International Trade

4. Trade and Resources: The Heckscher-Ohlin Model

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1. Introduction

- The Heckscher-Ohlin model (HO) shows how trade occurs because countries have different relative factor (resource) endowments.
- Technologies are the same across countries.
- After Swedish economists Eli Filip Heckscher and Bertil Gotthard Ohlin (1977 Nobel prize winner)
  - Sometimes also called H-O-Samuelson model because of contributions of Paul Samuelson.
- The model was developed after WWI, at the end of the "golden age" of international trade which saw dramatic improvements in transportation.
  - HO wanted to explain this increase in trade.

1. Introduction

- HO model has two factors, two goods, two countries.
- Specific-factors model in last chapter was short-run model; mobile labor, immobile capital and land.
- The HO model is a long-run model because all factors of production can move between the industries.
- To obtain better predictions from the HO model, extensions allow for more than two goods and factors, and countries with differing technologies.

2. HO model assumptions

- Two countries, Home and Foreign.
- Each country produces two goods, computers and shoes.
- Production uses two factors of production, labor (L) and capital (K).
- We can add up the resources used in each industry to get the total for the economy.
  - Capital in each good for each country
    - $K = K_C + K_S$ and $K^* = K^*_C + K^*_S$
  - Labor in each good for each country
    - $L = L_C + L_S$ and $L^* = L^*_C + L^*_S$

2. HO model assumptions

1. Both factors can move freely between industries.
   - Capital must earn the same rental rate R in both industries.
   - All labor earns the same wage in both industries.
2. Shoe production is labor-intensive; it requires more labor per unit of capital to produce shoes than computers, so that $L_S/K_S > L_C/K_C$.
   - Computer production is capital-intensive—more capital per worker is used to produce computers than to produce shoes.

- Figure 4.1 shows relative demand curves for labor in each industry.

2. HO model assumptions

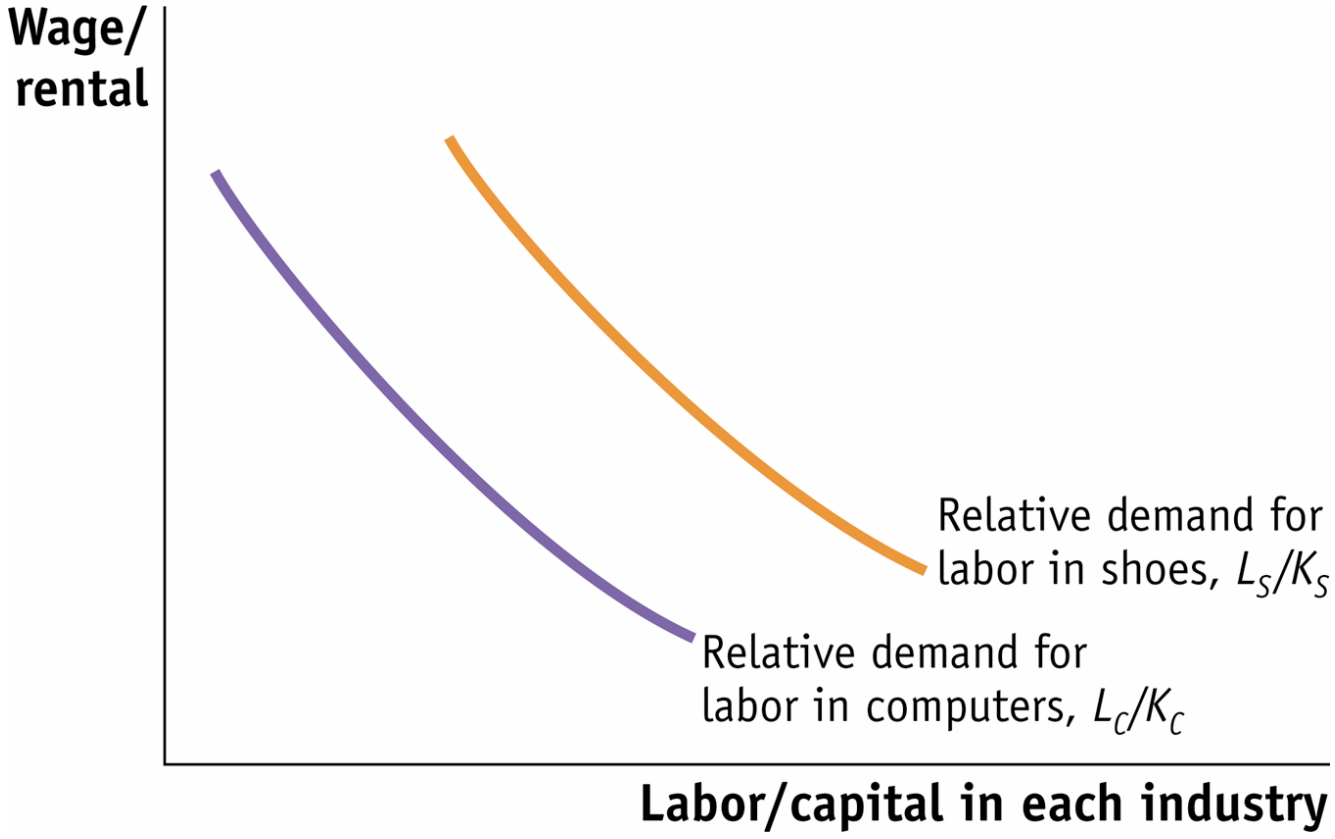

Figure 4.1 Labor intensity of each industry

2. HO model assumptions

3. Foreign is labor abundant; the labor-capital ratio in Foreign exceeds that in Home. Home is capital abundant
   - $L^*/K^* > L/K$ and $K/L > K^*/L^*$
   - We do not consider why the amount of resources differs across countries.
4. The final outputs, shoes and computers, can be traded freely, without restrictions, between countries, but labor and capital do not move between countries.

2. HO model assumptions

5. The technologies used to produce the two goods are identical across the countries.
   - Unlike Ricardian model.
6. Consumer tastes are same across countries, and preferences for computers and shoes do not vary with a country's level of income.
   - A poorer country will buy less of both shoes and computers, but in the same ratio as a wealthier country facing the same prices.

- Simplifying assumptions which allow focus on single reason for trade – differing relative factor endowments!

2.1 HO model assumptions - empirics

- One assumption is that factor intensities in each industry are the same in both countries.
  - E.g. shoes are labor intensive in both countries.
- This assumption is not obvious when comparing other industries such as shoes and call centers.
- All countries may have access to same technologies, but machines used in U.S. are different from those used in Asia and elsewhere.
- While the U.S. still produces some shoes, the production is different (highly technological) from the production in Asia.

2.1 HO model assumptions - empirics

- Asian production uses old technology and workers earn relatively little compared to the U.S. – more workers to operate less productive machines.
- In call centers, technologies and therefore factor intensities are similar across countries.
- So, shoes in India are labor intensive compared to the call center—the opposite of the U.S.
- This illustrates **Reversal of Factor Intensities** between the two countries.

2.1 HO model assumptions - empirics

- Similar reversal of factor intensities when comparing agricultural sectors across countries.
- In the U.S. agriculture is capital intensive, but in India it is labor intensive.
  - Capital is relatively cheaper in the U.S.
  - Labor is relatively cheaper in India.
- However, assumption is that the labor-capital ratio (*L/K*) exceeds that of the other country in an industry *regardless of the wage rental ratio (W/R).*
- In the HO model, we will ignore the possibility of "factor intensity reversals."

3. HO no-trade equilibrium

Production Possibility Frontiers (figure 4.2)

- Home is capital-abundant and computer production is capital-intensive.
- Home is capable of producing relatively more computers than shoes.
- Foreign is labor-abundant and shoe production is labor-intensive.
- Foreign is capable of producing relatively more shoes.

3. HO no-trade equilibrium

Indifference Curves

- Same consumer tastes across countries, so shape of the indifference curves is same in each country.
- When the indifference curves are tangent to the PPF, the slopes are equal.
  - The relative price that consumers are willing to pay for computers equals the opportunity cost of producing them—the no-trade equilibrium.
- The slope at tangency equals the relative price of computers—the steeper the slope, the higher the relative price of computers.

3. HO no-trade equilibrium

No Trade Equilibrium Price

- Different relative prices in each country because of different shapes of the PPFs.
- Slope of the Home price line $(P_C/P_S)^A$ is quite flat.
  - Low relative price of computers, high relative price of shoes.
- Foreign slope of price line $(P^*_C/P^*_S)^{A^*}$ is quite steep.
  - High relative price of computers, low relative price of shoes.
- No-trade prices reflect differing amounts of resources found in two countries.

