LUÍS M B CABRAL

INTRODUCTION TO MICROECONOMICS

This book was typeset in LaTeX using the memoir style as well as multiple macros developed by the author. All images included in this book are in the public domain. Whenever appropriate, links to the license and author are included.

Cover design based on *Arch* (2005), oil on canvas (18x18in), by Luís Cabral.

Luís Cabral is Paganelli-Bull Professor of Economics at NYU's Stern School of Business. Updated information about this book will appear at luiscabral.net/economics/books/micro/

Version 1.3.4 (August 24, 2024)

CONTENTS

PREFACE

We hear it from politicians, journalists, activists — anyone who's paying attention. The clamor is near unanimous, or so it seems: We need to break with capitalism. Technology and economics have gotten us into a huge mess:

- The planet is at great risk.
- From France to Chile to the United States, social tension is at an all-time high, largely the result of increasing income inequality.
- Stable jobs seem like a thing from the past.

The list goes on and on. So, we need to get rid of a system that does not work as well as the technocrats who designed it.

Economists have not always been at the forefront of policy. However, their influence has increased substantially in the past forty years. As such, we might say that the problem is not just the market economy but also economics as an academic discipline. Some swear by economics, some swear *at* economists. As I will argue in the next few hundred pages, both are right in some sense and wrong in a different sense.

This book is an attempt to correct the way economics is taught and at the same time an attempt to answer the critics' wake-up call. The book's motto might be

> *Technology and the market economy got us into the present mess, but technology and the market economy are the only hope of getting us*

out of the present mess.

The world and the world's economy have changed a lot in the past half century. The microeconomics textbook, however, has really not evolved that much since Samuelson's *Economics* was first published in the 1940s. The graphs got better, new examples were added, but the core has remained the same for the longest time. One exception is the core-econ project, in particular the eBook *The Economy*. I learned a lot from reading *The Economy*. In fact, I have adopted or adapted several features from that book. However, I have different ideas regarding the optimal organization of a textbook. To this I turn next.

STRUCTURE

Introduction to Microeconomics is divided into five parts. Parts II and III correspond to the "traditional" approach to microeconomics. I have no interest in throwing out the baby with the bathwater: The basic economic model of rational, optimizing behavior remains an important tool to understand economic agency (not so much how an agent *should* behave but rather how it *actually* behaves). Part IV deals with market failure. While competitive markets represent an important reference point, most markets today fundamentally deviate from that ideal model. Part V, arguably the most innovative part of the book, is devoted to social justice: equity, solidarity, opportunity. Finally, Part I corresponds to a longish introduction to the economy (the real-world phenomenon) and to economics (the academic discipline).

NAVIGATING THE BOOK

Introduction to Microeconomics is primarily intended to be read as a pdf-based eBook. Other formats, such as ePub, have the great advantage of being easily scalable. However, they are poor at handling graphs; and it's virtually impossible to write an economics text without graphs. I chose font size and page size so as to allow for comfortable reading on a tablet as well as on a large-screen smartphone. Naturally, you are free to print the pdf file if so inclined, but there is a loss in the process: One of the advantages of electronic publishing is the inclusion of hyperlinks. In the present context, a simple rule ap-

plies: "if it's blue, it will link for you." Data and photo sources, references to article and books, individuals and events, and so on, are typeset in blue and accompanied by an external internet link. Chapter, section, figure, table and page numbers, in turn, correspond to internal links and are also typeset in blue.

A special reference should be made to the page number (top right corner of each page), which functions as a "button" linking to the table of contents. From the table of contents, in turn, you can link to any chapter or section of the book by pressing the chapter or section name (typeset in blue).

Given all of these internal links, it helps a lot if you are able to go back to the previous reading position. Not all pdf readers include this feature. Based on my experience and that of others, some possible suggestions of free apps include: for Windows OS, *Foxit PDF Reader*; for Android smartphones and tablets, *XODO*; for macOS, the native app *Preview*; and for iOS (iPhone and iPad), PSPDFKit's *PDF Viewer*. (Disclaimer: I have no financial or other interests in any of these products.)

FEEDBACK

Introduction to Microeconomics is a free, open-access text primarily intended for college undergraduate courses. I plan to develop additional materials and will be happy to share them with instructors. I will also appreciate any feedback you might have. The current version may be found on the first page after the cover. The latest version, as well as the version history, may be found on the book page. Please submit comments, corrections, typos, etc, to luis.cabral@nyu.edu.

Roger W

PART I

INTRODUCTION

CHAPTER 1

THE ECONOMY

1.1. LIVING STANDARDS AND HAPPINESS

Popular wisdom has given us a number of witticisms about money and happiness. Playwright George Bernard Shaw misquoted Paul of Tarsus by claiming that, "Lack of money is the root of all evil." Alexander Hamilton, first US Secretary of the Treasury (and inspiration for the Broadway smash hit *Hamilton*) wisely remarked that, "Money isn't everything, but it certainly keeps you in touch with your children." Novelist Gertrude Stein assures us that "Whoever said money can't buy happiness didn't know where to shop." Addressing specifically the issue of happiness, actor Alan Alda teaches us that "It isn't necessary to be rich and famous to be happy, it's only necessary to be rich." Spike Milligan, in turn, pleads, "All I ask is the chance to prove that money can't make me happy." And finally, a quote (of uncertain origin) that summarizes much of what this chapter is about:

> I've been rich and I've been poor. And, believe me, rich is better.

All joking aside, a general principle that most if not all agree upon is that a minimum living standard is a necessary condition for happiness. Perhaps not a sufficient condition, but certainly a necessary one. As Franklin D. Roosevelt famously stated, "We have come to a

clear realization of the fact that true individual freedom cannot exist without economic security and independence." Economics is about managing (individually, as a household, as a country, as a planet) the limited resources we have so as to achieve a reasonable living standard for all.

MEASURING LIVING STANDARDS

Economics is largely a quantitative discipline. Of the many measures used to describe the level of economic activity and living standards, the most important is probably **Gross Domestic Product (GDP)**. GDP measures the total goods and services produced in the economy *at market prices* and in a given period. If you get a haircut and pay $20 for it, then an extra $20 is added to GDP. The same applies to all other consumer purchases of products and services.

A related measure of living standards is **Per-capita GDP**. This is simply given by GDP divided by population. For example, in 2018 the US GDP was $20.50 trillion (that is, 20.50×10^9 dollars). The US population, in turn, was 327.2 million. This implies that per-capita income was $20.50 trillion divided by 327.2 million, or simply $62,652 per capita. In addition to the *levels* of GDP and per-capita GDP, we frequently measure their respective **growth rates**. For example, US GDP in 2018 was 5.2% higher than in 2017.

There are a number of issues when using GDP and per-capita GDP to make comparisons across time. First, we must take into account that prices change over time. Even more important, the range of products and services available can vary greatly at different moments in time: How do you compare per-capita GDP in 2000 and 1970, considering that in 1970 there were no smartphones? (Recommended video: *The Numbers Game: Let's Party Like It's 1973!*)

Comparisons across nations are also difficult to ascertain. For one, prices vary considerably from country to country, as I recently found when I ordered wine in Sweden. Equally important, some products and services (e.g., health and/or education) are available "for free" in some countries but not in others. For example, a visit to the hospital may be free in Denmark, whereas an American patient must pay a high price. This may lead to overestimating the value of GDP in the US relative to Denmark. Along similar lines, In Algeria (and in 2019) only 15% of women were part of the labor force. In the same year and

in the Republic of Congo, that number was 68%. While Congolese women earn market wages for their labor, most women in Algeria work at home, earning no market wages. This does not mean their work is less important, simply that it is not accounted for by GDP measurement.

So far, the issues with GDP measurement are largely technical problems which can be "solved" with appropriate corrections. For example, it is customary to make cross-country comparisons by correcting for price differences, that is, by computing per-capita GDP in **purchasing power parity** (PPP) units. However, the limitations of GDP as a measure of wellbeing run deeper than the above technicalities. How do we account for the quality of the social and physical environment? Do people have access to clean air and clean water? Do people trust each other? Is the social environment conducive to friendship? Do individuals and families have sufficient free time and vacation time? More generally, the argument can be made that the market price we pay is not always a correct measure of any thing's value. For example, many people spend more on diamonds than on water, but it would be easier for them to live without diamonds than without water. (We will return to these issues in a later chapter, namely in reference to the so called "water-and-diamonds" paradox.)

For all of these reasons, many question the legitimacy of GDP as a measure of living standards; and over the years there have been repeated calls for a different measure of living standards. For example, Robert F Kennedy's 1968 speech at the University of Kansas included a deep criticism of the concept of Gross National Product (a similar measure to GDP). More recently and more specifically, New Zealand Prime Minister Jacinda Ardern, at the 2019 World Economic Forum, proposed a "well-being budget" as an alternative to simple growth (as measured by GDP). At about the same time, Cambridge's Diane Coyle claimed that

> Over eight decades after its introduction, there is a widespread consensus that GDP is no longer a useful measure of economic progress.

"Widespread consensus" is a bit of a stretch. I for one am not part of that consensus. Here's why: Referring to democracy, Winston Churchill famously wrote in 1947 that

> No one pretends that democracy is perfect or all-wise. Indeed it has been said that democracy is the worst form of government except for all those other forms that have been tried from time to time.

Many economists think similarly regarding GDP: It's the worst measure except for all the others! GDP is not a single number that tells you unequivocally how well or poorly an economy or a society is doing. In fact, that single magic number will likely never exist. So, rather than looking for such a magic number, we're much better off by complementing GDP with other measures of living standards and, more broadly, measures of happiness. Here's an analogy: When you want to know what the weather will be like, you look for (objective) measures such as temperature and humidity. Many weather sites in the US also provide a "feel like" index, which corrects for temperature by also taking humidity and wind into consideration. But I would much rather have the values of temperature, humidity and wind than a "feel like" index. What does "feel like" mean anyway? Whose feeling? To summarize,

> *GDP is a limited measure of economic development. However, together with other indicators, it provides a helpful picture of an economy's performance.*

GDP AND HAPPINESS

As we have just seen, GDP is an index with many limitations. But does it at all help understand how living standards contribute to happiness? Figure 1.1 shows the relation between per-capita GDP and self-reported life satisfaction in the 144 countries for which data was available in 2017. The blue line (a logarithmic function) describes a possible approximation to the relation between the two variables. Clearly, the relation is positive. In particular, for low values of per-capita GDP (say, lower than $10,000 a year) the relation is particularly steep. The estimated curve implies, for example, that an increase in per-capita GDP from $1,000 to $2,000 is associated with an increase in "happiness" (self-reported satisfaction) from 3.786 to 4.282, a 13% increase. By contrast, an increase in per-capita GDP from $50,000

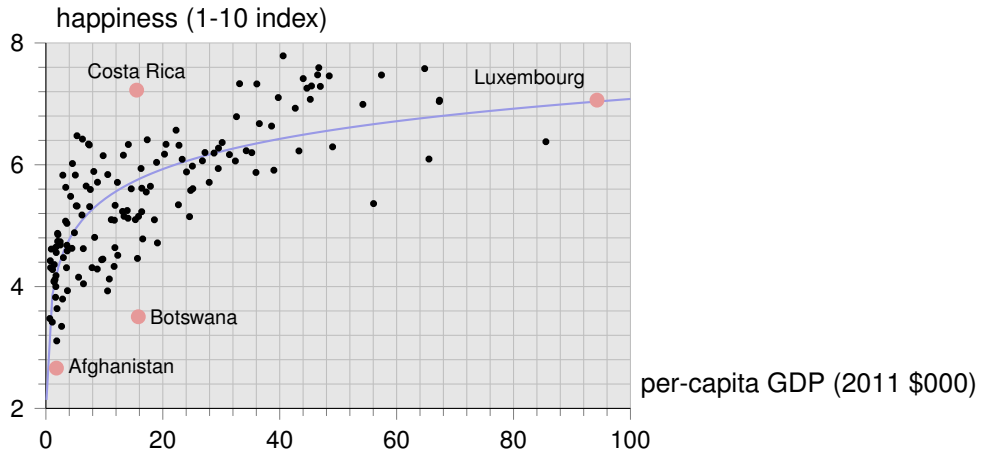


FIGURE 1.1
Relation between GDP and self-reported life satisfaction.
(source: ourworldindata.org)

to $51,000 is associated with a small increase in "happiness", from 6.584 to 6.599, a mere .02% increase. (As we will see at various points throughout this book, this is an instance of an important "law" in economics, the law of diminishing marginal returns: the gain from getting more of a certain good tends to decrease as we get more of it.)

Three important notes regarding the relation between per-capita GDP and self-reported happiness. First, Figure 1.1 only shows a *correlation* between the two variables. No claim is made regarding any causal relation between the two. It could well be that there is a third variable (for example, social cohesion or health or political stability) that influences *both* GDP and happiness, to the point that we observe a correlation between GDP and happiness that does not correspond to causality. (The distinction between correlation and causality will be frequently reiterated throughout this book.)

A second note is that, notwithstanding the positive relation between per-capita GDP and happiness, we also observe considerable variation in the levels of self-reported satisfaction. For example, Botswana and Costa Rica had similar levels of per-capita GDP ($15,807 and $15,524, respectively). However, the happiness indicator is considerably higher in Costa Rica (7.225) than in Botswana (3.505). Clearly, there is more to happiness than just GDP. The World

Happiness Report considers a list of factors including (in addition to per-capita GDP) measures of social support, life expectancy, freedom to make life choices, generosity, and the perception of corruption. I encourage you to read their report, which is published annually.

Notwithstanding these qualifications, the fact remains that a country like Afghanistan has both a very low per-capita GDP and a very low level of self-reported happiness, whereas a country like Luxembourg has high values of both. It's possible, it's likely, that economic conditions have something to do with it.

> *Economic living standards are an important component of human welfare and happiness. Per-capita GDP is a limited but helpful indicator of living standards.*

To conclude this subsection, a third feature of note in Figure 1.1 is that the observations (the dots) are especially clustered near the left axis. In other words, most countries in the world have relatively low levels of per-capita GDP (say, lower than $10,000), with a few countries enjoying substantially higher values (say, higher than $60,000). In addition to the levels of world inequality this reflects (more on this in Section 1.3), this variation makes it difficult to represent the data. Whenever we have observations with highly dispersed values, one trick economists use is to represent variables on a logarithmic scale. This we do in Figure 1.2, where the horizontal axis is drawn on a logarithmic scale (and everything else is as in Figure 1.1).

On a linear axis (the one we normally use) each tick increment corresponds to a constant increase in value. For example, each tick on the horizontal axis of Figure 1.1 corresponds to a $2,000 increase in per-capita GDP. By contrast, on a logarithmic graph, each equidistant tick corresponds to *multiplying* the variable in question by 10. For example, each labeled tick on the horizontal axis of Figure 1.2 corresponds to $1k, $10k and $100k, respectively. Also, so as to avoid printing multiple zeros, frequently we simply use exponential notation. For example, 10^0 is the same as "1", 10^1 is the same as "1" followed by one zero, and 10^2 is the same as "1" followed by two zeros. (If you would like to learn more about logarithms, I suggest you watch this helpful video.)

As can be seen, the dots in Figure 1.2 are more evenly spaced than in Figure 1.1. You will also notice that the relation between per-capita

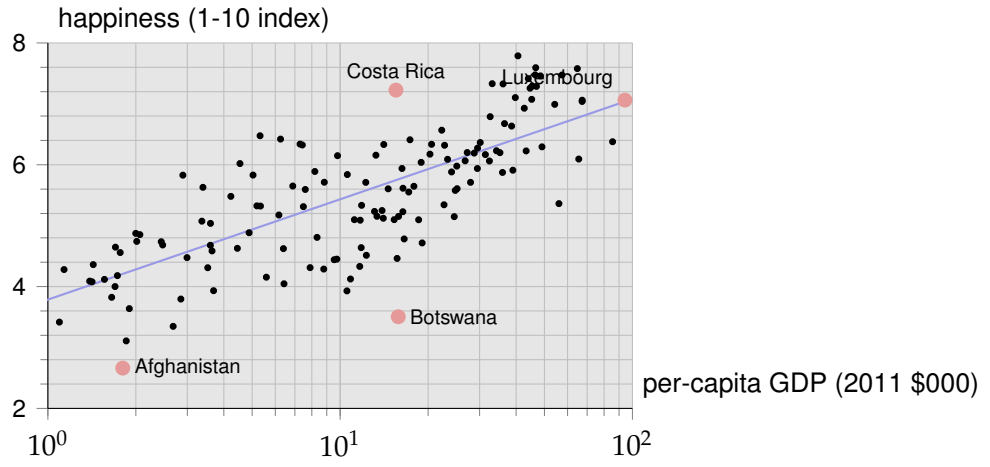


FIGURE 1.2
Relation between GDP and self-reported life satisfaction.
(source: ourworldindata.org)

GDP and happiness looks like a linear relation. Don't be fooled by this: the relation looks linear because the x variable, per-capita GDP, is plotted on a logarithmic scale, not on a linear scale. As shown in Figure 1.1, the relation is very non-linear, specifically very concave, with the effect of an increase in GDP much stronger at low values of GDP than at higher values of GDP.

In other words, when reading a graph on a logarithmic scale, one must account for the fact that distances don't always mathematically equate with one another. For example, in Figure 1.2 the horizontal distance (the difference in per-capita GDP) between Costa Rica and Luxembourg seems less than the difference between Costa Rica and Afghanistan. However, as Figure 1.1 shows, in dollar terms, the GDP gap between Costa Rica and Luxembourg is much greater than the GDP gap between Costa Rica and Afghanistan.

Another way of appreciating how distances don't mean the same on a logarithmic scale as they do on a linear one is to examine the various ticks on the x axis between 10^1 (that is, 10) and 10^2 (that is, 100). They correspond to the values 20, 30, 40, ..., 70, 80 and 90. As we get closer to 100, the distance corresponding to a \$10k increase becomes smaller and smaller.

As mentioned earlier, given the non-linearity of logarithmic scales, we need to be careful about interpreting a straight line on a

graph like Figure 1.2. A given shift in the x variable, in terms of horizontal distance, always leads to the same increase in the y variable. However, a given shift in x at small values of x corresponds to a much smaller change in per-capita income than the same shift in x at greater values of x. In other words, a linear relation on a logarithmic scale means that the effect of increases in the x variable become smaller and smaller as the value of x increases. In other words, no matter how you represent the relation between per-capita income and happiness, Figure 1.1 or Figure 1.2, we conclude that an extra $1,000 in per-capita GDP means a lot more in Afghanistan than in Luxembourg.

1.2. THE CAPITALIST REVOLUTION

Having established that per-capita GDP is an imperfect but helpful measure of living standards, we now turn to the question of what happened to living standards over the past few centuries, specifically as measured by per-capita GDP. Figure 1.3 presents estimates of the world average per-capita GDP from year 0 to year 2000. Economic historians actually have estimates going back to 1 million BC. However, I will spare you the boredom of the entire graph. Let it just be noted that it is essentially flat all the way until we hit the 1700s. After that, we observe a rapid inflection from a few hundred dollars to more than $7,000 (per capita per year) in the 20th century.

The change in the time trajectory of per-capita GDP in the 18th century is so sharp that economists refer to it as **history's hockey stick**: a relatively constant per-capita level (near-zero growth) suddenly turning into a high-growth pattern, a seemingly sudden take-off of economic growth. Figure 1.3 also includes a reference to two important historical events closely related to the inflection point in history's hockey stick. We will return to these later.

Figure 1.4 does two things. First, it zooms in on the past three centuries, beginning in 1700. Second, it focuses on the evolution of per-capita GDP in six specific countries: China, Japan, India, Italy, UK, and US. Once again, we observe a series of "hockey sticks". They appear less steep than the left panel for the simple reason that the time frame is three centuries rather than two millennia. The main differences across countries correspond to the time when **take-off** occurs.

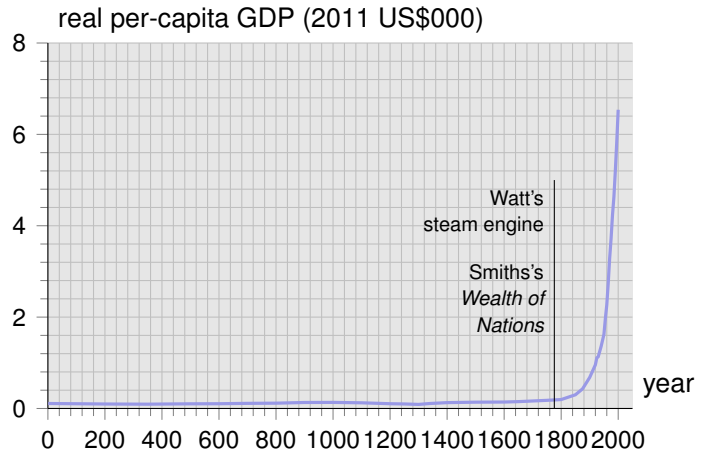


FIGURE 1.3
History's hockey stick: world per-capita GDP (source: Bradford De Long)

For Great Britain (now the UK) and for the US, it happened during the 18th century, whereas for China and India the take-off occurred during the latter part of the 20th century.

To the extent that the time of take-off varies from country to country, we also observe significant variations in world inequality during the past three centuries or so. As can be seen from Figure 1.4, by 1700 there wasn't much world inequality (that is, inequality across countries). For example, per-capita GDP in India and Great Britain were very similar. By contrast, in 1900 the UK-India gap was quite significant. However, this does not mean that the gap is always increasing: when China takes off, for example, the level of world inequality declines (China grows faster than Europe or North America). We will return to this later.

The term **capitalist revolution** usually refers to the extraordinary pace of economic growth experienced by the countries that first adopted the capitalist system of economic organization. **Capitalism** is a loaded word, in part because people have strong feelings about it. In the language of economics, we use the term in a precise way because that helps us to communicate better. Specifically, in economics we use the term "capitalism" to refer to a particular set of conditions and institutions. For our purpose, institutions are the laws and social customs governing the production and distribution of goods and services. The particular institutions that define capitalism as an eco-

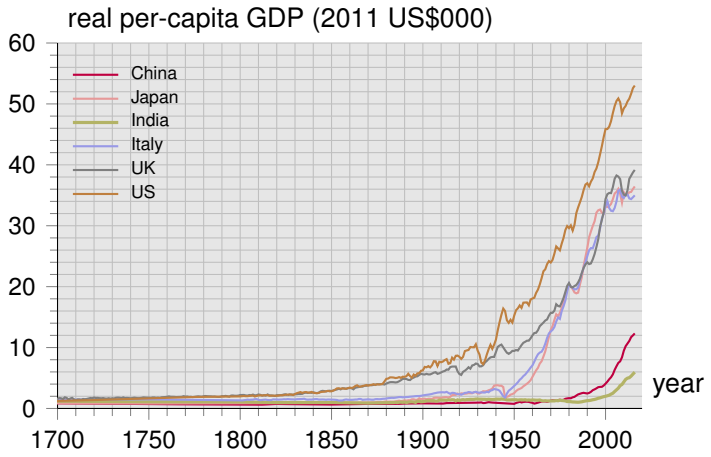


FIGURE 1.4
History's hockey stick: per-capita GDP by country (source: *The Economy*)

nomic system are **private property**, **markets**, and **firms** (firms being institutions that bring together capital and labor).

> *The capitalist system combines the institutions of private property, markets and firms (which in turn combine capital and labor).*

An additional note on terminology: Sometimes, economists refer to capitalist economies as market-based economies, or simply **market economies**. The term was used in particular to contrast capitalist systems from Soviet-style economies, where most economic decisions were made by central bureaucracies (central planning). Throughout the book, we will use the terms "capitalism" and "market economies" interchangeably to designate the same system (with the understanding that, as we will see later in this section, there are many variants of capitalist, or market-based, economies).

A (VERY) BRIEF HISTORY OF THE ECONOMY

At the risk of oversimplifying, we may divide the history of the economy into three different phases, each with its own institutions. For centuries, the various economies around the world were characterized by self-sufficient, family-based production. Of the various institutions previously mentioned, the one that we most clearly observe

is private property (arguably the oldest economics-relevant institution).

As these families produced surpluses of food and other products, they were able to exchange their surpluses in markets, typically local markets. This corresponds to the second phase in the history of the economy, the era of the market economy with family-based production. With respect to the previous era, we add a new economic institution: the market.

Finally, we come to the third phase in the history of the economy, the beginning of which is marked by Great Britain's **Industrial Revolution**. The Industrial Revolution took place in the late 18th century and early 19th century. It was a process of rapid transition from manual labor to mechanized production, from agriculture to manufacturing — and rapid population growth. (Why did the Industrial Revolution first take place in Great Britain and in the 18th century? This is one of the most fascinating questions in economic history, alas one we won't have time to dive into.)

In terms of economic institutions, the industrial revolution led to the emergence of physical capital and of factories. This in turn led to the creation of firms and the distinction between capitalists (or capital owners) and workers. In sum, to private property (first era) and markets (second era), the third era in the history of the economy (the capitalist economic system) adds the institution of the "firm" (firms being institutions that bring together **capital** and **labor**).

The emergence of capitalism was associated with extremely rapid improvements in production technologies (i.e., **technology progress**) and gains in **production efficiency**. These trends led to unprecedented **productivity** improvement. For example, the economic value created by one hour of work increased quite rapidly. Our next goal is to understand how and why this happened.

WHY CAPITALISM WORKS

In Figure 1.3 we marked two events which took place in 1776: James Watt patents his steam engine; and Adam Smith publishes *The Wealth of Nations*. (US readers will note that 1776 was also the year the US declared independence from England.) Watt's steam machine was not the first steam machine, but it was considerably more efficient

than previous models. It is frequently singled out as a watershed moment in Britain's Industrial Revolution.

Adam Smith, in turn, based his classic treatise on multiple visits to factories operating in England and Scotland. In other words, he observed the Industrial Revolution and the emergence of capitalism firsthand. His theory of the benefits of capitalism rests on two pillars: productivity gains from division of labour and efficiency gains from free market exchange. We will return to these several times in the book. *The Wealth of Nations* had a huge influence in the discipline of economics. In a way, we can say that it created a new discipline.

Based on Smith's work and on that of many economists since then, we have an understanding of how capitalism promotes economic growth. One first important point is that **competition** between firms incentivizes them to innovate. During the 18th and 19th centuries, it was a quest for a more efficient steam machine or a faster weaving machine. In the 21st century, we observe how Apple and Samsung, for example, vie for leadership in the smartphone market by constantly introducing new features.

A second factor is the **division of labor** and the increased efficiency it creates (i.e., gains from **specialization**). In Adam Smith's own words (in *The Wealth of Nations*),

> The greatest improvement in the productive powers of labor, and the greater part of the skill, dexterity, and judgment with which it is anywhere directed, or applied, seem to have been the effects of the division of labor.

Adam Smith proposed the example of a pin factory (an object which, as a result of the Industrial Revolution, went from a luxury item to one accessible to most people). If a pin factory employs one person only, then that person must execute all the tasks required to manufacture each pin. However, if demand for the factory's output is sufficiently great to justify hiring multiple workers, then each worker can specialize in one specific task and become good at it (i.e., efficient).

One reason why specialization allows for greater efficiency is **scale economies**. Suppose, for example, that each step in the pin production process requires a set up cost. If a worker works on one pin at a time, then the worker must incur this set up cost multiple times. By contrast, if the worker specializes in one task only then the worker only has to incur the set up cost once.

Wikimedia Commons

A Ford Motor Company assembly line in 1913. Division of labor allows for worker specialization, which in turn leads to significant efficiency improvements.

A second reason why specialization allows for greater efficiency is **learning by doing**. If our worker sticks to doing one thing only, then the worker is better able to experiment with different production methods, eventually choosing the best.

Last but not least, specialization allows for significant efficiency gains when there are differences in ability across workers. Suppose one of the workers is particularly good at cutting wire, whereas another one is good at sharpening the ends. If they each specialize in one particular task, then each of them will focus on what they are better at, leading to higher overall productivity.

A related idea, one that is central to Smith's work, is the concept that **market exchange** creates **value**. Consider international trade. If Scotland and France are isolated from each other, then Scotland must produce the wine it consumes and France the wool it uses. By contrast, if they trade with each other, then the Scots can specialize in what they're best at (wool) and the French in what they are best at (wine), each exporting its surplus in exchange for the other country's surplus. Note that, in the process of trading wool for wine, there is no change in the total quantity of wool and wine consumed in Scotland plus France. However, to the extent that Scots value wine more than wool and the French value wool more than wine, we can say that trade creates value; that is, it increases the value attributed to it by the consumers who end up purchasing that wool and that wine. This is an important concept, so important that we will return to it twice.

I previously mentioned the importance of the pin factory's output being great enough so as to allow for the division of labor. If you live

Bernard Spragg

International trade (one aspect of globalization) leads to the separation of the location of production and location of consumption. This in turn allows for specialization on a global level, leading to significant efficiency improvements.

in a small town or a small country, then the demand for pins will be low. If that is the case, then the local pin factory will produce a small output level. If that is the case, then division of labor will be impossible, for the factory will employ only one worker, and that worker will have to perform all the tasks required to make each pin. We conclude that the *size of the market limits the extent of division of labor*, one of Adam Smith's important concepts.

GLOBALIZATION

Another important trend during the capitalist era is the emergence of **globalization**. When Scotland and France trade, the market for French wine makers increases. Before, it was France; now, it's France and Scotland. As we saw before, a larger market brings greater opportunities for specialization and efficiency gains. In other words, globalization is a factor favorable to the efficiency gains promised by the capitalist system.

