$$a_{LF}w + a_{KF}r = P_F$$

$$w + 3r = 4$$

$$r = \frac{4}{3} - \frac{1}{3}w$$

### Example 5.3 Goods and Factor Prices

- What factor prices allow both goods to be priced at cost?

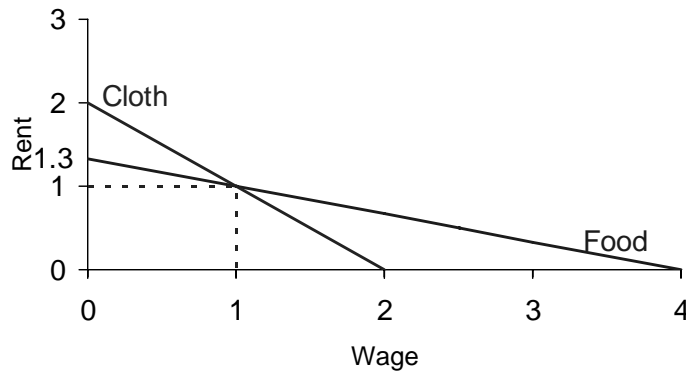
$$2 - w = \frac{4}{3} - \frac{1}{3}w \quad r = 2 - w$$

$$\left(1 - \frac{1}{3}\right)w = 2 - \frac{4}{3} \quad r = 2 - 1$$

$$\frac{2}{3}w = \frac{2}{3}$$

$$w = 1$$

### Example 5.3 Goods and Factor Prices



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### Exercise 5.3 Questions, Prices

- The price of food is always \$10/pound (everywhere). The price of cloth is \$10/yard in the United States under autarky.
- What is the pricing equation for food?
- What is the U.S. pricing equation for cloth in autarky?
- What U.S. factor prices allow both goods to be priced at cost in autarky?

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## Exercise 5.3 Solutions

- What is the pricing equation for food?

$$a_{LF}w + a_{KF}r = P_F$$

$$w + 3r = 10$$

$$r = \frac{10}{3} - \frac{1}{3}w$$

## Exercise 5.3 Solutions

- What is the U.S. pricing equation for cloth in autarky?

$$a_{LC}w^A + a_{KC}r^A = P_C^A$$

$$4w^A + 2r^A = 10$$

$$r^A = 5 - 2w^A$$

## Exercise 5.3 Solutions

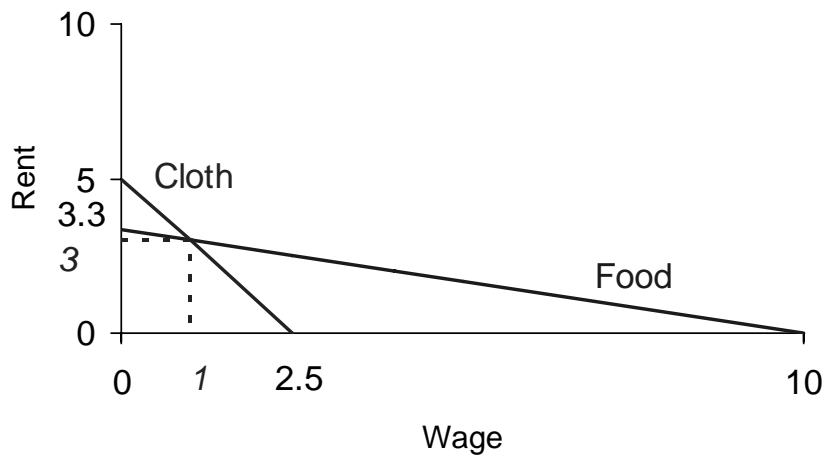
- What U.S. factor prices allow both goods to be priced at cost in autarky?

$$\begin{aligned}
 5 - 2W^A &= \frac{10}{3} - \frac{1}{3}W^A & r^A &= 5 - 2W^A \\
 \left(2 - \frac{1}{3}\right)W^A &= 5 - \frac{10}{3} & r^A &= 5 - 2(1) \\
 \frac{5}{3}W^A &= \frac{5}{3} & r^A &= 5 - 2 \\
 W^A &= 1 & r^A &= 3
 \end{aligned}$$

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## Exercise 5.3 Solutions



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## Increase in Price of Cloth

- Suppose the price of cloth rises.
  - Pricing equation for cloth shifts out parallel – slope unchanged
  - Both endpoints of cloth pricing equation become larger.
- How do the prices of factors (and the distribution of income) respond to changes in the prices of goods?