3. HO no-trade equilibrium

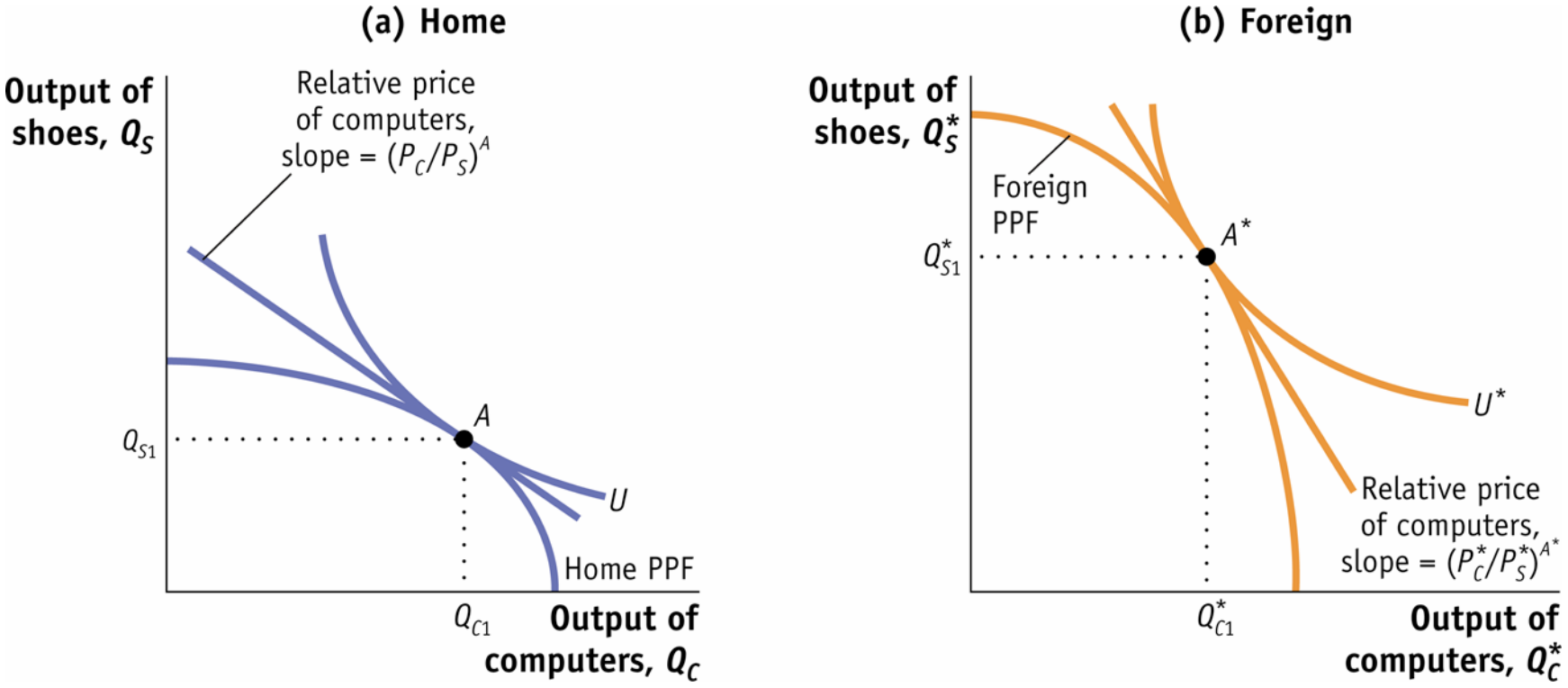

Figure 4.2 No-trade equilibria in Home and Foreign

3. HO free-trade equilibrium

- Assume that world relative price of computers is above no-trade relative price of computers at Home and below no-trade relative price of computers in Foreign.
- Home Equilibrium with Free Trade (figure 4.3a)
  - Equilibrium relative price of computers under free trade lies in between the no-trade relative prices in each country.
  - Home PPF will have free-trade (world) relative price of computers above no-trade Home relative price.
  - Home production moves based on the new relative price of computers—Point A to Point B.
  - Home produces more computers and fewer shoes.

3. HO free-trade equilibrium

Home Equilibrium with Free Trade (cont'd)

- Home can consume on any point along the world price line through point B.
- Highest utility at point C, where indifference curve is tangent to the world price line.
- Home produces at B and consumes at C.
- Home "trade triangle" connects points B and C.
  - The base of the triangle is the Home exports of computers (Q_{C2} - Q_{C3}).
  - The height of the triangle is the Home imports of shoes (Q_{S3} - Q_{S2}).

3. HO free-trade equilibrium

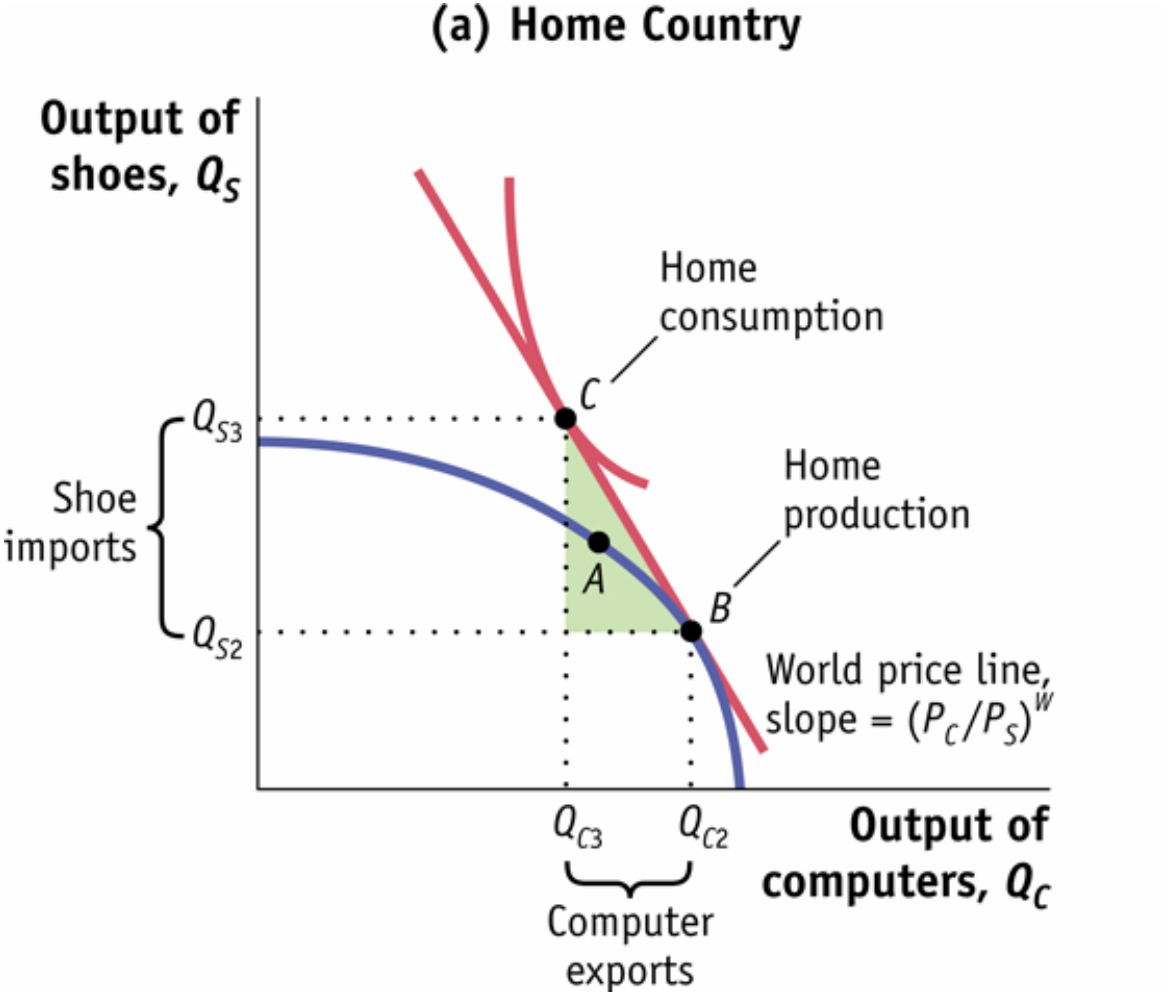

Figure 4.3 (a) International free-trade equilibrium in Home

3. HO free-trade equilibrium

- We can use the Home trade information to graph the exports of computers against the relative price.
  - At the no-trade price of $(P_C/P_S)^A$, exports are 0.
    - Point A (figure 4.3b)
  - At the world price of $(P_C/P_S)^W$, exports are $Q_{C2} - Q_{C3.}$
    - Point D
  - Home export supply curve is upward-sloping since at higher relative prices, Home is willing to specialize further in computers and export more of them.