Take, for example, medical tourism in India. By 2015, the industry was estimated to be worth US$3 billion, and it was projected to grow to US$9 billion by 2020. According to CNN, each year about half a million patients visit India to seek medical care, coming from Bangladesh, Afghanistan, Iraq, Maldives, Oman, Yemen, Uzbekistan, Kenya, Nigeria, Tanzania, and many other countries. Dr Ashok Rajgopal, one of the country's leading orthopedic surgeons, has performed more than 25,000 knee surgeries, achieving unprecedented efficiency levels (e.g., 28 replacements in 12 hours). We can see in this example the process described earlier: globalization leads

to a greater market size, which in turn leads to specialization, which in turn leads to learning by doing, which finally leads to greater efficiency. Against these benefits, we must also admit that globalization implies a series of challenges. For example, surgeons in Bangladesh, Afghanistan, etc, may have suffered a negative demand shock or even lost their jobs. Later in the course we will address some of these challenges.

INNOVATION

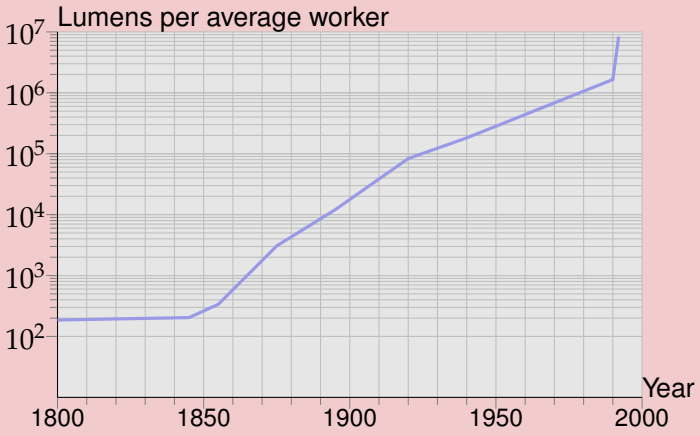
When we compare the 21st century to the pre-Industrial-Revolution 18th century economy, we notice two important differences. First, we are more efficient at producing goods and services which already existed in the 18th century. Second, we created multiple new products and services. Both of these are instances of **innovation**, which we can divide into **process innovation** (producing the same product or service but in a more efficient manner) and **product innovation** (creating new products or services).

Consider first process innovation. Steam engines have existed for a long time. Hero of Alexandria, a mathematician and engineer in Roman Egypt, invented a simple turbine in the first century AD. In 1698, Thomas Savery developed the first commercial steam-powered device. Watson's 1776 steam machine, which we alluded to earlier, was therefore not the first steam engine. Its importance lies in the fact that it was substantially improved and more efficient than previous models. The onset of the Industrial Revolution is largely connected with this instance of process innovation.

Another particularly interesting example of process innovation is given by lighting. Box 1.1 shows how, over the centuries, we've become increasingly better at providing this basic service. However, despite these efficiency improvements in producing energy, electricity, wine, wool, pins, etc, the most salient difference between the 18th and 21st centuries is the incredible array of products and services to which we have access today that simply did not exist back then, no matter how much we would have been willing to pay for them. And we do not need to go that far back to be shocked at the differences in terms of product availability: we did not have personal computers before the 1970s, or (widespread) internet access before the 1990s, or smartphones before the 2000s.

Box 1.1: A brief history of lighting

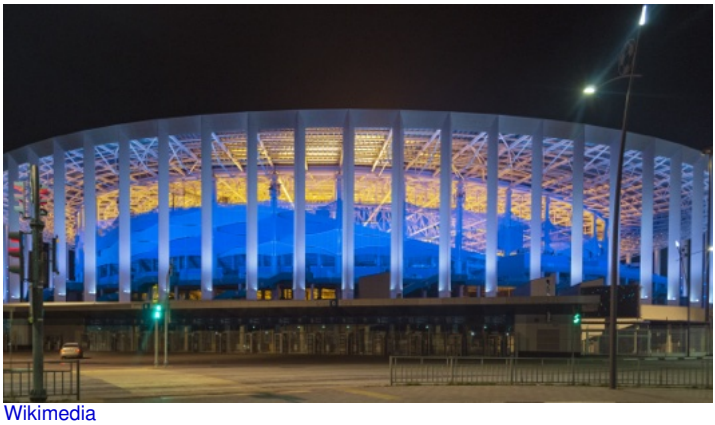
The figure below shows how much more efficient we have become, since 1800, at producing artificial light (source: *The Economy*). The horizontal axis measures time. The vertical axis measures, on a logarithmic scale, the number of lumens produced by one average worker. Lumen is a unit of brightness. Loosely speaking, a 100W lightbulb would correspond to about 1600 lumens. One candle corresponds to about 12 lumens.



Having started from close to $10^2 = 100$ lumens per hour of work in 1800, by the end of the 20th century we are closer to $10^7 = 10,000,000$ lumens per hour of work. In other words, we are 10^5 more efficient. That's 100,000 times more efficient!

So as to get a better idea of what this means, consider the following conceptual experiment. How many hours of work would it take to light up a ball room with the lumen-equivalent of 200 candles (think *Downton Abbey*) for one hour? In 1800 it would take approximately one person's work (that is, one hour of work for one hour of light). In 1900, that number hand dropped to .002 workers, and in 2000 it was only .00002.

To look at it differently, consider the number of workers required to produce the lumen equivalent to lightning up a typical sports stadium. If we were to use 1800 era lighting technology, that would be 50,000 workers! By contrast, with 1900 era technology we would only need 100 workers and, in the 20th century, one worker suffices!



Wikimedia

Nizhny Novgorod Stadium (Russia). The cost of achieving the lumens required to light up a large stadium during one hour correspond to 1 hour of human work in 2000, 100 hours in 1900 and 50,000 hours in 1800.

New products, more efficient production of existing products: In both cases, the capitalist system provides a very favorable system for the innovation that leads to higher living standards. What made inventors like Watson "tick" in the 18th century was largely the promise of economic profit resulting from better technology. Fast forward to the 21st century and we observe similar competitive races. For example, Apple and Samsung constantly add new products and features to increase their smartphone market share.

> *The capitalist system improves living standards in various ways: (a) market exchange creates value (both parties are better off); (b) markets allow for specialization, which in turn leads to greater efficiency; (c) the profit incentive leads individuals and firms to engage in product and process innovation.*

VARIETIES OF CAPITALISM

Earlier, we defined capitalism as the economic system that combines the institutions of private property, markets, and firms (capital and labor). Not all societies and economies have been organized according to this system. First, as an alternative to private property, there have been a number of systems with *common* property. Examples include early Christian communities and Israel's modern kibbutzim (plural of kibbutz). Similarly, not all societies and economies are based on markets. The Soviet Union (1917–1991) and China (until the late 1970s) are examples of societies where most economic activity was dictated by a centralized bureaucracy.

Moreover, capitalism is not a precisely identified concept. Looking around today's world we observe quite a few **varieties of capitalism**. To a great extent, we may classify the US, France, and present-day China as capitalist systems. However, clearly they correspond to different varieties of capitalism. Take the issue of private property: In China, for example, state-owned enterprises play an important role, considerably more than in the US. In France, eminent domain laws are more favorable to public projects than in the US (if a rail line, for example, is planned between City A and City B and this requires crossing over privately-owned land, it will typically be easier for the government to obtain access in France than in the US).

Given this wide variety of systems, a more appropriate description of today's societies is that they are **mixed economies**, a system combining free markets with state intervention (as well as private firms with public enterprises). One particular instance of the hybrid nature of today's economies is given by the innovation system. As mentioned earlier, the capitalist system provides an especially favorable setting for innovation and the resulting appearance of new products and services. However, from Finland to the US, from China to Switzerland, we observe that government investment and initiative has played an important role in innovation as well. Take for example the US innovation system. According to economist Mariana Mazzucato

> The parts of the smart phone that make it smart — GPS, touch screens, the Internet — were advanced by the Defense Department. Tesla's battery technologies and solar panels came out of a grant from the U.S. Department of Energy. Google's search engine algorithm was boosted by a National Science Foundation innovation. Many innovative new drugs have come out of NIH research.

This should not diminish the genius of inventors and innovators like Steve Jobs. Knowing how to put things together, knowing how to combine previously developed innovations, is an art that few can accomplish. But one must also recognize the important role of government-based financing in keeping the innovation system working. Perhaps the optimal system is neither the market economy nor the centrally planned one but rather the system that combines the best of free enterprise and government backing.

Wikimedia

Scientific research and innovation provide a good example of the value of a mixed economy, one which combines free markets and state intervention, private firms and public enterprises.

CASE STUDY: CHINA'S GREEN REVOLUTION

Private property is one of the institutions (one of the pillars) of the market economy. If we have not focused significantly on it, it's partly because private property is not exclusive to the capitalist system. As mentioned earlier, private property is arguably one of the oldest institutions in the history of the economy. But just like healthy people do not value health until they are sick, so we tend to underestimate the role played by private property in making the market economy work.

One good example of this is China's green revolution of the 1970s and 1980s. Decades of communist rule under Mao Zedong led the country to disastrous economic outcomes. For example, from 1958 to 1962, tens of millions of Chinese died of starvation. While there were various causes for the crisis, the famine is regarded as one of the greatest man-made disasters in human history, in particular the result of common property of land and other production means.

In 1976, Mao Zedong died and was succeeded by Deng Xiaoping, a pragmatist (selected quote: "It doesn't matter if a cat is black or white: as long as it catches mice, it's a good cat"). Then two things happened, one in the halls of Beijing, one in the fields of a small rural village.

In December 1978, eighteen local farmers in Xiaogang, led by Yen Jingchang, agreed to break the law by signing a secret agreement to divide the land, a local People's Commune, into family plots. Each plot was to be worked by an individual family. Each family committed to turn over a part of the crop to the government and the collective and was allowed to keep the surplus. The results were nothing

Wikimedia

In December 1978, a group of local farmers in Xiaogang agreed to create a form of private property in an otherwise collective property economy. Harvest levels during the experiment's first year were larger than the previous five years combined.

short of extraordinary: harvest levels during the first year were larger than the previous five years combined.

Inevitably, Beijing found out about the experiment. Deng Xiaoping, who could have punished the lawbreakers, decided to extend the so-called **household responsibility system** across China. He did so because he was a great pragmatist, but also because he listened to Xue Muqiao (1904–2005), the thought leader underlying the reform. In a 1977 letter, Xue prophetically states that

> It is hard to motivate farmers if growth in agricultural production cannot bring corresponding growth in income. Any interest in working suffers if extra work is not rewarded. … Boosting farmers' enthusiasm for agricultural production therefore outweighs improving the conditions for agricultural production.

In present-day economics jargon, we would say the system did not provide enough incentives ("enthusiasm") for farmers to work hard.

In retrospect, the household responsibility system increased the farmers' willingness to work hard and produce a significantly greater yield. Figure 1.5 shows the evolution of agricultural output following the rollout of the new system. The blue bars depict the average crop index, where the 1978 value is normalized at 100 (left scale). The red line, in turn, represents the fraction of China's land that adopted the household responsibility system (right scale). In 1978, no land had adopted the new system and the output index was at 100. By 1984, all of China had adopted the new system and the output index had increased to more than 140.

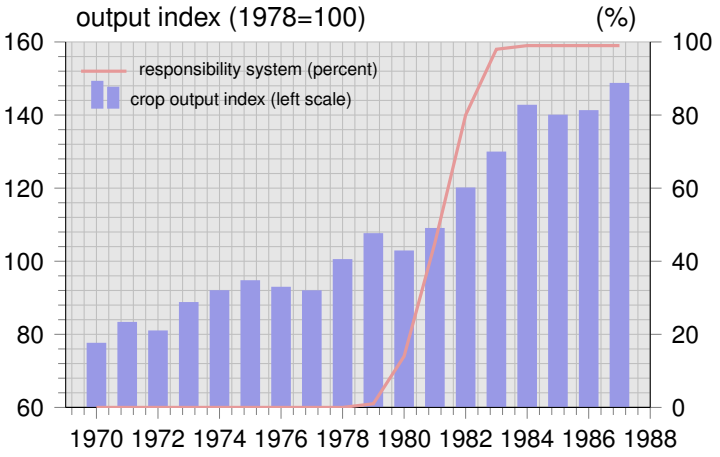


FIGURE 1.5
China's rural reform (source: Justin Yifu Lin)

The lesson of China's rural reform is that private, well-defined property rights matter a great deal for the functioning of an economy. As a result of the reform, each family effectively had property rights over the additional output resulting from their extra effort. Or, as we would now say in economics jargon, the incentives were well aligned: I'm the one who is working harder, I'm also the one who reaps the benefit from that extra effort.

There is another lesson, one which economists are keen to repeat. While the practical Deng Xiaoping and the Xiaogang families are considered the heroes of the green revolution, in the words of John Maynard Keynes,

> Practical men who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back.

Much credit is due to Xue Mugiao, arguably the most influential economist in Chinese history.

1.3. THE LIMITS OF THE MARKET ECONOMY

In his 2009 documentary, *Capitalism: A Love Story*, director Michael Moore highlighted many of the shortcomings of American capitalism. (The film was described as "an examination of the social costs of corporate interests pursuing profits at the expense of the public good.") In this section we focus on two: inequality (and discrimination) and the environment.

> *Among the many limitations of the capitalist system, inequality and the environment stand out as the most significant.*

INEQUALITY

As mentioned earlier in the chapter, history's "hockey stick" (the take-off of capitalism) affected different countries at different times, thus generating significant inequality across countries. In 1700 there was relatively little difference across countries in terms of per-capita income (a maximum factor of about 2, corresponding to UK vs China). By 2000 the difference is considerably higher (a maximum factor of 20, corresponding to the US vs India). It's not that India became poorer in 2000 than it was in 1700. In fact, the opposite is true. What happened was that, while most countries in the world became richer in the past few centuries, some did so at a much, much faster rate, namely the countries that experienced the "hockey stick take off" at an earlier moment in history.

Notwithstanding the previous paragraph, we also observe a reverse trend in world inequality when considering specific pairs of countries. For example, for the past few decades we have observed that China, having taken off in the late 20th century, narrowed the per-capita GDP cap with respect to the US (and other rich economies), so we may say that, to some extent, the degree of world inequality has decreased.

There are many dimensions of the inequality phenomenon. In addition to inequality across countries, we also have intra-country inequality. Figure 1.6 partly documents the evolution of inequality in the US. In the 1960s, the top 1% of the population earned about 10% of total income. The bottom 50% of the population, in turn, earned a little more than 20%. This is already a rather unequal distribution,

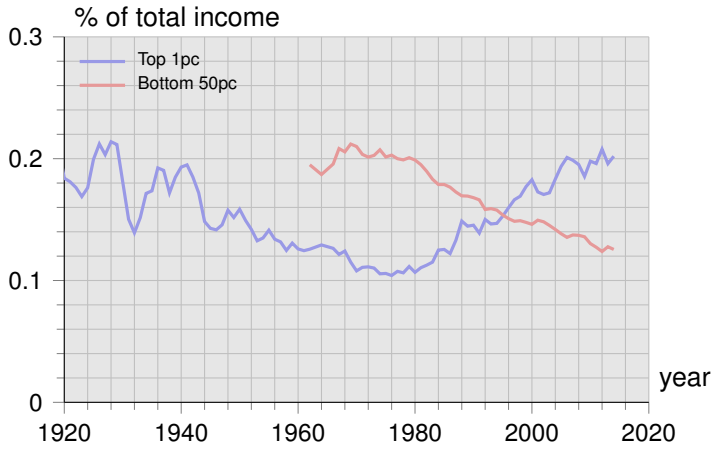


FIGURE 1.6
Income inequality in US. Source: World Inequality Database

but it's nothing compared to what came later. In 1995, the "top 1" and "bottom 50" curves crossed, and by 2010, their positions are reversed with respect to the 1960s: Now the top 1% earns close to 20% of total income, whereas the bottom 50% gets about 12.5% of the pie.

A big question in economics is the source of this increase in inequality. Is it about capital versus labor, as economist Thomas Piketty would have us believe? Many economists, including this one, would rather point to the effects of skill-biased technical change (e.g., artificial intelligence), globalization, and several other factors (which we will carefully analyze in Chapter 11).

Although much attention has been given to the US economy, this is hardly the only case of high levels of inequality. Figure 1.7 shows income concentration among the top 10% of various countries (or country blocks). Europe is the relatively more egalitarian part of the world, where the top 10% "only" get 34% of total income. At the opposite end of the spectrum, among Middle Eastern countries, the top 10% amass about two thirds of total income. The US lies somewhere in the middle of the sample. However, were we to restrict to high-income countries, the US would "lead" the world in terms of income inequality. China is somewhere between Europe and the US.

A related problem with the capitalist system, though not exclusive to the capitalist system, is that of **discrimination**. There are many forms of discrimination in our societies, but two in particular are

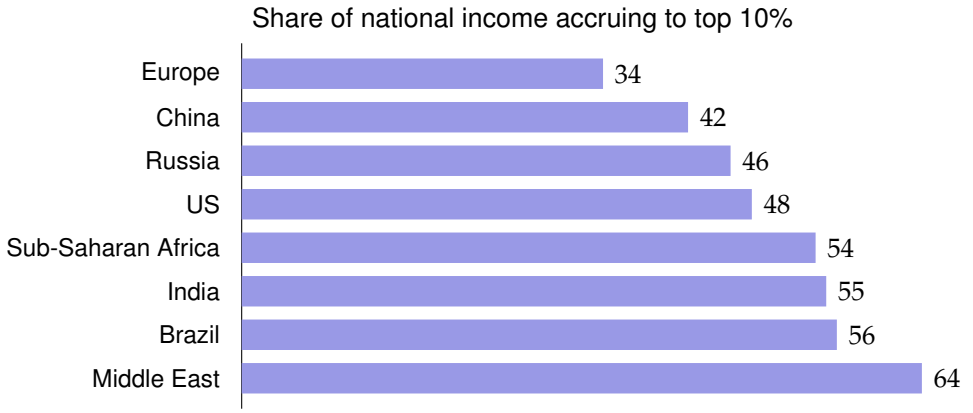


FIGURE 1.7
Within-country inequality by country. Source: Thomas Piketty, *Capital and Ideology*, 2019.

frequently related to diverse economic conditions: gender discrimination and racial discrimination. Figure 1.8 may be helpful for the purpose of analyzing the economic dimension of discrimination. It shows the mean weakly wage in the US for different groups of people. The first statistic to notice is that, while the mean wage rate is \$886, the 90th percentile corresponds to \$2,129 (that is, 10% of the US worker population is paid more than \$2,129 per week), whereas the 10th percentile corresponds to \$430 (that is, 10% of the US worker population is paid less than \$430 per week).

Focusing more specifically on the issue of discrimination, we notice that men earn on average \$973, whereas women earn on average \$789. This gap of approximately 20% has declined somewhat over the past few decades but remains high. We have to be careful before stating that women are discriminated in the labor market to the tune of 20%. In fact, one reason for this difference in averages is that women choose jobs that pay less on average than the jobs chosen by men. However, even correcting for the effect of **selection** into different types of jobs we still observe that women are paid less than men. Moreover, the very choice of jobs is likely influenced by society's prejudices regarding gender roles. The bottom line is that, while difficult to quantify exactly, the evidence for gender discrimination is significant. We will return to this issue in Chapter 11.

A similar qualification must be made regarding the economic di-

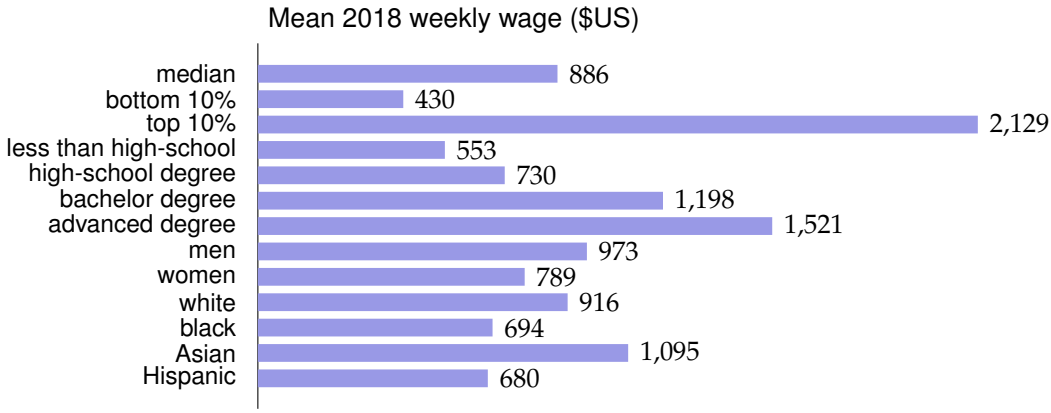


FIGURE 1.8
Wage inequality in US (source: Bureau of Labor Statistics)

mension of racial inequality. African Americans earn an average of $694, whereas white Americans earn $916, about 30% more. Is this gap due to discrimination in the labor market? One reason to be cautious is that wages are highly correlated with education levels, and education levels vary considerably across races. Specifically, Figure 1.8 shows that Americans with less than a high-school education earn an average wage of $553, whereas, at the opposite end of the distribution, Americans with an advanced degree earn an average of $1,521. Access to advanced education is highly biased with respect to race. This suggests that, in addition to discrimination in the labor market, one must also consider differences in access to education.

Economists have studied extensively the factors underlying the clearly lower living standards of African Americans. Education level, household structure, neighborhood of residence, etc. — all of these economic-related factors play an important role. However, the danger of a purely economic analysis is to think that race inequalities can be treated as a "technical" problem, one for which politicians can find a "technical" solution. In fact, the problem runs deeper and has its source in implicit (or explicit) prejudice which remains in place even decades after the law has recognized the equal status of all citizens. In sum, economics can help explain the problem, but is not itself sufficient to solve it. We will return to the issues of inequality and discrimination in Chapter 11, within the broader context of social justice.

To conclude this subsection, we should mention that labor-market discrimination is not only unfair but also inefficient. Take, for example, Sandra Day O'Connor. In 1952, she graduated from Stanford Law School third in her class. However, she was unable to find offers at law firms other than as an administrative assistant. Fortunately, gender discrimination in the legal profession has declined since then. As to Day O'Connor, she did follow a career in law and in 1981 was appointed by President Reagan to the US Supreme Court, the first woman to hold the post. In 2009, she was awarded the Presidential Medal of Freedom by President Barack Obama.

More generally, the case can be made that less discrimination in the labor market is responsible for the increased number of women and African-Americans who joined high-skill occupations that were previously reserved to white men. For example, in 1960, 94% of all doctors, 96% of all lawyers, and 86% of all managers in the US where White men. By 2010, those numbers had declined to 63%, 61% and 57%. Assuming that talent is evenly distributed across genders and races, this represents a tremendous boost in the match of talent with high-skilled jobs. Research by economists Chang-Tai Hsieh, Erik Hurst, Chad Jones and Peter Klenow on the evolution of the US economy suggests that 47% of the US growth since 1960 can be attributed to declining barriers to entry into high-skilled occupations.

THE ENVIRONMENT

A second important challenge to the current capitalist system is the effect that it's having on the environment. Unfortunately, the debate on climate change has become too polarized and politicized. As much as possible, economists try to bring the order of logical thought into the matter. This we will attempt in the next few paragraphs.

There is a general consensus regarding two important correlations: The correlation between CO_2 emissions and atmospheric CO_2 concentration; and the correlation between atmospheric CO_2 concentration and temperature anomalies. We next consider these.

Figure 1.9 plots the three time series in question. The blue line shows the atmospheric concentration of CO_2 since 1700, with units measured on the left scale (parts per million). As can be seen, atmospheric concentration increased slowly until about 1950, from about 275 parts peer million (ppm) in 1700 to about 310 ppm in 1950. Af-

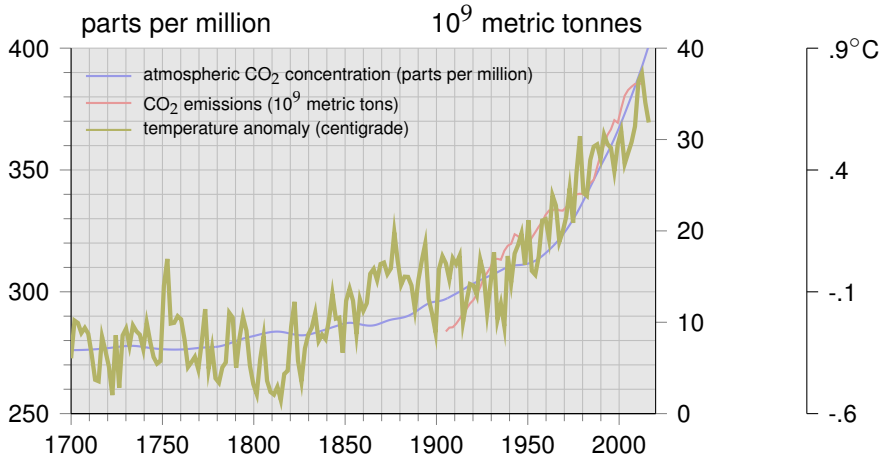


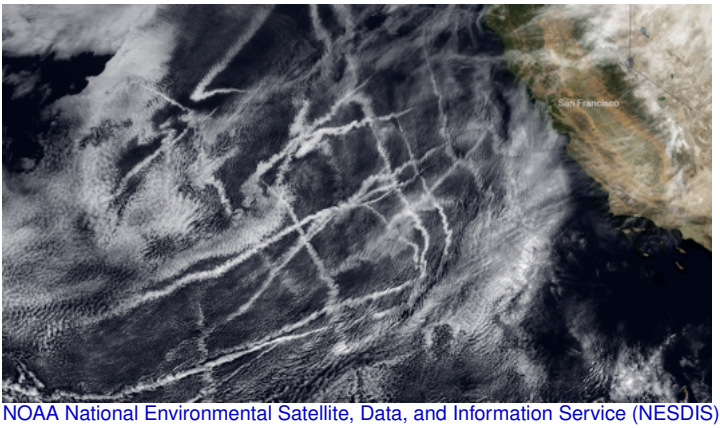
FIGURE 1.9
CO_2 emissions, atmospheric CO_2 concentration, and temperature anomaly (source: *The Economy*)

ter that, we observe an increase at a faster pace. By 2010, the level of atmospheric CO_2 concentration has already passed the 400 ppm mark.

The second series of interest is the level of CO_2 emissions due to economic activity (transportation, travel, manufacturing, etc). This corresponds to the red line in Figure 1.9 and is measured on the right scale (billions of metric tonnes). By the beginning of the 20th century (the earliest date for which we have reliable worldwide data), total emissions were about 10 billion metric tons. By 2010, the value has already passed 35 billion metric tons, an almost fourfold increase.

The third series of interest is the difference in temperatures with respect to the "normal" level; that is, the level one would estimate to result from the "natural" evolution of the planet. This is a controversial calculation (different scientists will give you different numbers), but there is broad consensus with regard to the values in Figure 1.9 (measured in degrees centigrade, marked on the far-right scale). And the evidence suggests that, in the 18th century, the planet's temperature was about a tenth of a degree colder than normal, whereas, by the beginning of the 21st century, the temperature anomaly is rapidly approaching one full degree centigrade (about 2.5 degrees Fahrenheit).

I purposely chose the three scales in Figure 1.9 so as to make the



NOAA National Environmental Satellite, Data, and Information Service (NESDIS)

As cargo ships steam across the oceans, the tiny aerosol particles in their exhaust act as seeds around which moisture in the atmosphere can condense. Occasionally this results in ship tracks becoming visible in cloud imagery.

two correlations easy to follow. First, the increase in CO_2 emissions during the 20th century is very closely followed by an increase in CO_2 atmospheric concentration. Second, the evolution of the temperature over a period of three centuries tracks very closely the evolution of atmospheric concentration.

While there is broad agreement regarding the correlation between these time series, there is some disagreement regarding the nature of causality. There is a general consensus that human activity (in particular economic activity in the more developed countries) has contributed significantly to the increase in atmospheric CO_2 concentration. There is some debate as to the precise level of human contribution to atmospheric CO_2 concentration, but it is generally agreed to be high.

The issue of the relation between atmospheric concentration and temperature is more controversial. It is generally agreed that it's positive, but the agreement is less than universal when it comes to the precise relation between atmospheric CO_2 concentration and temperature. In other words, Figure 1.9 clearly establishes a close correlation between atmospheric concentration and temperature anomaly, that is, deviations from the "normal" temperature. However, as we will see in Chapter 2, correlation does not imply causality. Climate scientists make a strong argument that this correlation corresponds to a causal relation, but there is considerable debate about the precise relation, in particular the rate at which changes in atmospheric CO_2 concentration translate into temperature increases, and ultimately on what the planet's temperature will be in 10- or 100-years' time.

Finally, there is also broad consensus that significant increases in

temperature may have significant effects on the planet's eco-system. Depending on whom you talk to, even among scientists, these effects may vary from very significant to catastrophic to apocalyptic. As the IPCC reports admit, it's very hard to predict climate change, so the best we can do is to assign probabilities to the various possible outcomes. This includes some very drastic outcomes that occur with strictly positive probability.

In sum, notwithstanding disagreement regarding precise values, there is broad consensus that climate change is a serious problem and that economic activity has played, and continues to play, a central role in it.

1.4. A SUSTAINABLE ECONOMY

In an article prepared for the 2017 World Economic Forum, we read that:

> Based on GDP and other measures of well-being, humanity has never been better off. ... Yet these historic advantages are being matched by a range of challenges felt keenly by many citizens.