## Example 5.4 Increase in Price of Cloth

- What is the new U.S. pricing equation for cloth if the price of cloth rises to \$6/yard?

$$2w + 2r = 6$$

$$r = 3 - w$$

### Example 5.4 Increase in Price of Cloth

- What new factor prices let both goods be priced at cost?

$$\begin{aligned}3 - w &= \frac{4}{3} - \frac{1}{3}w & r &= 3 - w \\ \left(1 - \frac{1}{3}\right)w &= 3 - \frac{4}{3} & r &= 3 - 2.5 \\ \frac{2}{3}w &= \frac{5}{3} & r &= 0.5 \\ w &= 2.5\end{aligned}$$

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### Example 5.4 Increase in Price of Cloth

- Compare the new relative factor price (wage to rent) to the old.
  - The new wage relative to rent is higher.

$$1 = \frac{1}{1} = \frac{w}{r} < \frac{w'}{r'} = \frac{5/2}{1/2} = 5$$

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## Example 5.4 Increase in Price of Cloth

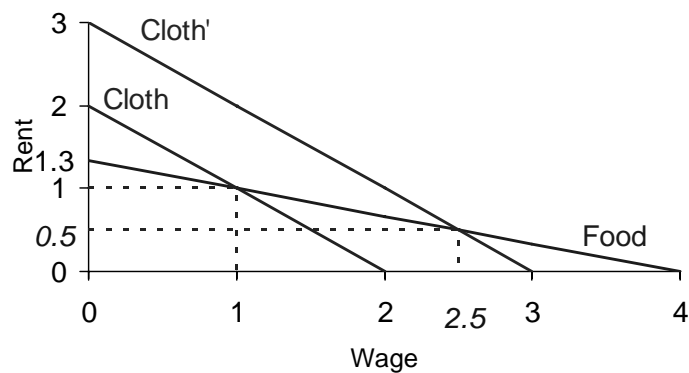
- Calculate and compare the proportional changes in the wage, rent, price of cloth, and price of food.  
*Wage rose by more than the price of either good and the rent fell.*

$$\hat{w} = 150\% > \hat{P}_C = 50\% > \hat{P}_F = 0 > \hat{r} = -50\%$$

$$\hat{P}_C \equiv \frac{\Delta P_C}{P_C} = \frac{6-4}{4} = 50\%$$

$$\hat{w} \equiv \frac{\Delta w}{w} = \frac{2.5-1}{1} = 150\%, \hat{r} \equiv \frac{\Delta r}{r} = \frac{0.5-1}{1} = -50\%$$

## Example 5.4 Increase in Price of Cloth



## Exercise 5.4 Questions

- The price of cloth is \$20/yard under free trade (everywhere). What is the pricing equation for cloth under free trade?
- Determine the factor prices under free trade.
- Compare U.S. relative factor prices (wage relative to rent) under free trade to autarky.

## Exercise 5.4 Questions

- Calculate and compare the proportional changes in the wage, rent, price of cloth, and price of food.
- In the United States, owners of which factor would oppose a free trade agreement?
- How can this group be identified, even in autarky?

