EC 111: Principles of Microeconomics

Lecture Notes, Chapters 2–3: The PPF and the Gains from Trade

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1 The PPF and the Gains from Trade

Chapter 1 listed the principles. This chapter builds the course's first model, the production possibilities frontier (PPF), and then uses it to answer the question behind Principle 5: how can trade make *both* sides better off, even when one side is better at producing everything? The material follows Mankiw's Chapters 2 and 3, in that order, with the middle of Chapter 2 left to your own reading.

1.1 Economists build models

Economists wear two hats. As *scientists*, they try to explain how the economy works: observe, build a theory that could explain what you saw, then look at new data to see whether the theory survives. As *policy advisers*, they try to improve it, which requires values as well as facts. A claim of the first kind is *positive*: it describes how the world is, and evidence could in principle confirm or refute it ("a $20 minimum wage would reduce teen employment"). A claim of the second kind is *normative*: it says how the world ought to be, and no dataset settles it on its own ("the minimum wage should be $20"). Positive does not mean true; it means testable. Watch for *should*, *ought*, and *needs to*.

Every science simplifies. A physicist studying a falling marble ignores air resistance because it barely matters; the same assumption would be foolish for a falling feather. Economists do the same thing. To study trade we assume the world has two countries, two goods, and one input. There are about 200 countries and millions of goods, but the small world captures the logic, and the logic does not change when the numbers grow.

Definition 1.1 (Economic model)**.** A simplified representation of some part of the economy, built from assumptions, and expressed in words, diagrams, or equations.

Key point

A model is judged by whether it answers the question at hand, not by how much of reality it reproduces. The art is choosing the assumption that fits the question: fixed prices are reasonable for next month and foolish for the next decade.

Note

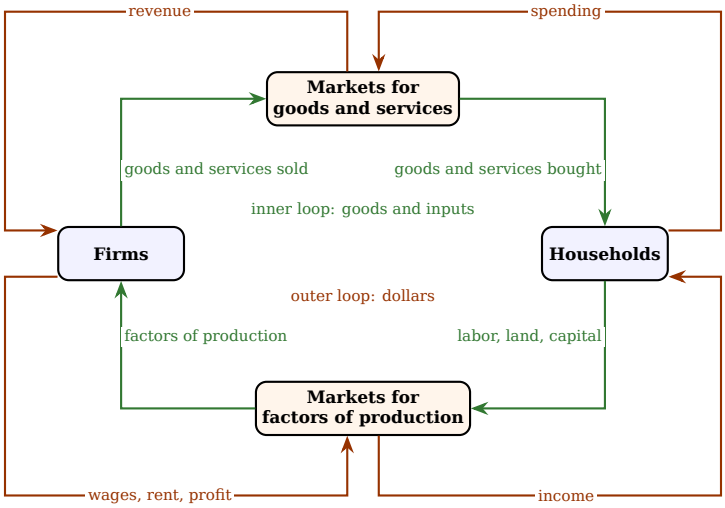
Mankiw's Chapter 2 also covers microeconomics versus macroeconomics, why economists disagree, and an appendix on graphs. We will not spend class time on them; read them once, since the MindTap homework draws on the chapter. The graphing rules (moving along a curve versus shifting it, slope, correlation versus causation) come back in Chapter 4, where they matter.

1.2 The circular-flow diagram

Definition 1.2 (Circular-flow diagram)**.** A visual model of the economy that shows how dollars flow through markets between households and firms.

The model has two kinds of decision makers and two kinds of markets.

- **Households** own the factors of production (labor, land, capital) and sell or rent them to firms. They use the income to buy goods and services.
- **Firms** hire the factors of production and use them to produce goods and services, which they sell to households.
- In the **market for goods and services**, firms are sellers and households are buyers.
- In the **market for factors of production**, households are sellers and firms are buyers.



The diagram has two loops. The inner loop shows real things: inputs move from households to firms, and goods and services move from firms to households. The outer loop shows dollars moving in the opposite direction: households spend on goods, that spending is revenue to firms, firms pay for inputs, and those payments are income to households.

Example 1.1 (Following a dollar)**.** You pay $5 for a coffee: spending in the market for goods and services, revenue to the cafe. The cafe pays it out as the barista's wage, the landlord's rent, and the owner's profit. All three are households, so the $5 is now income, and tomorrow it is spent again.

