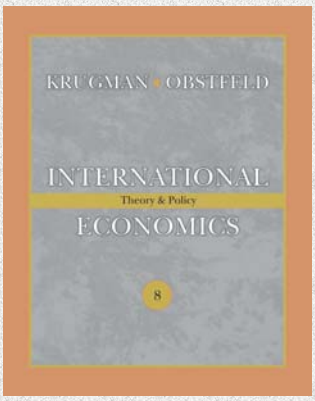


Chapter 3

Labor Productivity and Comparative Advantage: The Ricardian Model

Slides prepared by Thomas Bishop

Preview

- Opportunity costs and comparative advantage
- A one factor Ricardian model
- Production possibilities
- Gains from trade
- Wages and trade
- Misconceptions about comparative advantage
- Transportation costs and non-traded goods
- Empirical evidence

Introduction

- Theories of why trade occurs can be grouped into two categories:

a) Differences in labor, labor skills, physical capital, natural resources, and technology create productive advantages for countries.

b) Economies of scale (a larger scale is more efficient) create productive advantages for countries.

Introduction (cont.)

- The Ricardian model (chapter 3) says differences in the *productivity of labor* between countries cause productive differences, leading to gains from trade.
  - Differences in productivity are usually explained by differences in *technology*.
- The Heckscher-Ohlin model (chapter 4) says differences in *labor, labor skills, physical capital, land, or other factors of production* between countries cause productive differences, leading to gains from trade.

Comparative Advantage and Opportunity Cost

- The Ricardian model uses the concepts of *opportunity cost* and *comparative advantage*.
- The opportunity cost of producing something measures the cost of not being able to produce something else because resources have already been used.

Comparative Advantage and Opportunity Cost (cont.)

- A country faces opportunity costs when it employs resources to produce goods and services.
- For example, a limited number of workers could be employed to produce either roses or computers.
  - The opportunity cost of producing computers is the amount of roses not produced.
  - The opportunity cost of producing roses is the amount of computers not produced.
  - A country faces a trade off: how many computers or roses should it produce with the limited resources that it has?

Comparative Advantage and Opportunity Cost (cont.)

- Suppose that in the U.S. 10 million roses could be produced with the same resources that could produce 100,000 computers.
- Suppose that in Ecuador 10 million roses could be produced with the same resources that could produce 30,000 computers.
- Workers in Ecuador would be less productive than those in the U.S. in manufacturing computers.
- Quick quiz: what is the opportunity cost for Ecuador if it decides to produce roses?

Comparative Advantage and Opportunity Cost (cont.)

- Ecuador has a lower opportunity cost of producing roses.
  - Ecuador can produce 10 million roses, compared to 30,000 computers that it could otherwise produce.
  - The US can produce 10 million roses, compared to 100,000 computers that it could otherwise produce.

Comparative Advantage and Opportunity Cost (cont.)

- The US has a lower opportunity cost of producing computers.
  - Ecuador can produce 30,000 computers, compared to 10 million roses that it could otherwise produce.
  - The US can produce 100,000 computers, compared to 10 million roses that it could otherwise produce, or
  - The US can produce 30,000 computers, compared to 3.3 million roses that it could otherwise produce.

Comparative Advantage and Opportunity Cost (cont.)

- A country has a **comparative advantage** in producing a good if the opportunity cost of producing that good is lower in the country than it is in other countries.
- A country with a comparative advantage in producing a good uses its resources most efficiently when it produces that good *compared to producing other goods*.

Comparative Advantage and Opportunity Cost (cont.)

- The U.S. has a comparative advantage in computer production: it uses its resources more efficiently in producing computers compared to other uses.
- Ecuador has a comparative advantage in rose production: it uses its resources more efficiently in producing roses compared to other uses.
- Suppose initially that Ecuador produces computers and the U.S. produces roses, and that both countries want to consume computers and roses.
- Can both countries be made better off?

Comparative Advantage and Trade

	Millions of Roses	Thousands of Computers
U.S.	-10	+100
Ecuador	+10	-30
Total	0	+70

Comparative Advantage and Trade (cont.)

