

# International Trade

## 2. Trade and Technology: The Ricardian Model

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# The Ricardian Model of trade

- Ricardo model: after British economist David Ricardo (1772-1823)
  - Ricardo's writings came at time of *mercantilism*: exports are good because they bring gold and silver to treasury; imports are bad because they drain gold and silver.
  - Mercantilists were in favor of import tariffs.
  - Ricardo showed that free trade could benefit all trade partners (as in Adam Smith) thanks to comparative advantage.
  - Ricardo's ideas still fundamental for international economics.



# 1. Reasons for trade

- Possible reasons for trade include:
  - Technological differences
  - Differences in amounts of resources/factors of production (geography, i.e. natural, labor and capital resources)
  - Differences in costs of outsourcing
  - The proximity of countries to each other (costs of transportation).

# 1. Reasons for trade

- This chapter focuses on how technology differences across countries affect trade.
- It explains how the level of a country's technology affects wages paid to labor in a way that countries with better technology have higher wages.
- We use this to explain a country's trade pattern—the products it exports and imports.

# 1. Reasons for trade

- **Absolute advantage:**

- When a country has the best technology for producing a good, it has an **absolute advantage** in the production of that good.
- However: U.S. has absolute advantage in production of snowboards, so why does it import many snowboards from China?

→ Absolute advantage is not a good explanation for trade patterns.

# 1. Reasons for trade

- **Comparative advantage:**
    - A country has a **comparative advantage** in producing those goods that it produces best compared with how well it produces other goods.
    - China does not have an absolute advantage compared to U.S., but it is better at producing snowboards than some other goods.
- *Comparative advantage is the primary explanation for trade among countries.*

## 2. Ricardian Model

- To develop a Ricardian model of trade, we will use an example with two goods: *wheat* and *cloth*.
  - Wheat and other grains are major exports of the U.S. and Europe.
  - Many types of cloth are imported into these countries.
- *Home* will be the country exporting wheat and importing cloth.
- *Foreign* will export cloth and import wheat.

# 2. Ricardian Model

- The Home Country
  - We will assume that labor is the only resource used to produce both goods.
  - One worker can produce 4 bushels of wheat or 2 yards of cloth.
  - The **Marginal Product of Labor** (MPL) is the extra output obtained by using one more unit of labor.
  - Assume  $MPL_W = 4$  and  $MPL_C = 2$ .

# 2. Ricardian Model

- **Home Production Possibilities Frontier (PPF)**
  - We can use the marginal products of labor to construct Home's PPF.
  - Assume there are 25 workers in Home.
  - If all the workers were employed in wheat, the country could produce 100 bushels.
  - If they were all employed in cloth they could produce 50 yards.
  - The PPF connects these two points.

## 2. Ricardian Model

- Algebraically for Home:
  - Labor = 25,  $MPL_W = 4$ ,  $MPL_C = 2$
  - $Q_W = MPL_W(L) = 25(4) = 100$
  - $Q_C = MPL_C(L) = 25(2) = 50$
- This gives us *a straight-line PPF which is a unique feature of the Ricardian model.*
  - It assumes the marginal products of labor are constant.
  - There are no diminishing returns because the model ignores the use of other resources.

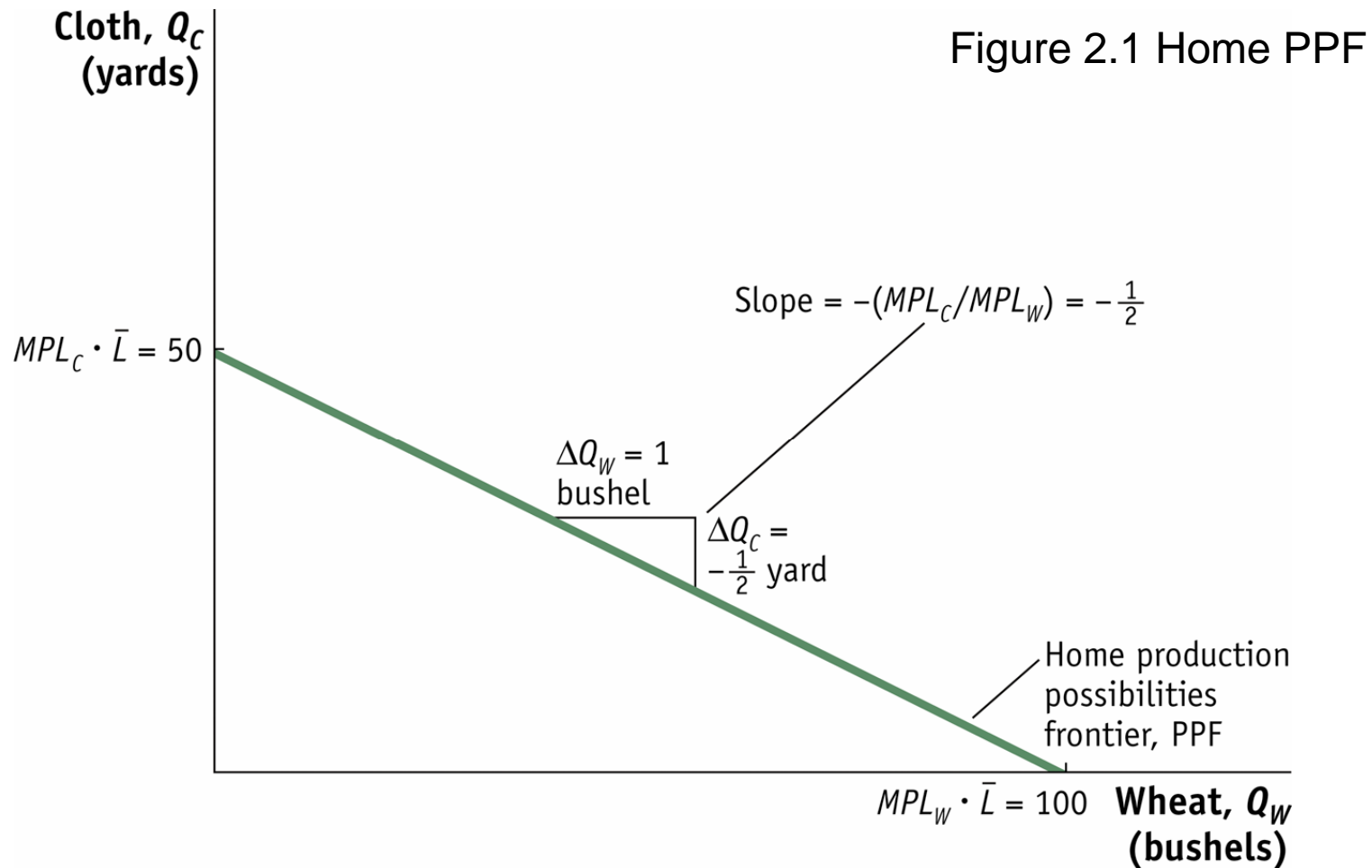
## 2. Ricardian Model

- The slope of the PPF can be calculated as the ratio of marginal products of the two goods.
- The slope also equals the opportunity cost of wheat—the amount of cloth that must be given up to obtain one more unit of wheat.

$$\text{Slope PPF} = -\frac{50}{100} = -\frac{MPL_C \cdot \bar{L}}{MPL_W \cdot \bar{L}} = -\frac{MPL_C}{MPL_W} = -\frac{1}{2}$$