Note

The model leaves out the government, the financial system, and the rest of the world. That is deliberate. Adding them makes the diagram more realistic and, for the questions we ask now, no more useful.

1.3 The production possibilities frontier

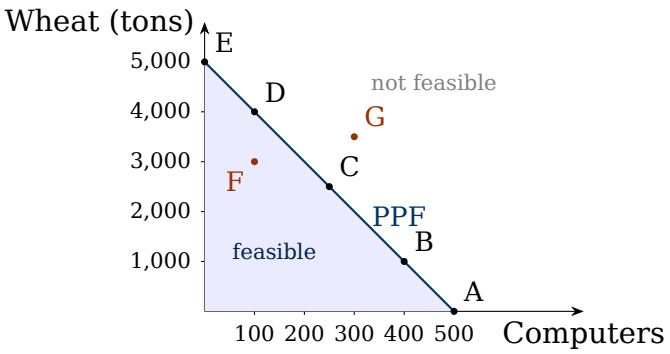
Definition 1.3 (Production possibilities frontier)**.** A graph showing the combinations of output that an economy can produce given its available factors of production and its technology.

We build the PPF from a small economy with one resource and two goods. Call it the United States; a second country arrives in Section 1.4.

- The only resource is labor: 50,000 hours per month.
- One computer takes 100 hours of labor. One ton of wheat takes 10 hours.
- Using all 50,000 hours on computers yields $50{,}000/100 = 500$ computers. Using all of them on wheat yields $50{,}000/10 = 5{,}000$ tons.

Every split of the 50,000 hours between the two industries gives one output combination. The table lists five; the graph plots them. Check one row: at C, 25,000 hours on computers produce $25{,}000/100 = 250$ computers, and the other 25,000 hours produce $25{,}000/10 = 2{,}500$ tons of wheat.

	Labor hours		Output	
Point	Comp.	Wheat	Comp.	Wheat (t)
A	50,000	0	500	0
B	40,000	10,000	400	1,000
C	25,000	25,000	250	2,500
D	10,000	40,000	100	4,000
E	0	50,000	0	5,000



The line through A to E is the PPF. Because the two goods use labor at fixed rates, the frontier is a straight line. The graph divides all output combinations into three groups.

- **On the frontier** (A through E): efficient. Every hour is used, and the only way to get more of one good is to give up some of the other.
- **Inside the frontier**: feasible but inefficient. Some labor is idle or badly used, and the economy could have more of both goods.
- **Outside the frontier**: not feasible with current resources and technology.

Example 1.2 (Points F and G)**.** Point F is 100 computers and 3,000 tons of wheat. It needs $100 \times 100 + 3{,}000 \times 10 = 10{,}000 + 30{,}000 = 40{,}000$ hours. That is less than 50,000, so F is feasible, but 10,000 hours are unused. F lies inside the frontier. Moving from F straight up to D (100 computers, 4,000 tons) or straight right to (200 computers, 3,000 tons) uses the idle hours and gives more of one good at no cost in the other.

Point G is 300 computers and 3,500 tons. It needs $300 \times 100 + 3{,}500 \times 10 = 30{,}000 + 35{,}000 = 65{,}000$ hours. The economy has 50,000. G is outside the frontier and cannot be produced.

In class

Pick a combination of computers and wheat. Compute the labor it requires and say where the point lies. The rule is one line: hours needed $= 100\times$ computers $+10\times$ wheat, compared with 50,000.

1.3.1 Opportunity cost and the slope of the PPF

Moving along the frontier means moving labor from one industry to the other. Going from A to B, 10,000 hours leave computers and go to wheat: the economy loses 100 computers and gains 1,000 tons. Going from B to C, 15,000 hours move: 150 fewer computers, 1,500 more tons. The exchange rate never changes. Each computer given up frees 100 hours, which grow 10 tons of wheat.

Key point

Along this PPF the opportunity cost of one computer is 10 tons of wheat, and the opportunity cost of one ton of wheat is $1/10$ of a computer. The opportunity cost of the good on the horizontal axis is the absolute value of the slope of the PPF: $5{,}000/500 = 10$.