- In this simple example, we see that when countries specialize in production in which they have a comparative advantage, more goods and services can be produced and consumed.
  - Initially both countries could only consume 10 million roses and 30 thousand computers.
  - If they produce goods in which they had a comparative advantage, they could still consume 10 million roses, but could consume 100,000 – 30,000 = 70,000 more computers.

A One Factor Ricardian Model

- The simple example with roses and computers explains the intuition behind the Ricardian model.
- We formalize these ideas by constructing a slightly more complex one factor Ricardian model using the following simplifying assumptions:

A One Factor Ricardian Model (cont.)

1. Labor services are the only resource important for production.
2. Labor productivity varies across countries, usually due to differences in technology, but labor productivity in each country is constant across time.
3. The supply of labor services in each country is constant.
4. Only two goods are important for production and consumption: wine and cheese.
5. Competition allows workers to be paid a “competitive” wage, a function of their productivity and the price of the good that they can sell, and allows them to work in the industry that pays the highest wage.
6. Only two countries are modeled: domestic and foreign.

A One Factor Ricardian Model (cont.)

- Because labor productivity is constant, define a **unit labor requirement** as the constant number of hours of labor required to produce one unit of output.
  - a_{LW} is the unit labor requirement for wine in the domestic country. For example, if a_{LW} = 2, then it takes 2 hours of labor to produce one liter of wine in the domestic country.
  - a_{LC} is the unit labor requirement for cheese

A One Factor Ricardian Model (cont.)

- Because the supply of labor is constant, denote the total number of labor hours worked in the domestic country as a constant number L.

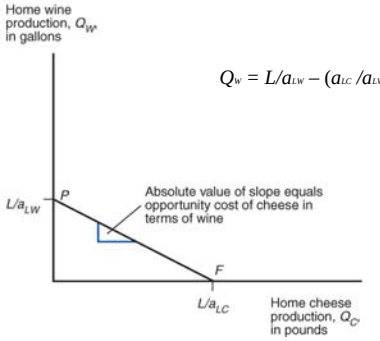
Production Possibilities

- The **production possibility frontier** (PPF) of an economy shows the *maximum* amount of a goods that can be produced for a fixed amount of resources.
- If Q_C represents the quantity of cheese produced and Q_W represents the quantity of wine produced, then the production possibility frontier of the domestic economy has the equation:

$$a_{LC}Q_C + a_{LW}Q_W = L$$

- a_{LC}: Labor required for each unit of cheese production
- Q_C: Total units of cheese production
- a_{LW}: Labor required for each unit of wine production
- Q_W: Total units of wine production
- L: Total amount of labor resources

Fig. 3-1: Home's Production Possibility Frontier



Production Possibilities (cont.)

$$a_{LC}Q_C + a_{LW}Q_W = L$$

- $Q_C = L/a_{LC}$ when $Q_W = 0$
- $Q_W = L/a_{LW}$ when $Q_C = 0$
- $Q_W = L/a_{LW} - (a_{LC}/a_{LW})Q_C$: the equation for the PPF, with a slope equal to $-(a_{LC}/a_{LW})$
- When the economy uses all of its resources, the opportunity cost of cheese production is the quantity of wine that is given up (reduced) as Q_C increases: (a_{LC}/a_{LW})
- When the economy uses all of its resources, the opportunity cost is equal to the absolute value of the slope of the PPF, and it is constant when unit labor requirements are constant.

Production Possibilities (cont.)

- To produce an additional kg of cheese requires a_{LC} hours of work.
- *Each* hour devoted to cheese production could have been used to produce a certain amount of wine instead, equal to

  1 hour/(a_{LW} hours/liter of wine)

  = ($1/a_{LW}$) liter of wine
- For example, if 1 hour is moved to cheese production, that additional hour of labor could have produced 1 hour/(2 hours/liter of wine) = 1/2 liter of wine.
- The trade-off is the increased amount of cheese relative to the decreased amount of wine: a_{LC}/a_{LW}.

Production Possibilities (cont.)

- In general, the amount of the domestic economy's production is defined by $a_{LC}Q_C + a_{LW}Q_W \leq L$
- This describes what an economy can produce, but to determine what the economy does produce, we must determine the prices of goods.