This is an appropriate summary of the previous two sections. At some level, capitalism has improved living standards remarkably. However, in the process it has also created a number of imbalances, including inequality within and across countries, racial and gender inequality, climate change and resource depletion. The precise extent to which the capitalist system is the cause of these imbalances is open to debate, but one must recognize that the imbalances have taken place within the context of the capitalist system.

These considerations form the basis for the concept of **sustainable development** or, alternatively, a sustainable economy. Broadly speaking, economists agree that a **sustainable economy** requires:

1. The right incentives for individuals and firms to engage in cost-reduction and quality improvement innovation, as well as efficient production.
2. A stable society, in particular one that is just.
3. A stable biophysical environment and resource base.

The UN's Sustainable Development Goals, adopted on September 25, 2015, as a part of the 2030 Agenda.

Widimedia

It's fair to say that the average capitalist economy has done a decent job at addressing Point 1: Private property and market competition provide strong incentives for individuals and firms to come up with new and improved products, as well as becoming more efficient and producing existing ones. The greatest challenges are to address Points 2 and 3, social justice and the environment.

The United Nations' 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a useful itemization of the generic goals of social justice and biophysical sustainability. At its heart are the 17 **Sustainable Development Goals** (SDG) to be achieved by 2030, including:

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation, and Infrastructure
10. Reduced Inequality
11. Sustainable Cities and Communities
12. Responsible Consumption and Production

13. Climate Action
14. Life Below Water
15. Life On Land
16. Peace, Justice, and Strong Institutions
17. Partnerships for the Goals

Some of these goals are more closely related to the economy, some are more a function of institutions such as democracy and the rule of law. All are at least *indirectly* related to the structure and performance of the economy. In what follows, we consider four particular aspects of the idea and ideal of a sustainable economy.

SOCIAL SUSTAINABILITY

It has become common to attribute the rise in inequality to the influence of particular political parties within particular countries. Undoubtedly politics has played an important role. However, one might say that the 21st century economy is characterized by "structures of inequality:" There are features of the current economy that naturally lead to greater inequality. (By "natural" I mean "unless specific intervention to the contrary is taken.") Popular literature offers multiple accounts of this phenomenon in books with titles such as *The Winner-Take-All Society*, *Average is Over*, or *The Vanishing Middle Class*. The arguments vary, but the common theme is that various features of our economy and society are responsible for a rapid increase in levels of inequality. We will go through these in detail in Chapter 11.

Social sustainability requires keeping these inequality trends in check. There is no magic number telling us how much inequality a society can tolerate, but the level of social instability observed, for example, in the 2011 Occupy Wall Street protests or the 2018 Yellow Vests movement suggests we are not far from that threatening threshold.

Social sustainability is not just about income inequality. The UN's very first SDG (see page 34) calls for an end to poverty by 2030. The number of people living in absolute poverty has fallen four-fold since 1980, a remarkable achievement for which the capitalist system deserves some credit. However, many countries still lag behind the

Protesters in Santiago, Chile, form a barricade to fight with the police. October, 2019.

Paracrito

economically developed world, and significant pockets of poverty persist in otherwise wealthy nations (including the US). Moreover, even when material poverty is alleviated or even eliminated, we observe continuing, even increasing, cases of social exclusion.

The distinction between poverty and social exclusion is important, as it helps explain the disconnect between the economic-growth and the social-justice diagnoses of what the capitalist system has achieved. If we examine income levels, it is undeniable that most of the world is better off now than it was half a century ago. Growth is good. Growth has been good. But take two households, one living in 1970 and one living in 2020, with the same real income level (i.e., correcting for inflation), or perhaps with the 2020 household earning a slightly higher income. Suppose that neither household has Internet access. In 1970, lack of Internet access is a foregone conclusion, as there was no Internet. For a household in 2020, not having Internet access implies an enormous barrier to social integration; for example, difficulty in access to education and multiple other services. Therefore, even if both households' earnings (in 1970 and in 2020) place them above the poverty line (no one is dying of hunger) there is a clear sense of social injustice regarding lack of Internet access in 2020.

Social sustainability requires an increasing engagement by individuals and by various institutions, both governmental and non-governmental, in remedying, both structurally and on a case-by-case basis, the excesses implied by a system that disproportionately benefits some in favor of others. In Chapters 11, 12 and 13 we will address these issues in greater detail, including controversial issues such as

Box 1.2: 100 Million Missing Women.

Frequently, we assume that there are slightly more women in the world than men. In the US and in 2013, for example, there were 161 million females and only 156 million males. However, worldwide there are fewer women than men. What explains the female/male ratio in the population? In an influential article, economist Amartya Sen stated that

> At birth, boys outnumber girls everywhere in the world, by much the same proportion—there are around 105 or 106 male children for every 100 female children. Just why the biology of reproduction leads to this result remains a subject of debate.

If men and women receive similar nutritional and medical attention and general health care, then women tend to live noticeably longer than men. In Europe, the US, and Japan, despite persistent bias against women, the latter outnumber men substantially. However, in South Asia, West Asia, and China, the ratio of women to men can be as low as 0.94. Specifically, Sen calculates that

> A great many more than 100 million women are "missing." These numbers tell us, quietly, a terrible story of inequality and neglect leading to the excess mortality of women.

Several scholars have attempted to explain the sources of this large gap, with explanations ranging from selective abortion and female infanticide to discrimination in access to employment and health services. The jury is still out as to the relative importance of each of these factors, but they all seem to reflect some form of gender discrimination.

wealth taxation.

Social sustainability also requires sustainable social relations. Gender inequality, for example, is an important hindrance to social sustainability. Box 1.2 reports on a specific aspect of gender inequality, the missing women problem. And, as recent events in the US show, racial conflict is still a major challenge to social sustainability.

SUSTAINABLE RESOURCE USE

In Section 1.3, we outlined the limitations of the capitalist system, or at least the versions of the capitalist system we've lived with for the past two centuries. One of these limitations is the negative impact that economic activity has had on the environment, both on the physical environment and the biosphere.

If the market works so well in allocating resources, as Adam Smith argued, why have natural resources been so poorly managed by the capitalist system? As we will discuss in greater detail in Chapter 9, the problem is essentially one of poorly enforced property rights. In some sense, everyone owns planet Earth; in some other sense, nobody does. Many actions that I carry out harm the planet, implying that they harm me as well. However, by harming the planet, I also cause harm to billions of other people who have little or no control over my actions. In this sense, property rights over the planet are not well defined, well enforced, or both. It's a bit like farms in China before the responsibility system was put in place (see page 23).

Sustainable resource use requires, first of all, acknowledging that economic activity does not take place in a vacuum, rather in the context of a specific planet (or, looking at future prospects, in the context of a specific solar system). Figure 1.10 illustrates this point. Particularly important are the arrows in green, representing the use of natural resources related to land, raw materials, energy, water; and the red and blue arrows connecting the economic agents (firms, households) to the surrounding environment (arrows which represent, inter alia, pollution and waste). It is fair to say that, in the past, economic analysis has placed greater emphasis on the remaining arrows (market based relations, firm investment, etc) than on the environment-related arrows, that is, the ones that link the economy to its environment. It's time to change that, for the sake of an economy with sustainable resource use.

From an economics point of view, it helps to distinguish three types of issues related to resource sustainability: (a) exhaustible resources, (b) environment, and (c) climate change. Let us next discuss each of these in turn. Since at least Thomas Malthus' classic, *An Essay on the Principle of Population*, economists have been aware that the planet has limited amounts of various natural resources, and that

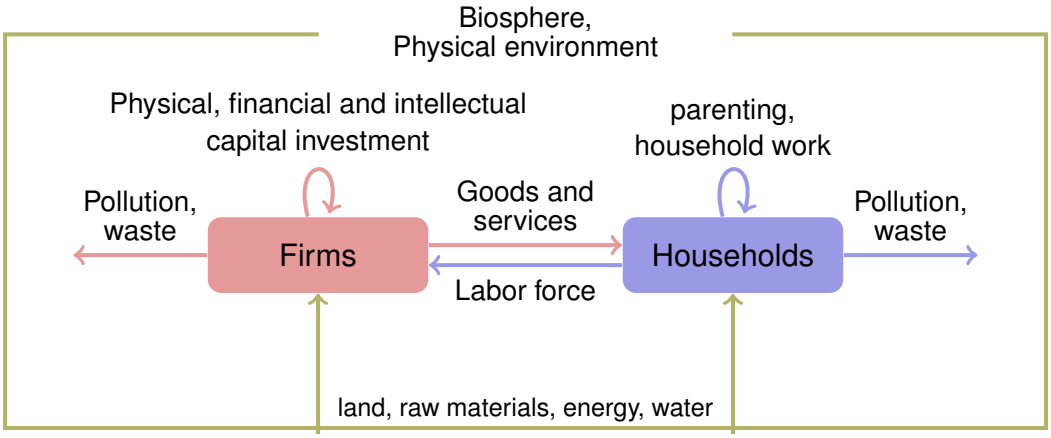


FIGURE 1.10
A model of the economy (adapted from *The Economy*)

the passage of time (as well as population growth) renders those resources increasingly scarce. Malthus predicted that

> The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race.

Since then, and with remarkable regularity, multiple experts have predicted calamities of one sort or another on account of the limited supply of resources. In the 1968 classic, *The Population Bomb*, Paul Ehrlich warned of a worldwide famine in the 1970s and 1980s due to overpopulation. Four years later, *The Limits of Growth*, a report by an MIT team requested by the famous Club of Rome, predicted that the planet's oil reserves would be depleted before the end of the century.

Limited resources remains a problem for humankind. In fact, the limited availability of resources is, in a certain way, the central problem in economics. However, of the three problems listed above (limited resources, environment, climate change) the threat posed by the scarcity of natural resources (such as oil, copper or gold) is arguably the least dramatic one. The reason is that market prices — Adam Smith's **invisible hand** — tend to do a good job in turning economic agents away from resources that become increasingly rare. By contrast, most environmental problems result from market failure. In particular, climate change is a truly global problem (unlike most

other environmental problems); that is, one that cannot be solved by the market or by isolated local or even national authorities in isolation. In Chapter 9, we will discuss government policies, as well the role of individuals and non-governmental institutions, in achieving an environmentally sustainable economy.

SUSTAINABLE BUSINESS

In a famous (or infamous, according to some) *New York Times Magazine* article, economist Milton Friedman stated that

> In a free-enterprise, private-property system, a corporate executive is an employee of the owners of the business. He has direct responsibility to his employers. That responsibility is to conduct the business in accordance with their desires, which generally will be to make as much money as possible while conforming to the basic rules of the society, both those embodied in law and those embodied in ethical custom. Of course, in some cases his employers may have a different objective.

Friedman is frequently quoted with the more catchy and provocative statement, "The social responsibility of business is to increase its profits." However, as the above paragraph shows, he makes two important qualifications. First, a manager's responsibility toward the firm's owners is moderated by "the basic rules of the society, both those embodied in law and those embodied in ethical custom." Second, Friedman admits that "in some cases [firm owners] may have a different objective" than profit maximization.

These two qualifications are quite important. First, the norms of "ethical custom" related to business have evolved considerably in half a century (that is, since Friedman wrote his piece). Second, many corporations (most corporations?) espouse mission statements that go well beyond profit maximization. In 2019, the Business Roundtable (BRT), a non-profit association whose members are CEOs of major US companies, released an updated *Statement on the Purpose of a Corporation* by which the CEOs commit to lead their companies "for the benefit of all stakeholders — customers, employees, suppliers, communities and shareholders."

Many analysts saw BRT's Statement of Purpose as the ultimate vindication of the supremacy of stakeholders over shareholders, a condition *sine qua non* for the sustainability of business and society. To put it differently: A society must pursue the common good. Corporations are members of society, hence they too should pursue the common good. By contrast, other experts — mostly skeptical economists — interpreted BRT's Statement of Purpose as little more than a marketing ploy.

The concept of **corporate social responsibility** (CSR) largely corresponds to the evolution of beliefs reflected in BRT's Statement of Purpose. (Other terms related to CSR include corporate sustainability, sustainable business, corporate conscience, corporate citizenship, conscientious capitalism, and responsible business. These terms don't necessarily mean the same thing but clearly overlap, and clearly contrast with Friedman's view of the firm as pure profit maximizer.) While it is difficult to find a precise definition of CSR, most would agree that it corresponds to a company's sense of responsibility towards the community and the environment, both ecological and social, in which it operates.

One perspective on CSR is that it is good business. For example, the NYU Stern Center for Sustainable Business's (CSB) mission statement declares that "Sustainable business is good business: delivering better financial results while protecting the planet and its people." The Center's goal is to help business leaders "embrace proactive and innovative mainstreaming of sustainability, resulting in competitive advantage and resiliency for their companies as well as a positive impact for society." This view is frequently encapsulated in the catchy phrase, "doing well by doing good" (where "doing well" is understood as shareholder performance and "doing good" is understood as being socially responsible). For example, CSB's founder Tensie Whelan contends that

> Embedding environmental, social, and governance (ESG) concerns into business strategies is not only good for making money, but also essential to customer allegiance and protecting against the rising number of major threats to social stability, vibrancy, and inclusiveness that makes a healthy business possible in the first place.

A more "radical" perspective acknowledges that frequently the ben-

efit of relevant stakeholders (e.g., local communities or the environment) comes at the expense of direct shareholders' financial value. However, even then a socially responsible CEO does not necessarily violate a broader interpretation of the Friedman doctrine whereby the CEO is responsible for pursuing the company's mission. Fortunately, an increasing number of companies adopt mission statements which explicitly include elements of CSR; and those who acquire shares of those firms effectively buy into those mission statements. As a result, a CEO who conducts "business in accordance with [the shareholder's] desires" (Friedman's words) is effectively pursuing CSR even if at the expense of shareholder financial performance.

HUMAN-CENTERED ECONOMY

The Universal Declaration of Human Rights, the milestone document proclaimed by the United Nations General Assembly on December 10, 1948, states in its very first article that "All human beings are born free and equal in dignity and rights." As part of his 2020 presidential campaign, then candidate Andrew Yang proposed that "The unit of a Human Capitalism economy is each person, not each dollar." At a May 6, 2020 briefing to discuss the New York post-COVID-19 re-opening plan, Governor Cuomo asked and answered a rhetorical question: "The question comes back to how much is a human life worth? To me, I say the cost of a human a human life is priceless, period."

An important condition for a sustainable economy is that it be based on people, not on money. In this regard and at a general level, the above statements seem bland, obvious, almost tautological. However, as one goes deeper into the issues one realizes there is considerable controversy. First, do all beings have the same dignity and rights? Highly influential philosopher Peter Singer defines a person as "a being who is capable of anticipating the future, of having wants and desires for the future," thus excluding, for example, many handicapped infants or patients suffering from Alzheimer's disease, a distinction some find offensive and excessively utilitarian.

Second, while we may consider human beings to be priceless, the truth is that, in practice, we are forced to make comparative judgements where the economic value of a life comes into play. For ex-

ample, a new regulation that costs X and promises to save Y lives has to be judged based on some standard. In most countries, policy makers and courts employ the concept of the **value of life** (VL), an economic value used to quantify the benefit of avoiding a fatality. Different institutions in different countries in different years have proposed different VL. For example, in the US and in 2010, the Environmental Protection Agency set VL at $9.1 million, whereas the Food and Drug Administration set it at $7.9 million. The Department of Transportation, in turn, set VL at $9.2 million in 2014 and $9.6 million 2016. In other developed countries we find somewhat lower values, including $4.2 million in Australia (2014), $4.14 million in New Zealand (2016) and $4.15 million in Sweden. Finally, for the purpose of estimating the value of life-extending measures, private and government-run health insurance plans apply VL on a per-year-of quality-life basis, with values ranging from $50,000 to $129,000 per year.

In sum, while most agree with the primacy of people in a sustainable economy (and society), it is inevitable that some tension will arise between a purely utilitarian approach to personhood, at one end, and a working definition of value where economic calculus has no role to play, at the opposite end. Some common sense is required to balance these extremes. We will continue this important discussion (trade-offs) in Section 2.3. For now, let us return to Yang's notion of "human capitalism," the central tenets of which are: (a) humans are more important than money; (b) the unit of a Human Capitalism economy is each person, not each dollar; and (c) markets exist to serve our common goals and values. While I don't disagree with these principles, I prefer to rephrase them as follows:

1. Labor is more than just a production factor; that is, work has an intrinsic, subjective value beyond the economic value it creates.
2. Market exchange generates value beyond the gains from trade considered by Adam Smith (the material value of the transaction).
3. The value of economic freedom transcends the economic efficiency it engenders.

Let us next consider each of these in turn, beginning with the subjective value of work. A commonly proposed policy to address increas-

Box 1.3: The economic cost of Christmas

Upon surveying a group of Yale students, economist Joel Waldfogel concluded that many of them valued holiday gifts received considerably less than their market price. Overall, Waldfogel estimated that ill-chosen gifts caused between $4 billion and $13 billion a year in economic waste. There is, however, considerable variation in the effect of gift-giving: When the two parties know each other well (e.g., father and daughter), then the likelihood of an ill-chosen gifts is lower.

More important, even economists understand that an important component of the value of receiving a gift is not the gift itself but what it signifies ("it's the thought that counts").

Since the study on "the cost of Christmas" was made, one important development has taken place: the emergence of the gift card. Almost non-existent in 1995, by 2019 gifts cards already exceeded $163 billion in the US alone. This is positive in terms of the cost of ill-chosen gifts, but it also implies a decline in the value of effort to find an appropriate gift, that is, the value of the "thought" that counts.

ing inequality is to enact a Universal Basic Income: every citizen receives X regardless of whether they are employed or not. However, people derive value from being employed that goes well beyond the compensation provided by wage payments. Readers of a certain age may remember one of the most popular TV shows of the 1970s, the *Mary Tyler Moore Show*. In its very first episode, Mary Richards interviews for a job with WJM News. Lou Grant, the station's manager, offers Mary the job of Associate Producer. This comes as a pleasant surprise to Mary, who had actually applied for a secretarial job. Then this dialogue follows regarding job titles and compensation:

— The job pays $10 less a week than a secretarial job.
— That will be fine.
— If you can get by on $15 less a week, we'll make you producer.
— No, no, I think all I can afford is associate producer.

On a more serious note, in a 2019 interview economist Robert Shiller stated that

> Jobs are more than a source of income. One has a story about one's life that involves one's job, and a job defines how I am important and why people should love me.

This matters, for example, when discussing the impact of AI on human welfare: There is a fear that it may lead to the "loss of even more of one's identity." More generally, Shiller argues that:

> Economists should focus more on the 'meaning of life' and look beyond the figures on the page.

The second point raised is that market exchange creates value beyond the transaction itself. Economic exchange involves human beings, individuals whose welfare depends not only on the result of the transaction but also on the relationship that is established in the context of such transaction. This becomes an issue, for example, when debating the impact of online sellers such as Amazon on local commerce (the idea that local stores create more value than the value of the goods they sell). In Chapter 9 we will return to this important debate. Box 1.3 presents another example.

Finally, the third point is that economic freedom is a good in and of itself. In Chapter 7 we show how, under certain conditions, a market economy leads to an efficient allocation of resources (a result economists refer to as the First Welfare Theorem). For many economists, this is a strong argument in favor of free markets. However, in Part IV of the book we present extensive evidence that the conditions required by the First Welfare Theorem largely fail to hold. For many, this justifies the tight regulation of markets or, even more, replacing markets with the public provision of a variety of goods and services (housing, education, health, energy, etc). One argument against this view is that the defense of economic freedom is not solely based on its efficiency properties. Rather, economic freedom is an important component of human dignity. This is the view that "man's eminence is to be seen in the fact that he chooses between alternatives," and that the virtues of economic freedom (entrepreneurship, personal responsibility, equality of opportunity, meritocracy) are the best guarantee of upward mobility and ultimately social justice. One problem with this view is that it easily morphs into radical forms of libertarianism, where the individual should "exists for his own sake,

neither sacrificing himself to others nor sacrificing others to himself.” It’s complicated.

KEY CONCEPTS

Gross Domestic Product (GDP) | Per-capita GDP | growth rates | purchasing power parity | history's hockey stick | take-off | capitalist revolution | capitalism | private property | market | firms | market economies | Industrial Revolution | capital | labor | technology progress | productive efficiency | productivity | competition | division of labor | specialization | scale economies | learning by doing | market exchange | value | globalization | innovation | process innovation | product innovation | varieties of capitalism | mixed economies | household responsibility system | discrimination | selection | sustainable development | sustainable economy | Sustainable Development Goals | sustainable resource use | invisible hand | corporate social responsibility | value of life

REVIEW AND PRACTICE PROBLEMS

■ **1.1. Per-capita GDP.** What are some of the issues with comparing per-capita GDP across time and countries?

■ **1.2. GDP during COVID-19.** Listen to the podcast GDP -32.9%???!!! (or read the transcript). In it, we learn that "for the months of April, May and June (that's the second quarter), the U.S. economy grew at an annualized rate of negative 32.9%."

(a) Does this mean that the US economy shrunk by one third?

(b) What makes the 2020 recession different from the Great Depression in terms of GDP numbers?

■ **1.3. What should we measure?** While campaigning for the US presidency in 1968, Senator Robert Kennedy gave a famous speech questioning "the mere accumulation of material things" in American society. Read his speech in full or listen to an audio recording.

(a) Which goods does Kennedy list as included in the GDP measure (starting at about 16 minutes)?

(b) Do you think these should be included, why or why not ?

(c) Which goods does Kennedy list as missing from the measure?

(d) Do you think they should be included, and why?

(e) More than half a century later, how applicable do you think Kennedy's speech is? (This is an open question.)

■ **1.4. Per-capita GDP.** Visit the site https://fred.stlouisfed.org/.

(a) Obtain the values of US GDP in 1968 and in 2018. (For GDP, look for the "national accounts" category and choose "Real Gross Domestic Product".) Obtain the values of US population in the same years. Indicate the sources of the data (i.e., where the site you are visiting obtained its data). Also, indicate the units in which the data are measured.

(b) Based on these data, indicate how much better an average American is in 2018 with respect to 1968?

(c) Explain the limitations of this type of calculation (e.g., what aspects of quality of living does it leaves out?).

■ **1.5. GDP and happiness.** Select a country (preferably not the US).

(a) Consult the graph Self Reported Life Satisfaction. Obtain the values of per-capita GDP and self-reported life satisfaction corresponding to your country.

The blue line in Figure 1.1 corresponds to the function

$$3.7861 + .7153 \ln(x)$$

where $\ln(x)$ corresponds to the natural logarithm of x.

(b) Use the value of per-capita GDP obtained in part (a) as the value of x and compute the expected value of self-reported life satisfaction; that is, the value corresponding to the blue line in Figure 1.1.

(c) Based on your knowledge of your country of choice and on additional research you may conduct, suggest reasons for the difference between the actual value of self-reported satisfaction, obtained in part (a), and the value predicted by the blue line in Figure 1.1 (and computed in part (b)).

■ **1.6. Capitalism.** What is capitalism?

■ **1.7. The capitalist revolution.** What do we mean by "the capitalist revolution"?

■ **1.8. Division of labor.** Provide an example of how division of labor leads to greater efficiency. Indicate the role played by market size.

■ **1.9. Rome.** In his essay *The Economy of the Early Roman Empire*, economic historian Peter Temin argues that "the standard of living in ancient Rome was similar to that of early modern period of seventeenth- and eighteenth-century Europe, an extraordinary

TABLE 1.1
Income inequality: cross-country comparisons

		Income levels	
Country	Year	(a) Decile 1	(b) Decile 10
China	1980	79	520
China	2014	448	18689
Liberia	1980	125	7175
Liberia	2014	17	994
United States	1980	3392	37949
United States	2014	3778	60418

achievement for any economy in the ancient world." What factors explain such economic success — and how do they relate to this chapter's themes?

■ **1.10. Capitalism and growth.** Why do economists believe that capitalism has been a source of economic growth?

■ **1.11. The nature of capitalism.** Read the article, Covid and the nature of capitalism. How does it relate to the discussion in Section 1.2 regarding varieties of capitalism.

■ **1.12. Cosmic Crisp™.** Visit the Wikipedia page on the Cosmic Crisp apple (and the pages it links to). How does the emergence of the Comic Crips relate to the discussion in Section 1.2 regarding the relative importance of public and private funds in innovation?

■ **1.13. The limits of capitalism.** What are the primary limitations of the capitalist system?

■ **1.14. Growth and inequality.** Consider Table 1.1, which displays the top and bottom decile income levels in three different countries, in 1980 and in 2014. (Source: Global Consumption and Income Project, via Exercise 1.2 in *The Economy*. All incomes are expressed in 2005 USD PPP.)

(a) How has within-country inequality evolved from 1980 to 2014? (Suggestion: compute the ratio of Decile 10 income over Decile 1 income.)

(b) How has between-country inequality evolved from 1980 to 2014? (Suggestion: compute the ratio of Decile d income between the richest and the poorest country, where $d = 1$ and $d = 10$.)

(c) What important inequality issues do the numbers miss?

(d) Comment: "The past three decades have witnessed tremendous improvement in the economic condition of all peoples."

■ **1.15. Globalization.** It's a cliché to say we live in a global world, but it is true, and increasingly so. The Internet, in particular, has played an important role in this trend. Using the Google Trends service, show how interest in certain events (for example, the emergence of "Gangnam style") takes place at the same time all over the world.

■ **1.16. Globalization is dead.** Carmen Reinhart, then chief economist of the World Bank, stated in 2020 that "COVID-19 is like the last nail in the coffin of globalization." Do you agree that the era of globalization is probably dead? Who are the winners and the losers from the process of de-globalization?

■ **1.17. Capitalism works.** Discuss the following tweet:

> I get really frustrated when privileged white people say "capitalism is the only economic system that's worked." You mean, worked for *you*. For me and my communities, my friends, it's *killing us*. That's not a system that "works".

■ **1.18. Sustainable economy.** What do we mean by a sustainable economy?

■ **1.19. Netflix and CSR.** After George Floyd was killed on May 25, 2020, several US corporations promised to put money toward fighting racial inequality. For example, Netflix placed a $10 million deposit into Hope, a Mississippi credit union that focuses on helping low-wealth people and communities. Netflix is a public company. Its shares are mainly held by institutional investors such as Capital Group Companies, The Vanguard Group, and BlackRock. Is Netflix's decision a violation of the Milton Friedman principle that "the social responsibility of business is to increase its profits"? Do you approve of Netflix's decision? Why or why not?

CHAPTER 2

ECONOMICS

This book is about economics and the economy. If the previous chapter dealt primarily with the economy (capitalism: its accomplishments and its limitations), this chapter deals with the discipline of economics: what it's all about, how it relates to other areas of social research, and what its primary themes are.

2.1. SCOPE AND METHOD

What is economics? Instead of offering a formal definition, let us consider three important aspects of microeconomics, three aspects which correspond to different parts of this course: *(a) choice, (b) markets, and (c) public policy*. By **choice** we mean how consumers, workers, firms, etc, make choices: primarily choices regarding what you would think of as economic choices (e.g., whether to buy X or Y), but also choices you might not have thought as economic choices (e.g, how many hours to study for the Microeconomics final). We are particularly interested in situations when agents (consumers, workers, firms, etc) must choose between alternative uses of scarce resources (such as time and money). Part II of the book is devoted to the study of choice, first in generic terms, then with specific applications to household choices and to choices by firms.

By **markets** we mean the interaction between buyers and sellers who transact products or services, where the latter might be a cup

of coffee, help designing a website, or shares in Apple Inc., to give three possible examples. Part III of the book deals with markets: supply, demand, and the interaction between supply and demand. We will be particularly interested in understanding how prices are determined and whether, or in what conditions, markets work well (for a precise definition of "well").

Finally, by **public policy** we mean how the government (or government-like institutions) impose constraints on consumers, firms and markets to address system failures. Examples of economics-related public policies include merger policy (i.e., deciding whether firms A and B should be allowed to merge), carbon taxation (that is, taxing activities that generate greenhouse gases), or welfare transfers to the poor (e.g., food stamps). Broadly speaking, Parts IV and V of the book focus on public policy. Part IV is devoted to market failure (i.e., cases where a market left to itself fails to work well). Part V, in turn, is devoted to issues of social justice (e.g., cases where markets work well but not for all).

The reader may have noticed that I have used the terms "economics" and "microeconomics" interchangeably. The time has come to be more precise. The economics discipline is normally divided into two main branches: microeconomics and macroeconomics. **Macroeconomics** is the branch of economics that deals with aggregate economic variables, such as GDP growth, interest rates, unemployment, inflation. By contrast, **Microeconomics** is the branch of economics that deals with behavior of individual economic units (consumers, firms, workers) and the markets that these units comprise. The previous chapter started off with a macro perspective on the economy, namely GDP as a measure of economic activity. However, the rest of the chapter (and the rest of the book) will focus on the micro approach to economics.

MODELS AS MAPS

Methodologically, economic analysis is based on a series of theories, and theories are primarily expressed in the form of economic models. An **economic model** is a description of an economic situation by means of words, diagrams and mathematical expressions.