Common mistake

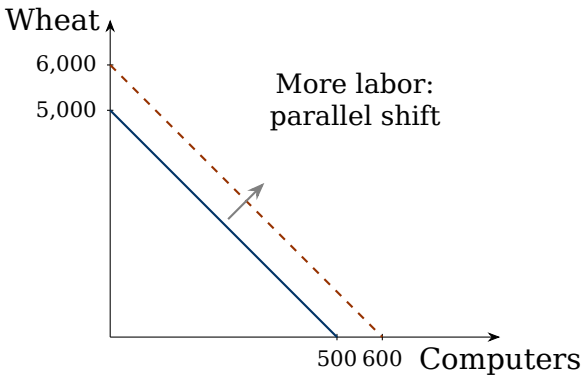
The slope tells you the opportunity cost of the horizontal-axis good in units of the vertical-axis good. If the axes were swapped, the slope would be $1/10$. Always say which good you are pricing and what it is priced in.

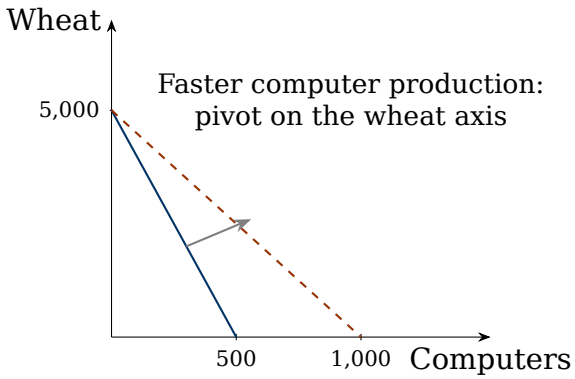
1.3.2 Shifts of the PPF

The frontier is drawn for a fixed amount of labor and a fixed technology. Change either and the frontier moves.

More resources. Suppose immigration adds 10,000 labor hours per month, so the economy has 60,000. The all-computer point becomes $60{,}000/100 = 600$ and the all-wheat point $60{,}000/10 = 6{,}000$. Both intercepts rise by 20 percent, and the new frontier is parallel to the old one. Opportunity cost is unchanged: a computer still costs 10 tons. Point G (300, 3,500) needed 65,000 hours and is still out of reach.

Better technology. Suppose instead that a new process cuts the labor per computer from 100 hours to 50, with wheat unchanged. All 50,000 hours in computers now yield 1,000; all in wheat still yield 5,000. The frontier pivots on the wheat intercept and swings out along the computer axis. Because the computer axis moved and the wheat axis did not, the slope changes: a computer now frees 50 hours, which grow 5 tons, so the opportunity cost of a computer falls from 10 tons to 5.





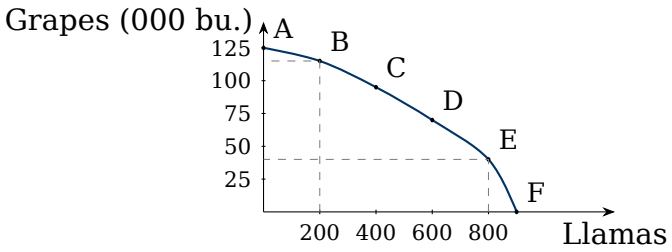
Note

Each of these is economic growth: the set of feasible combinations expands. Growth shifts the frontier; it is not a move along it. The second half of this chapter uses the same linear PPF to show how two countries with different slopes gain from trade.

1.3.3 A bowed-out PPF

The computer-and-wheat frontier is straight because every labor hour is identical. Most resources are not. Suppose you own land in California and can use it to grow grapes or raise llamas. Some of the land is fertile and grows excellent grapes; the rest is rocky and poor for vines. Llamas do equally well anywhere.

Point	Llamas	Grapes (000 bu.)	Cost per llama (bushels)
A	0	125	
B	200	115	50
C	400	95	100
D	600	70	125
E	800	40	150
F	900	0	400



Start at A with only grapes. The first 200 llamas go on the rocky land, which was contributing little to the harvest, so grape output falls by only 10 thousand bushels: 50 bushels per llama. Each further 200 llamas takes better land, and the cost rises: 20, 25, 30 thousand bushels. The last 100 llamas displace the best vineyard and cost 40 thousand bushels, or 400 bushels per llama. The frontier is bowed outward because opportunity cost rises as more of a good is produced.