MPL Y-axis  
MPL X-axis

# 2. Ricardian Model



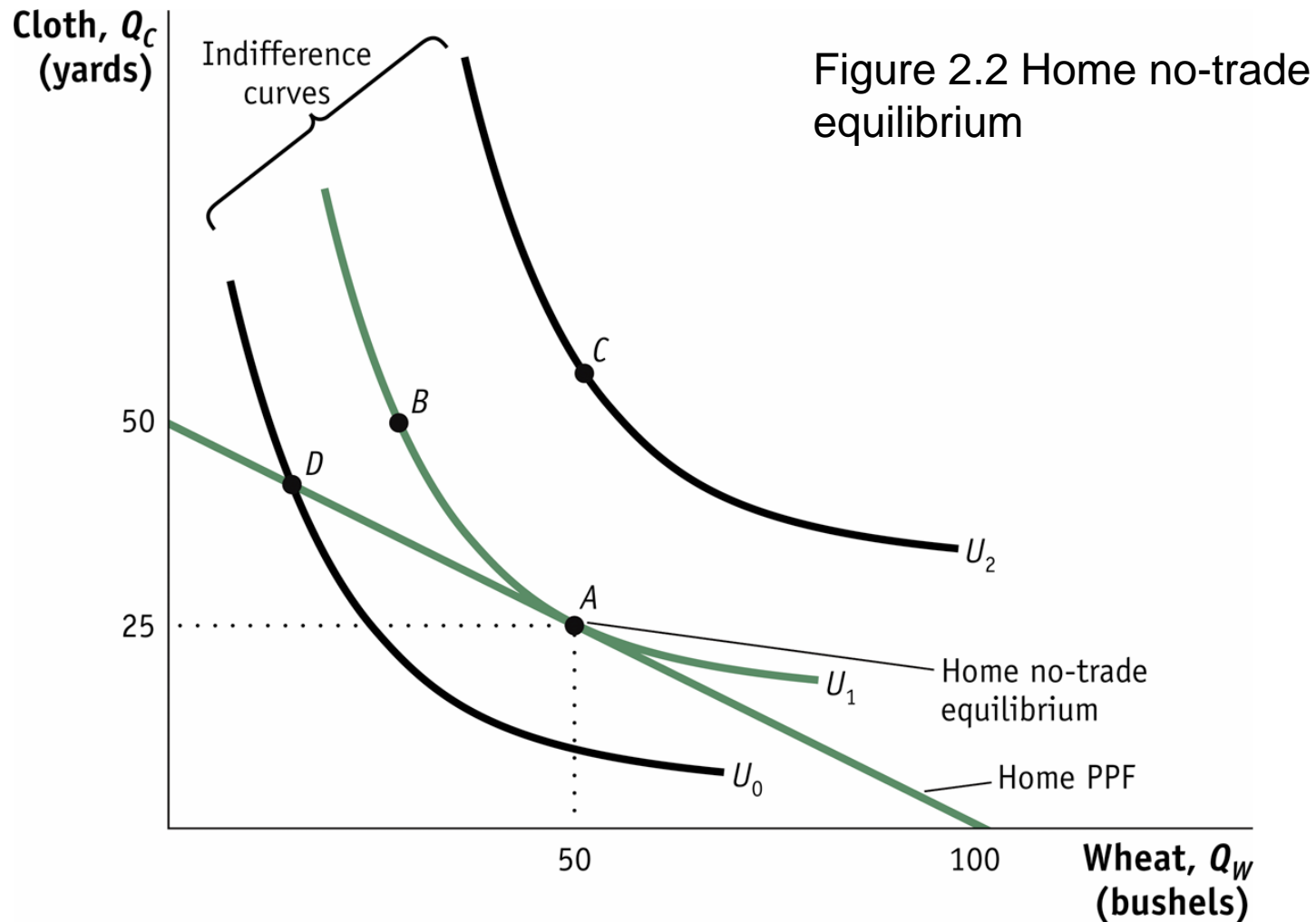
# 2. Ricardian Model

- **Home Indifference Curve:**
  - Given Home's PPF, how much wheat and cloth will home actually produce? The answer depends on demand.
  - Demand can be represented with an **indifference curve**.
  - An indifference curve shows the combinations of two goods that the country can consume and be equally satisfied.

## 2. Ricardian Model

- Indifference curves are often used to show the preferences of an individual; aggregated indifference curves show the preferences of an entire country.
- All points on an indifference curve have the same level of utility.
- Indifference curves are convex to the origin.
- Points on higher indifference curves have higher utility.
- Indifference curves for one individual or country do not intersect.

# 2. Ricardian Model



# 2. Ricardian Model

- Home Equilibrium
  - Without trade, the PPF acts as a budget constraint for the country.
  - With perfectly competitive markets, the country will produce at its highest level of utility within the limits of the PPF (point A in Figure 2.2).
  - Point A is the *no-trade equilibrium*.

# 2. Ricardian Model

- Opportunity Cost and Prices
  - The slope of the PPF reflects the opportunity cost of producing one more bushel of wheat.
  - Under perfect competition the opportunity cost of wheat should equal the price of wheat.
  - Price reflects the opportunity cost of a good.

# 2. Ricardian Model

- Determination of wages
  - In competitive markets firms hire workers up to the point at which the hourly wage equals the value of one more hour of production.
  - The value of one more hour of labor equals the amount of goods produced in that hour (MPL) times the price of the good.
  - Labor is hired up to the point where wage equals  $P \cdot MPL$  for each industry.

# 2. Ricardian Model

- Wages (cont'd)
  - In competitive markets, labor can move freely between industries.
  - Labor will move to the higher paid industry.
  - This will continue until there is equalization of wages between industries.

## 2. Ricardian Model

- The equalization of wages will give us the following:
  - The right-hand side is the slope of the PPF and the opportunity cost of obtaining one more bushel of wheat.
  - The left-hand side is the relative price of wheat.

$$P_W \cdot MPL_W = P_C \cdot MPL_C$$

$$\frac{P_W}{P_C} = \frac{MPL_C}{MPL_W}$$

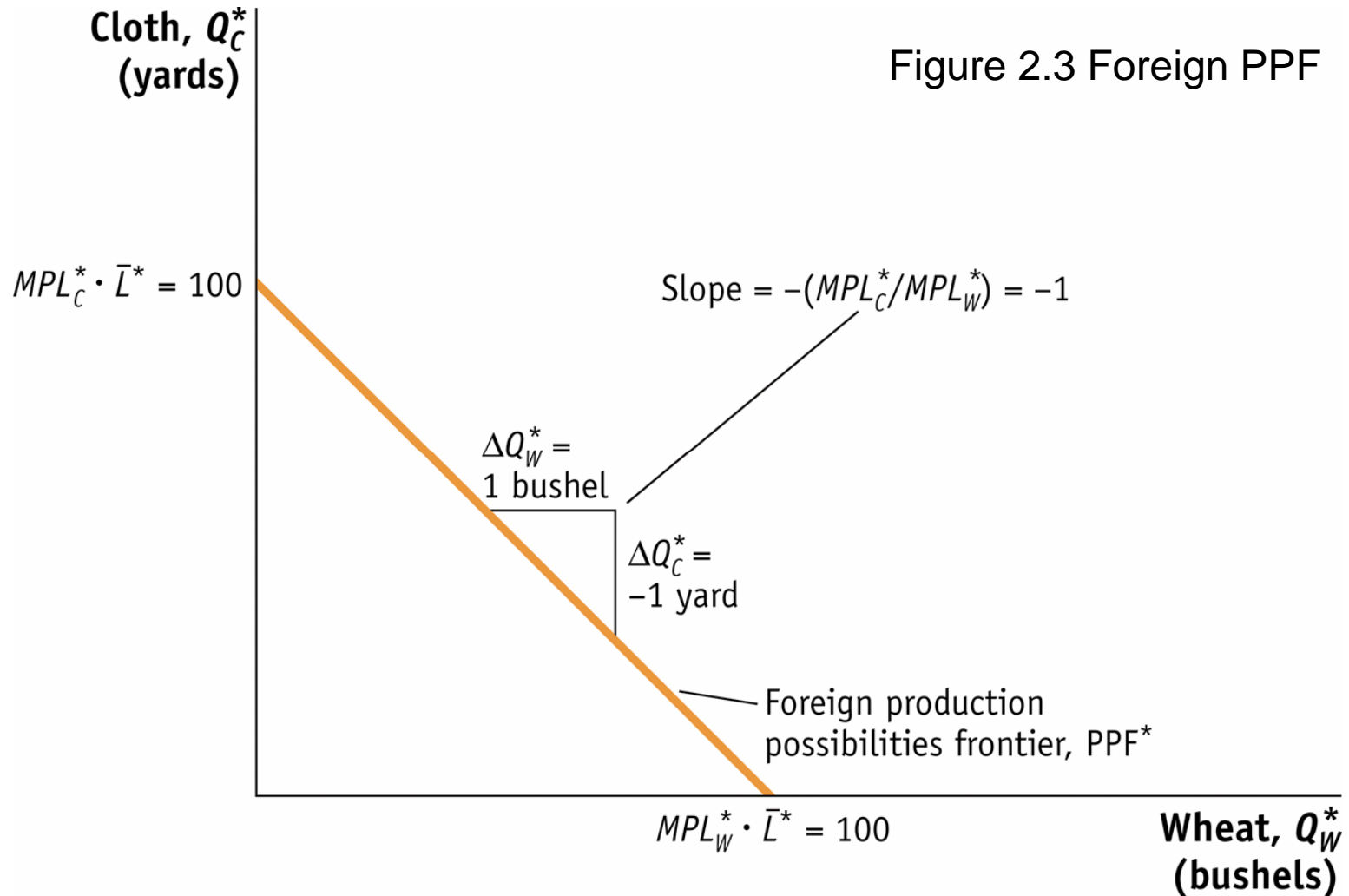
## 2. Ricardian Model

- The price ratio,  $P_W/P_C$ , always denotes the relative price of the good in the numerator, measured in terms of how much of the good in the denominator must be given up.
- The slope of the PPF equals the relative price of wheat, the good on the horizontal axis.

# 2. Ricardian Model

- The Foreign Country
  - Assume Foreign's technology is inferior to Home's.
  - Foreign has absolute disadvantage in producing both wheat and cloth as compared to Home.
- Foreign Production Possibilities Frontier
  - $MPL^*_W = 1, MPL^*_C = 1$
  - Assume there are 100 workers available in Foreign.
  - If all workers were employed in wheat they could produce 100 bushels.
  - If all workers were employed in cloth they could produce 100 yards.

# 2. Ricardian Model



## 2. Ricardian Model

- For comparative advantage: compare *opportunity costs* for goods in Home and Foreign.
- Home has comparative advantage in wheat, Foreign in cloth.