Production, Prices and Wages

- Let P_C be the price of cheese and P_W be the price of wine.
- Because of competition,
  - hourly wages of cheese makers are equal to the market value of the cheese produced in an hour: P_C/a_{LC}
  - hourly wages of wine makers are equal to the market value of the wine produced in an hour: P_W/a_{LW}
- Because workers like high wages, they will work in the industry that pays a higher hourly wage.

Production, Prices and Wages (cont.)

- If $P_C/a_{LC} > P_W/a_{LW}$ workers will make only cheese.
  - If $P_C/P_W > a_{LC}/a_{LW}$ workers will only make cheese.
  - The economy will specialize in cheese production if the price of cheese relative to the price of wine exceeds the opportunity cost of producing cheese.
- If $P_C/a_{LC} < P_W/a_{LW}$ workers will make only wine.
  - If $P_C/P_W < a_{LC}/a_{LW}$ workers will only make wine.
  - If $P_W/P_C > a_{LW}/a_{LC}$ workers will only make wine.
  - The economy will specialize in wine production if the price of wine relative to the price of cheese exceeds the opportunity cost of producing wine.

Production, Prices and Wages (cont.)

- If the domestic country wants to consume both wine and cheese (in the absence of international trade), relative prices must adjust so that wages are equal in the wine and cheese industries.
  - If $P_C/a_{LC} = P_W/a_{LW}$ workers will have no incentive to work solely in the cheese industry or the wine industry, so that production of both goods can occur.
  - $P_C/P_W = a_{LC}/a_{LW}$
  - Production (and consumption) of both goods occurs when the relative price of a good equals the opportunity cost of producing that good.

Trade in the Ricardian Model

- Suppose that the domestic country has a comparative advantage in cheese production: its opportunity cost of producing cheese is lower than it is in the foreign country.

$$a_{LC}/a_{LW} < a^*_{LC}/a^*_{LW}$$

When the domestic country increases cheese production, it reduces wine production less than the foreign country would because the domestic unit labor requirement of cheese production is low compared to that of wine production.

  - where "*" notates foreign country variables

Trade in the Ricardian Model (cont.)

- Suppose the domestic country is more efficient in wine and cheese production.
- It has an ***absolute advantage*** in all production: its unit labor requirements for wine and cheese production are lower than those in the foreign country:
  - $a_{LC} < a^*_{LC}$ *and* $a_{LW} < a^*_{LW}$
- A country can be more efficient in producing both goods, but it will have a comparative advantage in only one good—the good that uses resources most efficiently compared to alternative production.

Trade in the Ricardian Model (cont.)

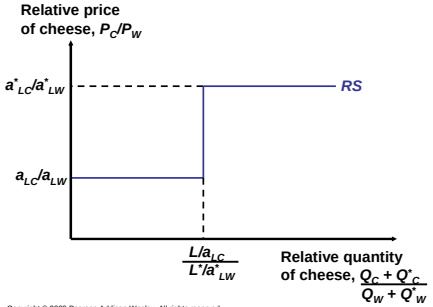
- Even if a country is the most (or least) efficient producer of all goods, it still can benefit from trade.
- To see how all countries can benefit from trade, we calculate relative prices when trade exists.
  - Without trade, the relative price of a good equals the opportunity cost of producing that good.
- To calculate relative prices with trade, we first calculate relative quantities of *world* production:

$$(Q_C + Q^*_C)/(Q_W + Q^*_W)$$

Relative Supply and Relative Demand

- Next we consider **relative supply** of cheese: the quantity of cheese supplied by all countries relative to the quantity of wine supplied by all countries at each price of cheese relative to the price of wine, P_c/P_W.

Relative Supply and Relative Demand (cont.)



Relative Supply and Relative Demand (cont.)

- There is no supply of cheese if the relative price of cheese falls below a_{LC}/a_{LW}.
  - Why? because the domestic country will specialize in wine production whenever $P_C/P_W < a_{LC}/a_{LW}$
  - And we assumed that $a_{LC}/a_{LW} < a^*_{LC}/a^*_{LW}$ so foreign workers won't find it desirable to produce cheese either.
- When $P_C/P_W = a_{LC}/a_{LW}$, domestic workers will be indifferent between producing wine or cheese, but foreign workers will still produce only wine.

Relative Supply and Relative Demand (cont.)