It helps to think of models as maps. Consider the following example, illustrated by Figure 2.1. You are currently at the Village Van-

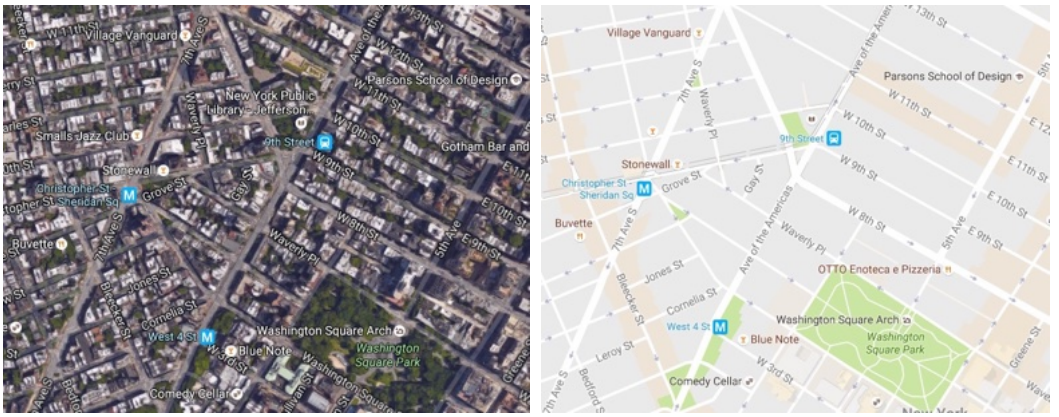


FIGURE 2.1
Finding your way from the Village Vanguard to the Blue Note

guard and want to find your way to the Blue Note (both are jazz clubs in Greenwich Village). Figure 2.1 displays two different images: a satellite photo (left) and a stylized map (right). The photo is clearly a more realistic depiction of reality, whereas the map is a rather stylized one. In other words, you might say that the satellite photo has more information, whereas the map is missing a lot of the details of the reality in question.

In spite of having less information, the map is a more useful tool for finding your way across the Village. In fact, it is more useful *precisely* because it has less information: it allows you to focus on what is essential (in particular, the streets, which are represented as "unrealistic" lines). The same is true of a good economic model. It abstracts from a number of details and zooms in on the essential aspects of the economic setting in question. This does not mean that all economic models are good, just as there are some really bad and unhelpful maps.

> *Economic models, like maps, provide a simplified depiction of reality, focusing on the most relevant elements and how they relate to each other.*

Or, as George Box famously put it, "All models are wrong but some are useful." There are many modeling simplifications we will make throughout the course. These include assuming that there are only two firms, two countries, two consumption goods, etc. Obviously

there are more than two firms, countries and consumers in the world. Our focus on only two is done for the purpose of understanding the main effects (and, in some cases, to represent them on a graph).

The level of abstraction in economics varies. We can think of economic models as construction blueprints: sometimes what we need is a rough hand-drawn draft (for example, to provide a broad idea of a building design concept). By contrast, we occasionally need a more detailed blueprint, to make sure the builder follows the architect's design as closely as possible. The same is true in economic modeling. Sometimes a brief description in English suffices to present an economic idea. By contrast, sometimes we need a detailed mathematical description of a model's "moving parts".

Modern economics uses a lot of math. The advantage of mathematics is that it allows for a more precise definition of concepts and relations. Natural language is full of nuances, great for poets and punsters but rather annoying for economists. The term "capitalism", introduced in the previous chapter, is a case in point. Words can be "loaded", which sometimes is a good thing but at other times leads to more confusion than clarity.

Unfortunately, as is the case in many other contexts, a good tool can be poorly used. Not infrequently, poorly written mathematical models create more confusion than clarity. Moreover, the mathematics barrier can be an exclusion factor for would-be economists with important ideas to contribute.

Reacting to criticisms of excessive "mathiness" in economics analysis, a recent trend has placed greater weight on data analysis: let the data speak. This has been aided by two important developments: a significant increase in the amount of available data (partly a result of the growth of online commerce), as well as an increased reliance on data from experiments, both in the laboratory and on the field (i.e., experiments in a real-world context). However, reliance on data without theory can be very limiting. How can we distinguish between correlation and causality unless we have a good model of how the world actually works? How can we generalize data from a special case (e.g., ten small factories in India) to the rest of the world unless we have a good model?

An additional problem with data-only approaches is out-of-sample prediction: How can we predict the demand for a new Hyundai model given that we only have data from old Hyundai

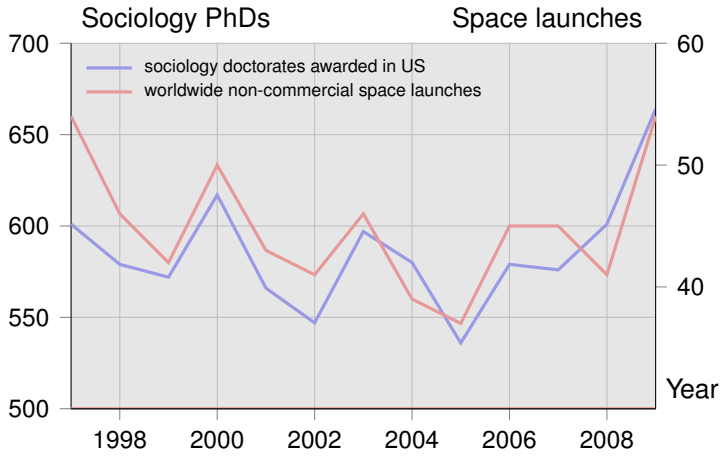


FIGURE 2.2
Spurious correlation: example

models? How can we predict the effect of a wealth tax if there is very little experience with wealth taxes?

In sum, data needs the support of theoretical frameworks if it is to be useful for decision-making. Conversely, economic modeling that is not based on evidence, or at least not checked by evidence, is a dangerous endeavor, and most likely a failed one.

CORRELATION AND CAUSALITY

One of the most common mistakes in analyzing and presenting data is confusing correlation with causality. Consider the two time series plotted in Figure 2.2, "Sociology doctorates awarded in the US and worldwide non-commercial space launches". As can be seen, they are highly correlated (during the period 1997–2009). Does that mean that once causes the other? Clearly not. If you have the time and want to have some fun, I recommend you visit the website Spurious Correlations. What this site does is troll the web for time series and then attempt all possible combinations of pairs of time series. Eventually, you are bound to find some that produces a high correlation. And there are lots of them, some ridiculously funny.

Here's a more serious example. A few years ago, the *New England Journal of Medicine*, one of medicine's leading journals, published an article on the correlation between per-capita number of Nobel laure-

ates and per-capita chocolate consumption. The correlation is very high indeed. The article was not intended as a spoof. In fact, the journal editor commented that

> Chocolate consumption could hypothetically improve cognitive function not only in individuals but also in whole populations. The principal finding of this study is a surprisingly powerful correlation between chocolate intake per capita and the number of Nobel laureates in various countries. Of course, a correlation between X and Y does not prove causation but indicates that either X influences Y, Y influences X, or X and Y are influenced by a common underlying mechanism.

What's wrong with the above paragraph? What's wrong is that it misses the fourth and most likely possibility, namely that the sample considered in the study is much too small. Perhaps the authors tried a bunch of variables (Brussel sprouts, pineapple, soy sauce, etc) and chocolate came out as the best correlation.

It is good to interpret correlations with a healthy dose of skepticism. Don't jump into the conclusion of causality too easily. This includes some of the correlations we've considered so far in the book; for example capitalism and growth or human CO_2 emissions and climate change. For a recent example in the news, see Exercise 2.3.

Another instance of the correlation / causality confusion is what economists refer to as the **post hoc fallacy**. There's a Latin phrase, "Post hoc ergo propter hoc," which in English means, "After this, therefore because of this." Politicians are particularly prone to this fallacy: "I became president and GDP grew by 3%, that's how good a president I am," which of course ignores that economic growth results from hundreds of factors, very few of which are under the president's control. "After this but not necessarily because of this," that should be our motto. This provides a natural segue into the next topic, where we provide general guidance for uncovering causality relations.

COUNTERFACTUALS

One way to avoid falling into the post hoc fallacy is to perform what economists and historians refer to as a counterfactual. Suppose that,

at the beginning of December, Luigi's lowered the price of its famous jeans. Revenues in November were $80 million, whereas revenues in December were $113 million. It seems that lowering the price was a good idea, right? Ahh ... no. Remember the motto: "after this but not necessarily because of this." In fact, if you are in the jeans business you should know that jeans sales tend to increase in December anyway (it's the holiday season) even if you don't change prices.

As it happens, Luigi's product manager has access to data on the sales of Kabral's jeans, a brand for which price remained the same in November and December. Their sales were $44 million in November and $67 million in December. With all of this data at hand, what can we say about the price-cutting strategy? One way to answer this question is to construct a **counterfactual** of December sales with no price change. In other words, given the data we have for Kabral's sales, what do we expect Luigi's December sales would have been had Luigi's not changed its price? Kabral's December sales were greater than their November sales by a factor of $67/44 \approx 1.52$ (that is, a 52% increase). Assuming that the seasonal variation in jeans sales is the same for Luigi's and Kabral's, our counterfactual estimate of Luigi's December sales would be 80 (November sales) times 1.52 (November-December change factor given no price changes). This implies a counterfactual of 121.6.

We conclude that, while Luigi's sales increased from 80 to 113, sales would have increased to 121.6 had price not decreased. We thus estimate that the *causal effect* of decreasing price was to decrease revenues by $121.6 - 113 = 8.6$! The problem is not that revenues did not increase, rather that they did not increase by as much as we would have expected them to increase had we not played with price. Note that the **identifying assumption**, that is, the assumption that allows us to identify the causal effect of the price decrease, is that the seasonal variation of sales at Luigi's is the same as at Kabral's. Not a perfect assumption but probably better than just comparing November and December sales. (This video provides a more systematic approach to this identification strategy, known as **difference in differences**.)

ALL OTHER THINGS EQUAL

Unlike chemistry and other so-called hard sciences, economists don't have the luxury of controlled laboratory experiments. (You can per-

form behavioral experiments in the laboratory, but not with the level of precision and generality that chemistry and other hard sciences can attain.) The beauty of a laboratory experiment is that one can control all of the relevant variables and then, by changing the value of X only, study the effect of X on Y (for example, X could be temperature and Y pressure). Economics is a behavioral and social science. The phenomena it studies involve multiple economic agents interacting in the most complex ways. For this reason, our best hope is to find real-world data that allows us to effectively keep all variables constant except for X.

As a specific example, consider an empirical study of the relation between hours of study and course grade (sneak preview: it's a positive relation, so keep studying). The research analyzes the habits and performance of 84 Florida State University students. For each student, researchers determined how many hours the students studied, as well as other variables. They also recorded the students' course grade. One question we may ask is whether hours of study are related to grade. A first possible answer is given by the following table:

	High study time (42 students)	Low study time (42 students)
Average GPA	3.43	3.36

In other words, if we divide the students into two groups (high study time and low study time), then we observe that students who study for more hours receive an average grade of 3.43, higher than the average of the students who study fewer hours (3.36). The difference seems rather small and may suggest that there isn't much of a causal relation between study and grades.

However, as we saw in the previous subsection, one must be careful not to confound correlation with causality. Sometimes we find a correlation which does not correspond to any particular causal relation. The opposite is also possible: although there is no simple correlation between two variables, they may actually be related by a causal link. To see how this is possible, consider the following breakdown of the data:

	High study time	Low study time
Good study environment	3.63 (11 students)	3.43 (31 students)
Poor study environment	3.36 (31 students)	3.17 (11 students)

We now observe that most of the students who spent many hours studying did so in a poor study environment, whereas most students who spent few hours studying did so in a good study environment. This implies that, in the first table, we were essentially comparing apples with oranges; that is, not correcting for **sample selection effects**. Students who spend more hours studying do not get a much higher grade because, in addition to spending more hours studying, they are also more likely to do so in a poor study environment.

This is one of the greatest challenges of social science: When we compare two situations, there are many dimensions on which they may differ, and as a result it is very difficult to assign the variation in y (e.g., grade) to a particular change in x (e.g., hours of study). In this regard, one of the methodological goals of economics is to proceed according to the **ceteris paribus** principle. *Ceteris* is Latin for "things" (as in "et cetera" or simply "etc."); and *paribus* is Latin for "similar" (as in "parity" or "comparable"). So, in plain English we would say "all other things equal." To return to our example, we would like to know the effect of increasing hours of study *keeping all other things equal* (including, in our particular example, the study environment).

In practice and in research studies like the present one, economists typically utilize multi-variate regression analysis to take into account the multiple factors that vary along with the number of hours of study. Students who are interested in this type of data analysis are encouraged to take the course ECON-UB.251: Econometrics at NYU or a similar one elsewhere. For now, suffice it to say that the research study in question concluded that, all other things equal, one extra hour of study is associated with a grade increase of 0.24. This may not seem a lot but is certainly a lot more than the 0.07 suggested by the table on page 60.

While we are on the subject of statistical analysis, it is worth mentioning two additional points related to identification of economic effects. First, there is the problem of **selection bias** (already mentioned

in passing on page 61). Here's an example: It has been observed that commercial hedge funds report their past performance in a selective way: poorly-performing funds are more likely to be delisted than highly performing funds. This implies that the average performance of *surviving* funds is greater than the performance an investor should expect by investing in a random fund. Therefore, when estimating the effect of investing on a hedge by means of reported historical data one should correct for this source of bias.

The second statistical correction relates to sample size. Why are Kenyan long-distance runners so much better than others? If we run a regression analysis we will probably find that genes, body size, diet, climate, location (altitude), and possibly other factors are highly correlated with performance. However, as usual we must be careful before jumping from correlation to causation. According to former American marathon runner Alberto Salazar, "in Kenya there are probably a million schoolboys 10 to 17 years old who run 10 to 12 miles a day." By contrast, author Malcolm Gladwell estimates that "the United States doesn't have more than 5,000 or so boys in that age bracket logging that kind of mileage." In other words, it may be that the main factor "causing" Kenyan runners to perform better is that we are selecting the best out of a bigger group. To give another example from the world of sports: The average height of Chinese men (as of 2020) is 5′ 6.5″ (169.5cm), whereas the average height of Dutch men is 5′ 11″ (180.8cm). However, the top five players on China's 2019 men's national basketball team averaged 6′ 10.6″ (2.098m), whereas the corresponding value for the Dutch team was a mere 6′ 9.9″ (2.08m).

POSITIVE AND NORMATIVE ANALYSIS

Continuing our overview of economics methodology, we now come to the important distinction between positive and normative analysis. **Positive analysis** corresponds to statements that describe a cause-effect relationship; that is, statements that predict future behavior or explain past behavior. In other words, statements about what *is*. By contrast, **normative analysis** corresponds to statements about what *ought to be*. In other words, normative analysis consists of, and is often supplemented by, value judgments.

> *Positive analysis corresponds to statements that describe what* is. *Normative analysis corresponds to statements about what* ought to be.

Take for example the relation between CEOs and shareholders. A positive statement would be that CEOs make choices so as to maximize firm value, specifically the total value of present and future revenue streams. (Economists disagree on this.) A normative statement would be that it is the CEO's duty to maximize firm value. (Economists also disagree on this.)

The distinction between positive and normative analysis is important in a number of ways. For example, economist Milton Friedman remarked that

> Two individuals may agree on the consequences of a particular piece of legislation. One may regard them as desirable on balance and so favor the legislation; the other, as undesirable and so oppose the legislation.

In other words, keeping the positive/normative dichotomy in mind can be helpful to knowing when to agree and when to agree to disagree.

At a more fundamental level, and as we will see in the next section, the central model of economic behavior assumes that agents (firms, consumers, workers, etc) are self-interested optimizers, that is, they try to do the best for themselves. This is a positive statement, that is, a set of predictions about the actual behavior of people and organizations. In subsequent chapters in this book, we will examine the extent to which this paradigm of economic modeling is correct and useful. For now it suffices to remark that, with the exception of a small fraction of the economics profession (those whom we might describe as Ayn Rand followers) we take the self-interested model as a positive statement, not a normative one (the world would be a better place if we cared more about others than we do — and now you know I am not an Ayn Rand follower).

One final note regarding positive economics: Many economists have come to regard the positive approach as a goal, almost an ideal, that the economics discipline should aim for. As Milton Friedman put it

> The ultimate goal of a positive science is the development of a "theory" or "hypothesis" that yields valid and meaningful [...] predictions about phenomena not yet observed.

This perspective on economics has largely been influenced by what some refer to as physics envy: the aspiration of turning economics into a hard science independent of the value judgements associated with normative economics. Many other economists (including this one) think this is not only impossible but undesirable as well. Can a conservative economist be neutral when writing about economics and gun control? Can a liberal economist be neutral when writing about economics and abortion? Even if research is based on "objective" statistical analysis, it's almost inevitable that researchers are more likely to keep results that better confirm their prediction or expectation. This bias (a type of confirmation bias) can be partly resolved by replication studies (extremely rare in economics) or by asking researchers to pre-announce their research design (also extremely rare). More important, even if we are able to correct for these potential biases there would remain a fundamental one, namely the choice of a research topic.

In sum, the distinction between positive and normative economics is helpful. However, the ideal of a neutral, value-free economist is probably not realistic. There is only one thing worse than a biased economist, and that is a biased economist who is convinced he or she is neutral.

2.2. BEHAVIORAL AND SOCIAL SCIENCE

Economics is both a behavioral and a social science. In other words, it deals with human behavior (how humans make certain types of decisions) and with social interaction among individuals, especially in the context of firms and markets. As such, economics relates to other behavioral sciences (e.g., psychology) as well as to other social sciences (e.g., sociology or history).

As a behavioral science, economics is based on a model known as **homo economicus** (Latin for "economic man"). This model portrays humans as agents who are consistently rational and self-interested, specifically agents who act with the purpose of optimally pursuing

their subjectively defined ends. If you have any knowledge of human behavior, including your own, you know this is not entirely realistic, to put it mildly. We are, at best, boundedly rational. In fact, research by psychologist Daniel Kahneman suggests that a large fraction of our decisions are based on mental shortcuts or rules of thumb. This is not necessarily inconsistent with the *homo economicus* model. In fact, to the extent that decision making implies costs (gathering information, processing data, etc) one would expect a rational decision-maker to develop simplified decision rules (that is, rationally decide how to decide). That said, there are a number of instances when the *homo economicus* model seems to fail, and psychology provides a helpful framework to understand these.

PSYCHOLOGY

As a behavioral science, economics benefits from the influence of related behavioral sciences. The field of **behavioral economics** studies the effects of psychological factors on the behavior of individuals and institutions, in particular to the extent that it differs from the behavior predicted by the rational economic behavior model. One classical example of such deviation is given by inter-temporal trade-offs. Suppose I give you the option of one bag of M&Ms now or two bags of M&Ms tomorrow. Most people will go for one bag now. Nothing wrong with that, an economist might say: it's simply that people have a strong preference for consumption in the present rather than a future promise. But suppose that you're given the choice between one bag of M&Ms one year from now or two bags one year and one day from now. Faced with this trade-off, most people will go for two bags in one year and one day. But if you put yourself in your own shoes one year from now, you will effectively be picking two bags of M&Ms "tomorrow" over one bag "today".

A second setting where behavior tends to deviate from the *homo economicus* prediction relates to risk-return trade-offs when there are small probabilities of high-payoff events. For example, wearing seat belts imposes a cost on a lot of people, who find them rather uncomfortable. This cost, which is visible and easy to predict, must be traded off against the benefit of wearing seat belts in the event an accident occurs, which is fortunately a rather low-probability event. Objectively speaking, that is, considering the enormous benefit of

wearing seat belts when an accident takes place, buckling up is the rational thing to do. However, left to their own will, many drivers and passengers prefer, or at least choose, not to wear seat belts.

There is a certain pattern to these failures to behave according to economic rationality. These are situations involving long time gaps or large payoffs with low probability. This suggests that while the economic model is reasonably appropriate for common and repeated agent decisions, it may falter when applied "on the boundaries" of agents' economic decisions. The message then is that economists should beware of the boundaries of applicability of their model of rational decision making.

An analogy can be made with respect to Newtonian mechanics. For centuries, this branch of physics has been of extraordinary use in a variety of applications. The deterministic predictions of Newtonian mechanics are fairly accurate when it comes to objects at a "human" scale: cars and bikes, projectiles, chairs and desks, buildings and bridges, etc. However, when we move to the subatomic level, Newtonian mechanics fail miserably. By no means does this imply that Isaac Newton's work was in vain, only that his laws must be interpreted and applied within a limited scope.

This distinction between a good framework and an appropriate framework is quite relevant. In a recent *Scientific American* interview, Dan Ariely, a psychologist specializing in behavioral economics, declares he is surprised that "many people, particularly economists, believe that we are perfectly rational." This is an unfair statement. Most economists use the *homo economicus* model as an approximation of human behavior that works well in many settings. Stating that this implies economists believe that "we are perfectly rational" makes as little sense as stating that engineers believe Newton's laws of motion are perfect, exact, and universal.

We must be aware of the boundaries of the basic economics paradigm model rather than throw the rational-choice baby out with the bathwater. Throughout this book, we will make reference to various instances when the *homo economics* model is a poor approximation of actual behavior. A recent survey discusses a variety of examples. There are two types of deviations that seem particularly important. First, different from the rationality paradigm, we observe that individuals lack self control. For example, in Section 10.2 we discuss recent research on addiction to Facebook, a pattern that seems at

odds with the basic economics paradigm. Second, individuals show a bias in favor of the status quo that extends beyond what rationality would predict. For example, in Section 13.3 we discuss this in the context of housing and education choices.

SOCIOLOGY

Psychology contributes to economics by enriching our view of the cognitive limitations and biases of decision makers. By contrast, **sociology** deals with the patterns of social relationships, social interaction and culture that surround everyday life, including economic life. Consider the example of work and employment. From a mainstream economics point of view, labor is a production factor (i.e., part of the process of transforming inputs into outputs) as well as an income source. The labor market brings together the firm's demand for labor and the individuals' labor supply, where the latter results from an optimization process involving income, leisure and other factors.

Although theoretical and empirical economic analysis allows for "other factors", in practice these "other factors" are not given as much importance as they should. For example, Section 1.4 includes the quote that "One has a story about one's life that involves one's job, and a job defines how I am important and why people should love me." The issue of **social status** plays an important role in sociology, less so in economics.

One's job is by no means the sole source of social status. In his classic, *The Theory of the Leisure Class*, economist and sociologist Thorstein Veblen, an early critic of the capitalist system, argues that social status is largely acquired by means of **conspicuous consumption**, that is, consumer spending on luxury goods and services to publicly display economic power rather than (or in addition to) enjoying them for their intrinsic value. **Positional goods**, a refinement on the concept of conspicuous consumption, are valued in terms of relative consumption. Here's an interesting thought experiment:

> You must choose between ... World A, in which you will live in a 4,000-square-foot house and others will live in 6,000-square-foot houses; and World B, in which you will live in a 3,000-square-foot house, others in 2,000-square-foot houses. ... If only absolute consumption mattered, A

would be clearly better. Yet most people say they would pick B.

Again, we find that

> *Social interaction plays an important role in an individual's actions and value judgements.*

In the above example, social interactions take the form of relative consumption comparisons. More generally, from an economics point of view, understanding these sociological patterns is important in order to explain economic behavior. It may also have specific policy implications. For example, several authors argue that luxury taxes (and, more generally, taxes on positional goods) may be a way of addressing the "arms race" of conspicuous consumption.

Gender and racial discrimination is another instance when economics can benefit from neighboring social sciences. Traditionally, economists have classified discrimination into two different "bins": **statistical discrimination** and **taste discrimination**. An example of statistical discrimination is provided by car insurance rates. A 16-year-old woman pays an average six-month premium of $3,378, whereas a 16-year-old man pays a higher $3,897 (data for New York in 2020). The fact that women are charged less does not reflect any animus against men; simply the fact that, statistically speaking, 16-year-old men are more prone to accidents than 16-year-old women. Similarly, the fact that a 24-year-old man pays on average $1,381, substantially less than his younger counterpart, does not necessarily reflect age discrimination in the sense that the expression normally has. By contrast, the differential way that racial minorities are treated in the labor market frequently goes beyond statistical outcome expectations, rather reflecting a distaste for hiring minorities.

The distinction between taste and statistical discrimination is helpful and has guided much of economics research. However, many criticize the approach as incomplete. Sociologists, in particular, place a greater weight on **institutional discrimination**, the idea that differential treatment by race is also, perhaps mainly, perpetrated by organizations or even codified into law. We will return to these issues in Section 11.2, where we will demonstrate the pervasive nature of the above types of discrimination.

POLITICAL ECONOMY

At some level, France, China and the US may all be characterized as societies based on the capitalist system. However, one may argue that the differences are greater than the similarities. More broadly, we observe considerable differences across countries, both in terms of their economies and in terms of their political systems. One of the most fascinating research questions, for economists and other scholars, is why such disparities exist. In 1960, Argentina's per capita GDP was 7.3 times greater than South Korea's. By 2018, South Korea's GDP was 2.6 times greater than Argentina's. How does one explain such wide variation in outcomes? In a famous 1992 memo, one of Bill Clinton's strategists reminded campaign workers to stay on message: "It's the economy, stupid." Clearly, economic conditions play an important role in addressing questions such as the Argentina-South Korea gap. For example, in Section 1.2 we saw how history's "hockey stick" explains a considerable portion of the cross-country variation in economic outcomes. However, economists have come to believe that:

> *Institutions, political institutions in particular, play a central role in a country's development.*

Some argue that economic and social development requires social orders "to control violence, provide order, and allow greater production through specialization and exchange." These orders may be supplied by a political system that limits its abuse or, in a small number of more recent cases, by means of political competition (that is, free entry into economic and political organizations). In this context, failed nations result from extractive economic institutions, "which destroy incentives, discourage innovation, and sap the talent of their citizens." Examples include lack of property rights, absence of rule of law, and many others.

It's not only political institutions that matter. In old and modern societies alike, non-governmental institutions (churches, charities, political action groups) have played an important role. Witness for example the impact that Greta Thunberg has had on the climate change debate, or the Gates Foundation on public health.


Wikimedia Commons and National Board of Review Magazine

The introduction of copyright protection in 19th century Italy provided a big boost to the creation of new operas. Can this tell us something about the current debate on extending the period of copyright protection?

ECONOMIC HISTORY

Spanish philosopher George Santayana pithily observed that "those who cannot learn from history are doomed to repeat it." (The actual quote is slightly different but the idea is the same.) The study of history plays an important role in general, and in particular in the study of economics. Unlike hard sciences such as chemistry or biology, social sciences such as economics lack the ability to test theories in the lab. (This is not entirely true but largely so.) In this context, the study of history can be of great help. In fact, many questions that were relevant in the past remain relevant in our day, and the lessons from the past can be lessons for today.

Take for example the issue of copyright protection, which gives its owner the exclusive right to make copies of a creative work (e.g., a book, a song, a movie, etc). There is considerable cross-country variation in copyright duration. For example, in the US and Europe copyright lasts until 70 years after the creator's death; in Canada, 50 years after the creator's death; in Mexico, 100 years after the creator's death. Which one is right? Does it make a difference? Specifically, do the incentives for artistic creation depend on the existence and the duration of copyright protection? Lest the reader think this an irrelevant issue, suffice it to say that the Copyright Term Extension Act (CTEA) of 1998, which extended copyright terms in the United States, was a highly controversial and hotly debated law.

Can history help address the above questions? Economic historians Michela Giorcelli and Petra Moser describe how Napoleon's military victories in Italy in the late 1700s effectively introduced copyright law into various Italian states. This led to a significant increase

in the number and the quality of operas written by Rossini and other great composers of 19th century Italy. However, when the duration of copyright protection was extended beyond the creator's life, there were no additional effects to speak of. In sum, history suggests that

> *Some copyright protection goes a long way toward incentivizing an author to create, but extending copyright protection beyond the author's death does not seem to provide any additional gain.*

Had copyright protection not been extended in the US (in 1998) from 50 to 70 years after the creator's death, Walt Disney's Mickey Mouse would by now be in the public domain. Would the benefits from open access outweigh the costs in terms of creativity incentives? History suggests the answer is "yes".

Consider now a current and controversial topic in the news: immigration. The primary economic rationale for immigration quotas is that it protects domestic employment. Against this alleged positive effect, we must take into account the human talent that is lost by preventing would-be immigrants from entering the country. Can history tell us anything about it? Research by economic historians Petra Moser and Shmuel San suggests that the negative effects of immigration quotas can be significant. Their view is based on an important historical precedent: Between 1921 and 1924, the US first adopted immigration quotas for "undesirable" nationalities, so as to stem the inflow of Eastern and Southern Europeans (ESE). It is estimated that, due to these quotas, 1,170 ESE-born scientists were "missing" from US science by the 1950s. This in turn led to an estimated 68% decline in patenting in the fields where ESE immigrants researched. Moreover, these effects were still felt well into the 1960s. This historical evidence confirms the relative consensus among economists that

> *Immigration quotas, especially when applied to skilled immigrants, produce significant harm to the domestic economy.*

GAME THEORY

Economic agents (buyers and sellers, employers and employees, households, firms and countries) frequently act in relation with other

		China: high effort	China: low effort
US	high effort	Global warming avoided.	China obtains large benefit from US effort, but climate change risk persists.
US	low effort	US obtains large benefit from China's effort, but climate change risk persists.	Extremely high risk of global warming and climate change.

FIGURE 2.3
Possible outcomes of the climate change dilemma

agents. Economics is a social science. Economic behavior is not only a matter of optimizing with respect to a series of constraints; it is also a matter of forming beliefs regarding other agents' behavior, predicting how our behavior will influence theirs and how best to react to their behavior, etc.

The field of **game theory**, long associated with economics, provides useful tools for the analysis of such situations of interdependent behavior. As a motivating example, consider one of the biggest issues of our time: climate change. Although this is not strictly an economics problem, the game-theory approach can be useful in understanding the fundamental issues. In essence, climate change is a **social dilemma**: Whenever there is a **common resource**, individual choices, good as they may be from each individual's point of view, may result in an inferior collective outcome.