	Cloth (1 Yard)	Wheat (1 Bushel)
Home	2 Bushels of Wheat	$\frac{1}{2}$ Yard of Cloth
Foreign	1 Bushel of Wheat	1 Yard of Cloth

## 2. Ricardian Model

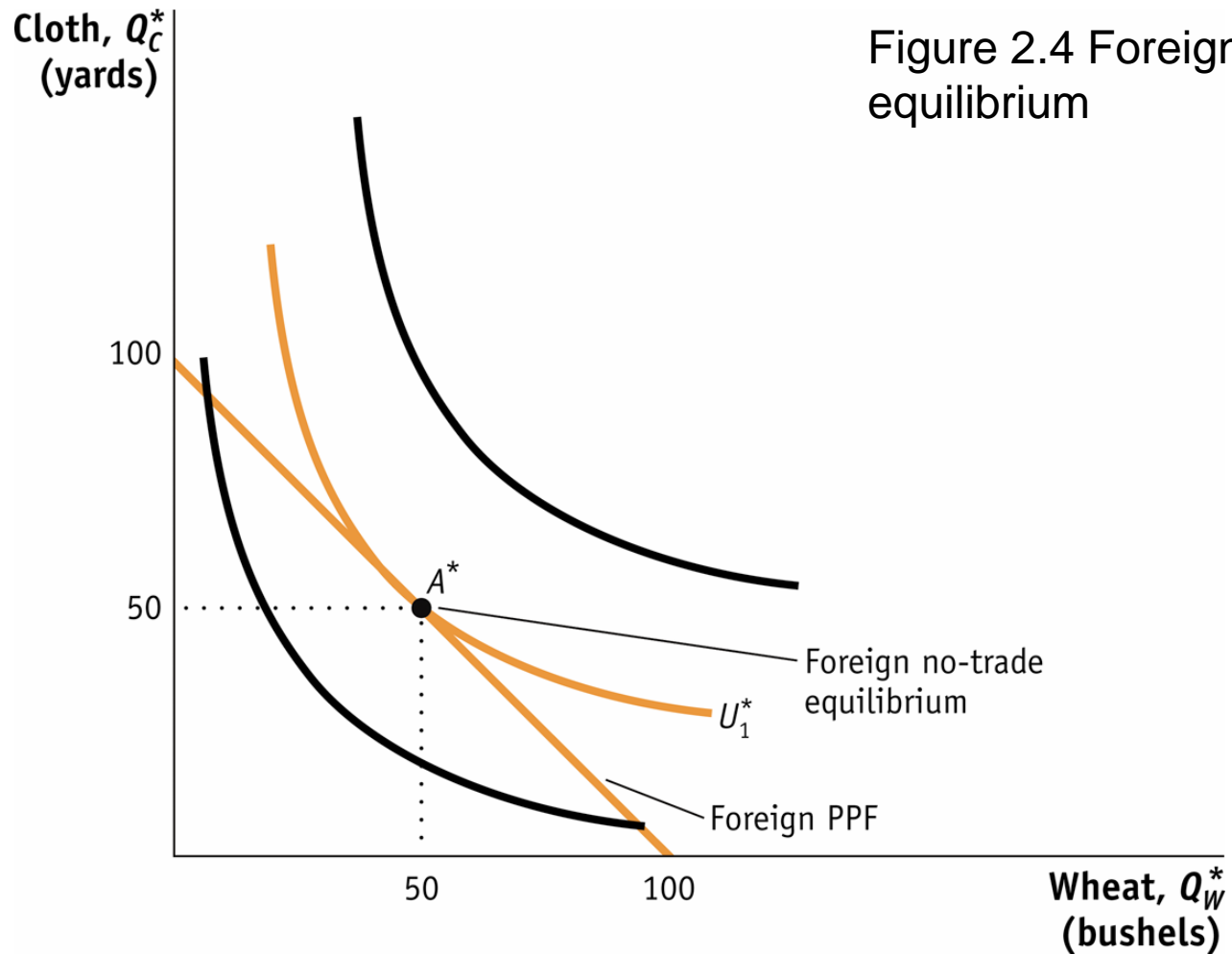
- *Comparative advantage defined in terms of opportunity costs:*

A country has a comparative advantage in the production of  $X$  if its opportunity costs of  $X$  in terms of  $Y$  are less than in the other country.

## 2. Ricardian Model

- Equilibrium in Foreign
  - Foreign's preferences represented by indifference curve.
  - Its economy produces at the point of highest utility for the country within the PPF constraint.
  - The slope of the PPF is the opportunity cost of wheat.
  - The no-trade relative price of wheat is  $P^*_W/P^*_C = 1$ .
  - The relative price exceeds Home's no-trade relative price of wheat:  $P_W/P_C = 1/2 < P^*_W/P^*_C = 1$ .
  - The difference in relative prices comes from the comparative advantage that Home has in wheat.

# 2. Ricardian Model



# 2.1 Ricardian Model - empirics

## U.S. – China in textiles & apparel and wheat

- U.S. Textile and apparels industries face intense import competition.
- Burlington Industries announced in January 1999 it would reduce production capacity by 25% due to increased imports from Asia.
- After layoffs they employed 17,400 people in the U.S. with sales of \$1.6 billion in 1999.
- Sales per employee were therefore \$92,000 - the average for all U.S. apparel producers.
- Textiles are even more productive with annual sales per employee of \$140,000 in the U.S.

# 2.1 Ricardian Model - empirics

- In China, sales per employee are only \$13,500 in apparel and \$9,000 in textiles.
- The U.S. is 7 times more productive in apparel and 16 times more productive in textiles.
- So U.S. has the absolute advantage in these products.
- For wheat, U.S. produces 27.5 bushels per hour of labor.
- China produces only 0.1 bushel per hour of labor.
- The U.S. is thus 275 times as productive in wheat.
- It has the absolute advantage in wheat.

# 2.1 Ricardian Model - empirics

- Since the absolute advantage in wheat for the U.S. is even greater than in apparel and textiles, it has the comparative advantage in wheat.
- China has the comparative advantage in apparel and textiles because its productive disadvantage relative to the U.S. is less than in wheat.
- This explains why the U.S. imports apparel and textiles from China despite higher productivity in the U.S.

# 2.1 Ricardian Model - empirics

## Further examples

- Average labor productivity of labor in Japanese manufacturing in 1990 20% lower than labor productivity in U.S.
- However, in auto sector Japanese labor productivity 16-24% higher than in US.
- Result: U.S. is heavy importer of Japanese automobiles.
- **Note:** comparative advantage can be created, example Canadian icewine.

# 3. Pattern of international trade

What happens when goods are traded between Home and Foreign?

- The country's no-trade relative price / opportunity costs of production determines which product it will export and which it will import → comparative advantage.
- In international trade equilibrium:
  - Home exports wheat, Foreign exports cloth.

# 3. Pattern of international trade

How trade occurs

- As Home exports wheat, quantity of wheat sold at Home falls → the price of wheat at Home increases.
- More wheat goes into Foreign's market → the price of wheat in Foreign falls.
- As Foreign exports cloth, the quantity sold in Foreign falls, and the price in Foreign for cloth rises.
- The price of cloth at Home falls.

# 3. Pattern of international trade

## International Trade Equilibrium

- Two countries are in a trade equilibrium when:
  - relative prices of goods are the same in two countries
  - amount of each good that countries want to trade is equal
- In understanding the trade equilibrium we need to:
  - Determine the relative price of wheat or cloth in the trade equilibrium.
  - See how the shift from the no-trade equilibrium to the trade equilibrium affects production and consumption in both Home and Foreign.

# 3. Pattern of international trade

## International Trade Equilibrium (cont'd)

- The relative price of wheat in the trade equilibrium will be between the no-trade price in the two countries.
- Assume the free-trade price of  $P_C/P_W$  is  $2/3$ . This is between the price of  $1/2$  in Home and 1 in Foreign.
- Change in Production and Consumption
  - Home producers of wheat can earn more than the opportunity cost of wheat by selling it to Foreign.
  - Home will therefore shift labor resources toward the production of wheat and increase its production.