- When $a^*_{LC}/a^*_{LW} > P_c/P_W > a_{LC}/a_{LW}$, domestic workers specialize in cheese production because they can earn higher wages, but foreign workers will still produce only wine.
- When $a^*_{LC}/a^*_{LW} = P_C/P_W$, foreign workers will be indifferent between producing wine or cheese, but domestic workers will still produce only cheese.
- There is no supply of wine if the relative price of cheese rises above a^*_{LC}/a^*_{LW}

Relative Supply and Relative Demand (cont.)

- Relative demand of cheese is the quantity of cheese demanded in all countries relative to the quantity of wine demanded in all countries at each price of cheese relative to the price of wine, P_C/P_W.
- As the price of cheese relative to the price of wine rises, consumers in all countries will tend to purchase less cheese and more wine so that the relative quantity of cheese demanded falls.

Relative Supply and Relative Demand (cont.)

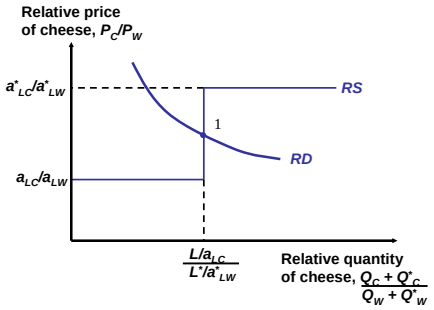
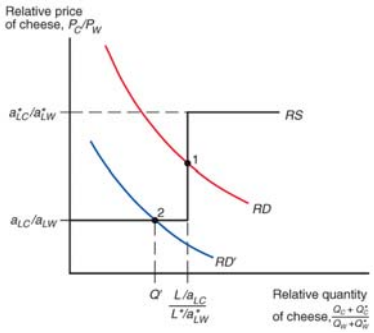


Fig. 3-3: World Relative Supply and Demand



Gains From Trade

- Gains from trade come from specializing in the type of production which uses resources most efficiently, and using the income generated from that production to buy the goods and services that countries desire.
  - where "using resources most efficiently" means producing a good in which a country has a comparative advantage.
- Domestic workers earn a higher income from cheese production because the relative price of cheese increases with trade.

Gains From Trade (cont.)

- Foreign workers earn a higher income from wine production because the relative price of cheese decreases with trade (making cheese cheaper) and the relative price of wine increases with trade.

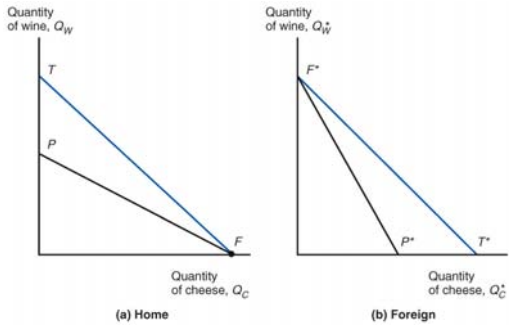
Gains From Trade (cont.)

- Think of trade as an indirect method of production or a new technology that converts cheese into wine or vice versa.
- Without the technology, a country has to allocate resources to produce all of the goods that it wants to consume.
- With the technology, a country can specialize its production and trade ("convert") the products for the goods that it wants to consume.

Gains From Trade (cont.)

- We show how consumption possibilities expand beyond the production possibility frontier when trade is allowed.
- Without trade, consumption is restricted to what is produced.
- With trade, consumption in each country is expanded because world production is expanded when each country specializes in producing the good in which it has a comparative advantage.

Fig. 3-4: Trade Expands Consumption Possibilities



A Numerical Example

Unit labor requirements for domestic and foreign countries		
	Cheese	Wine
Domestic	a_{LC} = 1 hour/kg	a_{LW} = 2 hours/L
Foreign	a^*_{LC} = 6 hours/kg	a^*_{LC} = 3 hours/L

- $a_{LC}/a_{LW} = 1/2 < a^*_{LC}/a^*_{LW} = 2$

A Numerical Example (cont.)

- The domestic country is more efficient in both industries, but it has a comparative advantage only in cheese production.
- The foreign country is less efficient in both industries, but it has a comparative advantage in wine production.
- Quick quiz: what is the domestic country's opportunity cost of producing wine? what is its opportunity cost of producing cheese?