Consider the following simplified depiction (a model) of the climate change social dilemma. Suppose there are only two countries in the world, the US and China. Each country must determine how much effort it will put into reducing greenhouse gas emissions. For simplicity, assume the US and China can choose a great effort or a minimum effort. The outcome (i.e., the payoffs received by each country) depends on the choices by both players. In fact, this is the essence of interdependency: my fate does not depend on my actions only.

Figure 2.3 illustrates the climate change dilemma, where the US's

		China: high effort	China: low effort
US	high effort	250 / 250	400 / 50
	low effort	50 / 400	60 / 60

FIGURE 2.4
The climate change game

choice is listed in rows and China's choice is listed in columns. If both the US and China opt for a high effort level, then the dangers of global warming and climate change are avoided. By contrast, if one of the countries chooses to go for a low effort level, then such a country gets a relatively good outcome: it benefits from the other country's effort to reduce greenhouse emissions without needing to pay the cost. Finally, if both countries go for low effort, then both plunge into the undesirable outcome of the extremely high risk of global warming and climate change.

The next step is to measure these outcomes quantitatively. Economists and climate scientists have built complex dynamic models to estimate the effects of different policies over the next decades. Figure 2.4 summarizes the dilemma faced by the US and China in terms of quantitative payoffs. For each combination of a choice by the US and a choice by China, the matrix in Figure 2.4 shows the payoff for the US and the payoff for China. We follow the convention of marking the row player's payoff in the lower left corner and the column player's payoff in the upper right corner. Moreover, we assume that each player's goal is to maximize its individual payoff.

Notice that the US's ultimate payoff depends on its choices *as well as on China's choice*. Specifically, the model in Figure 2.4 corresponds to a game. Game theory is a branch of economics dealing with behavior when outcomes depend on the interplay of various agents, who we refer to as players. One goal when using games, similarly to other models, is to understand and predict behavior. What outcome would we expect to unfold in a situation like the one depicted in Figure 2.4?

A first observation is that the US has a **dominant strategy**: If China chooses high effort, then the US is better off by choosing low effort. If

China chooses low effort, then the US is again better off by choosing low effort. So, regardless of what China does, the US is better off with low effort. More generally,

> *A strategy s for player a is a dominant strategy if it yields a higher payoff than any other strategy independently of player b's strategy.*

What's the point of mentioning dominant strategies? Simple: One expects rational players to choose dominant strategies (if they exist). So, in the present case we would expect the US to choose low effort. Looking now at China's payoffs, we conclude that, like the US, China too has low effort as a dominant strategy. Putting it all together, we would expect both the US and China to choose low effort, which is bad for both the US and China.

Figure 2.4 illustrates a fundamental and recurrent social dilemma: both countries are better off (collectively) if both choose high effort, but each country is better off (unilaterally) by choosing low effort and free riding on the other country's effort. Although this is a specific game and a specific situation, it is sufficiently common that we have given it a special name: the **prisoner's dilemma**.

> *In the prisoner's dilemma game, each player chooses its dominant strategy but the resulting outcome is the worse for both players.*

At first blush, this seems a contradiction: If each player chooses what's best for them, how can the outcome be the worst for them? That is the the reason why models such as games can help clarify and understand otherwise confusing and complex social interactions. In the present case, the game makes clear the difference between unilateral incentives and joint incentives: individually, low effort is optimal; jointly, high effort is optimal.

To conclude this subsection, note that not all instances of social interaction have the nature of a prisoner's dilemma. In fact, Chapter 7 presents one of the most important results of microeconomics. It states that, under certain conditions, the result of each agent's choosing their optimal strategy is an outcome which is globally optimal (in a specific sense). Essentially, this result, known as the First Welfare Theorem, corresponds to Adam Smith's "invisible hand" metaphor (cf Section 1.2). One of the biggest debates in economics and politics

is precisely the relative relevance of this theorem vis-à-vis the prisoner's dilemma. Both have a point to make. Ultimately, it's a case of glass half full versus glass half empty.

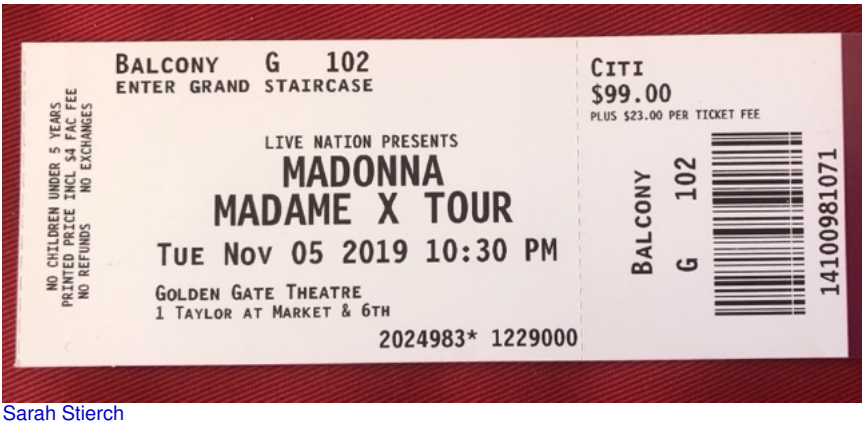
2.3. CENTRAL THEMES

Although there are still many chapters to come where we talk about economics and economics principles, in this section we cover some of the more central themes in microeconomics. Think of it as a sort of trailer for Chapters 3–7, where we cover the core of microeconomic theory. All of this implies some repetition, namely economics concepts that appear more than once throughout the book. As they say in computer lingo, "it's not a bug, it's a feature," (meaning, it's on purpose, not by mistake). Some of these economics concepts are not obvious or immediately intuitive, in which case repetition can be helpful.

MARGINAL THINKING

As often happens with other disciplines, economics is more than a series of ideas: it's a way of thinking about life. Non-economists may have noticed it, and be annoyed by it, when talking to economists. First, economists have a tendency to think about problems strictly in terms of costs and benefits (monetary or otherwise), i.e., they tend to follow a **cost-benefit** approach. For example, on May 2019 Madonna's Madame X Tour was officially announced, with concerts starting in September 2019. In this context, one important decision for Madonna is how many tour performances to include. Any time there is a "how many" question, economists think about it in terms of **marginal** variations. Suppose the current plan calls for 84 dates (it did as of January 2020). Is this an optimal number of concerts? To answer the question, Madonna should evaluate the benefits (monetary and otherwise) from an additional concert, both in terms of ticket sales and other related revenue streams. This should then be compared against the cost (monetary and otherwise) of an additional concert. If benefit is greater than the cost, then go for it; if not, then don't.

But there is more: Suppose that Madonna really thinks like an economist. Then it must be the case that 84 concerts is the number



Sarah Stierch

How many shows should Madonna include in her Madame X tour? She should think at the margin, an economist would say.

such that the benefit of an additional concert is about the same as the cost of an additional concert. Why? Well, if the benefit of the 85th concert is greater than the cost, then Madonna should extend the tour to 85 dates (at least). By contrast, if the benefit is lower than the cost, then it's also likely the case that the benefit of the 84th concert itself was lower than the cost, in which case Madonna would be better off by shortening the tour to 83 dates (or less). We will return to this in Chapters 3, 4, 5, and 6 (at least). It's that important!

> *The level of a given economic activity should be increased if and only if the additional benefit exceeds the additional cost. The optimal level of economic activity is such that the additional benefit is very close to the additional cost.*

SUNK COST AND OPPORTUNITY COST

The Airbus A300-600, better known as the Beluga, is a modified Airbus aircraft used to transport large payloads. Its creation follows the needs of a company with geographically dispersed production facilities. Although the Airbus assembly plants are located in Toulouse and Hamburg, major parts (including wings and landing gear) are manufactured in Airbus consortium plants located in Spain, Britain, and Germany. In addition to airplane parts, the Beluga can also be deployed to carry cargos owned by third parties. Examples of past loads include United Nations helicopters, sections of the International Space Station, and a collection of 17th-century paintings in an environmentally controlled container the size of a small house.

The Airbus A300, also known as Beluga (in the picture, the A330-743L version, a.k.a. Beluga XL).

WidiMedia

The Beluga is an input (one of many inputs) used in the construction of Airbus passenger planes. (Note a possible source of confusion: one plane, the Beluga, is an input in the production of another plane, an Airbus commercial plane.) Suppose the Beluga costs D in development costs (specific to the Beluga). Moreover, leasing of a Beluga yields an average revenue of L per year. Based on this information, how would you determine the cost of an Airbus passenger jetliner? In particular, how would you take into account the costs and revenues of the Beluga in computing the cost of building an Airbus passenger aircraft?

When it comes to cost accounting, it is common to distinguish the accounting perspective from the economics perspective. The typical accounting approach would be to amortize the cost of developing the Beluga and include that value in the production cost of an Airbus passenger plane. By contrast, the economics approach is to make the distinction between sunk cost and opportunity cost. A **sunk cost** is a cost that will be paid independently of the current and future course of action. An **opportunity cost**, by contrast, refers to something that needs to be given up in order to obtain a certain good x.

> *A sunk cost in an accounting cost but not an economic cost. An opportunity cost is an economic cost but not an accounting cost.*

The above is a bit of a caricature of the accounting approach, though it's fair to say that the accounting approach tends to be more history focused, whereas the economics approach tends to be forward looking. Going back to the Beluga example: By the time Airbus makes decisions regarding its passenger planes (e.g., what price to sell them),

Box 2.1: Sunk cost fallacy

Economic theory states that sunk costs should not matter in decision making (a normative statement). Do they matter in actual decision making (a positive statement)? Baseball provides an example of when they do, in which case we say the decision maker suffers from a sunk cost "fallacy". Here's the story: Chris Davis, a 33-year-old slugger for the Baltimore Orioles, went through a long stretch of hitless at-bats in 2018, the worst batting average in major league history (.168). Still, the Orioles manager kept fielding him. According to an article,

> In truth, the decision to keep playing Davis almost certainly has more to do with his $17 million salary this year and the $93 million the Orioles owe him beyond 2019 in salary and deferred payments, which will have the team sending him paychecks through the 2037 season.

The point is that the money the Orioles owe Davis is a sunk cost. It will be paid regardless of whether he plays or not. As such, it should be irrelevant to the decision of whether to field Davis. The fact he was fielded in spite of his poor performance suggests that not all behavior is consistent with basic economic thinking. This may not surprise you, but it continues to puzzle economists, especially in situations when the stakes are high.

the cost of developing the Beluga, D, is a sunk cost: no matter what price decisions are made regarding the passenger plane, Airbus will have to pay the Beluga development cost. By contrast, there is a cost which an accountant would ignore but an economist would not: the opportunity cost L of employing the Beluga to transport airplane parts as opposed to providing services to third parties. So, in terms of the above notation, the economic costing of Airbus passenger planes should include L but not D, whereas the accounting-based costing would include D but not L. See this video for other examples and Box 2.1 for another illustration of the so-called "sunk cost fallacy".

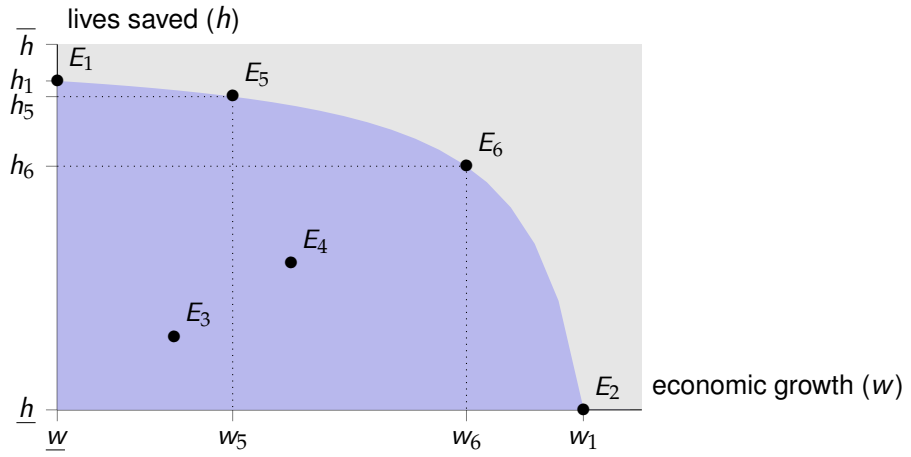


FIGURE 2.5
The health and wealth feasible set

FEASIBLE SET

There are many ways of defining economics. Some state that "economics is about making choices," which seems a little too broad. Others put a stress on the "relationship between ends and scarce means that have alternative uses." The concept of "feasible set", which provides an apt segue to the concept of opportunity cost, is the natural reflection of the scarcity-focused definition of economics. The **feasible set** is simply the set of outcomes that are attainable. This sounds like a tautology, but you would be surprised by how often people, in particular politicians, ignore this basic fact of life: you cannot have everything.

For the sake of concreteness, let us consider a recent and highly controversial issue: the extent to which, and the speed at which, we should "re-open" the economy as we recover from a pandemic such as COVID-19. Wealth vs health, lives vs economics, health crisis vs economic crash, etc. — with these or similar terms, the media raises the question of what the optimal policy is. One expert states that

> If you keep the shutdown going for two months more than we need to, that's just an unbelievably costly mistake. … If we lift the shutdown two months too soon, that would be an unbelievably costly mistake.

This is neither reassuring nor informative. A more useful tool might

be to estimate the relevant feasible set. Suppose that we have two main goals: economic growth and saving lives. Figure 2.5 measures the economy's growth rate on the horizontal axis and the number of lives saved on the vertical axis, where $\overline{h}$ represents the entire population. The region shaded blue represents the feasible set: the set of combinations of economic growth and lives saved that is feasible. Notice in particular that $h = \overline{h}$ is never part of the feasible set: it is impossible to save all lives, regardless of how much we focus on saving lives. The best we can do is to attain point E_1, where h_1 lives are saved and economic growth is at its lowest level (probably a highly negative value). At the opposite extreme, we could push economic growth to the max but then very few lives would be saved (point E_2).

It seems clear that E_2 is not an acceptable outcome. It is not as clear, but equally true, that E_1 is likely an undesirable outcome. Once we get close to extreme lockdown levels and duration, the opportunity cost of saving lives by means of an even stricter lockdown becomes very high, possibly prohibitively high. As was recently noted, economic decline itself has an adverse effect on health; for example, by increasing suicide rates.

What can we then say about the health vs wealth tradeoff? First, as the feasible set shows, many times there is no tradeoff at all! Going from E_3 to E_4, for example, is a no-brainer: it improves health and it improves the economy. Specifically, a well-designed system of testing and tracing and protective measures might do the trick. But once all of the "low hanging fruit" has been caught, we still have to make a choice, for example between E_5 and E_6. This is not something that technical analysis per se can do, it's a decision we need to make as a society. What economists can do is provide an estimate of what the trade-offs are: what the opportunity cost of increasing lives saved from h_6 to h_5 is in terms of economic growth. Or, conversely, what the opportunity cost of increasing economic growth from w_5 to w_6 is in terms of lives lost.

In other words, the typical economist will tell you that, on the one hand, we could try to open the economy slowly, which would probably save more lives (point E_5), but, on the other hand, we could open the economy quicker (E_6), though that would cost us a few more lives. Oral tradition has it that President Harry Truman, when briefed by an economist, pleaded "Please give me a one-handed economist!" Alas, once you are on the frontier of the feasible set, all

choices are going to be of the "on the one hand—on the other hand" type. In this sense, there are no one-handed economists.

At a May 6, 2020 briefing to discuss the New York post-COVID-19 re-opening plan, then Governor Cuomo stated that his "reopening plan doesn't have a tradeoff." With due respect, Governor, you just got an F on the first quiz. We will return to the concept of feasible set, in an explicit manner, in Chapters 3, 9 and 12, and implicitly at many points in the text. It's that important a concept!

DECREASING MARGINAL BENEFIT

Some people cannot start the day without a good cup of coffee. In economics terms, we would say that the benefit (also known as utility) you get from a first cup of coffee is very high. If you feel particularly sleepy, or if you like coffee a lot, then a second cup of coffee will still be greatly appreciated. By the time you are drinking a third cup of coffee (and it's still 8am), you realize you've had enough: the benefit you would get from that additional cup of coffee would be very small or even negative. This is a typical pattern in economics, so much so that we have a name for it: the law of **decreasing marginal benefit**. When it applies to consumers like you and me, we refer to it as the law of **decreasing marginal utility**.

It's important to distinguish total utility from marginal utility. The utility I get from drinking two cups of coffee is greater than the utility I get from drinking one cup of coffee. However, the utility I get from the second cup of coffee is lower than the utility I get from the first cup of coffee.

When we are talking about firms or individuals producing goods or services, instead of benefits, we normally refer to the **law of decreasing marginal returns**. For example, suppose I own a restaurant with a kitchen of a certain size. The more staff I hire to work in the kitchen, the more dinners I am able to serve. However, you can see how the contribution of an additional worker would decline as more and more workers are added to the kitchen. In fact, at some point the marginal contribution of a worker might actually be negative! Too many cooks spoil the broth, so the saying goes. This video goes through a similar example related to restaurant management. The concept of decreasing marginal returns will reappear multiple times in this book, in particular in Chapters 3 and 5.

> *The benefit provided by an economic good increases with the quantity of such good, but the benefit provided by each additional unit of the good tends to decline as total quantity increases.*

Closely associated with the concept of decreasing marginal returns is the concept of increasing marginal cost. Continuing with the restaurant kitchen example, suppose initially there is one cook and output is 10 plates per hour. If I add a second cook, it's unlikely they will equal the rate of 10 plates per hour (for the reasons discussed before). It follows that, if I want to increase the kitchen production rate to 20 plates per hour, I may need to go from one cook to three cooks. This means that the cost of getting the second 10 meals is greater than the cost of getting the first set of 10 meals. The concept of increasing marginal cost will prove very important at various points throughout the text, including the effects of import tariffs in Section 7.3 and the discussion of climate policy in Section 9.3.

GAINS FROM TRADE

As mentioned in Chapter 1, Adam Smith observed a fairly obvious fact: Scotland produces excellent wool but horrible wine; and France, by contrast, produces lousy wool and excellent wine. This clearly calls for an exchange of Scottish wool for French wine, thus making both countries happier with what they wear and drink.

> *Normally an economic transaction creates value for both parties.*

All too often we think of transactions as a **zero-sum game** ("my gain is your loss"). This may be true in chess and other such games, but not in most business situations. In fact, in today's economy the number of individuals and corporations involved in the creation of "stuff" is relatively small. Most of the modern economy produces services, and within services a big chunk corresponds to bringing together supply and demand. This is true for Walmart, Amazon, and for a multitude of online platforms. Although these individuals and corporations and platforms do not create any new "stuff", they do create considerable value simply by inducing trade. When you buy those jeans or earbuds or whatever, you typically pay less than you

Paul Sapiano

The market value of diamonds is higher than the market value of water, but the value in use of water is higher than the value in use of diamonds.

would be willing to pay; the seller gets more than it costs him to produce; and the platform itself gets a cut in the process. In sum, there is a lot of value that's just been created, even if no new product was created in the process. We will return to this issue in Chapter 7.

VALUE IN USE AND MARKET VALUE

There aren't many economist jokes (certainly not compared to lawyer jokes), but one that comes up frequently is this: An economist is someone who knows the price of everything, but the value of nothing. This is funny, but as an economist I must say it is not entirely fair. First, I should clarify that it all comes from the famous playwright Oscar Wilde. In *Lady Windemere's Fan*, he had Lord Darlington quip that a *cynic* was "a man who knows the price of everything and the value of nothing" (my emphasis). A cynic, not an economist.

Second, and most important, economists actually have a fairly good theory of value. Consider the so-called water-and-diamonds' paradox (also known as the **paradox of value**). Which of the two has greater value: water or diamonds? It really depends on what notion of value you consider. To quote Adam Smith:

> The word value, it is to be observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods which the possession of that object conveys. The one may be called "value in use"; the other, "value in exchange". The things which have the greatest value in use have frequently little or no value in exchange; on the

> contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarcely anything; scarcely anything can be had in exchange for it. A diamond, on the contrary, has scarcely any use-value; but a very great quantity of other goods may frequently be had in exchange for it.

In other words, the **market value** of diamonds is higher than the market value of water, but the **value in use** of water is higher than the value in use of diamonds. To put it in one sentence, I'd rather live without diamonds than without water, but I'd rather own DeBeers (a diamond company) than ConEdison (a water utility). In Chapter 7 we will return to this concept when discussing whether and how markets are efficient.

Market value refers to the transaction monetary amount. Value in use refers to the benefit received from using a good. The two values are not necessarily related.

COMPARATIVE ADVANTAGE AND SPECIALIZATION

David Ricardo, a 19th century economist, read Adam Smith's argument that trade creates value when different countries have advantage in supplying different products. For example, Scotland is better at producing wool and France is better at producing wine. But when Ricardo applied Smith's thinking to England and Portugal he was faced with the observation that Portugal produces better wine than England (easy) but is also more efficient at producing textiles (i.e., does so at a lower cost).

Put this way, it does not seem there is much room for exchange that creates value, but there is. The genius of Ricardo is to develop the concept of **comparative advantage**: What matters is not whether Portugal is better than England at producing wine or textiles. What really matters is what Portugal is *relatively* better at. As it happens, Portugal was better than England at producing textiles but *much better* than England at producing wine. It follows that the two countries can jointly create value by exchanging English textiles for Portuguese wine.

> *Economic agents should specialize on the activities for which they have a* comparative *advantage.*

The contrast between absolute and comparative advantage is relevant in many instances beyond international trade. One year after retirement, basketball legend Michael Jordan joined the Birmingham Barons baseball team. His 1994 batting average was a low .202. However, his teammate Ken Coleman had an even lower average, a mere .191. Suppose that we need to assign Jordan and Coleman to the Chicago Bulls and the Birmingham Barons, one to each team. The fact that Jordan is better at baseball than Coleman might suggest Jordan should be with the Barons. However, each player can only play one sport at a time. In this context, what matters is not whether Jordan is better or worse than Coleman at bat; what matters is the relative performance of the two athletes at the two sports. As far as I know, Coleman is not NBA material, so while Jordan is better than Coleman at baseball he is *much better* at basketball. The optimal assignment is not a matter of absolute advantage but rather comparative advantage.

REVEALED PREFERENCE

"Put your money where your mouth is," so goes the popular expression. In other word, your actions should reflect your convictions. One can also think about it backwards: show me your actions and I will tell you what your convictions are. Economists have a version of this: the concept of **revealed preference**. The idea is simple: If economic agents, consumers in particular, are rational decision makers, then we can infer their preferences from their actions. Suppose, for example, that Lena buys a YouTube TV subscription when the monthly rate is $40 but does not buy a YouTube TV subscription when the price is $60. Then I can infer that Lena's maximum willingness to pay for YouTube TV lies somewhere between $40 and $60.

This is not rocket science. The economic theory of revealed preference is more complicated than this, partly because it's not just the subscription price of YouTube TV that changes, lots of things change at the same time in the real world. However, the idea is fairly straightforward:

Car traffic in Auckland, New Zealand. Car fuel efficiency depends greatly on the incentives provided by gasoline prices, which in turn depend on gasoline taxes.

Wikimedia Commons

> *If we have enough observations of an economic agent's decisions, then we should be able to infer their preferences with reasonable precision.*

We will return to these issues at various points in the book, in particular in Chapter 6.

INCENTIVES

Many different fields of inquiry are involved in the business of understanding and predicting human behavior. Psychology, for example, explores behavior and mental processes: perception, cognition, attention, emotion, intelligence, and so forth. Sociology, in turn, focuses on patterns of social relationships and social interaction that surround everyday life. The economics approach, as we saw in Section 2.1, is based on the *homo economicus* framework. Economists think of consumers, workers, firms, etc, as rational agents who choose what's best for them, agents for whom economic incentives provide an important instrumental cause. To put it in a somewhat crass but nevertheless apt way, we assume that, faced with an economic situation, each agent asks him or herself, "What's in it for me?"

Consider the example of car fuel efficiency. Motivated by a desire to reduce dependency on oil (1970s and 1980s), or to reduce greenhouse gas emissions (more recent decades), governments have been keen on increasing car fuel efficiency. In the US fuel efficiency has been pursued primarily by means of regulation (e.g., fuel efficiency standards). By contrast, European countries levy a substantial tax on gasoline consumption. Regulations notwithstanding, US consumers (resp. manufacturers) have little economic incentive to buy

Box 2.2: Voluntary contributions

Founded in 2008, Stack Overflow (SO) is the largest online Q&A platform where programmers ask and answer programming-related questions. As of June 2020, 13 million users had posted nearly 20 million questions. More than 70% of the questions were answered, in many cases by more than one user. Considering the quality and length of many of these answers, it is clear that many hours were spent helping other users, with no direct financial compensation to speak of. Is it a case of altruism, or are there ulterior motives behind private contributions to such a public good?

Affiliated with SO, the Stack Overflow Careers (SOC) site hosts job listings and contributors' CVs so as to match employers and employees. The information regarding each job candidate includes their employment history as well as various summary statistics regarding their contribution to SO: how many questions and answers were posted, as well as how many positive votes such contributions received from peers.

The weeks leading up to a programmer's job change show an increase in SO activity, with a sudden drop immediately after the job change takes place. While there are various interpretations for these upward and downward shifts, statistical research suggests that users increase their SO activity as a means to improve their reputation and thus receive better job offers.

(resp. sell) fuel efficient cars. In Europe, the incentive is as high as gasoline taxes are. The results are clear: In 2013, average fuel efficiency in the US was 32 miles per gallon, whereas the EU showed a whopping 45. (For European readers, this corresponds to 5.2 liters per 100 kilometers in the EU against 7.6 liters per 100 kilometers in the US.)

The car fuel efficiency example illustrates the importance of economic incentives. In particular, it illustrates one of the dearest economics principles:

> *Market prices provide crucial information and incentives to decision makers.*

Box 9.2 provides a more in-depth look at the gasoline case. Box 2.2

discusses an example where one might have thought economic incentives do not play a role: voluntary contributions to an online site. As it happens, economic incentives do play an important role. The issue of incentives will be pervasive throughout the entire book, beginning with the next section, where we take a critical view at the role played by economics in our current society. A more in-depth discussion of the role played by incentives in economic relations is presented in Chapter 10.

2.4. A FORCE FOR THE GOOD

"Blame Economists for the Mess We're In" — such was the title of a recent controversial and much talked about op-ed. It makes two points about economists and economic policy in the US. First, that economists, who until the 1970s were largely ignored ("they don't know their own limitations"), gradually took over the reins of public policy. Second, that this resulted in a complete disaster: "The rise of economics is a primary reason for the rise of inequality," a particular reference to the free-market economics that inspired the Reagan and Thatcher deregulation waves.

This view misses two points. First, the influence exerted by economists has been quite significant since at least Adam Smith. Chapter 1 includes a famous quote by John Maynard Keynes, namely that "Practical men who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist." And living economists as well, beginning with Keynes himself ("nobody could have been more influential," John K Galbraith once said).

Second, it seems a bit unfair to place the rise of inequality at the feet of economists. For example, as we will see in Chapter 11, a combination of the digital revolution and globalization have been important factors. Societies are naturally attracted to scapegoating, and the role played by economists and economics makes for an easy target.

That said, the past few years have justifiably been a time of reckoning for economics as a field of research as well as a contributor to public policy. From a methodological point of view, the preference given to formal, often mathematical, tools has unwittingly led economists to focus more on efficiency (which is more easily mea-

surable) than on social justice (which is considerably more difficult to measure and act upon).

What is, then, the way forward? There is an old German expression, used by Luther, Kepler and Goethe, among others, which, translated and adapted into English, became "Don't throw the baby out with the bathwater." We should acknowledge that some aspects of economics thinking have done more harm than good to the economy and society. But ridding public policy from its economics foundation would likely lead to an even worse outcome. Economics is part of the problem, but it is also part of the solution. It is impossible to think about the effects of public policy without having a good idea of how economic agents will act and react. And it's impossible to predict behavior without a good model of what makes economic agents tick. This applies to all sorts of policies: which taxes to levy and at what level, how to set import tariffs and what immigration policy to implement, when to allow firms to merge and when not to, how to reopen the economy in a post-pandemic context, and so on.

Equally important, it's impossible to move forward without a clear knowledge of what the options are. We can and should think outside of the box, but we cannot live outside of the feasible set (see page 79). In one of the many recent critical appraisals of microeconomic analysis, an article states quite categorically that "Our priority should be to build resilient systems explicitly designed to withstand worst-case scenarios," whereas "mainstream economics has a single overarching objective,... efficiency." If we think of economic resiliency and economic efficiency as two different goals, then this statement makes little sense; it's like insisting on one of the extreme points in Figure 3.3. Why on earth should the extreme of maximum resiliency be optimal? If you want to minimize the probability of dying today (worst case scenario), then you should simply sit down at home and avoid any of a series of possible activities that carry some risk of death, small as it might be (e.g., crossing the street). Like it or not, life is made of trade-offs. Granted, economists have insisted too much on economic efficiency as opposed to other important goals (resilience, equity, sustainability), but again we should not throw the baby out with the bathwater.

In sum, the tool we call economics plays a crucial role in policy design. But as we use it, we must take into account that behind each policy there are individual people with individual aspirations and

US President Ronald Reagan and British Prime Minister Margaret Thatcher pushed privatization and deregulation during the 1980s.

goals, with individual problems and limitations; individuals who are as human as any other human being. Only then can economics become a force for the good.