### 3. Pattern of international trade

$$\frac{P_W MPL_W}{P_C MPL_C} = \left(\frac{2}{3}\right)\left(\frac{4}{2}\right) = \frac{8}{6} > 1$$

*Therefore*

$$P_W MPL_W > P_C MPL_C$$

*Wages in wheat > Wages in cloth*

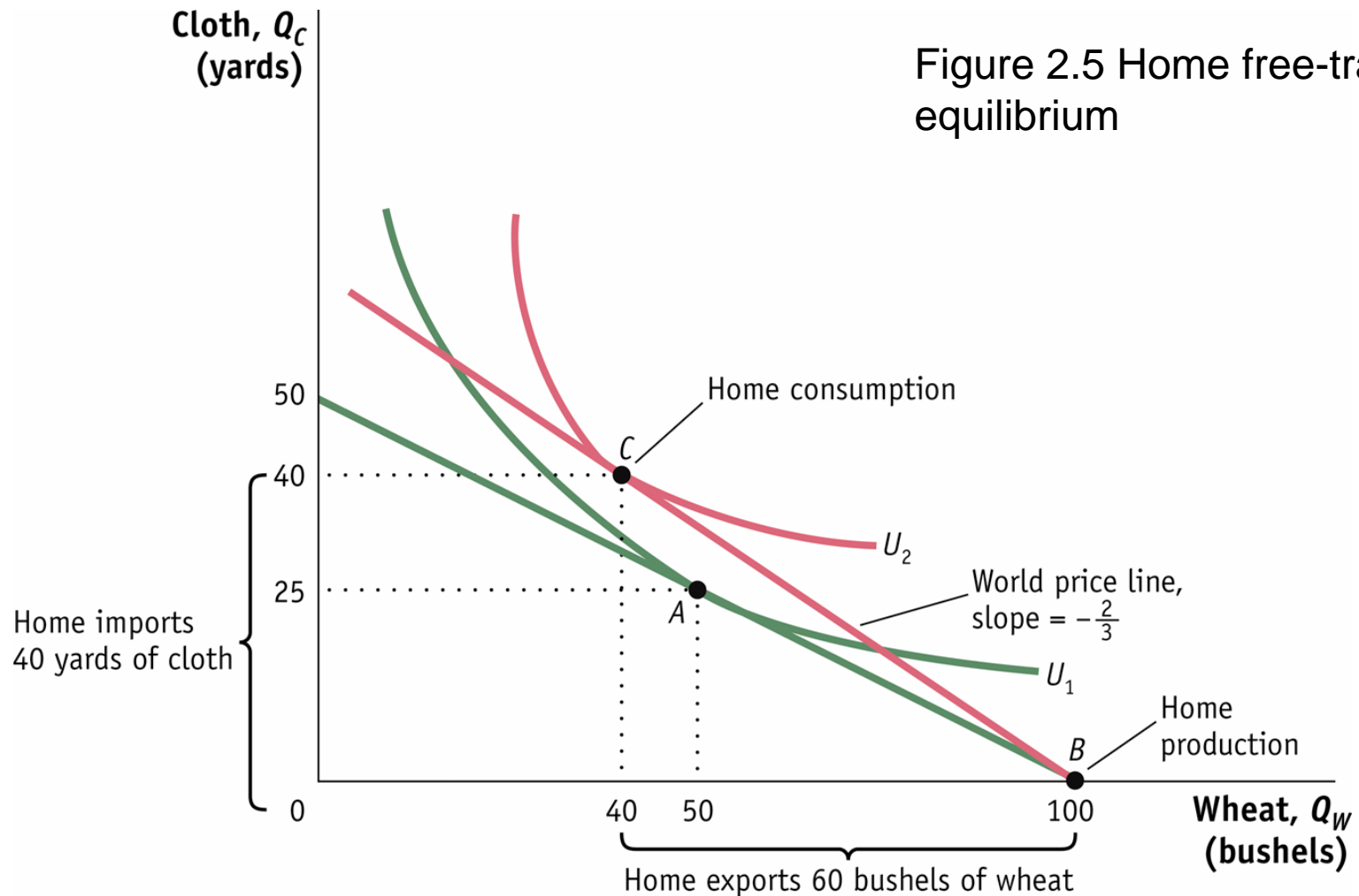
- Home's workers will want to work in wheat and *no cloth will be produced.*
- With trade, *Home will be fully specialized in wheat production.* This is another special feature of the Ricardo model.

# 3. Pattern of international trade

## International Trade

- Home can export wheat at the international relative price of  $2/3$  and get  $2/3$  yards of cloth in return for every bushel of wheat.
- Figure 2.5 shows the new price line with world price.
  - The world price line shows the range of **consumption** possibilities that a country can achieve by specializing in one good and trading.
  - **Production** is still constrained by the PPF.

# 3. Pattern of international trade



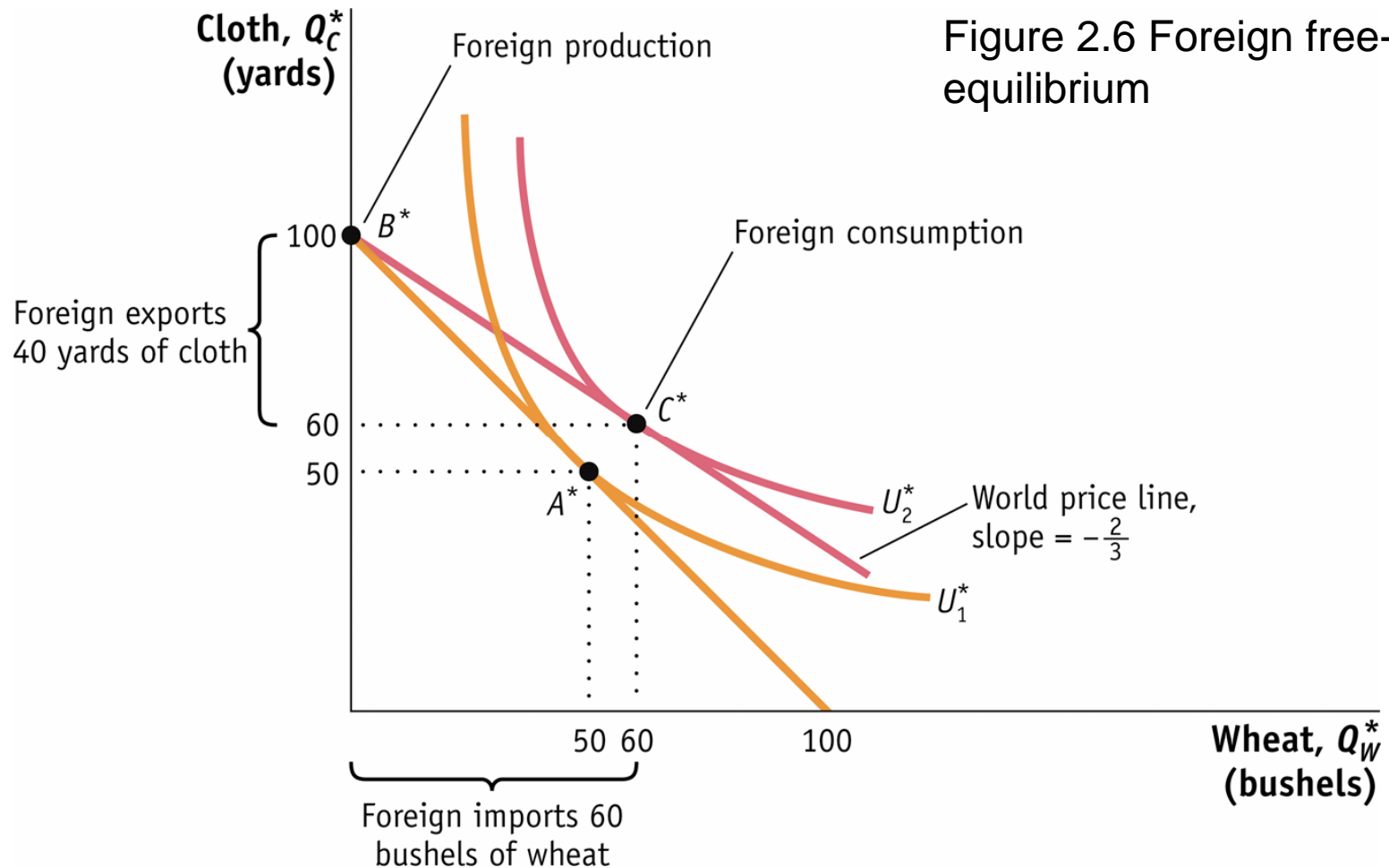
# 3. Pattern of international trade

## International Trade (cont'd)

- Trade allows a country to engage in consumption possibilities it did not have before trade → Home is on a higher indifference curve with trade than without it.
  - This is the first demonstration of **gains from trade**.
- Home's exports and imports are equal when valued in the same units.
- Home exports 60 bushels of wheat; multiplying this by the price of wheat in terms of cloth,  $2/3$ , gives 40. This equals the amount of cloth that is imported.
- Foreign free-trade equilibrium shown in Figure 2.6.

# 3. Pattern of international trade

Figure 2.6 Foreign free-trade equilibrium



# 3. Pattern of international trade

## Pattern of Trade and Gains from Trade

- Each country exports the good for which it has the comparative advantage.
- This confirms that the pattern of trade is determined by comparative advantage.
- There are gains from trade for both countries.
- Relative prices converge. Do wages?
  - Wages rise in each country, but *they do not converge*.
  - *Wages are determined by absolute advantage, not comparative advantage.*

# 3. Pattern of international trade

## Solving for Wages Across Countries

- Remember: in competitive labor markets, firms will pay workers the value of their marginal product.
- Since Home produces and exports wheat, they will be paid in terms of that good—the real wage is  $MPL_W = 4$  bushels of wheat.
- The workers sell the wheat on the world market at a relative price of  $P_W/P_C = 2/3$ .
- We can use this to calculate the real wage in terms of cloth:  $(P_W/P_C)MPL_W = (2/3)4 = 8/3$  yards.
- Same for Foreign.