A Numerical Example (cont.)

- With trade, the equilibrium relative price of cheese must be between $a_{LC}/a_{LW} = 1/2$ and $a^*_{LC}/a^*_{LW} = 2$
- Suppose that $P_C/P_W = 1$ in equilibrium.
  - In words, one kg of cheese trades for one liter of wine.

A Numerical Example (cont.)

- If the domestic country does not trade, it can use one hour of labor to produce $1/a_{LW}$ = 1/2 liter of wine.
- If the domestic country does trade, it can use one hour of labor to produce $1/a_{LC}$ = 1 kg of cheese, sell this amount to the foreign country at current prices to obtain **1 liter of wine**.
- If the foreign country does not trade, it can use one hour of labor to produce $1/a^*_{LC}$ = 1/6 kg of cheese.
- If the foreign country does trade, it can use one hour of labor to produce $1/a^*_{LW}$ = 1/3 liter of wine, sell this amount to the domestic country at current prices to obtain **1/3 kg of cheese**.

Relative Wages

- **Relative wages** are the wages of the domestic country relative to the wages in the foreign country.
- Although the Ricardian model predicts that relative prices equalize across countries after trade, it does not predict that relative wages will do the same.
- Productivity (technological) differences determine wage differences in the Ricardian model.
  - A country with absolute advantage in producing a good will enjoy a higher wage in that industry after trade.

Relative Wages (cont.)

- Suppose that P_C = \$12/kg and P_W = \$12/L
- Since domestic workers specialize in cheese production after trade, their hourly wages will be

$$(1/a_{LC})P_C = (1/1)\$12 = \$12$$

- Since foreign workers specialize in wine production after trade, their hourly wages will be

$$(1/a^*_{LW})P_W = (1/3)\$12 = \$4$$

- The relative wage of domestic workers is therefore

$$\$12/\$4 = 3$$

Relative Wages (cont.)

- The relative wage lies between the ratio of the productivities in each industry.
  - The domestic country is 6/1 = 6 times as productive in cheese production, but only 3/2 = 1.5 times as productive in wine production.
  - The domestic country has a wage rate 3 times as high as that in the foreign country.
- These relationships imply that both countries have a *cost advantage* in production.
  - The cost of high wages can be offset by high productivity.
  - The cost of low productivity can be offset by low wages.

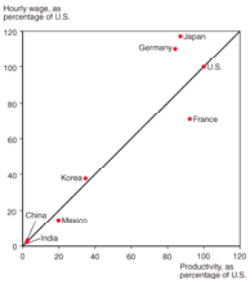
Relative Wages (cont.)

- Because foreign workers have a wage that is only 1/3 the wage of domestic workers, they are able to attain a cost advantage (in wine production), despite low productivity.
- Because domestic workers have a productivity that is 6 times that of foreign workers (in cheese production), they are able to attain a cost advantage, despite high wages.

Do Wages Reflect Productivity?

- In the Ricardian model, relative wages reflect relative productivities of the two countries.
- Is this an accurate assumption?
- Some argue that low wage countries pay low wages despite growing productivity, putting high wage countries at a cost disadvantage.
- But evidence shows that low wages are associated with low productivity.

Productivity and Wages



Source: International Labor Organization, World Bank, Bureau of Labor Statistics, and Orley Ashenfelter and Stepan Jurajda, "Cross-country Comparisons of Wage Rates," working paper, Princeton University

Do Wages Reflect Productivity? (cont.)

- Other evidence shows that wages rise as productivity rises.
  - In 2000, South Korea's labor productivity was 35% of the U.S. level and its average wages were about 38% of U.S. average wages.
  - After the Korean War, South Korea was one of the poorest countries in the world, and its labor productivity was very low. Even by 1975, average wages in South Korea were still only 5% of U.S. average wages.

Misconceptions About Comparative Advantage

1. Free trade is beneficial only if a country is more productive than foreign countries.
   - But even an unproductive country benefits from free trade by avoiding the high costs for goods that it would otherwise have to produce domestically.
   - High costs derive from inefficient use of resources.
   - The benefits of free trade do not depend on absolute advantage, rather they depend on comparative advantage: specializing in industries that use resources most efficiently.

Misconceptions About Comparative Advantage (cont.)