KEY CONCEPTS

choice | market | public policy | macroeconomics | microeconomics | economic model | post hoc fallacy | counterfactual | identifying assumption | difference in differences | sample selection effect | ceteris paribus | selection bias | positive analysis | normative analysis | homo economicus | behavioral economics | sociology | social status | conspicuous consumption | positional good | statistical discrimination | taste discrimination | institutional discrimination | game theory | social dilemma | common resource | dominant strategy | prisoner's dilemma | cost-benefit | marginal | sunk cost | opportunity cost | feasible set | decreasing marginal benefit | decreasing marginal utility | decreasing marginal returns | zero-sum game | paradox of value | market value | value in use | comparative advantage | revealed preference

REVIEW AND PRACTICE PROBLEMS

■ **2.1. Economic models.** What do we mean by the analogy of models as maps?

■ **2.2. Normative vs positive.** What is the difference between normative and positive analysis? How is this distinction relevant when modeling agents as self-interested utility maximizers?

■ **2.3. Diet soda and obesity.** Research suggests that diet drinks are associated with weight gain (see also this).

(a) Provide narratives consistent with causality from diet soda drinking to obesity, and, alternatively, from obesity to diet soda drinking.

(b) What other explanations can you find to explain the above correlation?

■ **2.4. Moderna vaccine.** Read on Twitter:

> Getting my second Moderna vaccine. A bit concerned about the side effects. For the first dose, I got a flat tire on the way home.

What fallacy, discussed in this chapter, does this amusing tweet refer to?

■ **2.5. Economics training and earnings.** A recent paper reports that students who majored in economics earned median wages at the age of forty of $90,000 in 2018, whereas students who majored in other social sciences earned only $65,000. Provide two different narratives, one that explains the above relationship as a simple correlation, one that is based on a causal effect.

■ **2.6. Class size and student performance.** Economic research shows that primary school children in classes of smaller size have better educational achievements (such as higher test scores) than children in larger classes. Provide two different narratives, one that

explains the above relationship as a simple correlation, one that is based on a causal effect.

■ **2.7. Roads and development.** A recent research paper, studying the mid-20th century construction of the US Interstate Highway System, finds that counties with highways passing through them had 17% higher employment than counties without highways by 2014. Provide two different narratives, one that explains the above relation as a simple correlation, one that is based on a causal effect.

■ **2.8. Bars and innovation.** Recent research suggests that in locations and during years where bars were closed (during the period of prohibition in the US) the rate of innovation (measured by new patents) was lower. Provide two different narratives, one that explains the above relationship as a simple correlation, one that is based on a causal effect.

■ **2.9. Evidence-based policy.** Read the article *Purely Evidence-Based Policy Doesn't Exist* by economist Lars Hansen. How does it relate to some of the ideas presented in this chapter?

■ **2.10. Yan Granola.** Yan Granola is a gourmet granola sold in two markets, East and West. In May 2019, a special promotional campaign took place in the West market. The price of Yan Granola has been constant at $4.99 in both markets and every month of 2019. The values of sales (in thousands of units) are given by Table 2.1.

(a) Plot the values of monthly sales in the East and West markets. Is there any sign that the promotional campaign had an effect on sales?

(b) Using the first four months of the year as a basis for East-West comparison, derive a counterfactual of sales in the West market had a promotional campaign not taken place. Be precise about the assumptions you make in order to create this counterfactual.

TABLE 2.1
Sales of Yan Granola

Month	East	West
1	52	42
2	53	41
3	49	40
4	50	42
5	49	41
6	48	46
7	51	47
8	47	45
9	48	44
10	50	45
11	54	48
12	64	59

(c) Based on the counterfactual, determine the increase in monthly sales due to the promotional campaign. Determine the effect that the campaign had in sales (in dollars) from June to December 2019.

■ **2.11. Toby Burgers.** Popular chain Toby Burgers showed the following sales numbers in 2019:

- New Jersey, January-June: 343
- Pennsylvania, January-June: 266
- New Jersey, July-December: 412
- Pennsylvania, July-December: 384

During July-December, Toby Burgers had a special promotion in Pennsylvania but not in New Jersey.

(a) Assuming that, other than the promotion, the New Jersey and Pennsylvania markets evolved in parallel, determine the counterfactual level of sales in New Jersey had the promotion been there as well.

(b) Assuming that, other than the promotion, the New Jersey and Pennsylvania markets evolved in parallel, determine the effect that the promotion had on sales in Pennsylvania.

(c) Discuss the assumptions underlying your analysis. Indicate what additional data you might use to improve your counterfactuals.

■ **2.12. Minimum wage in New Jersey.** A bill signed into law in 1989 raised the US Federal minimum wage to $4.25, effective on April 1, 1991. In early 1990 the New Jersey legislature went one step further, increasing minimum wage to $5.05 per hour effective April 1, 1992. A survey of 473 fast-food restaurants resulted in a sample of 410 responses (87% response rate) summarized in Table 2.2. The sample includes restaurants in New Jersey, where the extra increase in minimum wage took place, as well as restaurants in Pennsylvania, where only the federal minimum wage was in effect. The survey was taken in two "waves": Wave 1 from February 15-March 4, 1992, that is, before the higher NJ minimum wage went into effect; and Wave 2 from November 5-December 31, 1992, after the higher NJ minimum wage went into effect. (Note: the values in parentheses represent standard deviations.)

Based on these results, estimate the effect of minimum wage on FTE employment, the percentage of full-time employees, the price of a full meal, the hours a restaurant is open, and the recruiting bonus. Be clear about the assumptions required for deriving the estimates and the extent to which the data support that assumption. Based on these results, how would you describe the effects of increasing the minimum wage?

■ **2.13. Sunk cost fallacy.** What do we mean by the so-called sunk cost fallacy?

■ **2.14. GDP and the music industry.** Read the article, What the GDP Gets Wrong (*Why Managers Should Care*). How does it relate to the main themes from economics discussed in Chapter 2?

■ **2.15. Prisoner's dilemma.** The COVID-19 pandemic has given rise to a number of situations that have the nature of a prisoner's

TABLE 2.2
Effects of minimum wage on New Jersey and Pennsylvania fast-food restaurant employment (source: Card and Krueger) (values in parentheses are standard deviation values)

	New Jersey	Pennsylvania
Store Types (percentages)		
Burger King	41.1	44.3
KFC	20.5	15.2
Roy Rogers	24.8	21.5
Wendy's	13.6	19.0
Company-owned	34.1	35.4
Means in Wave 1: February 15-March 4, 1992		
FTE employment	20.4 (0.51)	23.3 (1.35)
Percentage full-time employees	32.8 (1.3)	35.0 (2.7)
Starting wage	4.61 (0.02)	4.63 (0.04)
Wage = $4.25 (percentage)	30.5 (2.5)	32.9 (5.3)
Price of full meal	3.35 (0.04)	3.04 (0.07)
Hours open (weekday)	14.4 (0.2)	14.5 (0.3)
Recruiting bonus	23.6 (2.3)	29.1 (5.1)
Means in Wave 2: November 5-December 31, 1992		
FTE employment	21.0 (0.52)	21.2 (0.94)
Percentage full-time employees	35.9 (1.4)	30.4 (2.8)
Starting wage	5.08 (0.01)	4.62 (0.04)
Wage = $4.25 (percentage)	0.0	25.3 (4.9)
Wage = $5.05 (percentage)	85.2 (2.0)	1.3 (1.3)
Price of full meal	3.41 (0.04)	3.03 (0.07)
Hours open (weekday)	14.4 (0.2)	14.7 (0.3)
Recruiting bonus	20.3 (2.3)	23.4 (4.9)

dilemma, both at the international level, at the national level (e.g., across states), and within small communities. Can you think of some of these situations? What solutions would you propose to avoid the

		Firm 2: restart	Firm 2: not restart
Firm 1	restart	250 250	0 -50
	not restart	-50 0	0 0

FIGURE 2.6
COVID-19 reopening game

"trap" posed by the prisoner's dilemma?

■ **2.16. Water and diamonds.** Listen to the podcast *The Diamond-Water Paradox* (or read the transcript). What is the water-diamond paradox? How does it form part of the history of economic thought? How does it relate to another concept introduced in Chapter 2, namely decreasing marginal benefit?

■ **2.17. Post-COVID-19 reopening.** Much of the economic contraction during the COVID-19 pandemic was due to public health reasons, not to direct economic reasons. In principle, once the health crisis is solved, the degree of economic activity can resume its previous level. However, one may argue that there are coordination issues at stake. For simplicity, consider an economy with two firms. Each of the firms must decide whether to restart activity or not restart activity. If only one of the firms starts, then it will not have sufficient customers to break even. The reason is that some of the workers in the economy (those employed by the second firm) have no earnings to purchase goods from the first firm. The same reasoning applies to the other firm. Putting all of this information together, we may represent the game played by each of the two firms as in Figure 2.6.

(a) Do any of the players have a dominant strategy in this game?

(b) What would you expect the outcome of a game like this to be? (Note: this is an open question.)

■ **2.18. COVID-19 liability.** In a May 27, 2020 press release, the US Chamber of Commerce called for COVID-19 liability protection for

businesses.

> American businesses are working hard to take measures to protect their employees and customers amid the COVID-19 crisis, however the risk of opportunistic lawsuits poses a significant barrier in their ability to bounce back from the economic crisis. As businesses start to reopen, employers simply want to know that if they take reasonable steps to follow public health guidelines, they will be protected against needless lawsuits.

How does this issue relate to some of the main economics themes discussed in class? (Hint: discuss the role played by opportunity cost, decreasing marginal benefit, incentives.)

■ **2.19. Standard setting.** Suppose Apple and Samsung are in the process of negotiating a common standard for a new 3D camera technology they plan to introduce in the next generation of smartphones. Apple has a preference for standard A, whereas Samsung has a preference for standard S. However, both recognize that multiple standards are a worse outcome for all. Specifically, Apple gets 240 if it selects A and Samsung does so too, but only 20 if Samsung does not adopt A. If Apple adopts standard S and Samsung does so too, then Apple gets a payoff of 190. If, however, Samsung chooses A then Apple gets zero. For Samsung, the situation looks similar: If Samsung chooses standard S and Apple does the same then Samsung gets 210, but if Apple chooses A the Samsung's payoff is only 30. If Samsung opts for standard A and Apple does so too then Samsung gets a payoff of 110, whereas if Apple chooses standard S then Samsung gets a payoff of zero.

(a) Suppose that both Apple and Samsung simultaneously choose A or S. Depict the game played by the two tech firms in matrix form.

(b) Does either of the players have a dominant strategy in this game?

(c) What would you expect the outcome of a game like this to be? (Note: this is an open question.)

■ **2.20. NYU building.** Suppose you manage NYU's facilities. There is a particular building which you are currently using to house short-term visitors (executive education). This use brings in 80 in room fees but requires 30 in cleaning and other expenses. The next best use of the space is to lease it out for office space at a rate of 60.

(a) What is the net (accounting) profit from using the building to house short-term visitors?

(b) How does this problem relate to the concept of opportunity cost? Specifically, what is the opportunity cost of using the building to house short-term visitors?

(c) What is your optimal choice if your goal is to maximize net revenue?

■ **2.21. Rail vs bus service.** Suppose the British Government must decide whether to continue rail service between two cities or instead to switch to bus service. The benefits stemming from both choices are valued at 120. The costs of the rail company are 30 for interest on bonds used to finance the rails, 50 to lease trains, and 50 for labor (or labour, since we're talking about the UK). The costs of running the bus service are 60 to lease the buses and 50 for labor. Determine the optimal choice. Be specific about thee assumptions you make.

■ **2.22. New business creation during the pandemic.** One of the most remarkable effects of the COVID-19 pandemic was an increase in the rate of new-business creation. According to economist John Haltiwanger, "The surge continues. We're now convinced this wasn't just a blip." What factors do you think motivated this increase in startups? How does this relate to concepts presented in this chapter?

■ **2.23. Diversity in the economics profession.** Listen to the podcast *A Race Reckoning In Economics* (or read the transcript). Why is diversity in the economics profession important not only for the profession but also to the economy?

■ **2.24. Most useful ideas in economics.** The podcast *13,000 Economists. 1 Question* (transcript) presents "The most useful ideas

in economics." Can you identify them from the podcast? Can you find them in the present chapter?

Nandaro

PART II

SCARCITY AND CHOICE

CHAPTER 3

OPTIMAL CHOICE

In Chapter 2 we referred to economics as the study of optimal allocation of scarce resources. Two important components in this definition are (a) allocation, which we may also refer to as choice; and (b) scarce resources. This chapter focuses precisely on the choices made by economic agents so as to optimally allocate scarce resources.

INCOME AND LEISURE OVER TIME

One of our scarcest resource is time: 24 hours a day for a limited number of years. We can use this resource to engage in a variety of activities. A particularly important distinction is between time spent working and leisure time. We define leisure as time not working, that is, 24 minus daily working hours; or, equivalently, 24×365 minus the yearly total number of working hours.

Figure 3.1 shows the number of hours of work as well as per-capita income in the US from 1870–2016 (both on a yearly basis). In 1870, Americans worked about 3,100 hours a year, which corresponded to about 75 hours a week. By 2016, the average American only worked for about 1,800 hours a year, that is, a little more that one half of the 1870 average. (The number of hours per week did not drop as much as the total number of hours because the number of workdays also declined considerably during the 1870–2016 period.) In the meantime, per-capita income increased by a factor of about 16.

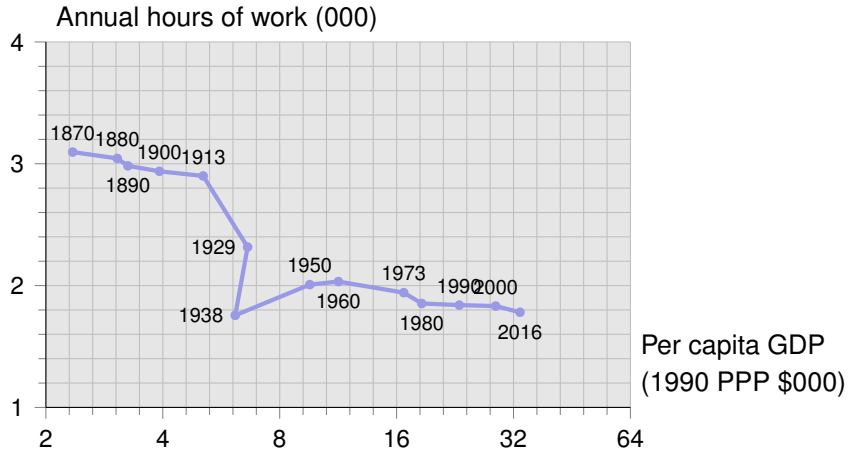


FIGURE 3.1
Hours of work and income in US

Excluding the 1938 observation, which corresponds to a very special period in American economic history (the Great Depression), we observe that, over time, Americans have a higher income and work fewer hours. To put it differently, today's average American has a higher income *and* enjoys more hours of free time than an average American in 1870.

From an economics point of view, the positive relation between income and free time is not obvious. The increase in income is closely associated with an increase in the wage rate. So, over time we observe an increase in the wage rate *and* a decrease in the number of hours worked. One might have expected that, as the wage rate increases, Americans might choose to work more hours. As we will see, from a theoretical point of view it could go either way, as there are two effects of opposite sign: On the one hand, a higher wage makes working longer hours more attractive, but on the other hand, as income and consumption increase, people attach greater value to leisure, and more leisure time implies less work time. Which effect dominates? This chapter lays out the basic framework to address questions like this, and the next chapter addresses a variety of applications including the wage-leisure problem.

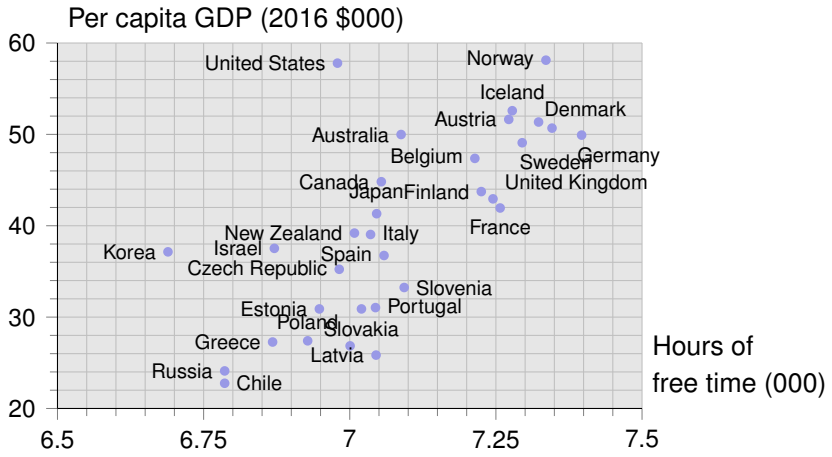


FIGURE 3.2
Free time and income in 2016

INCOME AND LEISURE ACROSS COUNTRIES

Consider now the data shown in Figure 3.2. We fix a particular date (2016) and compare income and leisure (free time) combinations across countries. One first stylized fact we get from eyeballing the scatter plot is that higher income is associated with more free time. This is consistent with what we observed for the US over time (cf Figure 3.1).

A second observation regarding Figure 3.2 is that there are many "outliers" from the purported positive correlation. Consider, for example, France and the US. The average French person has lower income than the average American, but also more free time than the average American. Why is this so? Which is better in terms of living standards?

ROADMAP

Our goal in this and the next two chapters is to analyze the optimal allocation of scarce resources (time, income, natural resources, etc) by economic agents (consumers, firms, workers, students, etc). Throughout the present chapter, we will consider a specific example: Alexei must choose how to use time (scarce resource) to study or simply enjoy leisure.

In Chapter 2 we read about research on the habits and perfor-

mance of 84 Florida State University students. It was estimated that one extra hour of study is associated with a grade increase of 0.24. In other words, there is a trade-off between enjoying leisure time and getting a better course grade (surprise!).

In the next sections, we address this trade-off in a formal way. We first derive Alexei's feasible set, that is, the combinations of leisure and course grade that are attainable. We then model Alexei's preferences regarding grade and leisure time by means of indifference curves. Finally, given Alexei's preferences and feasible set, we derive Alexei's optimal choice.

3.1. FEASIBLE SET

Consider the fictional case of Alexei (adapted from the excellent textbook *The Economy*), a student who must choose how many hours to study. Suppose that we have determined that the relation between hours of study and Alexei's grade is given by the following table

Study hours	0	1	2	3	4	5	6	7
Grade	0	20	33	42	50	57	63	69

Study hours	8	9	10	11	12	13	14	15+
Grade	74	78	81	84	86	88	89	90

Both leisure time and grade are goods: the more Alexei has of them, the better off he is. Ideally, Alexei would like to have 24 hours of leisure and a grade of 100. Unfortunately, such combination is not feasible. Alexei's **feasible set** is the set of combinations of leisure and grade that Alexei can attain.

Alexei's feasible set is illustrated in Figure 3.3. Alexei owns the resource time, specifically 24 hours per day. Alexi can turn time into grade according to the above table. If Alexei does not study at all, he gets all 24 hours of leisure, but a grade of zero. It follows that (24,0) is a point in Alexei's feasible set. Naturally, Alexei can enjoy *up to* 24 hours of leisure, but he can also enjoy fewer than 24 hours, so all points $(x, 0)$, where $x \leq 24$, also belong to Alexei's feasible set.

Suppose now that Alexei works for 6 hours. This leaves up to $18 = 24 - 6$ hours of leisure to be enjoyed. Moreover, the 6 hours of

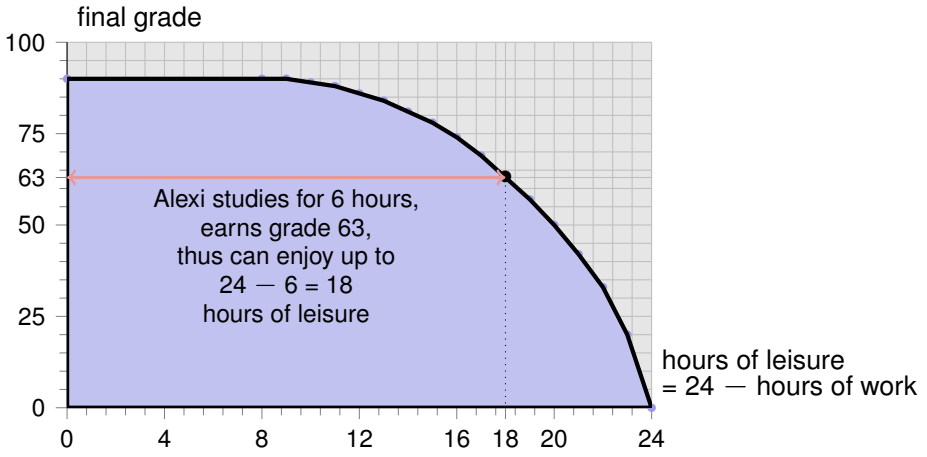


FIGURE 3.3
Alexei's feasible set

study yield a grade of 63. This generates another point in Alexei's feasible set. More generally, we can choose a value of hours of leisure, determine the corresponding number of hours of study (24 − leisure), and, based on Alexei's studying abilities, determine the expected grade. We thus obtain a point on the (leisure, grade) map corresponding to the *boundary* of Alexei's feasible set.

MARGINAL RATE OF TRANSFORMATION

The boundary of Alexei's feasible set illustrates the trade-off that Alexei faces in the choice of grade vs leisure. Specifically, we measure this trade-off by computing the **marginal rate of transformation (MRT)**. The MRT is given by the absolute value of the slope of the outer edge of the feasible set. The MRT indicates how much Alexi needs to give up of one good in order to obtain more of the other good (assuming, for simplicity, the choice is between two goods). In other words, the MRT measures the opportunity cost of getting more leisure (the good on the horizontal axis) in terms of forgone good grades (the good on the vertical axis).

> *The marginal rate of transformation (MRT) measures the opportunity cost of getting one additional unit of x in terms of foregone units of y.*

TABLE 3.1
Marginal Rate of Transformation

Study (hours)	Grade (points)	Leisure (hours)	MRT (point/hour)
0	0	24	N/A
1	20	23	20
2	33	22	13
3	42	21	9
4	50	20	8
5	57	19	7
6	63	18	6
7	69	17	6
8	74	16	5
9	78	15	4
10	81	14	3
11	84	13	3
12	86	12	2
13	88	11	2
14	89	10	1
15	90	9	1
16+	90	9−	0

In Table 3.1, we compute the MRT at each point on the edge of Alexei's feasible set. For example, if Alexei studies for 4 hours then he enjoys 20 hours of leisure time. Moreover, 4 hours of study produce a grade of 50 (not so good). What is the MRT at this point? If Alexi wants to enjoy an additional hour of leisure — the 21st unit of leisure — then he must reduce study time to 3 hours. This implies a drop in grade of $8 = 50 - 42$. It follows that the MRT is given by $(50 - 42)/(21 - 20) = 8$.

Notice that, as Alexei spends more and more hours of time on leisure, the academic cost of an additional hour of leisure time increases. We can see this in Table 3.1 as we move up the third column (more hours of leisure) and check the corresponding value in the fourth column (MRT). Conversely, as Alexei spends fewer and fewer hours on leisure, and more and more time studying, the benefit (in

TABLE 3.2
Alexei's indifferent combinations

leisure	grade
15	84
16	75
17	67
18	60
20	50

terms of grade) of an additional hour of study time decreases. We can see this in Table 3.1 as we move down the first column (more hours of study) and check the corresponding value in the fourth column (MRT). We will return to this in Chapter 5 and show that this corresponds to the property of decreasing marginal product: the more you study, the less an *additional* hour of study helps improving your grade. In terms of Figure 3.3, this corresponds to a feasible set boundary that is concave with respect to the origin.

3.2. PREFERENCES

In the previous section we dealt with Alexei's feasible set: what Alexei can do in terms of grade and leisure. In this section we deal with Alexei's preferences: what he likes in terms of grade and leisure. Economic choice is precisely the combination of preferences/goals (what we want) and constraints (what we can do).

Unlike the feasible set, which is given by objective data, preferences are a highly subjective business: there's no arguing about tastes, so the saying goes. However, economists believe that preferences, subjective as they may be, can be measured. With that in mind, suppose that Alexei is known to be indifferent between the combinations of leisure time (in hours) and final grade (in points) listed on Table 3.2. We say all of these combinations give Alexei the same level of **utility**, a concept that describes a person's preferences. (Note that the values in Table Table 3.2 are different from those in Table 3.1. The former refer to what Alexei likes, whereas the latter refer to what Alexei can do.)

Consider the following alternative combination of free time and grade: 13 hours of leisure and a grade of 84. Would this give Alexei a lower or a higher utility than any of the combinations above? The answer is: lower. The reason is that one of the combinations in Table 3.2 is (15, 84). The proposed alternative, (13, 84), has the same of good 2 and less of good 1. And more of a good is better (so we assume). And since all of the combinations in Table 3.2 provide the same utility level, it follows that (13, 84) is worse than *any* of the combinations in the table above (by transitivity, which we also assume).

Consider the following alternative combination of free time and grade: 18 hours of leisure and a grade of 70. Would this give Alexei a lower or a higher utility than any of the combinations above? The answer is: higher. The reason is that one of the combinations in the table above is (18, 60). The proposed alternative, (18, 70), has the same of good 1 and more of good 2. And more of a good is better (so we assume). And since all of the combinations in the table above provide the same utility level, it follows that (18, 70) is better than any of the combinations in the table above (by transitivity, which we also assume; more below).

Generally speaking, given two choices c_1 and c_2, either Alexei

- prefers c_1 to c_2 (which we denote by $c_1 \succ c_2$)
- prefers c_2 to c_1 (which we denote by $c_2 \succ c_1$)
- is indifferent between c_1 and c_2 (which we denote by $c_1 \sim c_2$)

If c_2 has more of both good things (e.g., leisure and final grade) than c_1, then $c_2 \succ c_1$. Otherwise, it depends on each person's trade-off between the two goods.

More generally, we assume that economic agents (including Alexei) have preferences characterized by a relation $\succ$. Specifically, we say that $c_1 \succ c_2$ if the agent prefers c_1 to c_2; and we say that $c_1 \sim c_2$ if the agent is indifferent between c_1 and c_2. Moreover, we assume the preference relation satisfies the following behavioral postulates or **behavior axioms**:

1. **Completeness**: given c_1 and c_2, either $c_1 \succ c_2$ or $c_2 \succ c_1$ or $c_1 \sim c_2$
2. **Transitivity**: if $c_1 \succ c_2$ and $c_2 \succ c_3$ then $c_1 \succ c_3$
3. **Monotonicity**: if c_2 has more of every good than c_1 then $c_2 \succ c_1$

In economics we refer to agents who choose their best option based on preferences consistent with these postulates as **rational agents** (*homo economicus*). Let us now look at each of these in detail. **Completeness** means that "I have no idea" does not apply when it comes to preferences: each agent can always tell, given any two options, which one she prefers (or whether she is indifferent). Note that this does *not* imply that the agent is fully cognizant of the pluses and minuses of each option. In most real-world situations, there is a lot of uncertainty regarding outcomes. That said, we assume that, factoring in all of that uncertainty, economic agents are able to — and actually do — compare alternative options and evaluate their relative merits.

Transitivity is a fundamental postulate of rational behavior. If Alexei prefers a to b, prefers b to c, and finally prefers c to a then there is something wrong with Alexei, or so an economist would say. Finally, **Monotonicity** is simply the formal counterpart of the idea that we are dealing with *goods*: more of a good thing is better. What about that time when you ate way too many potato chips and felt sick for two days? The way economists deal with that is by remarking that you can freely dispose of extra amounts of goods. In other words, if you are given 100 tubes of *Pringles* you don't need to eat them all, so having more tubes of *Pringles* cannot make you worse off. You can see how the assumption is controversial, and we will return to this in Section 3.3.

How do we deal with "bads" such as pollution? Unfortunately, the free disposal assumption clearly does not apply here. Let x be the amount of pollution that an agent suffers from. The trick is then to say that the agent benefits from a "good" (call it "lack of pollution", for example) in the amount $-x$. A greater value of $-x$ then increases the agent's utility, which is the same as saying the agent benefits from less pollution.

INDIFFERENCE CURVES

Let us return to the values in Table 3.2. We can plot these combinations of free time and grade on a graph. We can then connect the various combinations that Alexei is indifferent about. We refer to this line as one of Alexei's **indifference curves**. Since Alexei is indifferent among all of the points on this indifference curve, and since Alexei

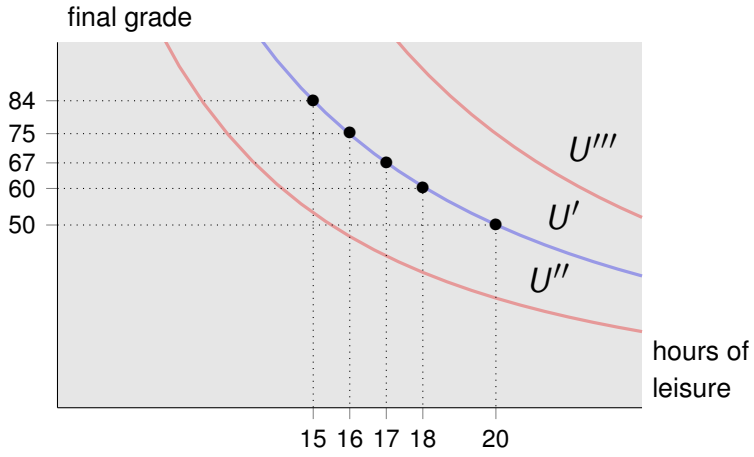


FIGURE 3.4
Alexei's indifference curves

prefers combinations that induce higher utility levels, it follows that all points along the indifference curve correspond to the same utility level, which we denote by U'.