Key point

A straight PPF means constant opportunity cost; a bowed-out PPF means increasing opportunity cost. The bow comes from resources that are not equally suited to both uses: the first units of a good use the resources with the lowest opportunity cost, and later units use resources that were more valuable in their old job.

1.4 Why trade?

Nearly everything you consume was made by people you will never meet, each of whom produced something for you and got something else in return. Imagine a week in which you had to grow your own food, sew your own clothes, and build your own phone: you would be poorer, hungrier, and worse dressed. Principle 5 says trade can make everyone better off. The hard case is the one that matters: suppose one country is better at producing *everything*. Should it trade at all? Does the other country gain, or get exploited?

In class

"Trade with China makes most Americans better off because, among other things, they can buy goods that are made more cheaply there." Agree, disagree, or uncertain? Keep your answer; we return to it at the end of the chapter.

1.5 A second country

Keep the U.S. from the first half of the chapter and add Japan. Same two goods, computers and wheat; same single input, labor hours per month.

	Labor hours	Hours per computer	Hours per ton of wheat
United States	50,000	100	10
Japan	30,000	125	25

The U.S. PPF is the one already drawn: 500 computers, or 5,000 tons of wheat, or any point on the line between, with a computer costing 10 tons. Japan has fewer hours and needs more of them per unit of each good. All-in on computers: $30{,}000/125 = 240$. All-in on wheat: $30{,}000/25 = 1{,}200$ tons. Along Japan's PPF each computer costs $125/25 = 5$ tons of wheat, and each ton of wheat costs $1/5$ of a computer.

1.5.1 Without trade: consume what you produce

A country that does not trade consumes exactly what it produces, so its consumption point is on its PPF. Suppose each country splits its labor evenly between the two goods.

- U.S.: 25,000 hours in each good, so 250 computers and $2{,}500$ tons of wheat (point A, left panel of Figure 1).
- Japan: 15,000 hours in each good, so 120 computers and 600 tons of wheat (point A, right panel).

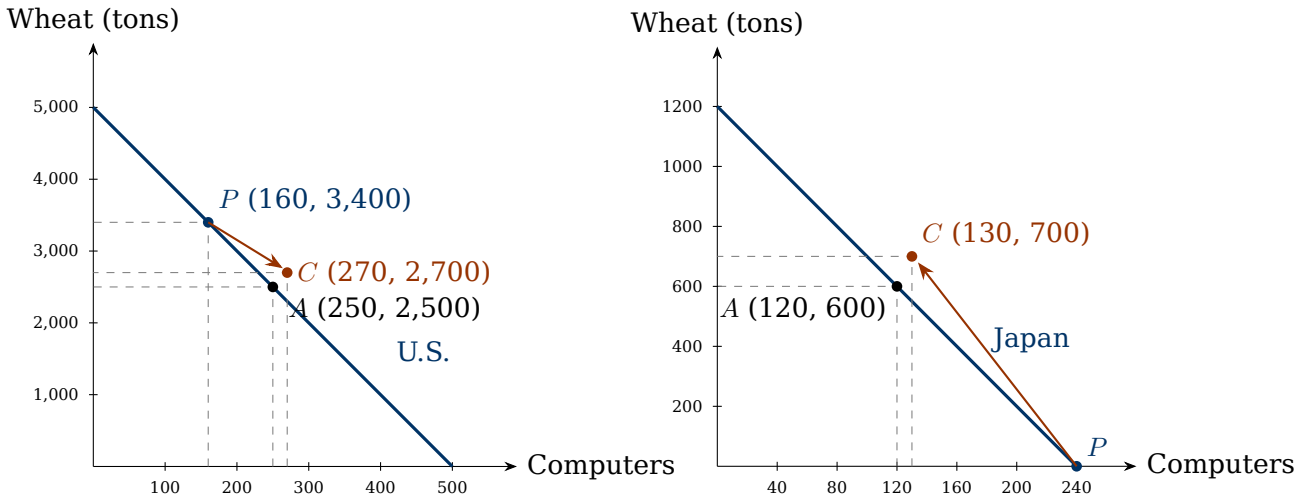


Figure 1: Left: the U.S. PPF. Right: Japan's PPF. A: production and consumption without trade. P: production with trade (Japan specializes completely in computers). C: consumption with trade, outside each PPF. The arrows are the trade: the U.S. exports 700 tons of wheat and imports 110 computers.