2. Free trade with countries that pay low wages hurts high wage countries.
   - While trade may reduce wages for *some* workers, thereby affecting the distribution of income within a country, trade benefits consumers and other workers.
   - Consumers benefit because they can purchase goods more cheaply.
   - Producers/workers benefit by earning a higher income in the industries that use resources more efficiently, allowing them to earn higher prices and wages.

Misconceptions About Comparative Advantage (cont.)

3. Free trade exploits less productive countries.
   - While labor standards in some countries are less than exemplary compared to Western standards, they are so with or without trade.
   - Are high wages and safe labor practices alternatives to trade? Deeper poverty and exploitation (ex., involuntary prostitution) may result without export production.
   - Consumers benefit from free trade by having access to cheaply (efficiently) produced goods.
   - Producers/workers benefit from having higher profits/wages—higher compared to the alternative.

Comparative Advantage With Many Goods

- Suppose now there are N goods produced, indexed by $i = 1,2,\ldots N$.
- The domestic country's unit labor requirement for good i is a_{Li}, and that of the foreign country is a^*_{Li}

Comparative Advantage With Many Goods (cont.)

- Goods will be produced wherever it is cheaper to produce them.
- Let w represent the wage rate in the domestic country and w^* represent the wage rate in the foreign country.
  - If $wa_{L1} < w^*a^*_{L1}$ then only the domestic country will produce good 1, since total wage payments are less there.
  - Or equivalently, if $a^*_{L1}/a_{L1} > w/w^*$
  - If the relative productivity of a country in producing a good is higher than the relative wage, then the good will be produced in that country.

Comparative Advantage With Many Goods (cont.)

- Suppose there are 5 goods produced in the world:

Good	Home Unit Labor Requirement (a_{Li})	Foreign Unit Labor Requirement (a^*_{Li})	Relative Home Productivity Advantage (a^*_{Li}/a_{Li})
Apples	1	10	10
Bananas	5	40	8
Caviar	3	12	4
Dates	6	12	2
Enchiladas	12	9	0.75

Comparative Advantage With Many Goods (cont.)

- If $w/w^* = 3$, the domestic country will produce apples, bananas, and caviar, while the foreign country will produce dates and enchiladas.
  - The relative productivities of the domestic country in producing apples, bananas, and caviar are higher than the relative wage.

Comparative Advantage With Many Goods (cont.)

- If each country specializes in goods that use resources productively and trades the products for those that it wants to consume, then each benefits.
  - If a country tries to produce all goods for itself, resources are "wasted".
- The domestic country has high productivity in apples, bananas, and caviar that give it a cost advantage, despite its high wage.
- The foreign country has low wages that give it a cost advantage, despite its low productivity in date production.

Comparative Advantage With Many Goods (cont.)

- How is the relative wage determined?
- By the relative supply and relative (derived) demand of labor services.
- The relative (derived) demand of domestic labor services falls when w/w^* rises. As domestic labor services become more expensive relative to foreign labor services,
  - goods produced in the domestic country become more expensive, and demand of these goods and the labor services to produce them falls.
  - fewer goods will be produced in the domestic country, further reducing the demand of domestic labor services.

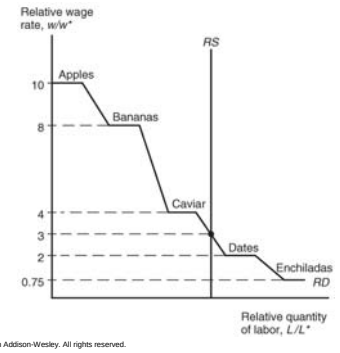
Table 3-3: Home and Foreign Unit Labor Requirements

Good	Home Unit Labor Requirement (a_{Li})	Foreign Unit Labor Requirement (a^*_{Li})	Relative Home Productivity Advantage (a^*_{Li}/a_{Li})
Apples	1	10	10
Bananas	5	40	8
Caviar	3	12	4
Dates	6	12	2
Enchiladas	12	9	0.75

Comparative Advantage With Many Goods (cont.)