## Exercise 5.4 Solutions

- The price of cloth is \$20/yard under free trade (everywhere). What is the pricing equation for cloth under free trade?

$$4w + 2r = 20$$

$$r = 10 - 2w$$

## Exercise 5.4 Solutions

- Determine the factor prices under free trade.

$$10 - 2w = \frac{10}{3} - \frac{1}{3}w \quad r = 10 - 2w$$

$$\left(2 - \frac{1}{3}\right)w = 10 - \frac{10}{3} \quad r = 10 - 2(4)$$

$$r = 10 - 8$$

$$\frac{5}{2}w = \frac{20}{3}$$

$$r = 2$$

$$w = 4$$

## Exercise 5.4 Solutions

- Compare U.S. relative factor prices (wage relative to rent) under free trade to autarky.
  - *In the United States, the wage to rent ratio rises in the move from autarky to free trade.*

$$\frac{1}{3} = \frac{w^A}{r^A} < \frac{w}{r} = \frac{4}{2} = 2$$

## Exercise 5.4 Solutions

- Calculate and compare the proportional changes in the wage, rent, price of cloth, and price of food.  
*Wage rose by more than the price of either good and the rent fell.*

$$\hat{w} = 300\% > \hat{P}_C = 100\% > \hat{P}_F = 0 > \hat{r} = -33.3\%$$

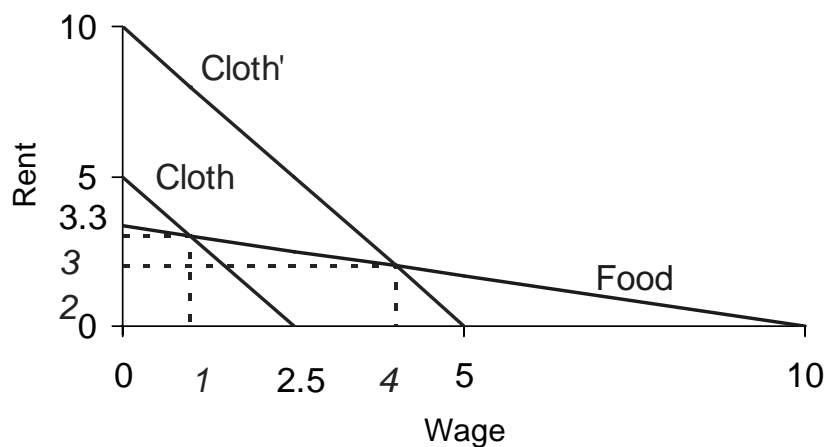
$$\hat{P}_C \equiv \frac{\Delta P_C}{P_C} = \frac{20-10}{10} = 100\%$$

$$\hat{w} \equiv \frac{\Delta w}{w} = \frac{4-1}{1} = 300\%, \hat{r} \equiv \frac{\Delta r}{r} = \frac{-1}{3} = -33.3\%$$

## Exercise 5.4 Solutions

- In the United States, owners of which factor would oppose a free trade agreement? *Capital owners, because their purchasing power was reduced (rent fell relative to price of both goods)*
- How can this group be identified, even in autarky? *Relatively scarce factor*

## Exercise 5.4 Solutions



## Factor Prices and Goods Prices

- In competitive markets, the price of a good should equal its cost of production, which depends on the factor prices.
- How changes in the wage and rent affect the cost of producing a good depends on the mix of factors used.
  - An increase in the rental rate of capital should affect the price of food more than the price of cloth since food is the capital intensive industry.
- Changes in  $w/r$  are tied to changes in  $P_C/P_W$ .

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**Fig. 5-6: Factor Prices and Goods Prices**



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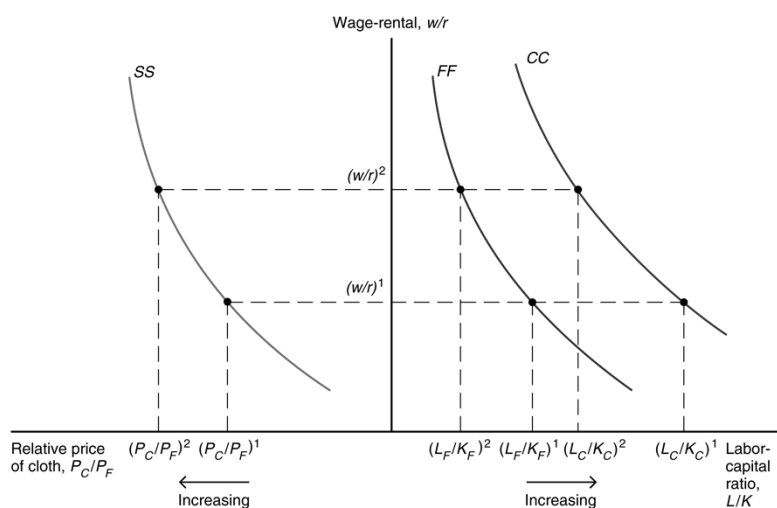
## Factor Prices and Goods Prices