1.6 Specialization and trade

Now let the countries trade. Each can produce a different bundle from the one it consumes; exports and imports make up the difference.

Definition 1.4 (Exports and imports)**. Exports** are goods produced at home and sold abroad. **Imports** are goods produced abroad and bought at home.

1.6.1 Production with trade

Suppose the U.S. shifts labor toward wheat and Japan shifts labor toward computers.

- The U.S. produces 3,400 tons of wheat. This takes $3{,}400 \times 10 = 34{,}000$ hours. The remaining $50{,}000 - 34{,}000 = 16{,}000$ hours make $16{,}000/100 = 160$ computers. Production point: $P = (160 \text{ computers}, 3{,}400 \text{ wheat})$.
- Japan produces 240 computers. This takes $240 \times 125 = 30{,}000$ hours, all of Japan's labor. Japan produces 0 wheat. Production point: $P = (240, 0)$.

1.6.2 Consumption with trade

Suppose the two countries agree on the following exchange: the U.S. sends 700 tons of wheat to Japan, and Japan sends 110 computers to the U.S.

	United States		Japan	
	Computers	Wheat	Computers	Wheat
Produced	160	3,400	240	0
+ Imported	110	0	0	700
− Exported	0	700	110	0
= Consumed	270	2,700	130	700

Compare with the no-trade bundles.

	Without trade	With trade	Gain
U.S. computers	250	270	+20
U.S. wheat (tons)	2,500	2,700	+200
Japan computers	120	130	+10
Japan wheat (tons)	600	700	+100

Each country ends up with more of *both* goods. The consumption points C in Figure 1 lie outside the PPFs. No country gained resources or technology; the only thing that changed is that each produced a different mix and then exchanged.

Key point

Without trade, consumption is tied to production: the consumption point must be on the PPF. With trade, production stays on the PPF but consumption can

move outside it. In this sense trade works like a technological improvement: society gets bundles it could not produce on its own.

Where does the extra output come from? Add up world production. Without trade the two countries make $250+120=370$ computers and $2{,}500+600=3{,}100$ tons of wheat. With trade they make $160+240=400$ computers and $3{,}400+0=3{,}400$ tons. Reallocating labor raised world output by 30 computers and 300 tons, exactly the sum of the two countries' gains. The pie got bigger.

Note

The U.S. does not specialize completely and does not need to: Japan's whole labor force makes only 240 computers, while the two countries together consume 400. What matters is the direction of the shift. Each country moves toward the good it is relatively better at.

1.7 Absolute advantage and comparative advantage

Why did Japan specialize in computers and the U.S. in wheat, and not the other way around? Two different notions of "who is the better producer" give different answers, and only one of them is correct.

Definition 1.5 (Absolute advantage)**.** A producer has an **absolute advantage** in a good if it can produce that good using fewer inputs than another producer.

In our example, the U.S. needs 100 hours per computer versus Japan's 125, and 10 hours per ton of wheat versus Japan's 25. The U.S. has an absolute advantage in *both* goods.

If the U.S. is better at everything, why does it import computers from Japan, and why does Japan gain? Absolute advantage measures cost in inputs. The cost that matters for the decision is opportunity cost.

The opportunity cost of one computer is the wheat that could have been produced with the labor used for that computer: hours per computer divided by hours per ton of wheat, the slope of the PPF.

- U.S.: one computer uses 100 hours, which could have made $100/10=10$ tons of wheat. The opportunity cost of 1 computer is 10 tons of wheat; the opportunity cost of 1 ton of wheat is $1/10$ computer.
- Japan: one computer uses 125 hours, which could have made $125/25=5$ tons of wheat. The opportunity cost of 1 computer is 5 tons of wheat; the opportunity cost of 1 ton of wheat is $1/5$ computer.

Opportunity cost of…	1 computer	1 ton of wheat
United States	10 tons of wheat	$1/10$ computer
Japan	5 tons of wheat	$1/5$ computer

Definition 1.6 (Comparative advantage)**.** A producer has a **comparative advantage** in a good if it can produce that good at a lower opportunity cost than another producer.