# 3. Pattern of international trade

## Solving for Wages Across Countries (cont'd)

- Home real wage is
  - 4 bushels of wheat
  - $\frac{8}{3}$  yards of cloth
- Foreign real wage is
  - $\frac{3}{2}$  bushels of wheat
  - 1 yard of cloth
- Foreign workers earn less than Home workers as measured by their ability to purchase either good.
  - This fact reflects Home's absolute advantage in the production of both goods.

# 3. Pattern of international trade

- Wages are determined by absolute advantage and trade is determined by comparative advantage.
  - The only way a country with poor technology can export at a price others are willing to pay is by having low wages.
- As a country develops better technology, its wages will rise.
  - Workers become better off through receiving higher wages.
  - As countries engage in trade, the Ricardian model predicts that their real wages will rise.

# 3. Pattern of international trade - empirics

Question: Does the Ricardian model make accurate predictions about actual international trade flows?

- The answer is a (heavily) qualified yes.
- Qualified, because the Ricardian model makes a number of misleading predictions:
  - The model predicts extreme specialization that we do not observe in the real world.
  - The model assumes away distributional effects within countries. In practice, international trade has strong effects on income distribution.

# 3. Pattern of international trade - empirics

- The model allows no role for differences in resources among countries as a cause of trade (→ Heckscher-Ohlin model).
- The model neglects the possible role of economies of scale as a cause of trade, which leaves it unable to explain the large trade flows between apparently similar nations (chapter 6).
- Despite these failings, the basic prediction – that countries should tend to export those goods in which their productivity is relatively high – has been strongly confirmed by a number of studies.

# 3.1 Trade and wages - empirics

## Example of China and India

- Per capita income in China in 1978 was estimated at \$925.
- In 2000, per capita income in China had risen to \$3750.
- Per capita income in India more than doubled from \$1180 in 1978 to \$2480 in 2000.
- It is strongly believed that the opportunity for these countries to engage in international trade has been crucial in raising their standard of living.

# 3.1 Trade and wages - empirics

Measuring labor productivity in practice

- Labor productivity can be measured by **value-added** per hour in manufacturing.
  - Value-added is the difference between sales revenue in an industry and the costs of intermediate inputs.
  - It equals the payments to labor and capital in an industry.
  - Ricardian model ignores capital, so we measure labor productivity as value-added divided by the number of hours worked, or value-added per hour.
- Figure 2.7 shows value-added per hour in manufacturing for several countries.
  - Countries with higher labor productivity pay higher wages, just as the Ricardian model predicts.

# 3.1 Trade and wages - empirics

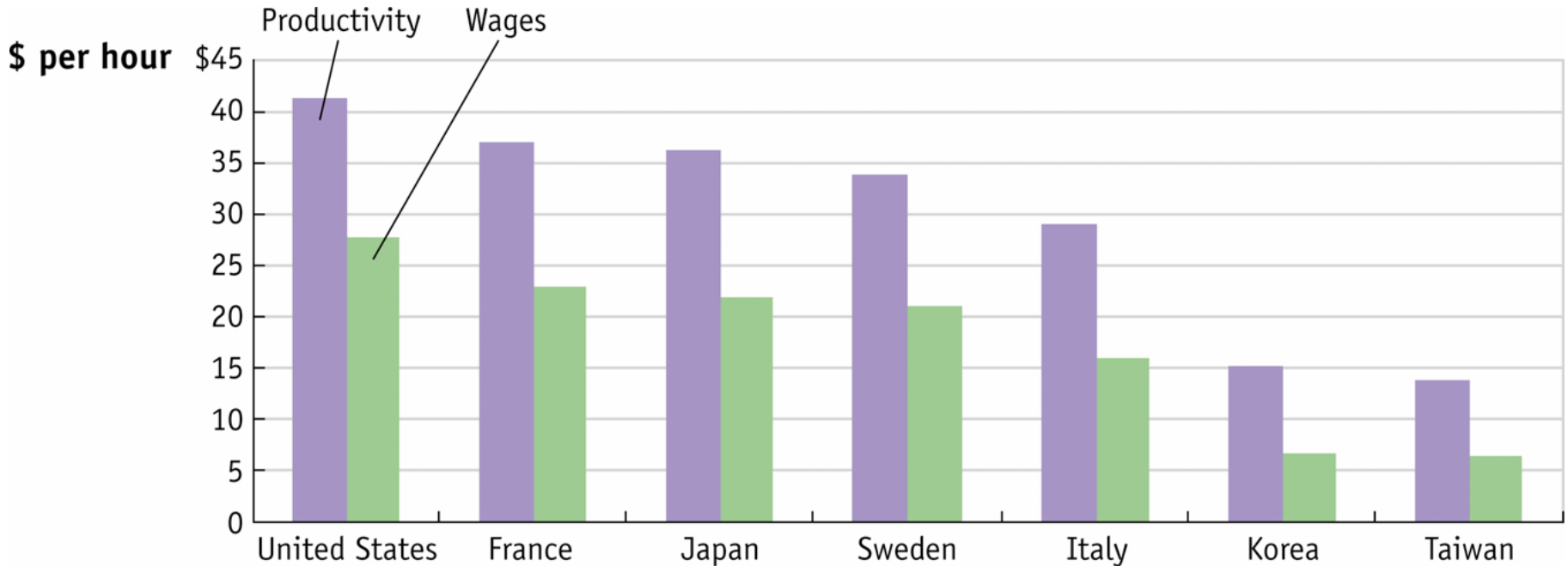


Figure 2.7: Labor Productivity and Wages, 2001

# 3.1 Trade and wages - empirics

- Figure 2.8 shows connection between productivity and wages over time.
  - General upward movement in labor productivity is matched by upward movement in wages.
  - This is also predicted by the Ricardian Model - relative wages of two countries reflect their relative productivity.

# 3.1 Trade and wages - empirics

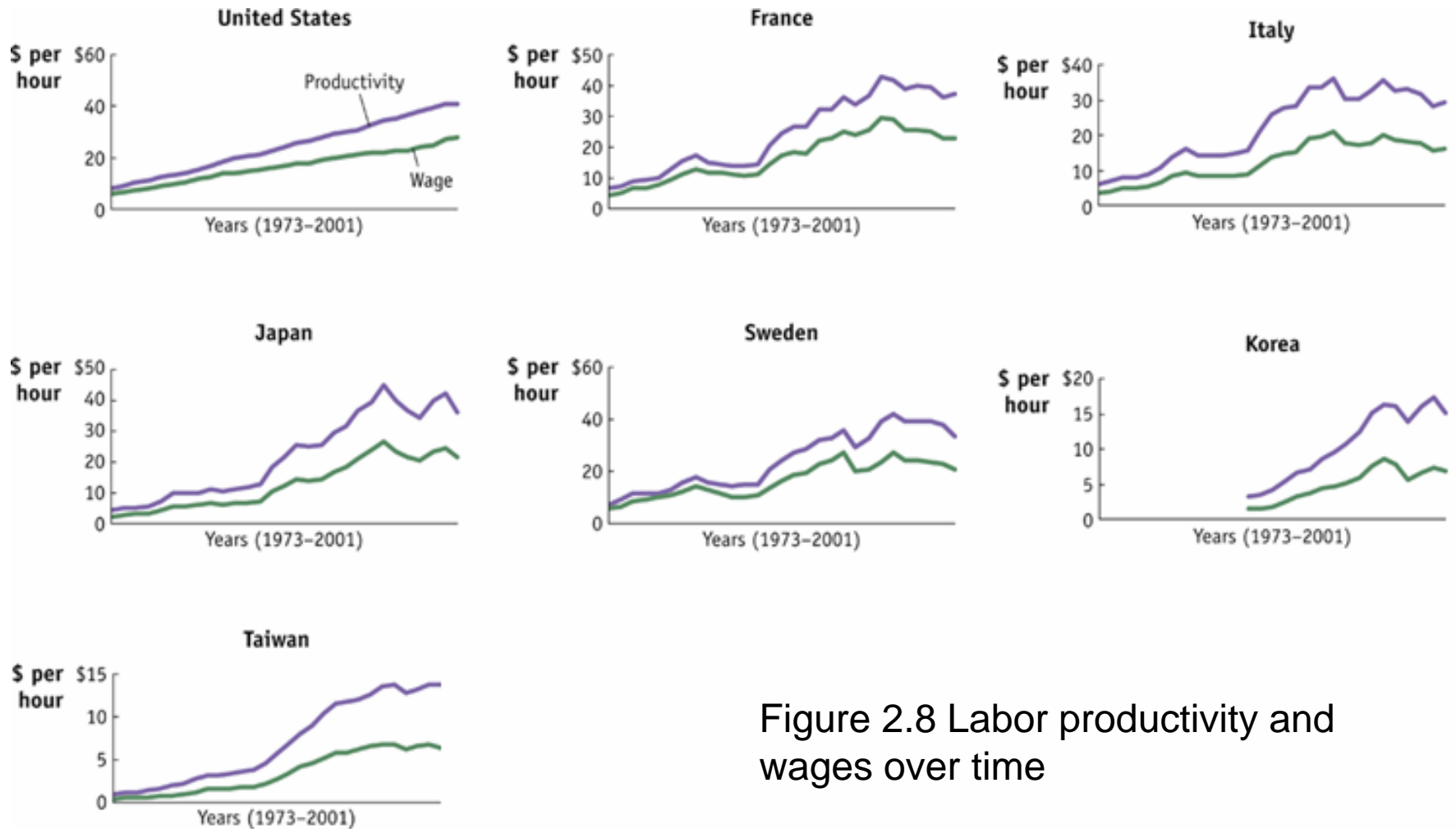


Figure 2.8 Labor productivity and wages over time

# 4. Solving for international prices

- In the previous analysis we assumed the world price of wheat was  $P_W/P_C = 2/3$ .
- In reality world price is determined by a market for exports and imports.
- We will derive a Home export supply curve.
  - Shows the amount it wants to export at various relative prices.
- Similarly we will derive a Foreign import demand curve.
  - Shows the amount of wheat that it will import at various relative prices.