A brief digression which may help understand the concept of indifference curves. There is an analogy between indifference curves and iso-altitude curves in topographic maps. Iso-altitude curves connect points on the terrain that have the same altitude. If the lines are very close together, we know the terrain is very steep at that point. More generally, iso-altitude lines allow us to represent a three-dimensional object in a two-dimensional graph. Figure 3.5 shows a topographic map (top) as well as a section of a two-peaked mountain. The line labeled "20" on the top map, for example, connects all points with an altitude of 20. Similarly, the middle indifference curve in Figure 3.4 connects all points with utility level U'.

Similarly to a topographic map, which has many iso-altitude lines (one per altitude level), we also have a multitude (in fact, a continuum) of indifference curves. In Figure 3.4 we see the indifference curves corresponding to utility levels U', U'' and U'''. Given our monotonicity postulate (more of a good thing implies higher utility) we can conclude that $U' > U''$ and $U''' > U'$. In fact, when it comes to indifference curves we know that the farther away they are from the origin, the higher the utility level they correspond to. The same is not true for maps, that is, we don't know which way altitude

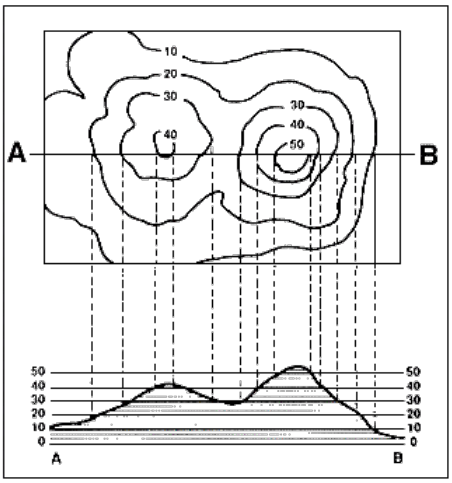


FIGURE 3.5
Digression: topographic maps

increases. For this reason, we need to label each iso-altitude line to know which way the mountain slopes.

Just like the shape of iso-altitude lines show us the shape of a given area, so the shape of the indifference curves gives us an idea of a person preferences. For example, if Alexei did not care about grade *at all*, then his indifference curves would be vertical. The idea is that, for a given number of hours of leisure, giving Alexei a higher grade would not change his utility.

If you look at a topographical map, you will note that iso-altitude lines do not cross. Why not? Two different iso-altitude lines correspond to two different altitude levels. Were two lines to cross we would have a point with two different altitudes simultaneously, which is clearly impossible. Similarly, no two different indifference curves can cross. This is illustrated in the top panel of Figure 3.6. According to the indifference curves, $A \sim B$ and $A \sim C$, hence $B \sim C$. But B has more of both goods than C, so $B \succ C$, which in turn implies a contradiction!

Another property of indifference curves is that they are (normally) convex. This is illustrated in the bottom panel of Figure 3.6. Combinations A and B lead to the same utility level (they lie on the same indifference curve). Consider now combination C, which consists of one half of A and one half of B. Since the indifference curve containing A and B is convex, combination C lies to the north east

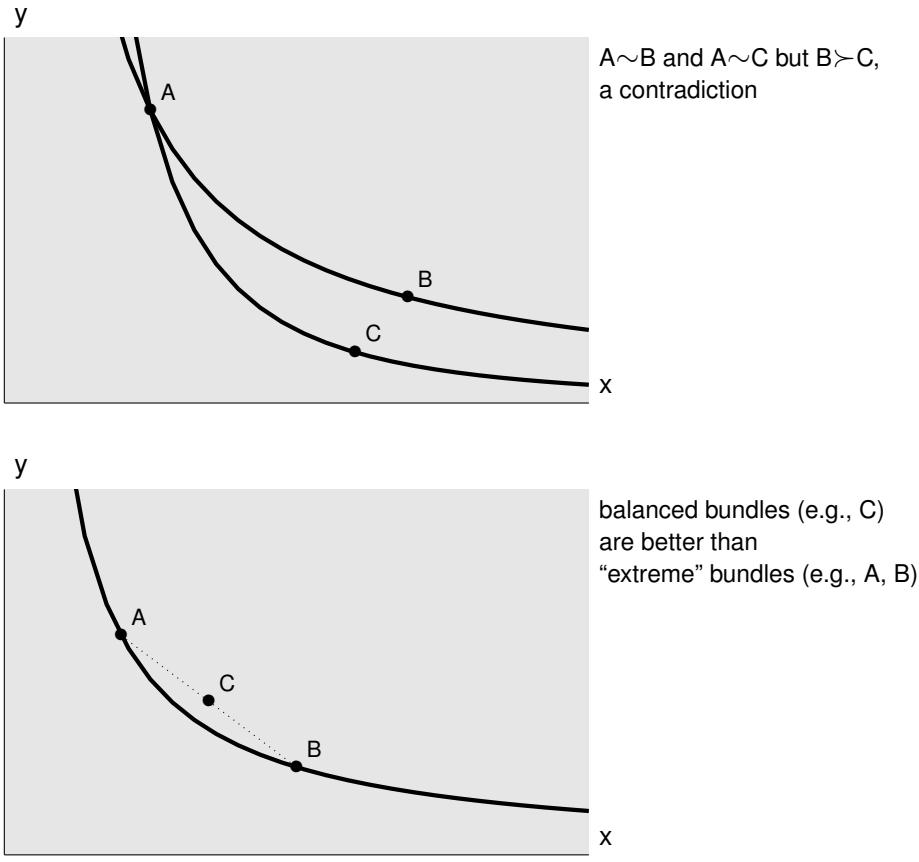


FIGURE 3.6
Properties of indifference curves

of the indifference curve, that is, C corresponds to a higher utility level than A or B. Intuitively, convexity of the indifference curve corresponds to the property that people prefer a moderate amount of each good to a very high amount of one and a very low amount of the other.

Going back to the analogy between indifference curves and topographical maps. The latter correspond to altitude, which is a well-defined quantity (e.g., 1,000 feet). The former correspond to an individual's utility level, which is a not-so-well defined quantity. In fact, as long as the indifference curves remain the same, it really does not matter what the specific values of U', U'' and U''' in Figure 3.4 are: Indifference curves help describe an individual's *preferences*, not an absolute value of "happiness."

Let us summarize what we've seen so far regarding utility and indifference curves.

- Better combinations (higher utility) correspond to indifference curves farther from the origin (monotonicity, also know as non-satiation assumption)
- Indifference curves slope downward (more of one good compensates for less of the other good)
- Indifference curves are typically convex (a mix is better than extremes)
- Indifference curves never cross (if that were the case, we would have a violation of transitivity, thus a violation of rationality)
- Particular shapes of indifference curves reflect an agent's preferences (there's no arguing about tastes)
- It doesn't matter what units we measure utility with, so long as utility levels are consistent with an agent's indifference-curve mapping

MARGINAL RATE OF SUBSTITUTION

The shape of each person's indifference curves reflects that person's preferences. We are particularly interested in the slope of the indifference curves. The **marginal rate of substitution (MRS)** corresponds precisely to the absolute value of the slope of a person's indifference curve. This slope can be approximated by the ratio of point-to-point variations between two nearby points of an indifference curve. Since in general indifference curves are not linear, the slope depends of the particular combination we consider. Accordingly, the MRS varies from point to point.

The MRS measures how a person trades off one good for another. Specifically, it quantifies how much an agent is willing to give up of one good in order to obtain more of another good. Consider Table 3.3, which includes various combinations that Alexei is indifferent about. In order to increase leisure from 15 to 16 (i.e., study one hour less), Alexei is willing to receive a 9 point lower grade. This implies that the MRS (at 15 hours of leisure and a grade of 84) is (approximately) given by $(84 - 75)/(16 - 15) = 9$, that is, loss in grade divided by gain in leisure.

TABLE 3.3
Alexei's MRS

leisure	grade	MRS
15	84	9
16	75	8
17	67	7
18	60	5
20	50	-

As mentioned earlier, the shape of the indifference curves reflects an individual's tastes. And the MRS is equal to the slope (in absolute value) of an individual's indifference curves. Given that, we conclude that an individual with high MRS cares a lot for the good measured on the horizontal axis. For example, a student who cares a lot for free time has a very high MRS of free time for grade.

The definition of MRS has some similarities with the definition of MRT. Recall that MRT indicates how much an agent *has to* give up of y in order to obtain one additional unit of x. By contrast, MRS indicates how much an agent *is willing* to give up of y in order to obtain one additional unit of x. In words, the two definitions seem very similar, but there is a big difference between "willing to give up" and "having to give up", as many of us have found out in our own lives. In other words, the concept of MRS relates to an individual's preferences, whereas the concept of MRT relates to an individual's feasible set. The essence of this chapter is precisely to bring together the two concepts — what an individual wants and what an individual can do — so as to determine an individual's optimal choice.

As mentioned earlier, indifference curves are normally convex. Figure 3.7 shows Alexei's indifference curve corresponding to the combinations on Table 3.3. At 15 hours of leisure and a grade of 84, the slope of Alexei's indifference curve is approximately equal to 9. However, at 18 hours of leisure and a grade of 60 (another point in the same indifference curve), the slope of the indifference curve is approximately equal to 5, the ratio of the change in final grade, $60 - 50$, divided by the change in leisure time, $20 - 18$. In other words, considering two points *on the same indifference curve*, the one with a higher value of x (leisure in this case) has a lower slope (in ab-

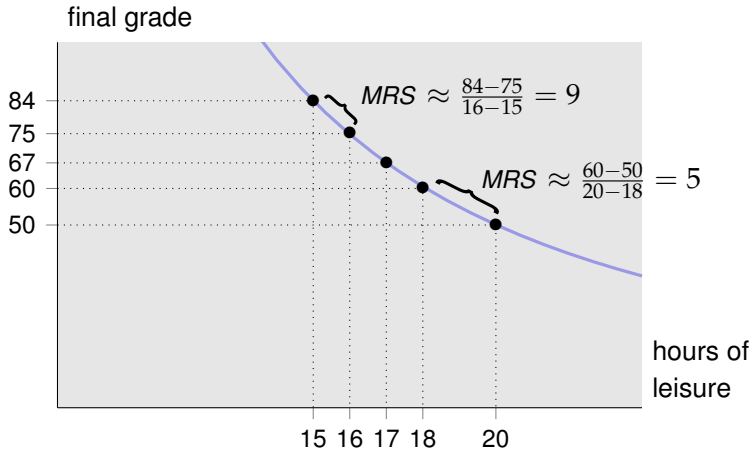


FIGURE 3.7
Alexei's MRS

solute value). Since MRS is equal to the absolute value of the slope of the indifference curve, the above property is equivalent to the law of **decreasing marginal rate of substitution**. Specifically, MRS is decreasing with respect to the variable measured on the horizontal axis (in this case, hours of leisure).

The law of decreasing marginal rate of substitution has a simple economic intuition: the more you have of one given thing, the less you care about having *more* of it *in relative terms*, that is, in relation to other goods. For the sake of illustration, suppose you have pizza and soda for lunch. If you have 10 slices of pizza and no soda in front of you, you would easily give up one slice of pizza for a can of soda. If instead you have one slide of pizza and three cans of soda, then you don't particularly care for an additional can of soda.

> *The marginal rate of substitution of good x is decreasing in x: the more you get of x, the less you are willing to give up of y in order to get more of x.*

In terms of indifference curves, a decreasing marginal rate of substitution implies that indifference curves are convex, as shown in Figure 3.6. In this regard, there are two extreme cases of indifference curves. If two goods are **perfect substitutes**, then the corresponding indifference curves are straight lines (no strict convexity). At the opposite

extreme, if two goods are **perfect complements**, indifference curves are L shaped (extreme convexity).

A note on notation: The way we refer to the MRS can sometimes be confusing. Therefore, it helps to agree on a series of conventions which we will try to follow throughout the book. Suppose that the good on the vertical axis is called y, whereas the good on the horizontal axis is called x.

- When we say MRS of x for y, we mean replacing y with x. One way to think about it is that "for" means "in place of".
- We represent MRS of x for y as MRS_{xy}
- When we simply refer to MRS we mean MRS_{xy}
- Given the above convention, MRS_{xy} is the absolute value of the slope of the indifference curve
- While I will not insist a lot on this, MRS_{xy} corresponds to the ratio of incremental (or marginal) utility of x divided by incremental (or marginal) utility of y
- A similar convention applies to MRT_{xy} (cf Section 3.1)

To conclude this section, let us summarize the main points regarding agent preferences:

- If individuals obey certain behavioral postulates, then they are able to rank all available options
- The ranking can be illustrated with an indifference curve map (i.e., a series of iso-utility curves)
- The negative of the slope of the indifference curve measures the marginal rate of substitution (MRS)
- MRS is the rate at which an individual would forego a good y in order to get one more unit of good (x)
- MRS decreases as x is substituted for y

3.3. THE MARGINAL RULE

Having derived Alexei's preferences (what he likes) and Alexei's feasible set (what he can do), we can now turn to Alexei's optimal decision making.

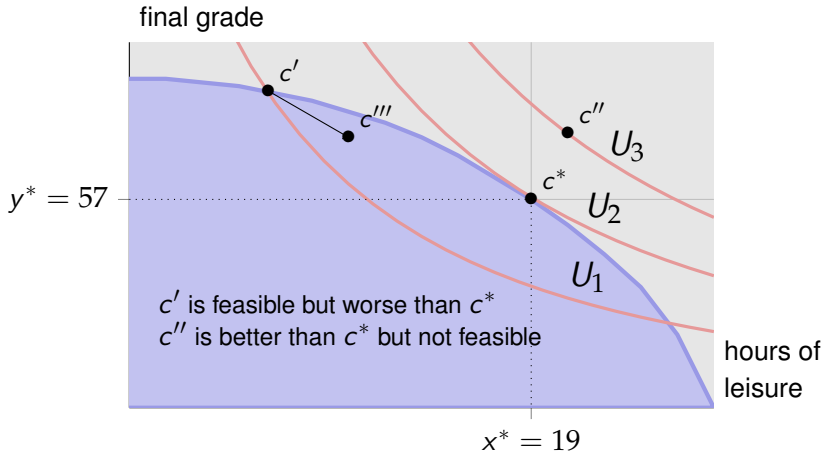


FIGURE 3.8
Alexei's optimal choice

Alexei's optimal choice corresponds to a combination of leisure and grade. Specifically, Alexei prefers the combination which (a) belongs to the feasible set and (b) is associated with an indifference curve located the farthest possible from the origin. Figure 3.8 illustrates this. Combination c^* is Alexei's optimal choice. There is no indifference curve associated with utility level greater than U_2 which contains a point contained in the feasible set (area in blue).

To put it differently, all points in the feasible set other than c^* correspond to a lower utility level than c^*. Take for example combination c'. It is associated with an indifference curve U_1, which corresponds to lower utility than U_2. To see this, note that there are points in the U_2 curve with strictly less of final grade and leisure than c^*. This implies that $U_1 < U_2$. Since c' belongs to the U_1 curve and c^* belongs to the U_2 curve, it follows that Alexei prefers c^* to c'. The argument would be even stronger if we considered a combination c''' located strictly within the feasible set. (Why?)

Note also that combinations such as c'' are strictly better (from Alexei's point of view) than c^*. Does that imply that c^* is not optimal? Not really: Since c'' is not feasible (that is, does not belong to the feasible set), c'' cannot be optimal. Strictly speaking, the concept of optimality we are defining here is one of **constrained optimization**. After all, that's what economics is all about: finding the optimal resource allocation in a world where resources are *scarce* (thus the idea

of constrained optimization).

We now come to a very important rule regarding constrained optimization. In Figure 3.9, we see that at the optimal point c^* the slope of the boundary of the feasible set is equal to the slope of the corresponding indifference curve (that is, the indifference curve that goes through point c^*). Since the slope of the frontier of the feasible set is equal (in absolute value) to the MRT, and the slope of the indifference curve is equal (in absolute value) to the MRS, we conclude that, at the optimum point

$$MRS = MRT$$

I should add that I frequently choose font size to reflect the importance of a result. The above equality is typeset in a very, very large font size.

To understand why the equality MRS = MRT must hold, it may help to understand what happens when it does *not* hold. Take for example point c' in Figure 3.8. At this point, the feasible set boundary is flatter than the indifference curve going through the same point. This means that MRT $<$ MRS. This in turn implies that Alexei is willing to give up more grade for an extra hour of leisure than is required by his feasible set. But then there must be a combination which is both (a) feasible and (b) better than c'. Specifically, point c''' in Figure 3.8 corresponds to this move.

Note that the slope of the segment connecting c' and c''' is higher (in absolute value) than the MRT at c'. This implies that c''' is feasible. In other words, by moving from c' to c''' we're giving up more grade than required by the feasible set. Moreover, the slope of the segment connecting c' and c''' is lower (in absolute value) than the MRS at c'. This implies that c''' is preferred to c'. In other words, by moving from c' to c''' we're giving up less grade than required to keep the same utility level.

Combination c^* is the only combination where such argument does not hold, precisely because MRS = MRT. Figure 3.9 presents the above arguments in a more systematic way. Whenever MRS $\neq$ MRT, there is room for improvement. Combination c^* is the only combination where such argument does not hold, precisely because MRS = MRT to begin with.

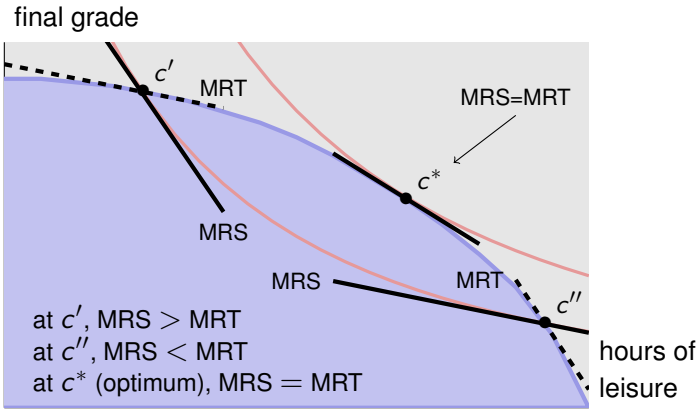


FIGURE 3.9
Alexei's optimal choice

RATIONAL BEHAVIOR?

Given the emphasis that economics and economists place on the "marginal approach" (MRT, MRS, etc.) to decision making, it's important to pause and think a bit about the validity of the economics model of human behavior. First, the economics model assumes that each individual is doing what's best for him or herself. One common objection to this assumption is that the economics model ignores the fact that we care for others. Here it's important to make the distinction between positive and normative analysis (cf Section 2.1). It is a wonderful thing to aim for a society where we all care for each other (normative statement), but we must take into account that we have a natural tendency to think about ourselves (positive statement). We should therefore design social institutions that foster social behavior taking as given the constraint of individualistic behavior. Moreover, taking into account that we do care for others, we could, for example, include Ana's grade as part of Alexei's preferences.

A second criticism is that the models — at least the ones we've considered so far — are far too simplistic. Alexei's problems, for example, go well beyond determining how many hours to study. He needs to find a good tutor and a quiet place to study, he has a bunch of errands to run and no time to do it, etc, etc. The answer here is the idea of models as maps introduced in Section 2.1. Deriving the optimal number of hours of study is not the only decision that Alexei

needs to make, but it is certainly one of the more important ones. And simplifying the analysis by focusing on that one decision helps understanding the main trade-offs and how to handle them.

The idea of models as analogical narratives of human behavior is important when we consider the various concepts introduced in this and the next two chapters. With very few exceptions, economic agents have no idea of what an indifference curve is or what is the definition of marginal rate of substitution. So why all this talk about the "marginal approach" and formulas such as MRS = MRT? The answer is that, from an economic analysis point of view, what is relevant is whether economic agents behave *as if* they were finding the point where MRS = MRT. Economists such as Milton Friedman emphasized this point with examples such a baseball playing. Suppose a baseball batter pops up a ball. If you want to predict where a good left fielder will move to, all you need to do is determine the ball's trajectory, for good left fielders find their way to the ball and catch it. This you can do by solving a differential equation (taking as inputs the strength and direction of initial impact, wind conditions, and perhaps a few other parameters). Most baseball players are not familiar with differential equations. All they do is look at the ball and gradually adjust their position as a function of the ball's position and movement. It's *as if* the baseball player were constantly re-calculating the solution to a differential equation, Friedman would say. So, for the purpose of predicting the baseball player's behavior we can assume that he solves a mathematical equation in his head and then acts based on the equation's solution. This is not *literally* true, but it does the job of describing and predicting the player's actions.

Similarly, by repeatedly facing the choice between two consumption goods, for example, a consumer might try small adjustments and determine how good each particular bundle is. By dint of repeated experimentation the consumer will eventually converge to something that is likely close to the point where MRS = MRT. Were that not the case, there would be small local changes that would make the consumer better off, in which case I would expect the consumer to continue experimenting. So, even though no consumer explicitly solves the equation MRS = MRT, in practice we expect they end up with a choice that corresponds to solving MRS = MRT.

KEY CONCEPTS

feasible set | marginal rate of transformation (MRT) | utility | behavior axioms | rational agents | completeness | transitivity | monotonicity | indifference curves | marginal rate of substitution (MRS) | decreasing marginal rate of substitution | perfect substitutes | perfect complements | constrained optimization

REVIEW AND PRACTICE PROBLEMS

■ **3.1. Feasible set.** What is a feasible set?

■ **3.2. Student's feasible set.** Figure 3.10 depicts a student's feasible set. It shows combinations of final grade and hours of free time per day. The coordinates of the relevant points are:

- *A*: (13,84)
- *B*: (20,70)
- *C*: (19,57)
- *D*: (10,70)
- *E*: (14,81)
- *F*: (20,50)

Based on this information, we can say that (select all correct answers):

(a) At B, the student can get a higher grade for the same hours of free time compared to F. Therefore the student will choose B.

(b) At D, the student is able to attain a higher grade but has less free time compared to C. Whether she would choose C or D then depends on her preferences.

(c) The marginal rate of transformation at A is 3, meaning that the student can "transform" one hour of free time into 3 extra points on her grade.

(d) At C, the student can attain the grade of 50 for 20 hours of free time. Therefore for one extra hour of studying, she can increase her grade by 2.5 points.

■ **3.3. Marginal rate of transformation.** What is the marginal rate of transformation?

■ **3.4. Feasible set and opportunity cost.** What is the relation between the concepts of feasible set and opportunity cost?

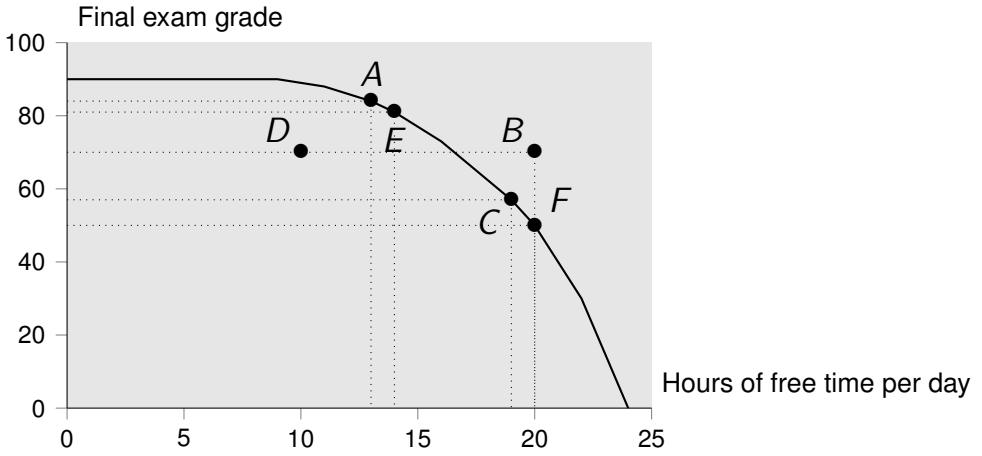


FIGURE 3.10
Student's feasible set

■ **3.5. Uber driver's choice.** Consider an Uber driver's choice between income and leisure time. Is the boundary of the feasible set a straight line or a curved line? Justify your answer.

■ **3.6. Consumer preference axioms.** What is the meaning of the completeness, transitivity and monotonicity axioms (or postulates) of economic behavior?

■ **3.7. Robin.** Robin cares a lot about good x (relative to good y). What does that tell us about the shape of Robin's indifference curves?

■ **3.8. Properties of indifference curves.** Consider an individual's indifference curves for the consumption of two goods (things you would like to have more of). In this case, which of the following statements are true?

(a) The indifference curves are downward-sloping

(b) The indifference curves can sometimes cross

(c) The indifference curves cannot have sections that are straight lines

(d) The indifference curves cannot have kinks

■ **3.9. Preferences and indifference curves.** Assume that a consumer purchases only two goods, x and y. Based on the information in each of the following questions, sketch a plausible set of indifference curves (that is, draw at least two curves, and indicate the direction of higher utility).

(a) Nomis enjoys muffins (x) and chai latte (y) if they are consumed together.

(b) Tra likes chocolate (x) but he hates broccoli (y).

(c) Aras likes steaks (x) but she doesn't care one way or the other about apples (y).

(d) Fernando always buys five Polo-shirts (x) with every pair of jeans (y).

■ **3.10. Marginal rate of substitution.** What is the marginal rate of substitution?

■ **3.11. Computing MRS.** Confirm the values in the third column Table 3.3.

■ **3.12. Decreasing MRS.** What is the meaning of the "law" of decreasing marginal rate of substitution (MRS)?

■ **3.13. Optimal choice.** Explain, in words, the meaning of the MRS = MRT rule for optimal decision making.

■ **3.14. Juan and Weichen.** True of false (or true or false with qualifications): At the optimal choice points, the MRS of Juan and Weichen are the same, therefore they have the same preferences.

■ **3.15. Alexei's decision problem.** Consider Figure 3.8 in Chapter 3, depicting Alexei's choice between free time and grade.

(a) Explain why a point like c' cannot be an optimal choice.

(b) Explain why a point c'' located strictly within the feasible set cannot be optimal.

■ **3.16. Portfolio choice.** Consider the following investment portfolio problem. There are three possible assets in which to invest. Treasury Bills yield a return of 3% with zero risk. Investing in a stock market index yields an expected gain of 14% with standard deviation (a measure of risk) 5%. Finally, buying stock in a new venture fund yields an expected gain of 18% with a standard deviation of 15%. Assume that if an investor buys $1 of a stock market index and $1 of a new venture index, then the expected value is 16% (the average of 14 and 18) and the standard deviation is 10% (the average of 5 and 15). (This is theoretically possible, though unlikely to hold in reality. We make this assumption to simplify the analysis.) Suppose moreover that the investor has standard preferences over expected return and risk (as measured by standard deviation).

(a) Represent the three assets on a (x, y) plane, with return on the x axis and risk on the y axis. Draw the feasible set of combinations of risk and return.

(b) Explain how different preferences, indicated by different indifference curve mappings, reflect different degrees of risk aversion. (Hint: note that risk is a "bad", not a "good".)

(c) Show how different sets of indifference curve result in different optimal portfolios.

(d) Show that a rational investor will choose at most two different types of investment.

(e) In practice, investment portfolios frequently include more than two types of investment. What features of the problem (not included in the previous set of assumptions) explain this pattern? (Hint: The podcast, *How Investment Advisors Invest Their Money*, partly answers this question.)

■ **3.17. The marginal way and the common person.** Consider the *homo economicus* model of behavior, in particular the MRS = MRT rule. Does the average economic agent know what a marginal rate of substitution is? Does it make sense to model such agent as setting MRS equal to MRT? Why or why not?

CHAPTER 4

HOUSEHOLDS

In the previous chapter we presented a basic framework to study an agent's optimal behavior. We did so in a very particular context: a student who must decide the optimal trade-off between leisure and course grade. In this chapter we consider more common applications of the optimal-choice framework, in particular decisions in a market context, that is, in a context where agents face prices. Examples include choice of consumption bundles, labor supply, and fertility decisions. We also look at the effect of changes in prices on an agents' optimal choices.

4.1. CONSUMPTION

Consider a particular, but very important, choice problem: the choice of an optimal consumption bundle given market prices. One example is given by Exercise 4.5. In it we learn that Maria has an income of 56 which she spends entirely on clothing and food. The price of food is $p_f = 1.75$, whereas the price of clothing is $p_c = 1.12$. Figure 4.1 plots Maria's feasible set. Suppose that Maria were to spend all of her income on clothing. Then she could afford $56/1.12 = 50$ units of clothing. Alternatively, she could spend all of her income on food. Then she could afford $56/1.75 = 32$ units of food. Maria can also attain any combination of these extremes, that is, positive amounts of clothing and food such that total expenditure falls below or equals

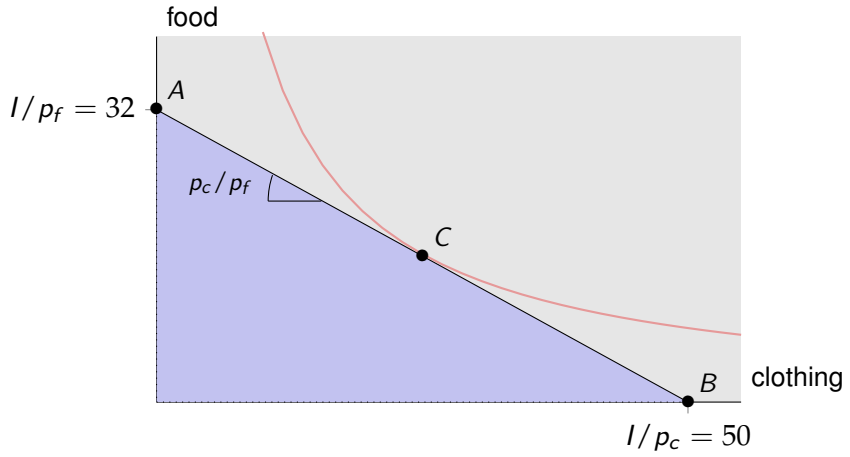


FIGURE 4.1
Maria's budget set and budget line

her available income. Specifically, if Maria is to spend all of her income on clothing and food then the following equality holds:

$$p_x x + p_y y = I \tag{4.1}$$

In other words, the feasible set is defined by a straight line in the (x, y) space, where the coefficients on x and y are given by the prices of each good.