Japan gives up 5 tons of wheat per computer; the U.S. gives up 10. Japan has the comparative advantage in computers. The U.S. gives up $1/10$ computer per ton of wheat; Japan gives up $1/5$. The U.S. has the comparative advantage in wheat.

Key point

Principle of comparative advantage. Each good should be produced by the party with the lower opportunity cost of producing it. The gains from trade come from differences in opportunity costs, not from differences in input requirements. Absolute advantage is neither necessary nor sufficient for gains from trade.

For any one producer, the opportunity cost of one good is the reciprocal of the opportunity cost of the other (10 and $1/10$; 5 and $1/5$). So a producer can have an absolute advantage in both goods but cannot have a comparative advantage in both: if your opportunity cost of computers is lower than mine, your opportunity cost of wheat must be higher. The only exception is equal opportunity costs, and then there are no gains from trade.

Common mistake

Comparing hours per unit (absolute advantage) gives the wrong answer: here it says the U.S. should make everything. Compare opportunity costs, and keep the units straight: the opportunity cost of a computer is in tons of wheat, that of wheat in computers.

1.8 The price of trade

At what rate should computers exchange for wheat? For both countries to gain, the price of a computer must lie between the two opportunity costs:

$$5 \text{ tons of wheat} \;<\; \text{price of 1 computer} \;<\; 10 \text{ tons of wheat.}$$

- Japan makes a computer at a cost of 5 tons of wheat. If it can sell a computer for more than 5 tons, it gains by exporting computers.
- The U.S. makes a computer at a cost of 10 tons of wheat. If it can buy a computer for less than 10 tons, it gains by importing computers.

Our trade was 700 tons of wheat for 110 computers, a price of $700/110 \approx 6.4$ tons of wheat per computer. That is above Japan's cost (5) and below the U.S. cost (10), so both gain. Equivalently, the price of wheat is $110/700 \approx 0.16$ computers per ton, which is between $1/10 = 0.10$ and $1/5 = 0.20$.

A price outside the range makes one side worse off. At 4 tons per computer Japan would rather grow its own wheat; at 12 the U.S. would rather build its own computers.

Neither trade happens voluntarily. Where in the range the price settles depends on bargaining or, in a market, on supply and demand (Chapter 4). The closer to 10, the more of the gains go to Japan; the closer to 5, the more go to the U.S.

1.9 A second example: Argentina and Brazil

Example 1.3 (Coffee and wine)**.** Argentina and Brazil each have 10,000 labor hours per month. In Argentina, one pound of coffee takes 2 hours and one bottle of wine takes 4 hours. In Brazil, one pound of coffee takes 1 hour and one bottle of wine takes 5 hours. Which country has an absolute advantage in coffee? Which has a comparative advantage in wine?

Absolute advantage. Brazil needs 1 hour per pound of coffee versus Argentina's 2: Brazil has the absolute advantage in coffee. Argentina needs 4 hours per bottle of wine versus Brazil's 5: Argentina has the absolute advantage in wine. Here each country is better at one good, so absolute and comparative advantage happen to line up; that is a coincidence, not the reason for trade.

Opportunity costs.

Opportunity cost of…	1 lb coffee	1 bottle wine
Argentina	$2/4 = 0.5$ bottle wine	$4/2 = 2$ lb coffee
Brazil	$1/5 = 0.2$ bottle wine	$5/1 = 5$ lb coffee

Comparative advantage. Brazil gives up 0.2 bottle of wine per pound of coffee versus Argentina's 0.5: Brazil has the comparative advantage in coffee. Argentina gives up 2 pounds of coffee per bottle of wine versus Brazil's 5: Argentina has the comparative advantage in wine. Brazil should export coffee and import wine; Argentina should do the reverse. A mutually beneficial price of wine is anywhere between 2 and 5 pounds of coffee per bottle.

The recipe is always the same: (1) hours per unit, or units per hour, for each producer; (2) opportunity cost of each good for each producer, as a ratio; (3) the lower opportunity cost gets the comparative advantage; (4) the trade price lies between the two opportunity costs.