# 4. Solving for international prices

## Home Export Supply Curve

- The export supply curve has the relative price of wheat on the Y-axis and the amount of wheat on the X-axis.
- A relative price of  $\frac{2}{3}$  leads to exports of 60 bushels  
→ point C in Figure 2.9(a), point C' in Figure 2.9(b).
- With relative price of wheat  $\frac{1}{2}$ , Home exports of wheat are zero (no-trade equilibrium) → Points A and A'

# 4. Solving for international prices

- Points B and B': relative price of wheat at  $\frac{1}{2}$ .
  - Home could export some wheat in exchange for cloth.
  - Production could shift from A to any other place on the PPF - workers willing to shift between industries as the wages are the same.
- Assume all workers in wheat production.
  - With relative price of  $\frac{1}{2}$ , consumption still at A and difference between A and B is amount of wheat that Home is exporting.
  - At relative price of  $\frac{1}{2}$ , with wheat exports of 50, we get point B'.

# 4. Solving for international prices

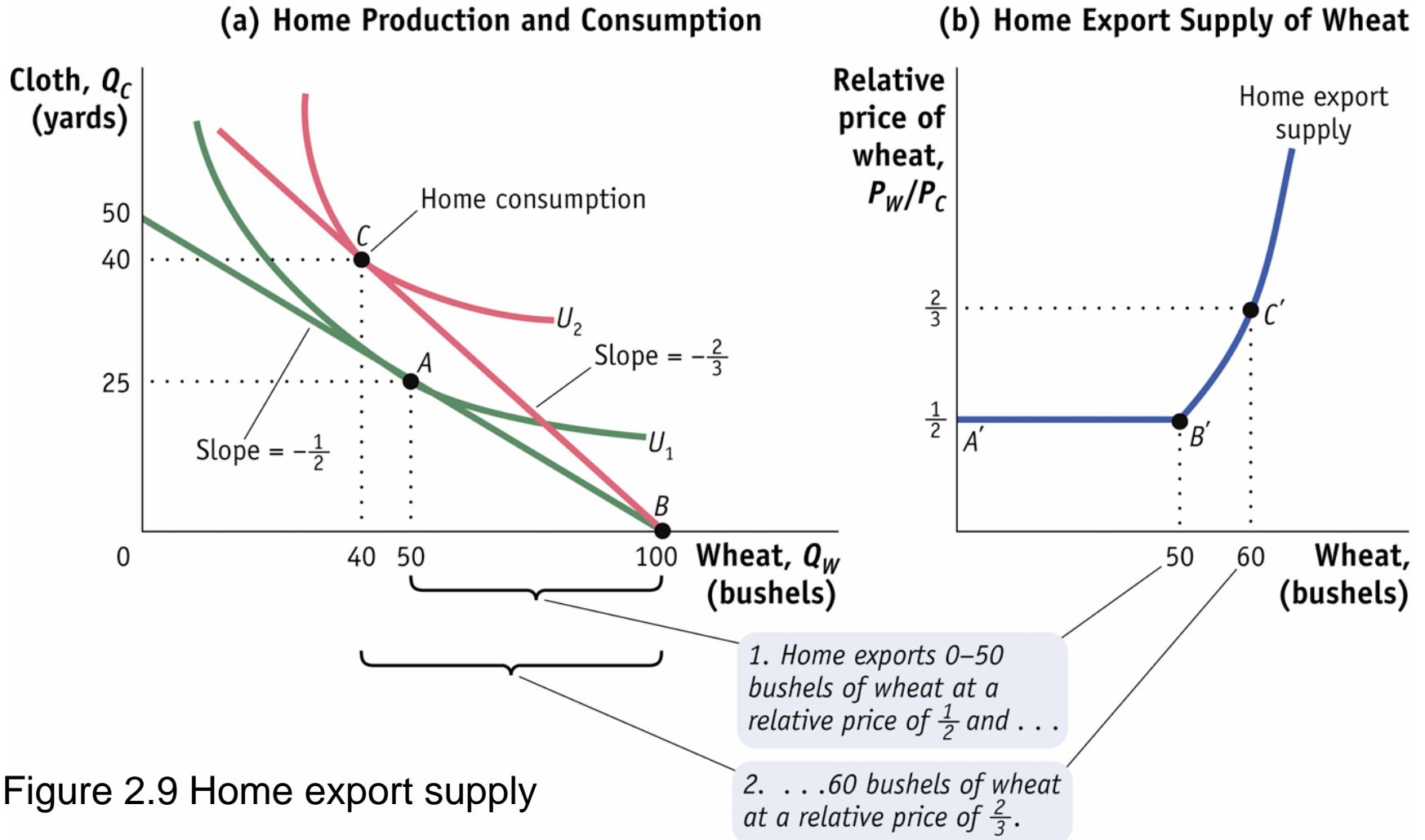


Figure 2.9 Home export supply

# 4. Solving for international prices

- Flat portion of the export supply curve special feature of Ricardian model.
  - The PPF is a straight line.
  - Production can occur anywhere along the PPF as workers shift between industries.
  - This leads to all export levels between A' and B'.
  - At prices above  $\frac{1}{2}$ , production is same but consumption changes, rising above point A.

# 4. Solving for international prices

## Foreign Import Demand

- At the world relative price of  $2/3$ , Foreign imports 60 bushels of wheat,  $C^*$  and  $C^{*'} in Figure 2.10.$
- No-trade equilibrium in Foreign with relative price of 1 is zero imports,  $A^*$  and  $A^{*'}$ .
- Production can shift from point A, at a price of 1, as workers move between industries:
  - If workers all shift to cloth.
  - Foreign imports 50 bushels of wheat,  $B^*$  and  $B^{*'}$ .
- This gives us the import demand curve.