- **Stolper-Samuelson theorem:** If the relative price of a good increases, then the real wage or rental rate of the factor used intensively in the production of that good increases, while the real wage or rental rate of the other factor decreases.
- Any change in the relative price of goods alters the distribution of income.

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**Fig. 5-7: From Goods Prices to Input Choices**



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## Factor Prices and Goods Prices

- An increase in the relative price of cloth,  $P_C/P_F$ , is predicted to
  - raise income of workers relative to that of capital owners,  $w/r$ .
  - raise the ratio of capital to labor services,  $K/L$ , used in both industries.
  - raise the real income (purchasing power) of workers and *lower the real income of capital owners*.

## Factor Price Equalization

- Unlike the Ricardian model, the Heckscher-Ohlin model predicts that factor prices will be equalized among countries that trade.
- Free trade equalizes relative output prices.
- Due to the connection between output prices and factor prices, factor prices are also equalized.
- Trade increases the demand of goods produced by relatively abundant factors, indirectly increasing the demand of these factors, raising the prices of the relatively abundant factors.

## Factor Price Equalization

- In the real world, factor prices are not equal across countries.
- The model assumes that trading countries produce the same goods, but countries may produce different goods if their factor ratios radically differ.
- The model also assumes that trading countries have the same technology, but different technologies could affect the productivities of factors and therefore the wages/rates paid to these factors.

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### Table 5-1: Comparative International Wage Rates (United States = 100)

TABLE 5-1 Comparative International Wage Rates (United States = 100)	
Country	Hourly Compensation of Production Workers, 2005
United States	100
Germany	140
Japan	92
Spain	75
South Korea	57
Portugal	31
Mexico	11
China*	3

\*2004

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

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## Factor Price Equalization

- The model also ignores trade barriers and transportation costs, which may prevent output prices and thus factor prices from equalizing.
- The model predicts outcomes for the long run, but after an economy liberalizes trade, factors of production may not quickly move to the industries that intensively use abundant factors.
  - In the short run, the productivity of factors will be determined by their use in their current industry, so that their wage/rental rate may vary across countries.

## Does Trade Increase 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?

## Does Trade Increase Income Inequality?

- 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.

## Does Trade Increase Income Inequality?

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.
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 prices should be small.

## Trade and Income Distribution

- Changes in income distribution occur with every economic change, not only international trade.
  - Changes in technology, changes in consumer preferences, exhaustion of resources and discovery of new ones all affect income distribution.
  - Economists put most of the blame on technological change and the resulting premium paid on education as the major cause of increasing income inequality in the US.
- It would be better to compensate the losers from trade (or any economic change) than prohibit trade.
  - The economy as a whole does benefit from trade.

## Trade and Income Distribution

- There is a political bias in trade politics: potential losers from trade are better politically organized than the winners from trade.
  - Losses are usually concentrated among a few, but gains are usually dispersed among many.
  - Each of you pays about \$8/year to restrict imports of sugar, and the total cost of this policy is about \$2 billion/year.
  - The benefits of this program total about \$1 billion, but this amount goes to relatively few sugar producers.

## Empirical Evidence on the Heckscher-Ohlin Model

- Tests on US data
  - Leontief found that U.S. exports were less capital-intensive than U.S. imports, even though the U.S. is the most capital-abundant country in the world: **Leontief paradox**.
- Tests on global data
  - Bowen, Leamer, and Sveikauskas tested the Heckscher-Ohlin model on data from 27 countries and confirmed the Leontief paradox on an international level.