3. HO free-trade equilibrium

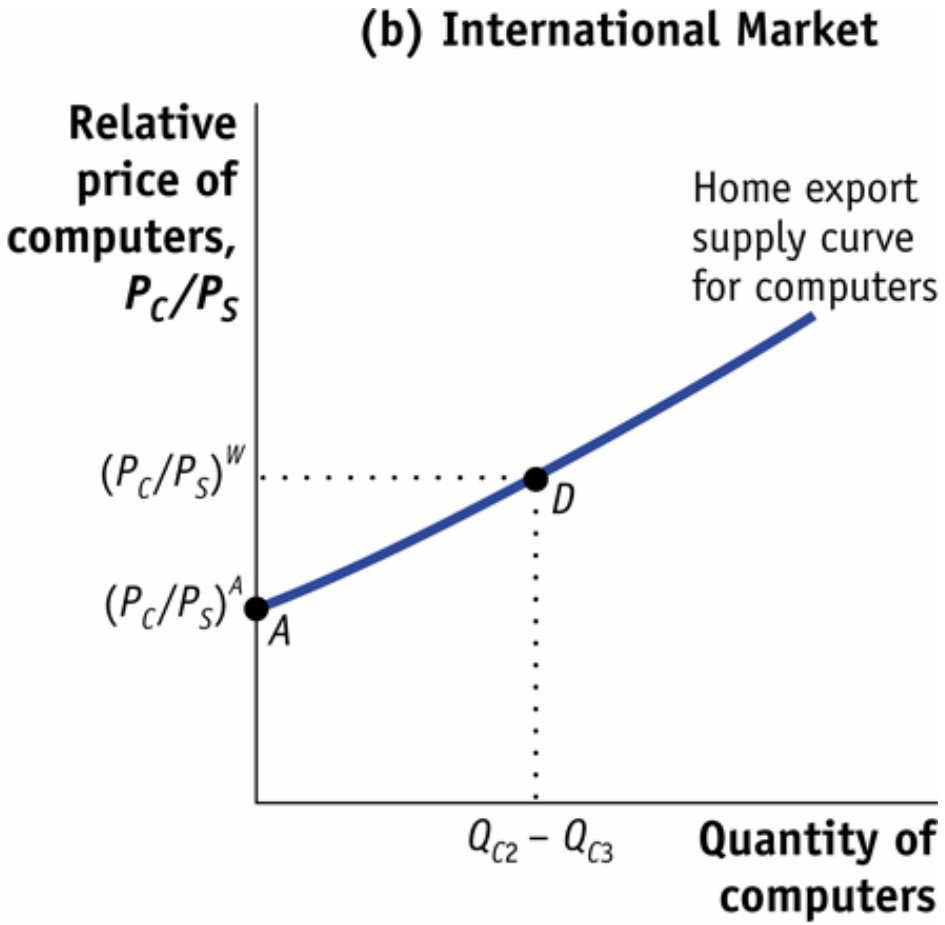

Figure 4.3 (b) International free-trade Home export supply curve

3. HO free-trade equilibrium

Foreign Equilibrium with Free Trade (figure 4.4)

- Foreign PPF will show a free trade or world relative price of computers that is lower than the no-trade Foreign relative price.
- Foreign production moves from point A* to B* with more shoes and fewer computers.
- Foreign can consume on any point along the world price line through point B*.
- The highest utility is obtained at point C*, where the indifference curve is tangent to the world price line.

3. HO free-trade equilibrium

Foreign Equilibrium with Free Trade (cont'd)

- Foreign "trade triangle" connects points B* and C*.
- Foreign produces at B* and consumes at C*.
- Base of triangle gives Foreign imports of computers.
- Height of triangle gives Foreign exports of shoes.

3. HO free-trade equilibrium

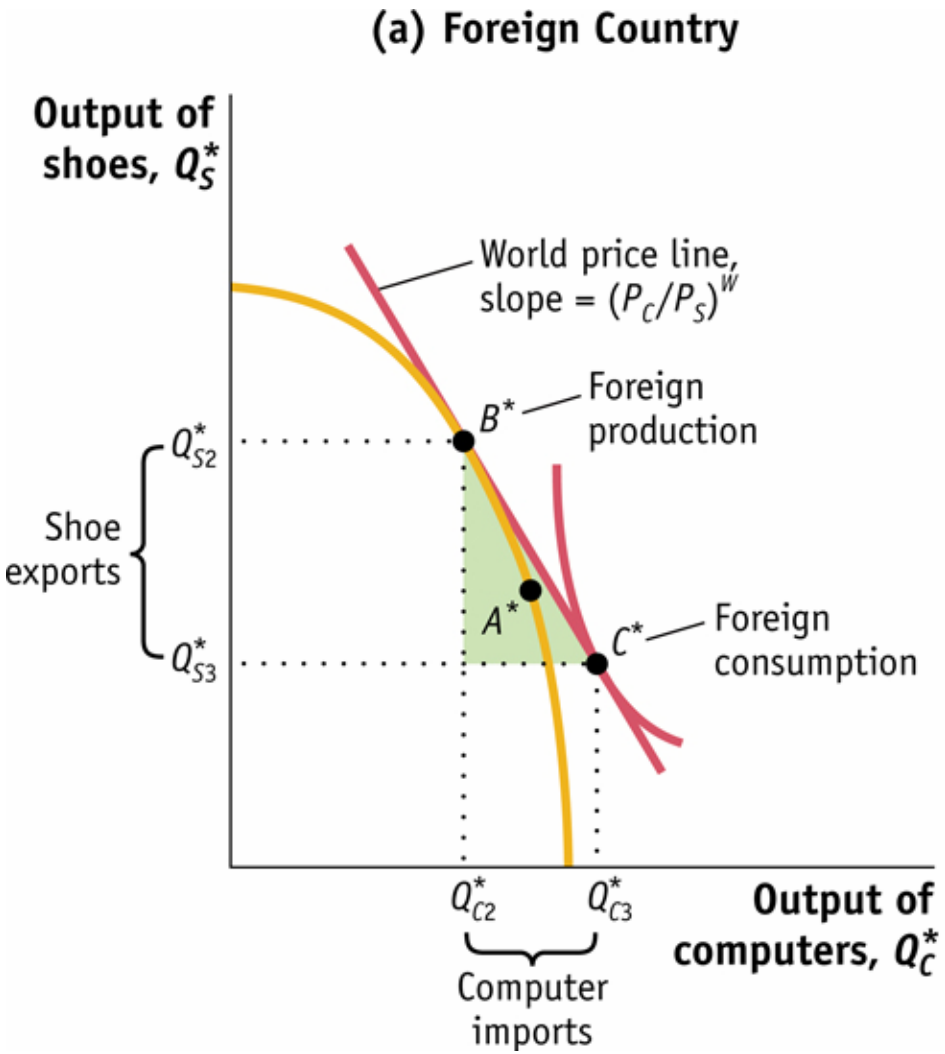

Figure 4.4 (a) International free-trade equilibrium in Foreign

3. HO free-trade equilibrium

Foreign import demand curve for computers (figure 4.4b).

- At the free trade price of $(P^*_C/P^*_S)^A$, exports are 0.
  - Point A*
- At the world price of $(P^*_C/P^*_S)^W$, imports are $Q_{C^*2} - Q_{C^*3.}$
  - Point D*
- Import demand curve is downward-sloping since at higher relative prices, Foreign is willing to specialize further in shoes and import more computers.

3. HO free-trade equilibrium

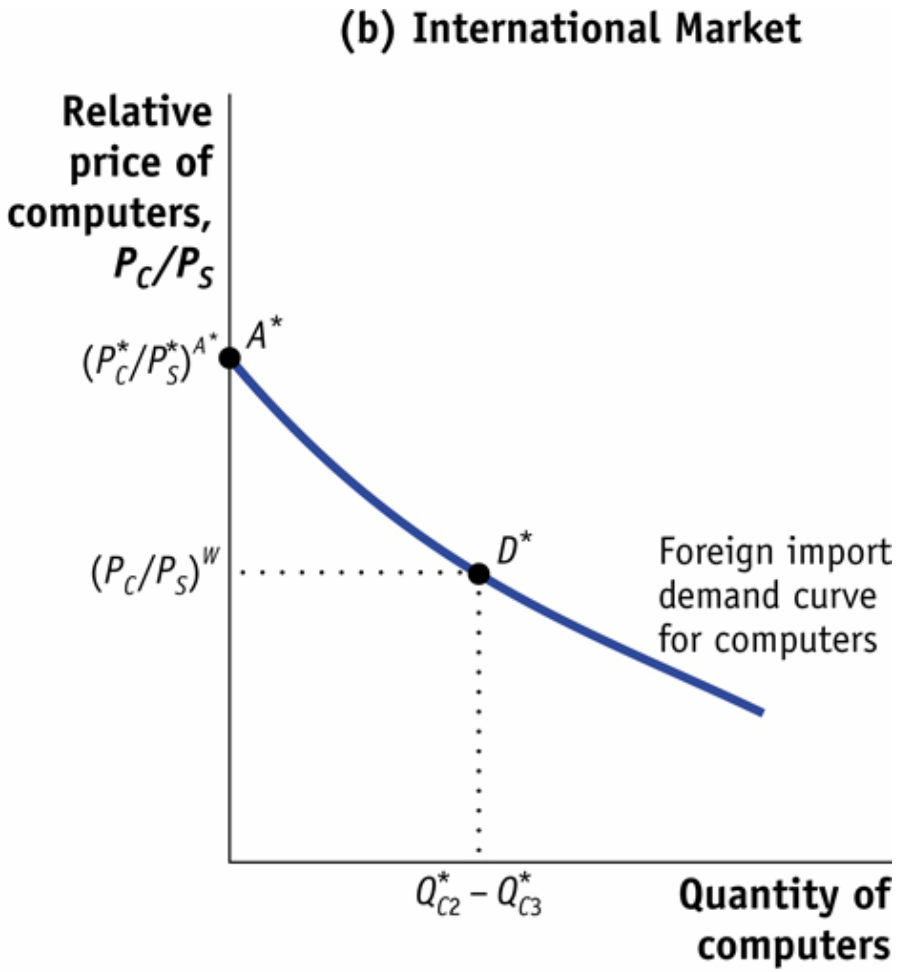

Figure 4.4 (b) International free-trade import demand curve for Foreign

3. HO free-trade equilibrium

Equilibrium Price with Free Trade (figure 4.5)

- Intersection of Home export supply and Foreign import demand curves gives equilibrium free trade price (point D).
- At world relative price, the quantity that Home wants to export equals the amount that Foreign wants to import.
- **Free-trade equilibrium** since there is no reason for the relative price to change.
- Trade triangles of two countries are identical in size.