# 4. Solving for international prices

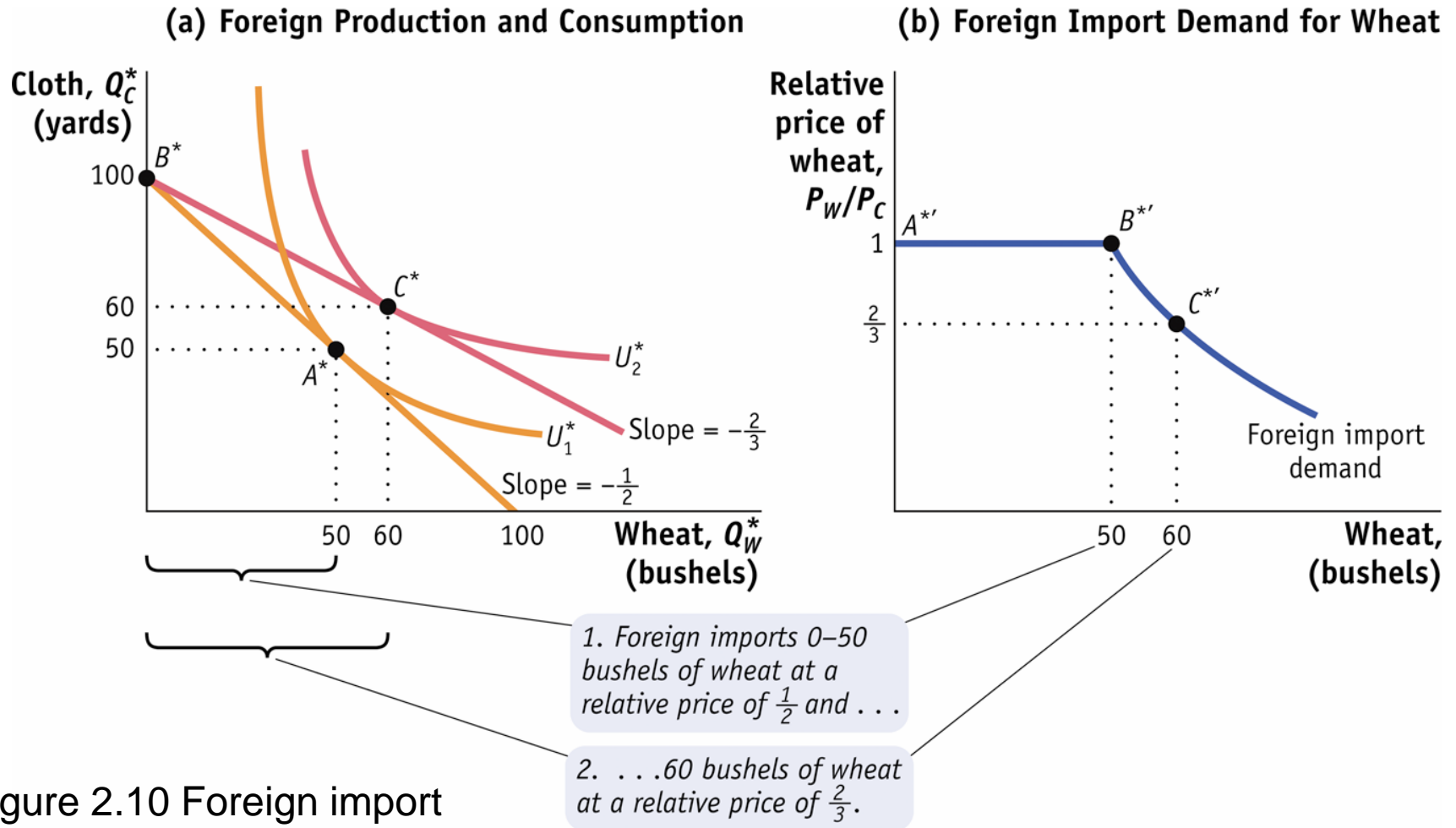


Figure 2.10 Foreign import demand

# 4. Solving for international prices

## International Trade Equilibrium

- The exports from Home come from the *excess domestic supply*.
- The imports to Foreign come from the *excess domestic demand*.
- *World market for wheat in Figure 2.11:*
  - Equilibrium price of  $2/3$  and trade of 60 bushels of wheat.
  - This is the amount that clears the world market.
  - Desired sales of Home equal the desired purchases by Foreign.

# 4. Solving for international prices

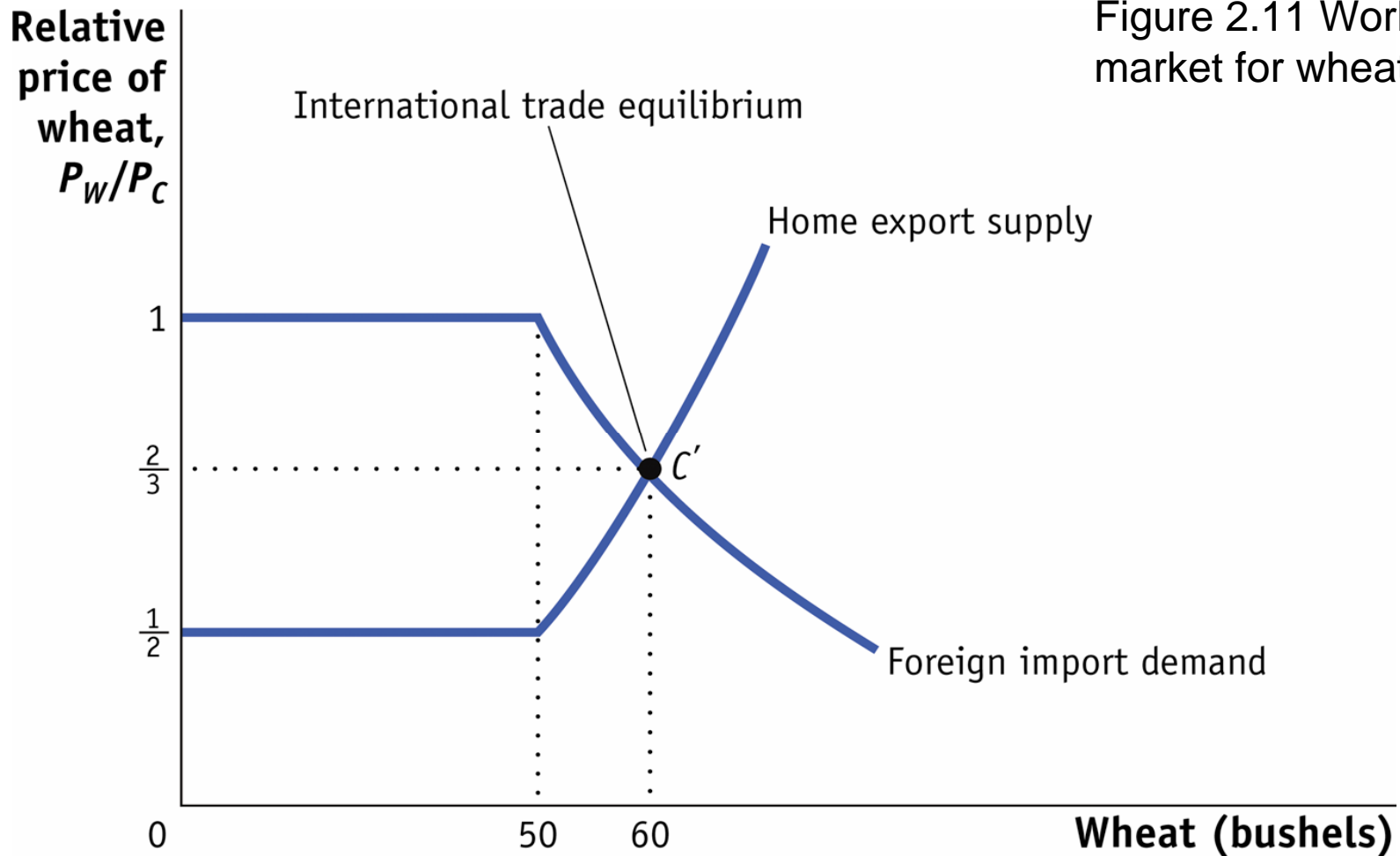


Figure 2.11 World market for wheat

# 4. Solving for international prices

## The Terms of Trade (ToT)

- Price of country's exports divided by price of its imports.
- For Home,  $P_X/P_Y = P_W/P_C$  is their terms of trade.
- An increase in  $P_W$  or a fall in  $P_C$  will raise Home's ToT.
- An increase in the terms of trade is good for a country: it makes it better off.
  - A country will earn more for its exports.
  - A country will pay less for its imports.
- For Foreign,  $P_C/P_W$  is the terms of trade and a higher relative price for cloth makes it better off.

# 4.1 Terms of Trade - empirics

## Prebisch-Singer hypothesis

- Latin American economist Raúl Prebisch and British economist Hans Singer each put forward the hypothesis that the price of primary commodities would decline over time relative to the price of manufactured goods.
- Primary commodities are often exported by developing countries, so their terms of trade would decline over time.

# 4.1 Terms of Trade - empirics

- This theory might be true for a couple of reasons:
  - First, as countries become richer, they spend a smaller share of their income on food. As world income grows, demand for food falls relative to the demand for manufactured goods. Therefore, the price of agricultural products can also be expected to fall relative to manufactured goods.
  - Second, for mineral products, industrialized countries continually find substitutes in the production of manufactured products. The substitution away from mineral products is a form of technological progress, and as it proceeds, can lead to a fall in the price of raw materials.

# 4.1 Terms of Trade - empirics

- There are also reasons why the theory might not be true:
  - First, technological progress in manufactured goods can lead to a fall in the price of these goods as they become easier to produce. This is a fall in terms of trade for industrialized countries rather than developing countries.
  - Second, at least for oil, the cartel restricting prices has caused an increase in the terms of trade for oil-exporting countries.
  - Third, the Hotelling Rule for non-renewable natural resources predicts rising resource prices as the reserves are depleted.

# 4.1 Terms of trade - empirics

- Figure 2.12 shows 24 primary commodities from 1900–1998, with their world price relative to the overall price of manufactured goods (from Kellard & Wohar 2006, JDE).
- There are some commodities that follow the pattern predicted by Prebisch and Singer, with falling prices relative to manufacturing.
- However, this is not the general rule—other primary commodities have had increasing or non-consistent change in their prices.