1.10 Applications

1.10.1 Should LeBron mow his own lawn?

LeBron can mow his lawn in 2 hours. In those 2 hours he could instead film a commercial for $30,000. The kid next door takes 4 hours to mow the same lawn and could otherwise earn $50 at McDonald's. LeBron has the absolute advantage in mowing (2 hours versus 4), but his opportunity cost of mowing is $30,000 against the kid's $50. The kid has the comparative advantage. Any payment between $50 and $30,000 makes both better off. The principle applies to individuals exactly as it applies to

countries; it is why people specialize in one occupation and buy almost everything else.

1.10.2 Should the United States trade with China?

Back to the question from the start of the chapter. Replace "Japan" with "China" and "computers" with clothing, furniture, or electronics. If China's opportunity cost of those goods is lower, Americans as a whole gain by importing them and putting U.S. labor into goods where the U.S. has the comparative advantage. When the IGM panel of academic economists was asked the statement above, nobody disagreed. They were also asked whether "some Americans who work in the production of competing goods, such as clothing and furniture, are made worse off by trade with China," and agreement was again near-unanimous. Both are true. The gains exceed the losses, so the winners could in principle compensate the losers, but that does not happen automatically. The losers are concentrated in particular towns and industries while the gains are spread thinly across every shopper, which is why trade benefits the country as a whole and is still politically contested.

1.11 Summary

Key point

- The PPF shows what an economy can produce. On the line: efficient. Inside: idle resources. Outside: not feasible. Its slope is the opportunity cost of the horizontal-axis good. More resources shift it out; a one-sided improvement in technology pivots it. Heterogeneous resources bow it outward.
- Trade lets a country consume outside its own PPF. It works like a technological improvement without any change in resources or technology.
- Absolute advantage: fewer inputs. Comparative advantage: lower opportunity cost. Gains from trade rest on comparative advantage. One party can have an absolute advantage in everything, but no one can have a comparative advantage in everything.
- Each party should specialize in its comparative advantage and trade for the other good, at a price between the two opportunity costs.
- Trade creates winners and losers inside a country. The gains exceed the losses; compensation is not automatic.

Exercises

Exercise 1.1 (The computer-and-wheat economy)**.** Use the computer-and-wheat economy: 50,000 labor hours, 100 hours per computer, 10 hours per ton of wheat.

(a) Point H is 200 computers and 2,800 tons of wheat. How many hours does it require? Is it on, inside, or outside the frontier?

(b) Starting from H, what is the largest wheat output the economy could reach without producing fewer computers?
(c) The economy moves from B (400, 1,000) to C (250, 2,500). What is the opportunity cost per computer given up? Does it match the slope?
(d) A new seed cuts the labor per ton of wheat from 10 hours to 5, with computers unchanged. Give the new intercepts, describe the shift, and compute the new opportunity cost of a computer.

Exercise 1.2 (Grapes and llamas)**.** Use the grape-and-llama land from the table above.

(a) What is the opportunity cost of raising llamas from 400 to 600? From 600 to 800? State each in bushels per llama.
(b) Why does the cost rise? What feature of the land drives the answer?
(c) Suppose every acre were equally good for grapes and for llamas. What shape would the frontier take, and why?

Exercise 1.3 (Socks in Boston and Chicago)**.** A worker in Boston can make 3 pairs of red socks or 3 pairs of white socks per hour. A worker in Chicago can make 2 pairs of red socks or 1 pair of white socks per hour.

(a) Which city has the absolute advantage in red socks? In white socks?
(b) Compute the opportunity cost of a pair of red socks and of a pair of white socks in each city.
(c) Which city has the comparative advantage in red socks? In white socks?
(d) If the two cities trade, what is the range of prices for a pair of white socks (measured in pairs of red socks) at which both gain?

Exercise 1.4 (Scones and sweaters)**.** In an hour, an English worker can produce 30 scones or 1 sweater. In an hour, a Scottish worker can produce 40 scones or 2 sweaters. Each country has 40 labor hours per week.

(a) Draw the PPF of each country (scones on the horizontal axis).
(b) Which country has the absolute advantage in each good? Which has the comparative advantage in each good?
(c) If England and Scotland trade, which good does each export? Give the range of prices for a sweater, in scones, at which both gain.
(d) Suppose instead a Scottish worker could produce 30 scones or 1 sweater per hour. Would there be gains from trade? Explain.