3. HO free-trade equilibrium

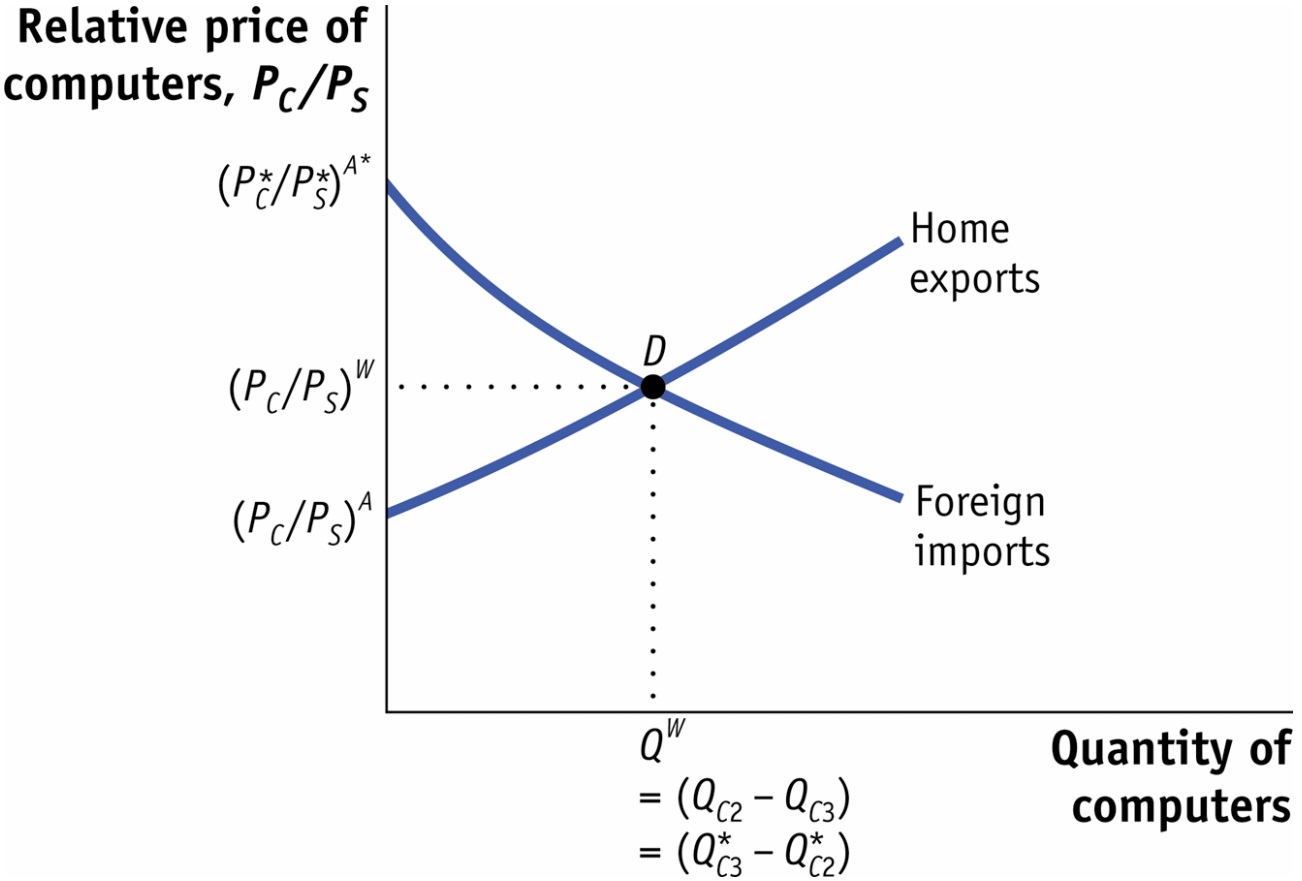

Figure 4.5 Determination of free-trade world equilibrium price

4. HO pattern of trade

Pattern of Trade

- Capital-abundant Home exports computers—the good that uses their abundant factor of production intensively.
- Labor-abundant Foreign exports shoes—the good that uses their abundant factor of production intensively.

Heckscher-Ohlin Theorem:

With two goods and two factors, each country will export the good that uses intensively the factor of production it has in abundance, and will import the other good.

4.1 HO – empirics: Leontief Paradox

Testing the HO Theorem: the ***Leontief Paradox***

- Wassily Leontief performed the first test of the HO theorem in 1953 using data for the U.S. from 1947.
- He measured the amounts of labor and capital used in all industries needed to produce $1 million of U.S. imports and to produce $1 million of imports into the U.S.
- This data is in Table 4.1 which also shows the capital/labor ratio in dollars per person.

4.1 HO – empirics: Leontief Paradox

	Exports	Imports
Capital ($ millions)	$2.55	$3.1
Labor (person-years)	182	170
Capital/labor ($/person)	$14,000	$18,200

Table 4.1 Leontief‘s Test

4.1 HO – empirics: Leontief Paradox

- Leontief used labor and capital used directly in the production of final good exports in each industry.
- He also measured the labor and capital used indirectly in the industries that produced the intermediate inputs used in making exports.
- The capital is high because we are measuring the whole capital stock—not the part actually used to produce exports.
- The capital/labor ratio was $14,000: each person employed was working with $14,000 worth of capital.

4.1 HO – empirics: Leontief Paradox

- It was impossible for Leontief to get information on the amount of labor and capital used to produce imports.
- He used data on U.S. technology to calculate estimated amounts of labor and capital used in imports from abroad.
  - Remember HO model assumes equal technologies across countries.
- This gave a capital/labor ratio of $18,200 per worker.
  - This exceeds the ratio for exports.

4.1 HO – empirics: Leontief Paradox

- Leontief assumed correctly that in 1947 the U.S. was capital abundant relative to the rest of the world.
  - From the HO model, Leontief expected that the U.S. would export capital intensive goods and import labor intensive goods.
- Leontief, however, found the opposite.
  - The capital labor ratio for U.S. imports was higher than for exports.
- This contradiction came to be called **Leontief's paradox**.

4.1 HO – empirics: Leontief Paradox

Possible reasons for Leontief Paradox:

- U.S. and foreign technologies are not the same.
- By focusing only on labor and capital, land abundance in the U.S. was ignored.
- No distinction between skilled and unskilled labor.
- The data for 1947 could be unusual due to the recent end of WWII.
- The U.S. was not engaged in completely free trade as is assumed by the HO model.

4.1 HO – empirics: Leontief Paradox

- Several explanations depend on having more than two factors of production.
  - The U.S. is land abundant, and much of what it was exporting might have been agricultural products which use land intensively.
  - It might also be true that many of the exports used skilled labor intensively.
- More current research aimed at redoing the Leontief test.
  - "Extended" HO model works much better for same year of data.

5. HO – effects of trade on factor prices

- How do the changes in pre-trade and post-trade relative prices affect the wage paid to labor in each country and the rental earned by capital?
  - Relative price of computers in Home increases, causing Home to export computers.
  - Relative price of computers in Foreign decreases, causing Foreign to import computers.

5. HO – effects of trade on factor prices

Effect of Trade on the Wage and Rental of Home

- Use relative demand for labor in each industry to derive an economy-wide relative demand for labor.
- Compare it to the economy-wide relative supply of labor, L/K.
- This determines Home's relative wage and what happens after the relative price of computers changes.

5. HO – effects of trade on factor prices

Economy-Wide Relative Demand for Labor (figure 4.6)

- The quantities of labor and capital used in each industry add up to the total available labor and capital.
  - $\overline{K} = K_C + K_S$ and $\overline{L} = L_C + L_S$
  - We can divide total labor by total capital to get the relative supply equal to the relative demand.

$$\underbrace{\frac{\overline{L}}{\overline{K}}}_{\text{Relative Supply}} = \frac{L_C + L_S}{\overline{K}} = \underbrace{\frac{L_C}{K_C}\left(\frac{K_C}{\overline{K}}\right) + \frac{L_S}{K_S}\left(\frac{K_S}{\overline{K}}\right)}_{\text{Relative Demand}}$$

5. HO – effects of trade on factor prices

- The relative demand is a weighted average of the labor-capital ratio for each industry (lies between two curves).
  - Weighted average obtained by multiplying labor-capital ratio for each industry by K_C/K and K_S/K.
- Equilibrium relative wage is determined by intersection of relative supply (L/K) and relative demand curves (point A).
  - Remember: amounts of labor and capital do not depend on relative wage.
  - Intersection of labor curves gives the wage relative to the rental: W/R.