# 4.1 Terms of Trade - empirics

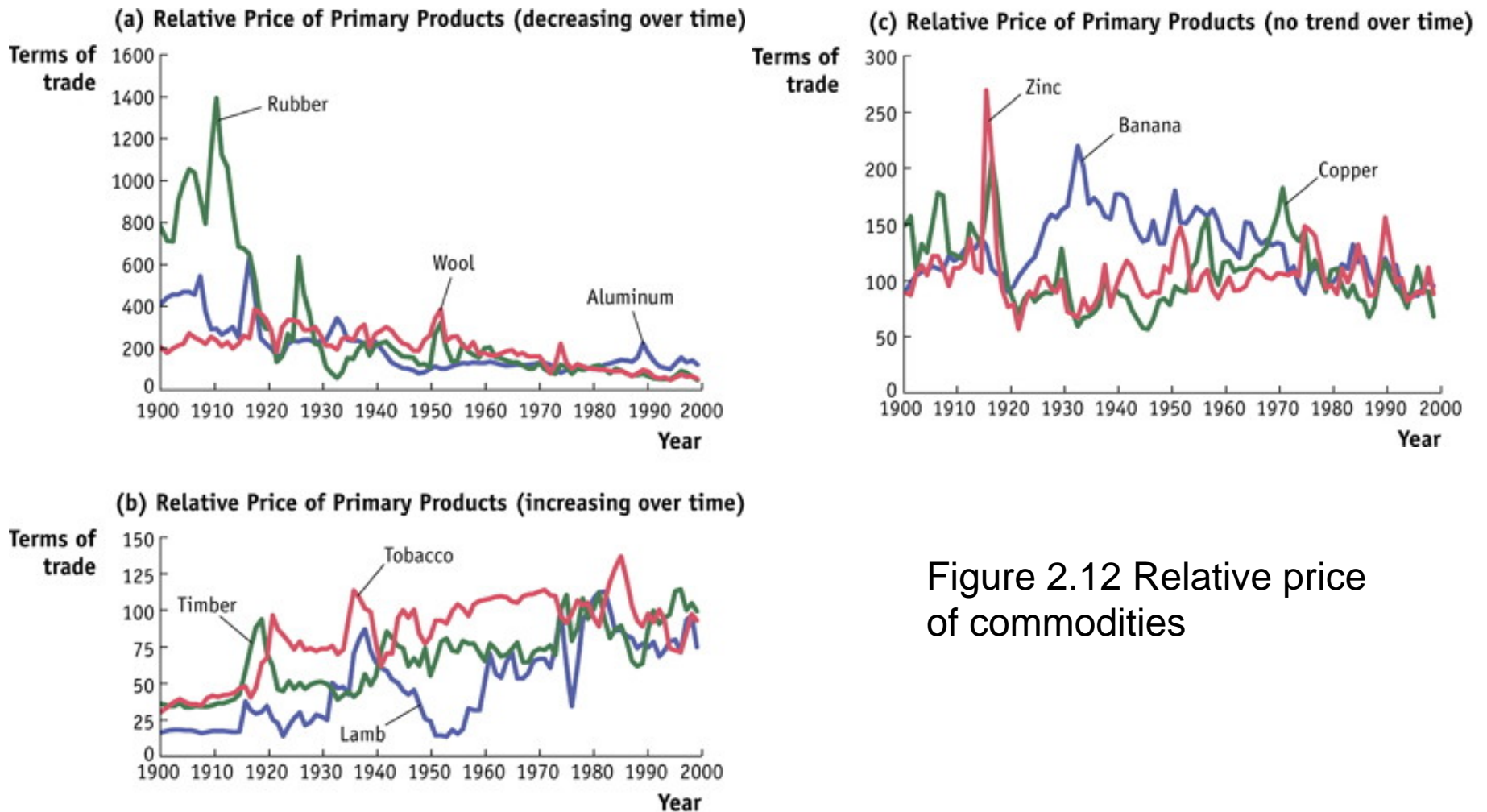


Figure 2.12 Relative price of commodities

# 4.1 Terms of trade - empirics

- Oil price has accounted for a large part of ToT fluctuations over recent decades.
- Figure 2.13 shows a plot of the ToT and crude oil prices for Canada and the U.S. 1955-1992 (from Backus & Crucini, 1998, NBER). *Note: ToT plotted as ratio of implicit deflator of imports over exports!*
  - ToT very volatile, shifting by 20% or more within a few years. Most dramatic shifts occur with large oil price fluctuations.
  - Negative correlation in Canada, positive correlation in U.S.: Canada net exporter of oil, U.S. net importer of oil, therefore opposite correlation patterns make sense!

# 4.1 Terms of Trade - empirics

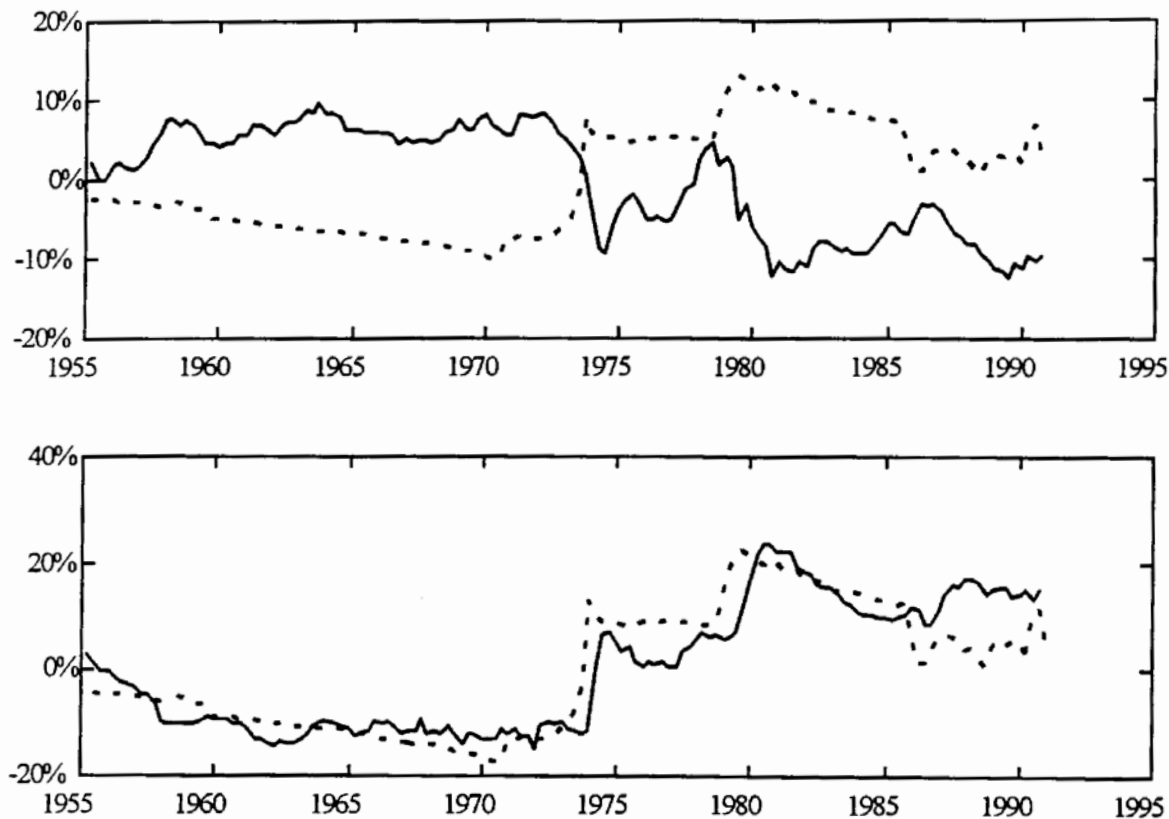


Figure 2.13 ToT and the price of crude oil in Canada (above) and the U.S. (below)

Source: Backus & Crucini (1998), NBER WP 6697

Fig. 1. The figure presents the terms of trade expressed as the ratio of the implicit deflator for imports to exports (solid lines) for Canada (upper panel) and the United States (lower panel). The dashed line is the international price of crude petroleum expressed in constant U.S. dollars (see the data appendix for the details of its construction) and normalized such that the sample standard deviation matches the standard deviation of the terms of trade with which it is plotted.

## 4.2 Gains from trade - empirics

- Direct measure of gains from trade difficult because one needs to compare autarky (which is virtually impossible to observe empirically) to free trade.
- On conceptual level: international trade seems to make countries better off since they could, in principle, refuse to trade with other countries (revealed preference argument).
- Policy of self-sufficiency is generally no more sensible for a country than it is for an individual.

## 4.2 Gains from trade - empirics

Historical examples of (nearly) no-trade to free-trade:

- Japan moved from a position of autarky in 1858 to one of nearly free trade in the 1870s.
  - Foreign trade rose from a negligible percentage of national income to about 7 percent, real national income rose by as much as 65% in 15 years, and terms of trade improved by 340%!
- US ban on overseas shipping in 1807 (during Napoleonic Wars) aimed against Britain.
  - Embargo effective but costly: real income in U.S. fell by about 5 percent of 1807's GNP (estimate), at a time when the trade share was about 13 percent .

## 4.2 Gains from trade - empirics

- US ban on overseas shipping in 1807 (cont'd).
  - Welfare costs were in fact lower than trade share: embargo did not eliminate all trade, and domestic producers successfully shifted production toward goods that were formerly imported (import substitution).
  - Britain did not feel equal pain; after 14 months, embargo was repealed. Three years later, Britain and U.S. went to war.

# 5. Conclusions

- The Ricardian model was devised to respond to the mercantilist idea that exports are good and imports are bad.
- David Ricardo found this was not true and considered an example where trade between two countries was balanced.
- Ricardian Model of trade:
  - Pattern of trade determined by comparative advantage.
  - Both countries gain from trade.
  - Only one factor of production—labor.

# 5. Conclusions

- Ricardian Model of trade (cont'd):
  - Because wages depend on the marginal products of labor in each country, they are determined by absolute advantage.
    - Country with better technology will be able to pay higher wages.
    - In addition, wages depend on the prices prevailing on world markets for the goods exported by each country.
  - Because we assume that labor is the only resource, the PPF in the Ricardian model is a straight line.
    - This leads to the export supply and import demand curves each have a flat segment.

# 5. Conclusions

- The terms of trade is commonly defined as the price of a country's exports divided by the price of its imports.
- Empirical evidence supports two principal implications – productivity differences are important and comparative rather than absolute advantages matters.