Exercise 1.5 (Wheat and oil)**.** In a day, a worker in Hungary can produce 10 bushels of wheat or 60 barrels of oil. A worker in Slovakia can produce 5 bushels of wheat or 55 barrels of oil.

(a) Which country has the absolute advantage in wheat? In oil?
(b) What is the opportunity cost of a bushel of wheat in each country? Of a barrel of oil?
(c) Which country should export wheat, and which should export oil?
(d) Slovakia offers 8 barrels of oil per bushel of Hungarian wheat. Does Hungary accept? What about 5 barrels? Would Slovakia offer 12?

Answers to exercises

Exercise 1.1. (a) $200 \times 100 + 2{,}800 \times 10 = 20{,}000 + 28{,}000 = 48{,}000$ hours, less than 50,000. H is inside the frontier, with 2,000 hours idle. (b) Keep 20,000 hours on computers; put the remaining 30,000 on wheat: 3,000 tons. That is the frontier point directly above H. (c) Giving up 150 computers frees 15,000 hours, which grow 1,500 tons. $1{,}500/150 = 10$ tons per computer, the same as the slope of -10 (in absolute value). Along a straight PPF the cost is the same everywhere. (d) Computer intercept unchanged at 500; wheat intercept doubles to $50{,}000/5 = 10{,}000$ tons. The frontier pivots on the computer intercept and swings up along the wheat axis. A computer now costs $100/5 = 20$ tons of wheat: its opportunity cost rose, because wheat became cheaper to produce.

Exercise 1.2. (a) 400 to 600: grapes fall from 95 to 70, so 25 thousand bushels for 200 llamas, or 125 bushels per llama. 600 to 800: 70 to 40, so 30 thousand bushels, or 150 per llama. (b) Land is heterogeneous. The first llamas use land that was poor for grapes and cost little harvest. Each later batch takes land that was more productive in grapes, so each llama displaces more bushels. (c) A straight line. If every acre gave up the same bushels when converted to llamas, opportunity cost would be constant and the frontier would be linear, like the computer-and-wheat example.

Exercise 1.3.

(a) Boston makes more of both per hour (3 vs. 2 red; 3 vs. 1 white): absolute advantage in both.
(b) Boston: 1 red pair costs 1 white pair, and vice versa. Chicago: 1 red pair costs $1/2$ white pair; 1 white pair costs 2 red pairs.
(c) Red: Chicago ($1/2 < 1$). White: Boston ($1 < 2$).
(d) Boston exports white, Chicago exports red. A white pair must sell for more than 1 red pair (Boston's cost) and less than 2 (Chicago's cost).

Exercise 1.4.

(a) Straight lines. England: from 1,200 scones to 40 sweaters. Scotland: from 1,600 scones to 80 sweaters.
(b) Absolute advantage: Scotland in both (40 vs. 30 scones; 2 vs. 1 sweaters). Opportunity cost of a sweater: 30 scones in England, $40/2 = 20$ in Scotland; of a scone: $1/30$ vs. $1/20$ sweater. Comparative advantage: Scotland in sweaters, England in scones.
(c) Scotland exports sweaters, England exports scones. The price of a sweater lies between 20 and 30 scones.
(d) No. Scotland's opportunity cost of a sweater would be 30 scones, the same as England's. With equal opportunity costs there is no comparative advantage and no price that makes both better off, even though Scotland still has an absolute advantage in scones.

Exercise 1.5.

(a) Hungary (10 vs. 5 wheat; 60 vs. 55 oil): absolute advantage in both.

(b) Wheat: $60/10 = 6$ barrels in Hungary, $55/5 = 11$ in Slovakia. Oil: $1/6$ bushel in Hungary, $1/11$ in Slovakia.

(c) Hungary exports wheat ($6 < 11$); Slovakia exports oil ($1/11 < 1/6$).

(d) The range is 6 to 11 barrels per bushel. At 8, Hungary accepts (more than the 6 it gets by making oil itself) and Slovakia gains (less than the 11 it costs to grow wheat). At 5, Hungary refuses. Slovakia would not offer 12, since it can grow a bushel itself for 11 barrels.