5. HO – effects of trade on factor prices

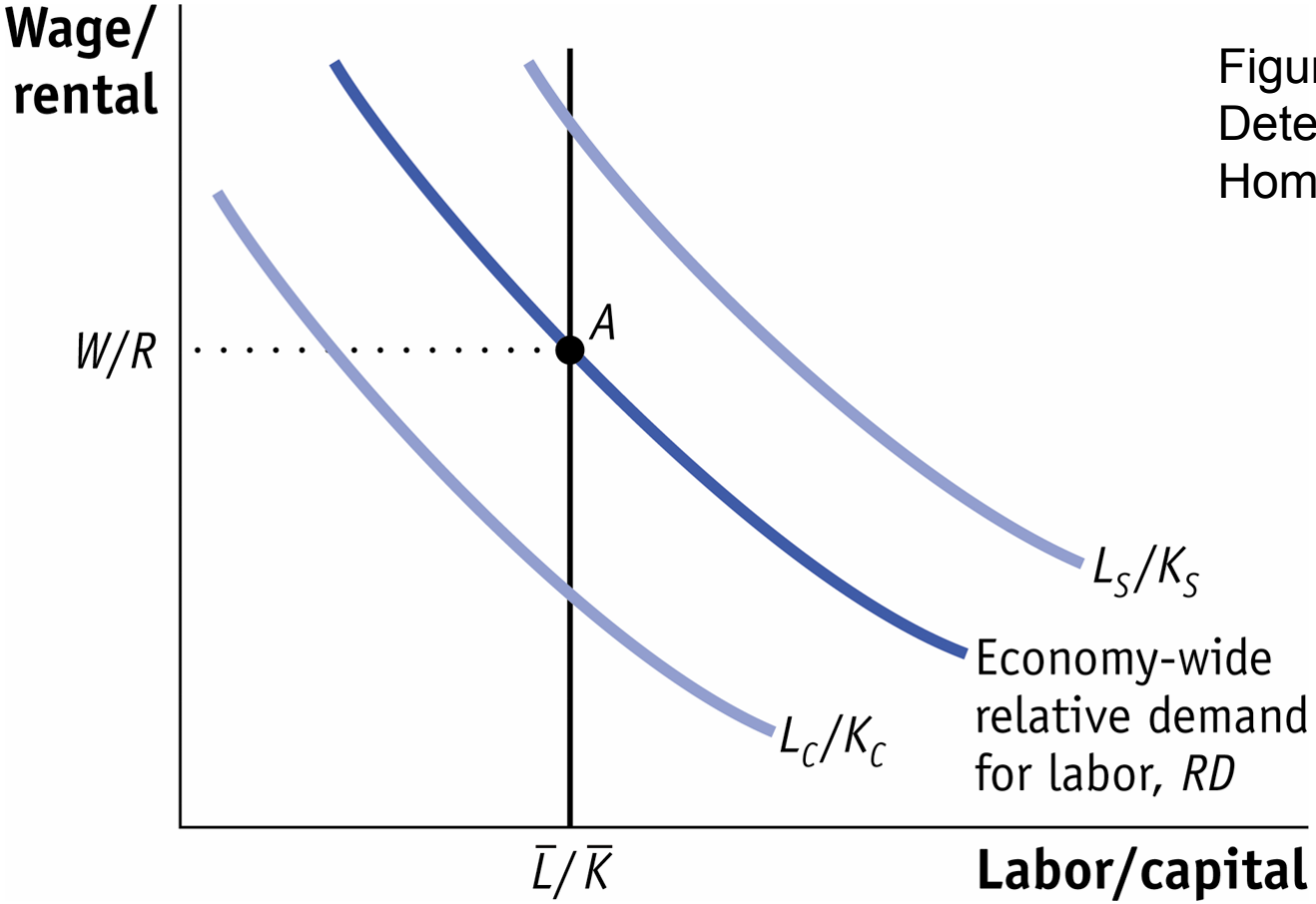

Figure 4.6
Determination of
Home Wage/Rental

5. HO – effects of trade on factor prices

Increases in the relative price of computers

- P_C/P_S increases at Home.
- Production shifts away from shoes to computers.
- Labor and capital *both* move from shoe to computer production.
- Relative labor supply does not change.
- Since capital has shifted to computer industry, relative demand for labor changes.
  - Terms used in weighted average, K_C/K and K_S/K, change.

5. HO – effects of trade on factor prices

Increases in the relative price of computers (cont'd)

- Relative demand for labor is now more weighted toward computers.
- Relative demand curve shifts left from RD_1 to RD_2.
  - Shifts in the direction of computers.
  - Equilibrium moves from point A to B in figure 4.8.

5. HO – effects of trade on factor prices

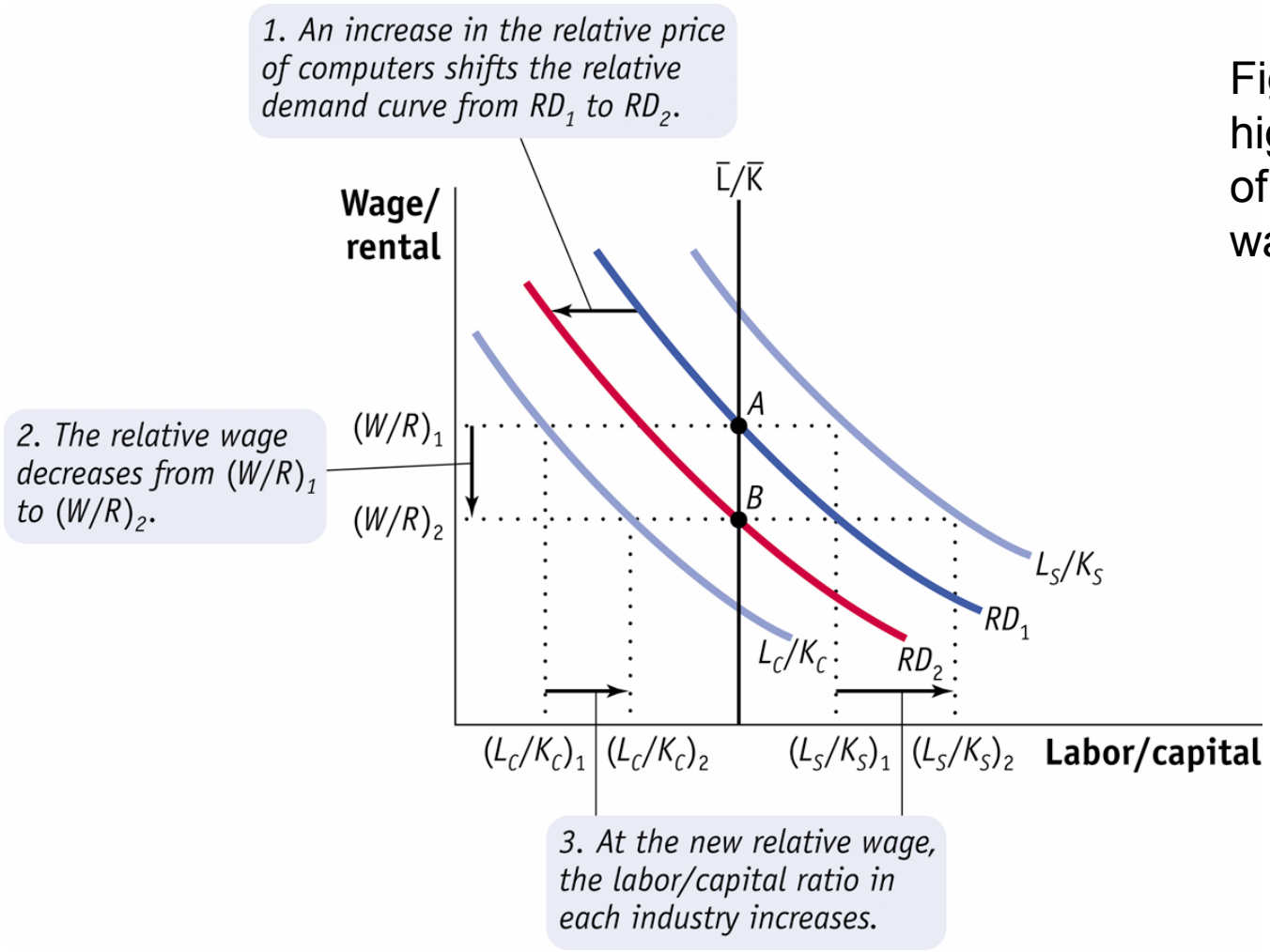

Figure 4.8 Effect of a higher relative price of computers on wage/rental

5. HO – effects of trade on factor prices

- The labor-capital ratio rises in both shoes and computers.
  - More labor per unit of capital is released from shoes than is needed to operate that capital in computers.
  - As relative price of computers rises, computer output rises while shoe output falls.
  - Labor is “freed up” to be used more in both industries.

5. HO – effects of trade on factor prices

- Use earlier equation for relative supply and demand to show response to increase in relative price of computers, P_C/P_S.

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

Relative Supply

No change

Relative Demand

No change in total

5. HO – effects of trade on factor prices

- Relative supply has not changed, so relative demand cannot change overall.
- Individual components of relative demand change.
  - More capital used in the computer industry so, K_C/K rises while K_S/K falls.
    - Output of computers rises and output of shoes falls.
  - Labor/capital ratio in both industries increases.
  - The relative demand continues to equal relative supply.

5. HO – effects of trade on factor prices

Determination of Real Wage and Real Rental

- Who gains and who loses from change in relative price of computers?
- Determine change in real wage and real rental –change in quantity of shoes and computers that each factor of production can purchase.
- Labor/capital ratio increases in both industries, so marginal product of capital increases (more people for each capital unit).