- Suppose w/w^* increases from 3 to 3.99:
  - The domestic country would produce apples, bananas, and caviar, but the demand of these goods and the labor to produce them would fall as the relative wage rises.
- Suppose w/w^* increases from 3.99 to 4.01:
  - Caviar is now too expensive to produce in the domestic country, so the caviar industry moves to the foreign country, causing a discrete (abrupt) drop in the demand of domestic labor services.
- Consider similar effects as w/w^* rises from 0.75 to 10.

Fig. 3-5: Determination of Relative Wages



Comparative Advantage With Many Goods (cont.)

- Finally, suppose that relative supply of labor is independent of w/w^* and is fixed at an amount determined by the populations in the domestic and foreign countries.

Transportation Costs and Non-traded Goods

- The Ricardian model predicts that countries should completely specialize in production.
- But this rarely happens for primarily three reasons:
  1. More than one factor of production reduces the tendency of specialization (chapter 4)
  2. Protectionism (chapters 8–11)
  3. Transportation costs reduce or prevent trade, which may cause each country to produce the same good or service

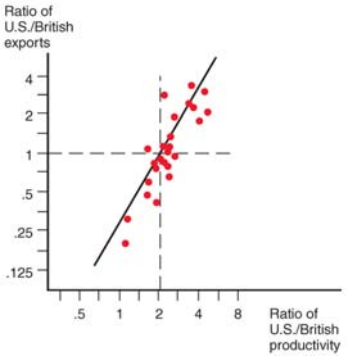
Transportation Costs and Non-traded Goods (cont.)

- Non-traded goods and services (ex., haircuts and auto repairs) exist due to high transportation costs.
  - Countries tend to spend a large fraction of national income on non-traded goods and services.
  - This fact has implications for the gravity model and for models that consider how income transfers across countries affect trade.

Empirical Evidence

- Do countries export those goods in which their productivity is relatively high?
- The ratio of U.S. to British exports in 1951 compared to the ratio of U.S. to British labor productivity in 26 manufacturing industries suggests yes.
- At this time the U.S. had an absolute advantage in *all* 26 industries, yet the ratio of exports was low in the least productive sectors of the U.S.

Fig. 3-6: Productivity and Exports



Summary

1. A country has a comparative advantage in producing a good if the opportunity cost of producing that good is lower in the country than it is in other countries.
   - A country with a comparative advantage in producing a good uses its resources most efficiently when it produces that good compared to producing other goods.
2. The Ricardian model focuses only on differences in the productivity of labor across countries, and it explains gains from trade using the concept of comparative advantage.

Summary (cont.)

3. When countries specialize and trade according to the Ricardian model; the relative price of the produced good rises, income for workers who produce the good rises and imported goods are less expensive for consumers.
4. Trade is predicted to benefit both high productivity and low productivity countries, although trade may change the distribution of income within countries.
5. High productivity *or* low wages give countries a cost advantage that allow them to produce efficiently.

Summary (cont.)

7. Although empirical evidence supports trade based on comparative advantage, transportation costs and other factors prevent complete specialization in production.

Additional Chapter Art

Table 3-1 Hypothetical Changes in Production

	Million Roses	Thousand Computers
United States	−10	+100
South America	+10	−30
Total	0	+70

Fig. 3-2 Foreign's Production Possibility Frontier

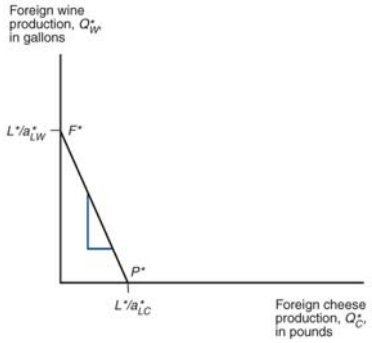


Table 3-2 Unit Labor Requirements

	Cheese	Wine
Home	a_{LC} = 1 hour per pound	a_{LW} = 2 hours per gallon
Foreign	a^*_{LC} = 6 hours per pound	a^*_{LW} = 3 hours per gallon

Table 3-4 China versus Germany, 1995

	Chinese output per worker as % of Germany	Total Chinese output as % of Germany
All manufacturing	5.2	71.6
Apparel	19.7	802.2

Source: Ren Ruoen and Bai Manying, "China's Manufacturing Industry in an International Perspective: A China-Germany Comparison," *Economie internationale*, no. 92–2002/4, pp. 103–130.