## Table 5-2: Factor Content of U.S. Exports and Imports for 1962

TABLE 5-2 Factor Content of U.S. Exports and Imports for 1962		
	Imports	Exports
Capital per million dollars	\$2,132,000	\$1,876,000
Labor (person-years) per million dollars	119	131
Capital-labor ratio (dollars per worker)	\$17,916	\$14,321
Average years of education per worker	9.9	10.1
Proportion of engineers and scientists in work force	0.0189	0.0255

**Source:** Robert Baldwin, "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review* 61 (March 1971), pp. 126–145.

## Table 5-3: Testing the Heckscher-Ohlin Model

Factor of Production	Predictive Success*
Capital	0.52
Labor	0.67
Professional workers	0.78
Managerial workers	0.22
Clerical workers	0.59
Sales workers	0.67
Service workers	0.67
Agricultural workers	0.63
Production workers	0.70
Arable land	0.70
Pasture land	0.52
Forest	0.70

\*Fraction of countries for which net exports of factor runs in predicted direction.

**Source:** Harry P. Bowen, Edward E. Leamer, and Leo Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review* 77 (December 1987), pp. 791–809.

## Empirical Evidence of the Heckscher-Ohlin Model

- Because the Heckscher-Ohlin model predicts that factor prices will be equalized across trading countries, it also predicts that factors of production will produce and export a certain quantity goods until factor prices are equalized.
  - In other words, a predicted value of services from factors of production will be *embodied* in a predicted volume of trade between countries.

## Empirical Evidence of the Heckscher-Ohlin Model

- But because factor prices are not equalized across countries, the predicted volume of trade is much larger than actually occurs.
  - A result of “missing trade” discovered by Daniel Trefler.
- The reason for this “missing trade” appears to be the assumption of identical technology among countries.
  - Technology affects the productivity of workers and therefore the value of labor services.
  - A country with high technology and a high value of labor services would not necessarily import a lot from a country with low technology and a low value of labor services.

## Empirical Evidence of the Heckscher-Ohlin Model

- Donald Davis and David Weinstein (*An Account of Global Factor Trade*, *American Economic Review* 2001) estimate the factor account of trade, allowing for technology differences across countries, and find strong support for the factor content predictions of the Heckscher-Ohlin model.
  - Through trade in goods, countries export the right (relatively abundant) factors, in right magnitude.

## Table 5-4: Estimated Technological Efficiency, 1983 (United States = 1)

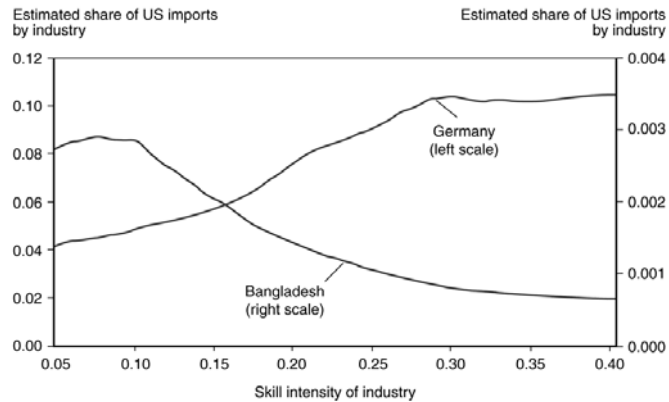
TABLE 5-4 Estimated Technological Efficiency, 1983 (United States = 1)	
Country	
Bangladesh	0.03
Thailand	0.17
Hong Kong	0.40
Japan	0.70
West Germany	0.78

**Source:** Daniel Treffer, "The Care of the Missing Trade and Other Mysteries," *American Economic Review* 85 (December 1995), pp. 1029–1046.

## Empirical Evidence of the Heckscher-Ohlin Model

- Looking at changes in patterns of exports between developed (high income) and developing (low/middle income) countries supports the theory.
- US imports from Bangladesh are highest in low-skill-intensity industries, while US imports from Germany are highest in high-skill-intensity industries.

**Fig. 5-12: Skill Intensity and the Pattern of U.S. Imports from Two Countries**



Source: John Romalis, "Factor Proportions and the Structure of Commodity Trade," *American Economic Review* 94 (March 2004), pp. 67–97.