5. HO – effects of trade on factor prices

Determination of Real Wage and Real Rental (cont'd)

- Rental rate of capital is determined by marginal product.
  - $R = P_C * MPK_C$
  - $R = P_S * MPK_S$
- Capital can move freely between industries in long run.
  - The rental rate will be equalized across industries.

5. HO – effects of trade on factor prices

Change in the Real Rental

- Both marginal products of capital increase.
- Rearranging previous equation we get:
  - $MPK_C = R/P_C$ and $MPK_S = R/P_S$
- R/P_C measures quantity of computers that can be purchased with rental; R/P_S measures quantity of shoes that can be bought with rental.
- Since MPK_C and MPK_S both increase, R/P_S and R/P_C must increase as well.
- Capital owners are clearly better off when relative price of capital increases.

5. HO – effects of trade on factor prices

Change in the Real Rental (cont'd)

- Computers are capital intensive industry and relative price of capital has increased.

An increase in the relative price of a good will benefit the factor of production used intensively in producing that good.

5. HO – effects of trade on factor prices

Change in the Real Wage

- Labor/capital ratio increases in both industries.
- Law of diminishing returns says marginal product of labor must decrease in both industries.
- Wage again determined by marginal product of labor and price of goods.
  - $W = P_C * MPL_C$ and $W = P_S * MPL_S$
- Rearranging
  - $MPL_C = W/P_C$ and $MPL_S = W/P_S$

5. HO – effects of trade on factor prices

Change in the Real Wage (cont'd)

- W/P_C is quantity of computers that can be purchased with wage; W/P_S is quantity of shoes that can be purchased with wage.
- MPL_C and MPL_S decrease, so W/P_C and W/P_S decrease.
- Labor is clearly worse off due to increase in price of computers.

5. HO – effects of trade on factor prices

The **Stolper-Samuelson Theorem**:

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

- Therefore, in the Heckscher-Ohlin model:

  The abundant factor gains from trade, and the scarce factor loses from trade.

5. HO – effects of trade on factor prices: numerical example

Changes in the real wage and rental: a numerical Example

– Suppose we have the following data:

• Computers	Sales Revenue	$= P_C Q_C = 100$
	Earnings of labor	$= WL_C = 50$
	Earnings of capital	$= RK_C = 50$
• Shoes	Sales Revenue	$= P_S Q_S = 100$
	Earnings of labor	$= WL_S = 60$
	Earnings of capital	$= RK_S = 40$

5. HO – effects of trade on factor prices: numerical example

- When trade opens, relative price of computers P_C increases while price of shoes P_S does not change.
  - Computers: % increase in price = $\Delta P_C/P_C = 10\%$
  - Shoes: % increase in price = $\Delta P_S/P_S = 0\%$
- Rental on capital: total sales revenue in each industry minus payments to labor, dividing by amount of capital:

$$R = \frac{P_C \cdot Q_C - W \cdot L_C}{K_C}$$

$$R = \frac{P_S \cdot Q_S - W \cdot L_S}{K_S}$$

5. HO – effects of trade on factor prices: numerical example

- $\Delta P_C > 0$ and $\Delta P_S = 0$

$$\Delta R = \frac{\Delta P_C \cdot Q_C - \Delta W \cdot L_C}{K_C}$$

$$\Delta R = \frac{0 \cdot Q_S - \Delta W \cdot L_S}{K_S}$$

- In percentage changes:

$$\frac{\Delta R}{R} = \left(\frac{\Delta P_C}{P_C}\right)\left(\frac{P_C \cdot Q_C}{R \cdot K_C}\right) - \left(\frac{\Delta W}{W}\right)\left(\frac{W \cdot L_C}{R \cdot K_C}\right)$$

$$\frac{\Delta R}{R} = -\left(\frac{\Delta W}{W}\right)\left(\frac{W \cdot L_S}{R \cdot K_S}\right)$$

5. HO – effects of trade on factor prices: numerical example

- With previous data:

$$\frac{\Delta R}{R} = 10\%\left(\frac{100}{50}\right) - \left(\frac{\Delta W}{W}\right)\left(\frac{50}{50}\right)$$

$$\frac{\Delta R}{R} = -\left(\frac{\Delta W}{W}\right)\left(\frac{60}{40}\right)$$

- Solve for 2 unknowns with 2 equations.
  - (ΔW/W) = -(20% / 0.5) = -40%
  - When price of computers increases by 10%, wage falls by 40%
  - *Real wage,* measured in terms of either good, has fallen, so labor is worse off.

5. HO – effects of trade on factor prices: numerical example

- We can also see:
  - $(\Delta R/R) = -(\Delta W/W)(60/40) = 60\%$
  - Rental on capital increases by 60% when price of computers rises by 10%
  - *Real rental* measured in terms of either good has gone up, and capital owners are clearly better off.

5. HO – effects of trade on factor prices

- General Equation for long-run change in factor prices
  - For an increase in P_C
    - $\Delta W/W < 0 < \Delta P_C/P_C < \Delta R/R$
    - Real wage falls, real rental increases
  - For a decrease in P_C
    - $\Delta R/R < \Delta P_C/P_C < 0 < \Delta W/W$
    - Real rental rate falls, real wage increases
  - For an increase in P_S
    - $\Delta R/R < 0 < \Delta P_C/P_C < \Delta W/W$
    - Real rental falls, real wage increases

5. HO – effects of trade on factor prices

- Equations relating the changes in product prices to change in factor prices called “magnification effect.”
  - Changes in prices of goods have magnified effects on earnings of factors.
  - Even modest fluctuations in relative prices of goods on world markets can lead to exaggerated changes in long-run earnings of both factors.
- Explanation for opposition to trade liberalization, for example by labor unions.

5.1 HO – empirics: Opinions towards free trade

- Survey conducted in the U.S. by the National Elections Studies (NES) in 1992 to see how citizens viewed trade.
  - Respondents could either answer that they favor placing limits on imports, not supporting free trade, or they could oppose limits on imports, supporting free trade.
  - How do these answers compare with characteristics of the respondents, such as their wages, skills, or the industries they work in?

5.1 HO – empirics: Opinions towards free trade

- An extension of the model could include considering that, in addition to wages, workers could also earn some of the rental on specific factors in their industry.
- In those situations, labor in exporting industries will support free trade and those in import-competing industries will be against free trade.
- In the short run, the *industry of employment* of workers will affect their attitudes toward free trade.
- In the long run HO model, the industry of employment should not matter.
- In the long run then, the *skill level* of workers should determine their attitudes toward free trade.

5.1 HO – empirics: Opinions towards free trade

- In the NES survey, the industry of employment was somewhat important in explaining respondents' attitudes toward free trade, but skill level (measured by wages or years of education) was much more important.
  - Workers in export-oriented industries are somewhat more likely to favor free trade. Those in import-competing industries favor import restrictions.
  - Workers with lower wages or fewer years of education are more likely to favor import restrictions. Those with higher wages and more years of education favor free trade.
- This suggests respondents are considering *long run* earnings as predicted by HO and Stolper-Samuelson.

5.1 HO – empirics: Opinions towards free trade

- Respondents were also asked if they owned a home.
- People who owned homes in communities where the local industries face a lot of import competition are much more likely to oppose free trade.
- People who owned homes in communities where the industries benefit from export opportunities are more likely to support free trade.
- People are concerned about the asset value of their homes, just like the owners of specific-factors in our model are concerned about the rental earned by the factor of production they own.

5.2 HO – empirics: A look back into history

A look back into history: income distribution and trade in early 19th century England

Krugman & Obstfeld (2006), chapter 4

From 1789 until the defeat of Napoleon at Waterloo in 1815, Britain and France were almost continuously at war. The war interfered with Britain's trade: privateers raided shipping, and the French attempted to impose a blockade on British goods. Since Britain was an exporter of manufactures and an importer of agricultural products, the trade limitations raised the relative price of food in Britain. Workers' wages and the profits of manufacturers suffered, while landowners prospered.

After the war, food prices fell. To avoid the consequences, the politically influential landowners got legislation that imposed fees to discourage importation of grain – the so-called Corn Laws. This change in relative prices – and the behavior of landowners when their position threatened to weaken as a result of renewed free trade – is quite in line with the predictions of the HO model.

One interesting bit of trivia: David Ricardo – a London businessman himself – invented his one-factor model of trade to argue against the Corn Laws. He knew that their repeal would make capitalists better and landowners worse off, but he preferred to argue in terms of a model where internal income distribution differences are assumed away in favor of the representation of the gains to the nation as a whole.

6. Extending the HO model

1. More than two goods, factors, and countries.
2. Technologies used to produce each good differ across countries.

- Many Goods, Factors, and Countries
  - Predictions of HO model depend on knowing what factor a country has in abundance, and which good uses that factor intensively.
  - With more than two goods, it is more complicated to evaluate factor intensity and factor abundance.

6. Extending the HO model

Measuring the Factor Content of Trade

- Using Leontief's test, we can look at similar data.
- We can multiply his numbers shown in Table 4.2 by actual value of U.S. exports and U.S. imports.
- These values are called the **factor content of exports** and **factor content of imports.**
- Difference between the factor content of exports and factor content of imports gives factor content of net exports, shown in the final column of 4.2.

6. Extending the HO model

	EXPORTS, *X*		IMPORTS, *M*		NET EXPORTS (*X* – *M*)
	For $1 Million Exports	For Total Exports	For $1 Million Imports	For Total Imports	
Capital ($ millions)	$2.55	$42,600	$3.1	$19,200	$23,400
Labor (person-years)	182	3.04 million	170	1.05 million	2 million
Capital/labor ($/person)	$14,000	$14,000	$18,200	$18,200	$16,700

Table 4.2 Factor content of trade for the United States, 1947

6. Extending the HO model

Measuring the Factor Content of Trade (cont'd)

- Since both these factor contents are positive, we see that the U.S. was running a trade surplus.
- The U.S. exported large amounts of goods to help countries of Europe rebuild after WWII.
- Note that the factor content of net exports for both capital and labor are positive.

6. Extending the HO model

Measuring Factor Abundance

- Compare country's share of factor with its share of world GDP.
- If the share of a factor > share of world GDP.
  - The country is ***abundant*** in that factor.
- If the share of factor < share of world GDP.
  - The country is ***scarce*** in that factor.

6. Extending the HO model

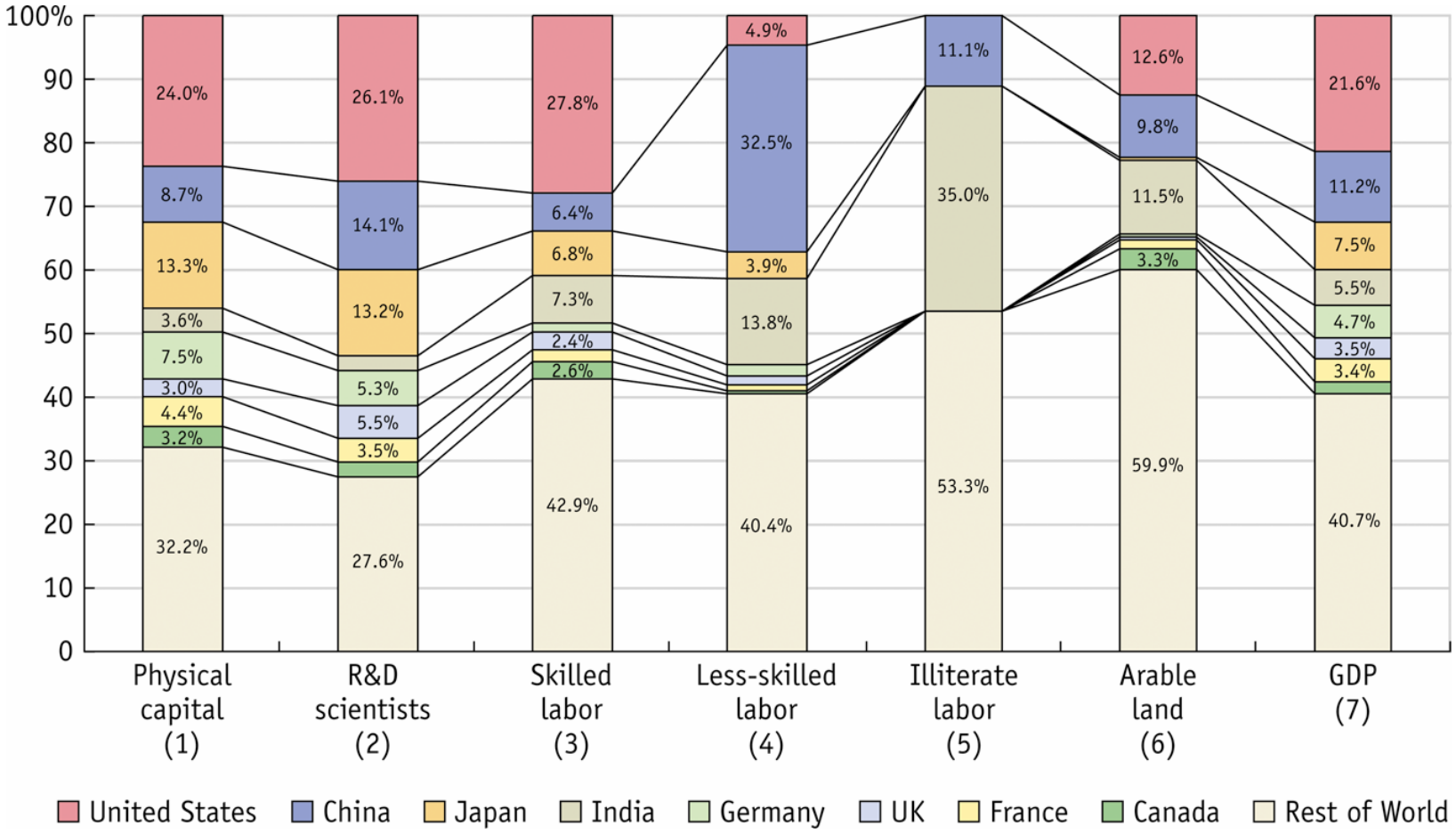

Figure 4.9 Country factor endowments, 2000

6. Extending the HO model

Labor and Land Abundance

- The U.S. is scarce in arable land which is surprising since we think of the U.S. as a major exporter of agricultural products.
- Another surprise is that China is abundant in R&D scientists.
- These findings seem to contradict HO model.
- It is likely that the productivity of R&D scientists and arable land are not the same in both countries.
- In this case, shares of GDP are not the whole story.
- We need to allow for differences in productivity.

6. Extending the HO model

Differing Productivities Across Countries

- Leontief found that the U.S. was exporting labor-intensive products even though it was capital-abundant at that time.
- One explanation is that labor is highly productive in the U.S. and less productive in the rest of the world.
  - The **effective labor force** in the U.S. is much larger than if we just count people.
  - **Effective labor force** is labor force times its productivity.

6. Extending the HO model

Measuring Factor Abundance once again

- **Effective Factor Endowment** is the actual factor endowment times the factor productivity.
- Amount of world effective labor is found by adding up effective factor endowments across all countries.
- To determine if a country is abundant in a certain factor, we compare the country's share of that effective factor with share of world GDP.

6. Extending the HO model

Effective R&D Scientists

- The effectiveness of an R&D Scientist depends on what they have to work with.
  - R&D spending per scientist: more spending, scientist will be more productive.
- Take the total number of scientists and multiply that by the R&D spending per scientists
- Figure 4.10 shows these shares.
- With these productivity corrections, the U.S. is more abundant in effective R&D scientists and China is lower.

6. Extending the HO model

Effective Arable Land

- Effective arable land is the actual amount of arable land times the productivity in agriculture.
- The numbers before and after the correction are very close (compare figures 4.9 and 4.10).
  - The U.S. is neither abundant nor scarce in effective arable land.
  - Note that it is expected that by about 2010, U.S. imports of agricultural goods will be about equal to exports.
  - Corresponds to HO model prediction since U.S. is neither abundant nor scarce in effective land.