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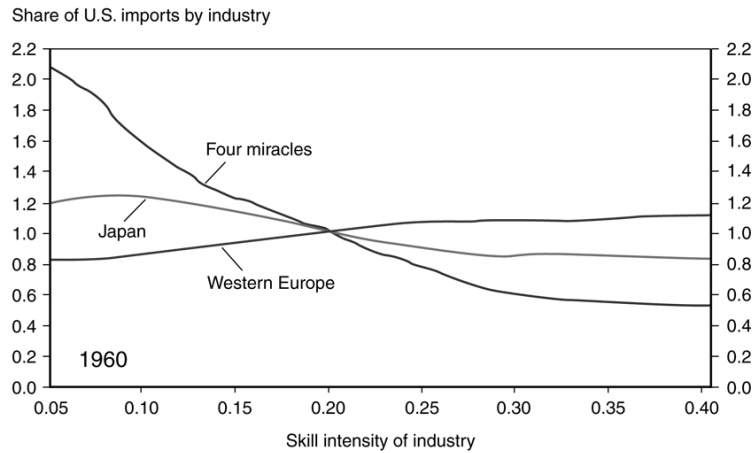
## Empirical Evidence of the Heckscher-Ohlin Model

- As Japan and the four Asian "miracle" countries became more skill-abundant, U.S. imports from these countries shifted from less skill-intensive industries toward more skill-intensive industries.

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**Fig. 5-13: Changing Patterns of Comparative Advantage**

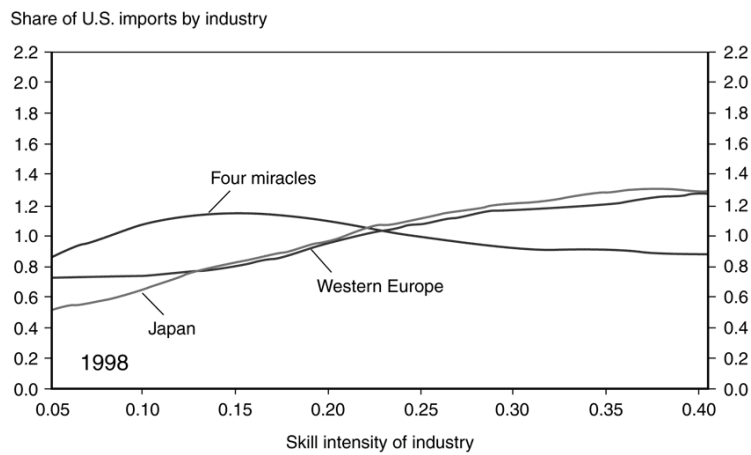


(a) 1960

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**Fig. 5-13: Changing Patterns of Comparative Advantage**



(a) 1998

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## Summary

1. Substitution of factors used in the production process generates a curved PPF.
  - When an economy produces a low quantity of a good, the opportunity cost of producing that good is low.
  - When an economy produces a high quantity of a good, the opportunity cost of producing that good is high.
2. When an economy produces the most value it can from its resources, the opportunity cost of producing a good equals the relative price of that good in markets.

## Summary

3. An increase in the relative price of a good causes the real wage or real rental rate of the factor used intensively in the production of that good to increase,
  - while the real wage and real rental rates of other factors of production decrease.
4. If output prices remain constant as the amount of a factor of production increases, then the supply of the good that uses this factor intensively increases, and the supply of the other good decreases.

## Summary

5. An economy exports goods that are relatively intensive in its relatively abundant factors of production and imports goods that are relatively intensive in its relatively scarce factors of production.
6. Owners of abundant factors gain, while owners of scarce factors lose with trade.
7. A country as a whole is predicted to be better off with trade, so winners could in theory compensate the losers within each country.

## Summary

8. The Heckscher-Ohlin model predicts that relative output prices and factor prices will equalize, neither of which occurs in the real world.
9. Empirical support of the Heckscher-Ohlin model is weak except for cases involving trade between high-income countries and low/middle-income countries or when technology differences are included.