6. Extending the HO model

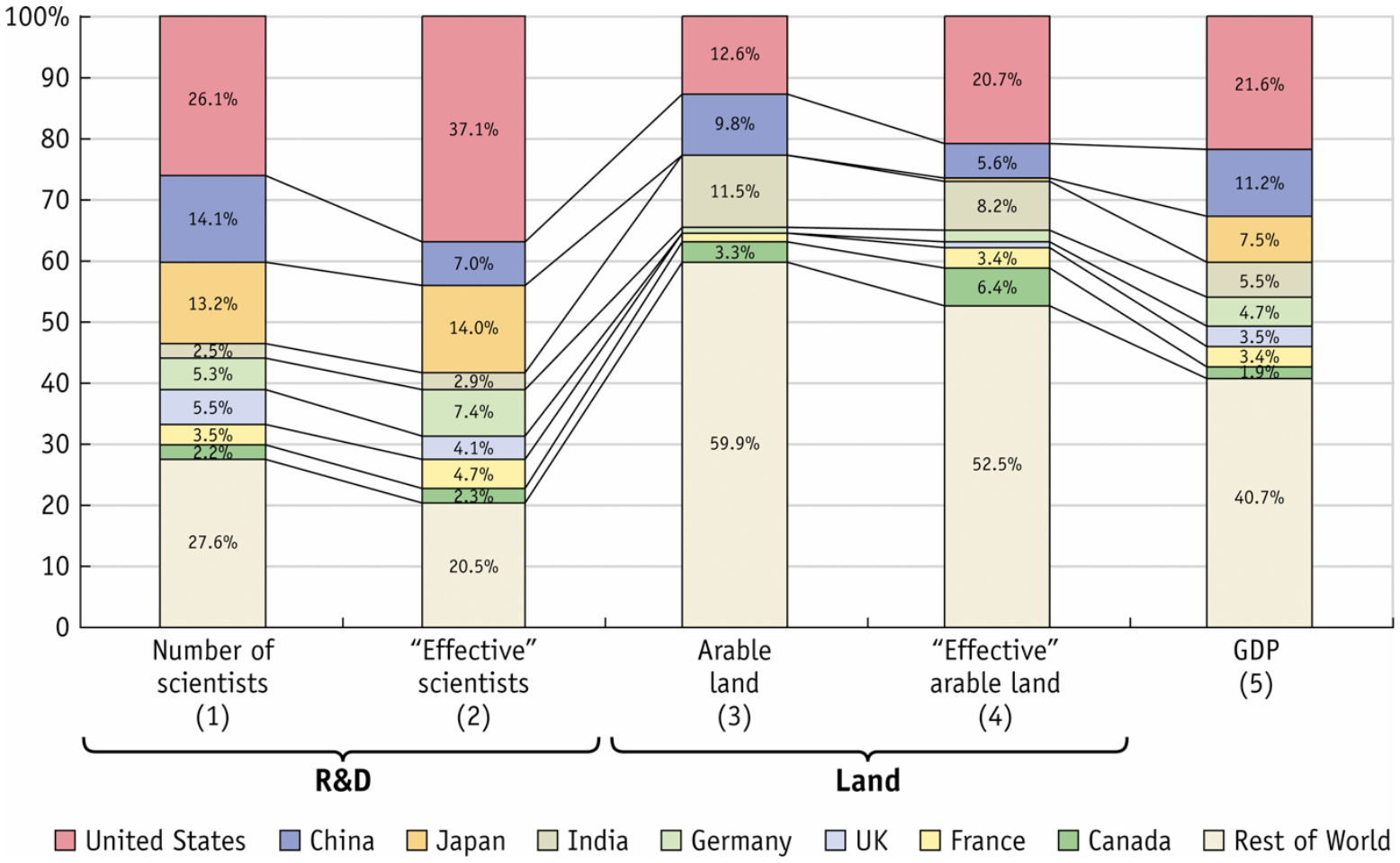

Figure 4.10 „Effective“ factor endowments, 2000

6. Extending the HO model

The “sign test” of factor abundance

- If a country is abundant in an effective factor, then the factor’s content in net exports should be positive.
- If a country is scarce in an effective factor, then that factor’s content in net exports should be negative.
- Sign of (country’s % share of effective factor minus the % share of world GDP) equals sign of (Country’s factor content of net exports).

6. Extending the HO model

- For example, Table 4.2 shows that for capital the U.S. had a positive factor content of net exports.
  - Using 35 countries, the U.S. share of GDP of those countries was 33%.
  - Given the timing after WWII, we can assume that the U.S. share of world capital was more than 33%.
  - The U.S. was abundant in capital and since that factor's content of net exports was positive, it passes the sign test.

6. Extending the HO model

- U.S. share of population for the 35 countries was about 8%.
- This is less than the U.S. share of GDP, 33%.
- U.S. was scarce in labor, but labor's factor content of net exports was positive.
  - The sign test seems to fail for the U.S. in 1947 in labor.
- U.S. share of the population is not right way to measure the U.S. labor endowment.

6. Extending the HO model

- One way to measure productivity is to use wages paid to workers.
- A plot of wages of workers in various countries and the estimated productivity of workers in 1990 is shown in figure 4.11.
- The effective amount of labor found in each country equals the actual amount of labor times the wage.
  - The amount of labor in each country times the average wages gives total wages paid to labor.

6. Extending the HO model

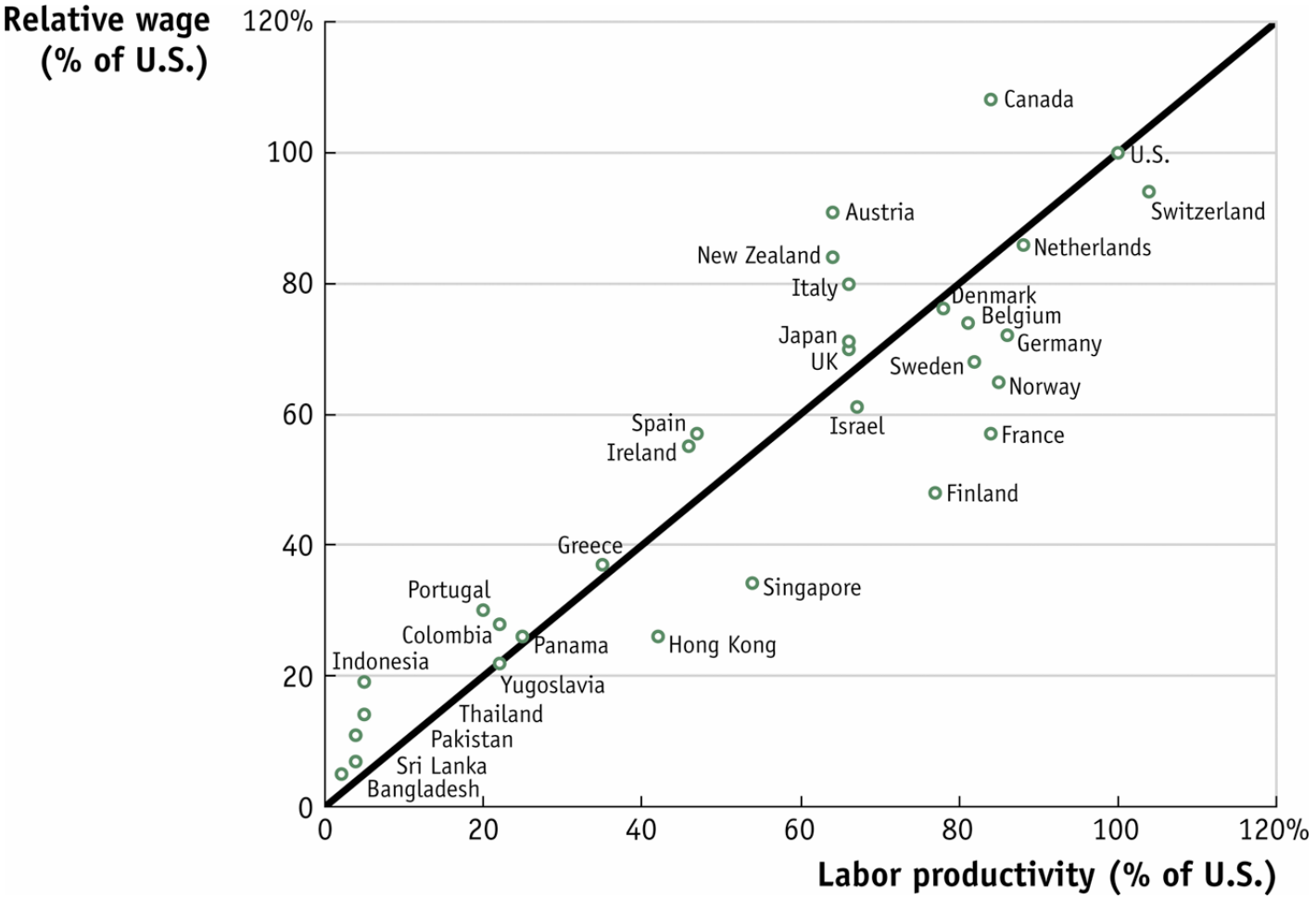

Figure 4.11 Labor productivity and wages

6. Extending the HO model

- Doing this for 30 countries in 1947 and comparing it to the U.S., we find that the U.S. was abundant in effective labor: it had 37% of GDP, and around 43% of wage labor paid across all 30 countries.
- U.S. was abundant in effective factor, so labor also passes the sign test.
- There is no “paradox” in the U.S. pattern of trade.
- This explanation for Leontief’s paradox relies on taking into account the productivity differences in labor across countries.

6.1 Extending the HO model - empirics

- From the 17th century until the early 19th century, India was a major world producer of cotton textiles and exported those goods to Britain and elsewhere.
- By the early 19th century, Britain had overtaken India as the world's dominant producer of cotton textiles and was exporting to India.
- India still produced raw cotton needed to manufacture cotton cloth—the raw cotton was exported to Britain.
- A similar trade pattern held for China and Egypt.
- These countries are all labor abundant rather than land abundant, therefore it is puzzling why they seem to be net exporters of land and net importers of labor.

6.1 Extending the HO model - empirics

- Two explanations
  1. Britain's rise as the world's leading exporter of cotton textiles related to technological improvements.
     - However, India was able to gain access to this technology, so the importing of textiles is contrary to the HO model.

6.1 Extending the HO model - empirics

2. The developing countries used this new technology to make textiles inefficiently.
   - This inefficiency applied more strongly to labor than it did to other factors such as land.
   - Estimates from 1910 and 1990 show that labor was not necessarily the abundant factor in India once we take into account its low productivity.
   - India could be considered land-abundant if land and labor are measured by their “effective” amounts.
   - This can explain the switch from exporter to importer.

7. Conclusions

- The HO framework is one of the most widely used models in explaining trade patterns.
- HO model isolates effect of different factor endowments across countries and determines the impact of these differences on trade patterns, relative prices, and factor returns.
- By focusing on the factor intensities among goods, the HO model also provides clear guidance as to who gains and who loses from trade.

7. Conclusions

- The HO model predicts real gains for the factor used intensively in the export good, whose relative price goes up with the opening of trade, and real losses for the other factor.
- First empirical test of HO model led to Leontief's paradox, the finding that U.S. exports just after WW II were relatively labor intensive.
- With factor amounts embodied in net exports and effective factor endowments in each country, U.S. had positive factor content of L and K in net exports, consistent with the sign test of the extended HO model.