The term feasible set, first introduced in Section 3.1, is a fairly broad term to describe the constraint that an economic decision-maker is subject to. In the particular but important case of a consumer with a given income level, the feasible set is referred to as the consumer's **budget set**. Moreover, the boundary of the consumer's budget set is referred to as the consumer's **budget line**.

Referring back to Figure 4.1, we see that Maria's budget line is defined by points A and B. The vertical coordinate of point A is given by I/p_f (how much food Maria can buy if she spends all of her income on food), whereas the horizontal coordinate of point B is given by I/p_c (how much clothing Maria can buy if she spends all of her income on clothes). It follows that the slope of the budget line, in absolute value, is given by $(I/p_f)/(I/p_c) = p_c/p_f$. (Note that the price in the numerator corresponds to the good on the horizontal axis.) We can also find this by solving (4.1) in order to y:

$$y = I/p_y - \left(p_x/p_y\right) x \tag{4.2}$$

which shows that the line's slope (in absolute value) is given by p_x/p_y. It follows that, for Maria, the MRS = MRT formula, introduced in Section 3.3, implies MRS $= p_c/p_f$. In words, Maria should choose consumption levels of food and clothing such that the marginal rate of substitution of clothing for food (how much food she's willing to give up for an extra unit of clothing) is exactly equal to the ratio (price of clothing divided by price of food). (Why is this the optimal rule?) In terms of Figure 4.1, the point on the budget line where this optimality condition is satisfied corresponds to point C.

> *The optimal consumption mix corresponds to the equality of the MRS and the price ratio.*

Economists engage frequently in the exercise of predicting how a change in x will affect y, where x could be an event and y an economic variable of interest. For example, x might be "an oil rig in Saudi Arabia is destroyed" and y the price of natural gas. This prediction exercise is generally referred to as **comparative statics**. This is not a very helpful expression, but we will stick to it (and discuss the process at length in Section 7.1). In what follows we will examine the impact of changes in two particularly important variables: income level and the price of one of the goods.

CHANGES IN INCOME

Consider the generic case when a consumer has income I which he splits between goods x and y (as in, for example, Figure 4.2). From Equation (4.2), we see that an increase in I implies a parallel shift in the budget line (that is, the intercept changes but the slope remains the same). What effect does an increase in I have on the optimal consumption bundle? As frequently is the case, the answer is — it depends. Specifically, it depends on the consumer's preferences. The two panels in Figure 4.2 illustrate two possibilities regarding the impact that an income increase has on the consumption level of x. In the top panel, the increase in income leads to an increase in the consumption of x. In the bottom panel, the increase in income leads to a decrease in the consumption of x.

Economists classify goods according to the relation between income and consumption. Specifically, we say a good is a **normal good**

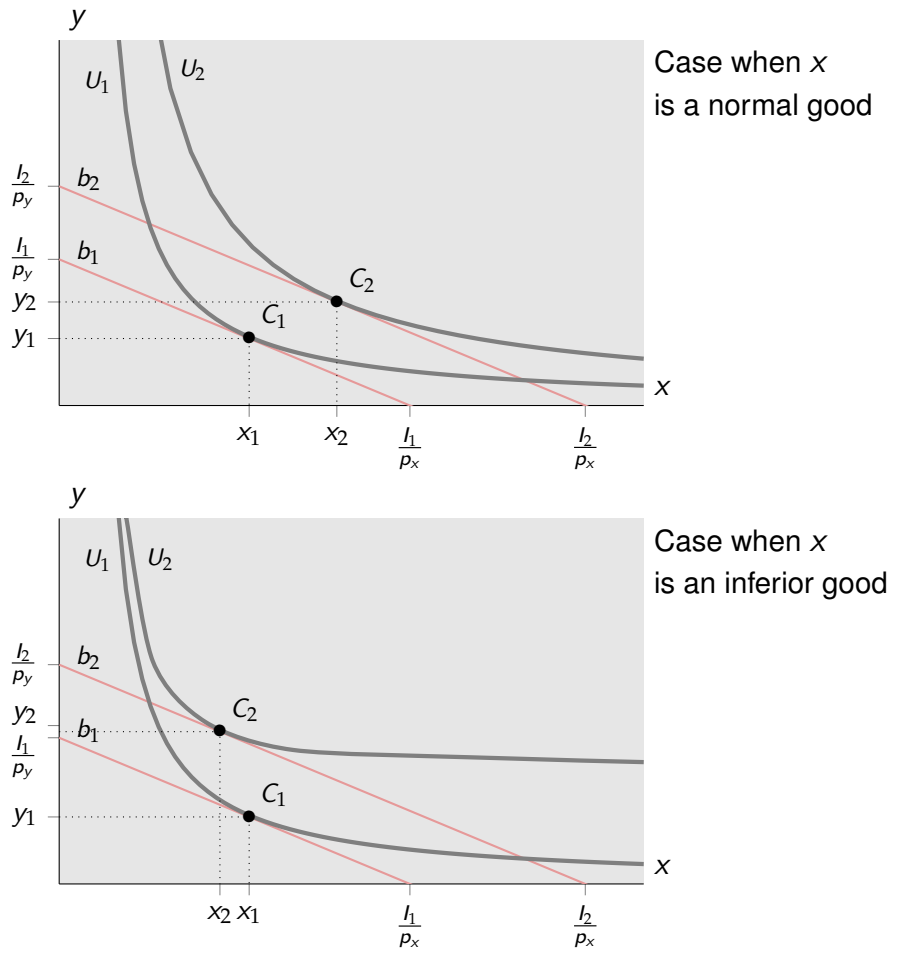


FIGURE 4.2
Effect of an increase in income

if its consumption increases when income increases. As the name suggests, most goods are normal goods. However, the opposite is also possible: we say a good is an **inferior good** if its consumption decreases when income increases. Although inferior goods aren't all that common, it's fun to think of examples. Spam comes to mind, on the assumption that anyone with enough money would eat something else. This example also suggests that what's a normal good for one person may be an inferior good for another one; and that what's a normal good for a given person at time 1 may become an inferior good at time 2. Can you think of examples? In terms of Figure 4.2, we would say that the top panel illustrates a case when x is a normal good, whereas the bottom panel illustrates a case when x is an

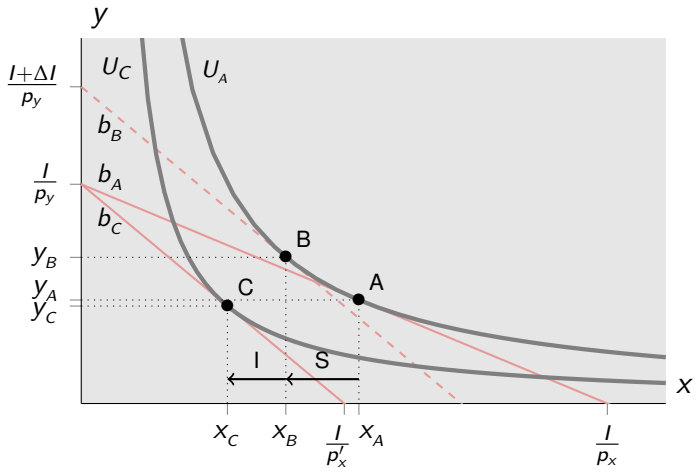


FIGURE 4.3
Income effect (arrow I) and substitution effects (arrow S)

inferior good.

INCOME AND SUBSTITUTION EFFECTS OF A PRICE CHANGE

Consider a consumer with income I. Initially prices are given by p_x for good x (quantity x measured on the horizontal axis) and p_y for good y (quantity y measured on the vertical axis). The consumer's budget constraint is given by b_A, a line with an intercept of I/p_y on the y axis and I/p_x on the x axis. Intuitively, if the consumer spends all of her income on y then all she can afford is I/p_y units of y, ditto for x. Given the consumer's preferences and her budget constraint, the optimal choice is given by point A, corresponding to x_A of x and y_A of y.

Now suppose that the price of x changes from p_x to p'_x (a price increase), so that the budget constraint pivots from b_A to b_C. (We know $p'_x > p_x$ because the intercept I/p'_x is lower than the intercept I/p_x.) This implies (for this particular consumer) a shift in optimal choice from A to C. In particular, the consumption of x drops from x_A to x_C. This is not surprising: when the price of x increases, normally its consumption decreases.

The shift from A to C may be decomposed into two parts, which we refer to as the income effect and the substitution effect of the change in the price of x on the consumption of x. Before getting into

formal definitions, a bit of economic intuition. If the price of x increases, then the consumer's real income decreases. In other words, a value I of income does not go as far as it did when p_x was lower. Moreover, if the price of x increases then the relative price of x (relative to y) increases. In other words, getting one additional unit of x requires sacrificing more units of y. We would like to disentangle the effect of a change in p_x (on the consumption of x) into these two effects: how much of the change in x is due to the fact that x is relatively more expensive than y, and how much of the change in x is due to the fact that the consumer's real income is now lower.

> *The substitution effect corresponds to the change in x caused by the change in relative prices keeping real income constant. The income effect corresponds to the change in x caused by the change in real income.*

In what situation could we say that the consumer's real income remains constant in spite of an increase in p_x? A natural definition of constant real income is that, given the new, higher price of x, the consumer also has higher nominal income so that her utility level remains constant. In terms of Figure 4.3, budget line b_B corresponds to the new price ratio but a higher income, high enough for the the consumer to get the same utility as before the increase in p_x. Notice that this is a hypothetical budget line: We are simply asking what income the consumer would need to get in order to keep the same utility level as initially.

Faced with the new, hypothetical budget line (the dashed line in Figure 4.3), the consumer optimally chooses B, *which gives her the same utility level as point A*. We thus say that the shift from A to B corresponds to the **substitution effect**. In other words, the substitution effect corresponds to the change in x *caused by the change in relative prices only*, that is, keeping real income constant, i.e., staying on the same indifference curve.

Once we derive the substitution effect, the income effect is simply what's left to account for the total effect of a change in p_x. Specifically, an increase in p_x implies a shift from A to C. In terms of consumption of x, we are talking about a decrease in x from x_A to x_C. Note that x_A and x_C are data, that is, are observable. Given our hypothetical dashed budget line, we determined the shift from x_A to x_B as the

substitution effect of the increase in p_x. Finally, we identify the shift from B to C, that is the drop in x from x_B to x_C, as the income effect of the increase in p_x.

To better understand the nature of the income effect, notice that the (vertical) intercept of b_B is given by $(I + \Delta I)/p_y$. This means the difference between b_C and b_B is that the latter corresponds to an extra ΔI income. This means that, given the new price level (higher p_x) we would have to give the consumer an extra ΔI in order for her utility to remain the same. In reality, she did not get that extra income ΔI, which implies she is at C, not at the hypothetical B. The shift from the hypothetical b_B to the actual b_C corresponds to the change in real income, and the shift from the hypothetical x_B to the actual x_C corresponds to the income effect.

Formally, the **income effect** on x of an increase in p_x corresponds to the effect of a reduction in income, from the level required to keep the initial utility level (income level $I + \Delta I$) to the actual (nominal) income level (I, which never changed). In other words, the income effect corresponds to the effect on the consumption of x of the change in real income caused by a change in the price of x. To rephrase the above point: An increase in p_x to p'_x makes the consumer poorer (prices are higher and income remains at I). However, if we give the consumer an extra income of ΔI, then her welfare under the new prices remains the same as with the initial prices. It follows that ΔI measures the (negative) shock to real income resulting form an increase in p_x.

In terms of Figure 4.3, the income effect is given by $x_C - x_B$. The substitution effect, in turn, is given by $x_B - x_A$. Notice that, in the present case, both the income and the substitution effects are negative (that is, $x_C < x_B$ and $x_B < x_A$). This need not always be the case, as we will see next.

The income effect may have the same sign or the opposite sign of the price change. If x is a normal good (as is the case in the above example), then the income effect on the consumption of x has the opposite sign than the change in price of x. In the previous example, the price of x increased and the income effect is negative ($x_C < x_B$). However, if x is an inferior good then the income effect on the consumption of x has the same sign as the change in the price of x.

The substitution effect on the consumption of x always has the opposite sign than the change in price of x. In the previous example,

the price of x increased and the substitution effect is negative ($x_B < x_A$). This property is known as the **law of demand**. In other words, if the price of x increases then the substitution effect on x is negative; if price of x decreases, then the substitution effect on x is positive.

Frequently, we refer to the law of demand as implying that when the price of x increases then the demand for x decreases (and vice versa). This is not quite right, that is, this is not true in general. It is possible that the demand for good x increase when its price goes up (and vice versa). This happens when the income and substitution effects have opposite signs and the income effect is bigger (in absolute value). (For aficionados: when this happens, we say x is a Giffen good.)

> *The law of demand states that the substitution effect is negative. In most cases, this means that an increase in price implies a decrease in quantity demanded.*

WHO CARES?

At this point (and often throughout the course) you may ask yourself: Who cares? Policymakers do, for a variety of reasons. First, in a world with fluctuating prices and income levels, economists are interested in estimating how such price changes affect consumer welfare. One way to do so is to compute consumer price indexes and use these to calculate the value of **real income**, that is, income level corrected for price changes. The income effect / substitution effect decomposition suggests a specific path for this correction.

Another practical application of the income effect concept is given by environmental policy. For decades, economists have advocated the creation of a **carbon tax** to induce lower consumption of CO_2-intensive goods. William Nordhaus, co-winner of the 2018 Nobel Prize, already recognized the threat of CO_2 emissions in the early 1970s. In 1992, he proposed a modest carbon tax as a means to rein in increasing emissions. In Section 9.3 we will return to this important issue. For now, we recognize that implementing a carbon tax is a difficult political problem: nobody likes taxes, least of all politicians who fear they might not get re-elected.

One possible political strategy to implement a carbon tax would be to accompany it by a compensating subsidy. Let us return to Figure 4.3. Suppose that x corresponds to carbon-intensive goods whereas y corresponds to "green goods". A carbon tax implies an increase in p_x, that is, consumers need to pay more for gasoline, airfares, etc. This in turn implies that, for a given dollar income, consumers will be poorer: their dollar will not reach as far as it did before. How much do we need to compensate the consumer for the drop in real income stemming from the carbon tax? The answer is, exactly ΔI. If we give consumers ΔI when the carbon tax is implemented, then their consumption bundle switches from A to B, that is, moving along the initial indifference curve, consumers substitute green goods for carbon-intensive goods while their welfare standard is maintained.

4.2. LABOR SUPPLY

In Chapter 3, we considered Alexei's problem of balancing leisure time and course grade. A more common problem is to balance leisure time and earned income. Specifically, for the sake of concreteness consider Ana's choice of how many hours to work. Ana likes income (from work) as well as leisure. An employer offers to pay w per hour that Ana works. What should Ana do?

Before continuing, a brief note on the motivation for studying Ana's problem. In some cases, Ana's decision problem is very much a problem that specific individuals need to make. For example, if I live in New Jersey and drive an Uber/Lyft car on weekends I need to decide how much income I want versus leisure time.

Generally speaking, we do not see employees deciding how many hours to work. Most people hold 9-to-5 type jobs, that is, jobs with well-determined hours. How realistic is then the idea of Ana choosing how many hours to work? The question becomes relevant if Ana must choose between various possible jobs, each of which has different hours. For example, suppose Ana has just graduated from law school and received several job offers. One is a government job in DC. The salary is low but the hours are very good: eight hours a day with very little overtime. Another possibility is to work for a top New York law firm. The pay is considerably higher but so are the

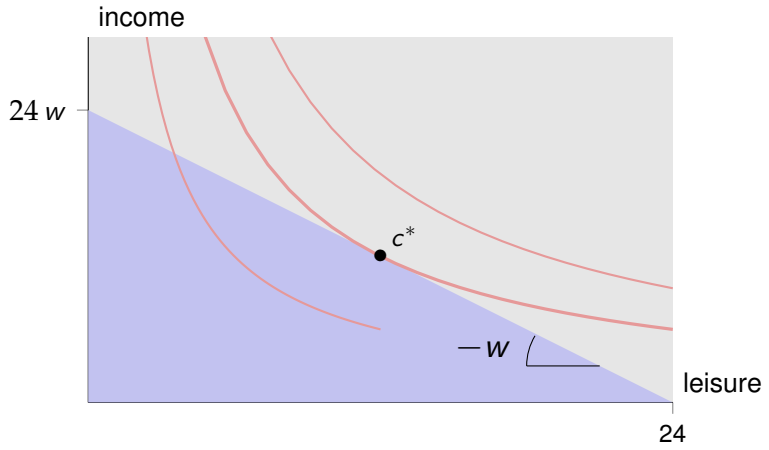


FIGURE 4.4
Ana's feasible set and optimal choice

hours. In between we find two or three more offers that correspond to intermediate levels of income and leisure. So, effectively Ana's decision problem is similar to the Uber/Lyft driver: even though within each job Ana does not have much leeway in terms of how many hours to work, at the moment of choosing which job to take she is effectively making a choice analogous to that of the weekend Uber/Lyft driver.

Just as Alexei had preferences for leisure and grade, so Ana has preferences for leisure and income. Just as Alexei was constrained by a feasible set, so Ana too is constrained by a feasible set. However, whereas Alexei's feasible set is determined by his study abilities, Ana's feasible set is determined by the wage rate she gets paid. This is illustrated in Figure 4.4, where Ana's feasible set is given by the triangle shaded blue. To see why this is indeed Ana's feasible set, consider one first possibility, namely Ana does not work at all. This gives her 24 hours of leisure but an income of zero. At the opposite extreme, Ana could work for 24 hours a day (though I would not recommend it). This leads to a combination of zero hours of leisure and an income of 24 w, where w is the hourly wage rate. In between, Ana can attain any combination of these extremes, that is, all points in the segment with extremes (24, 0) and (0, 24 w).

Why is the boundary of Alexei's feasible set curved whereas Ana's is a straight line? Because in Alexei's case the feasible set is

Rishin Chatterjee

Microeconomic theory models consumer choice as a comparison between marginal rates of substitution and price ratios.

determined by Alexei's studying abilities (i.e., the study $\longrightarrow$ grade mappping), whereas Ana's feasible set is determined by a market, namely the labor market; and in this market Ana is a **price taker**, that is, she is paid the going hourly wage rate w regardless of how many hours she works. (This is a reasonable assumption for most workers. In other parts of the book we will consider several cases when economic agents, in particular firms, are *not* price takers.) In other words, the non-linear relation we find in Alexei's pursuit of grade is absent from Ana's pursuit of income: each additional hour of work produces an extra w of income. (That said, both the Uber/Lyft driving interpretation and the multiple job offers interpretation of Ana's problem may involve some curvature in the feasible set: It's not the same thing driving an Uber at 3pm or 3am; and the different jobs offered to Ana likely correspond to different hours *and* different wage rates.)

Notice that the slope of the boundary of Ana's feasible set is given by $-w$, or simply w in absolute value. To see this, note that the absolute value of the slope is given by the vertical axis intercept, $24\,w$, divided by the horizontal intercept, 24. We thus have $(24\,w)/24$, or simply w. The economic intuition is as follows: MRT (the slope of the boundary of the feasible set) measures the opportunity cost of increasing x (the good on the horizontal axis) in terms of units of y (the good on the vertical axis). The opportunity cost of getting one extra hour of leisure (x in the present case) is the foregone income (y in the present case). And the foregone income of enjoying an extra hour of leisure is the income foregone from working one hour less, that is, w.

We can also appreciate the relation between Ana's income-leisure

problem and Maria's food-clothing problem. In both cases we have a budget line with slope given by the price ratio. This may seem a little tricky in Ana's case: What is the price of income? It's simple 1: it costs \$1 to have an extra \$1 (we are not allowing for investment in the present analysis). And what is the price of leisure? As we saw above, it's best to think about the opportunity cost of leisure, which is w. So the absolute value of the slope of the budget line is given by $w/1 = w$. It follows that the MRS = MRT formula implies MRS $= w$. In words, Ana should choose a level of leisure such that the marginal rate of substitution (how much income she's willing to give up for an extra hour of leisure) is exactly equal to the wage rate. Why is this the optimal rule?

CHANGES IN INCOME AND PRICES

Similar to the consumption problem (Section 4.1), we can now examine the effects of a change in income or a change in price on Ana's choice of leisure hours (or, equivalently, her choice of work hours). Specifically, we are interested in two comparative statics problems: (a) the impact of changes in (non-labor) income; and (b) the impact of changes in the wage rate. Answering these questions will take us some way in the direction of understanding the evidence with which we started Chapter 3, in particular the evolution of income and leisure over time (cf Figure 3.1).

One way in which the income-leisure problem is trickier than the consumption problem is that in the former we have two possible sources of income: labor income and non-labor income. Labor income is given by w times the number of hours worked, that is, 24 minus the number hours of leisure. In what follows, when we talk about the effect of a change in income we refer to a change in non-labor income.

Figure 4.5 illustrates the effect of an increase in (non-labor) income by ΔI. As can be seen, this corresponds to a *parallel* shift of the feasible set frontier. To understand this, consider first the case when Ana chooses 24 hours of leisure. Before, her income was zero (her income was exclusively labor income). Now, even not working any hours, Ana has an income of ΔI. Similarly, suppose that Ana works 24 hours a day, thus leaving no time for leisure. Before, her labor in-

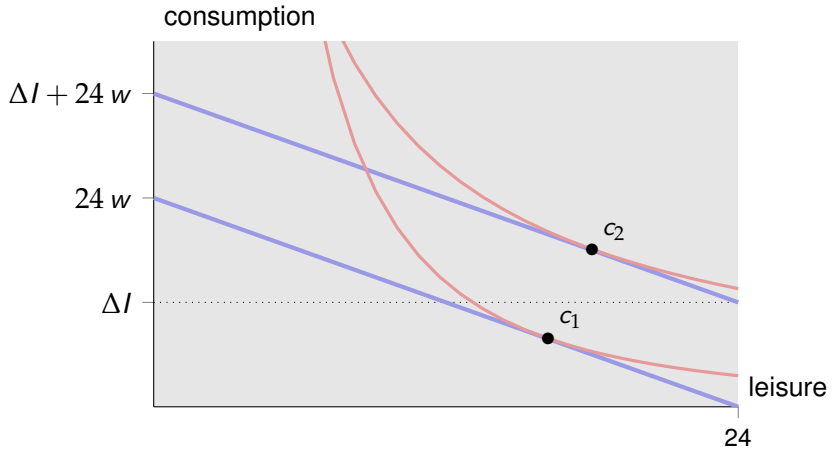


FIGURE 4.5
Effect of additional income

come was $24\,w$ (as we saw on p. 136). Now, Ana enjoys a total income of $24\,w + \Delta I$.

Continuing with Figure 4.5, we see that the effect of an increase in non-labor income by ΔI is to change Ana's optimal point from c_1 to c_2. This corresponds to an increase in leisure and income. It is theoretically possible that Ana would spend less leisure time (or indeed end up with a lower income level), but normally an increase in non-labor income results in an increase in leisure and in total income. In terms of the terminology introduced on p. 129, Figure 4.5 corresponds to the case when leisure is a normal good.

Consider now the effects of a higher wage, specifically an increase from w_1 to w_2. This is illustrated in Figure 4.6. If Ana chooses 24 hours of leisure, and thus zero hours of work, then an increase in wage has no effect on her labor income. By contrast, if she works for 24 hours then her labor income increases from $24\,w_1$ to $24\,w_2$. Putting these two points together, we conclude that the wage increase implies a *rotation* of the feasible set boundary around the point (24,0), similarly to the effect of a change in p_x in the consumption case considered in Section 4.1. What is the effect of a wage increase on Ana's optimal choice? In the top panel of Figure 4.6, we observe a change from c_1 to c_2 which corresponds to a higher income level and a lower level of leisure (that is, more hours of work). In the bottom panel of Figure 4.6, we observe a change from c_1 to c_2 which corresponds to a

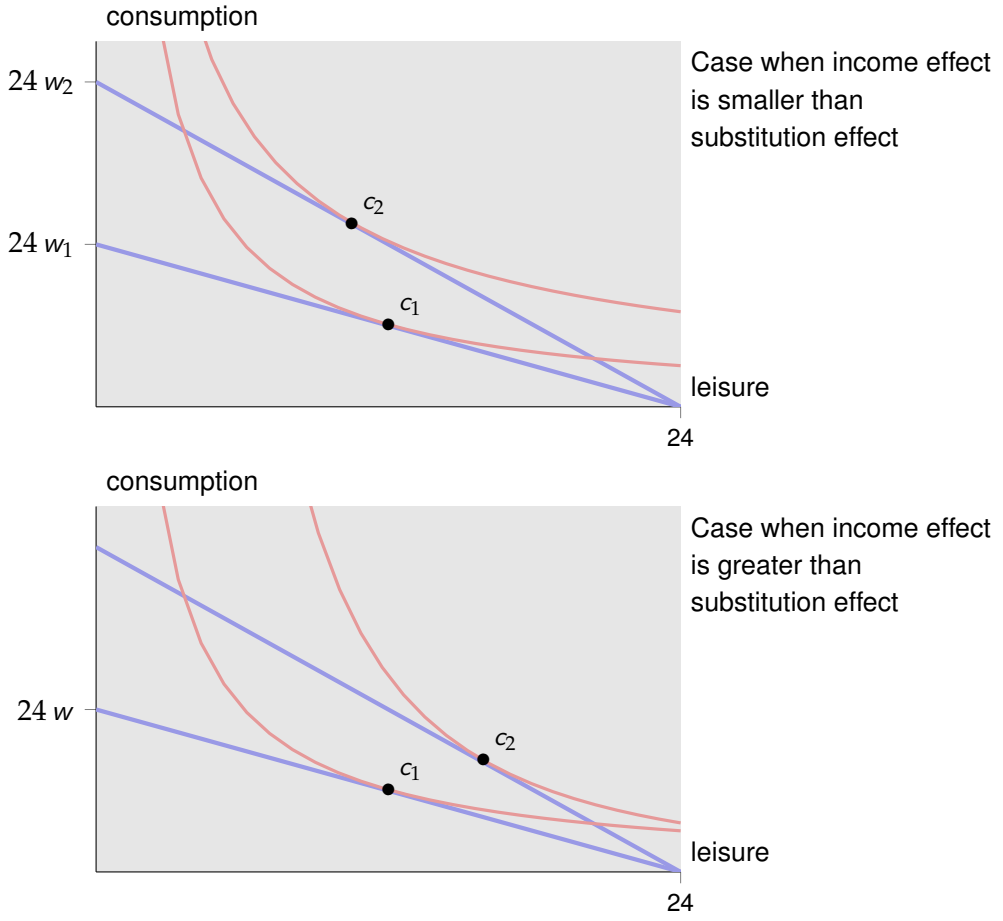


FIGURE 4.6
Effect of an increase in the wage rate

higher income level and a higher level of leisure (that is, fewer hours of work).

In other words, following an increase in wage the level of leisure may increase or decrease; it depends on Ana's preferences for income and leisure. In terms of our income-substitution effect decomposition, the case on the top panel of Figure 4.6 corresponds to the case when the income effect is so large that it outweighs the substitution effect: Although the price of leisure increases (w is the price of leisure), the amount of leisure chosen by Ana increases!

To conclude, recall that daily leisure time equals 24 hours minus work hours. As such, what was said about the demand for leisure can be reinterpreted as **labor supply**. In particular, the above analysis

shows that an increase in the wage rate may result in an increase *or a decrease* in the supply of labor. The latter is the case when the income effect of a wage increase is sufficiently large to compensate for the substitution effect of a wage increase.

> *The supply of labor may react positively or negatively to a change in the wage rate depending on the relative magnitudes of the substitution and income effects*

LEISURE CHOICES IN THE US AND SWEDEN

Having gone through the framework of optimal economic decision making, let us return to the data in Figures 3.1 and 3.2. Since leisure equals total time minus time of work, we can re-plot the points in Figure 3.1 with leisure on the horizontal axis. Specifically, annual hours of leisure are equal to 365 times 24 minus the value on the vertical axis of Figure 3.1. Given per-capita GDP (plotted on the horizontal axis of Figure 3.1), we estimate average wage as per-capita GDP divided by hours of work. This is not really correct, for income (measured by GDP) is equal to labor income plus capital income. However, to the extent that the share of labor income has remained relatively constant over the period in question, the evolution of the ratio per-capita GDP divided by hours of work provides a reasonable approximation of the evolution of the wage rate over time.

We next make an additional approximation which is a bit rough but nevertheless may help understand the evolution of income and leisure in the US: We assume that the average values plotted in Figures 3.1 and 3.2 correspond to a **representative** American worker; that is, to a "typical" American. This is OK so long as we remain aware that underneath an average there is significant dispersion.

In 2016 average income in the US was \$33,259 (in 1990 PPP dollars), whereas the average number of hours worked was 6,979 hours. This implies that the point (6.979,33.259) was attainable by the 2016 average American consumer, that is, the point was on the consumer's budget set (in fact, on the consumer's budget line). Since the actual number of leisure hours was 6979, we conclude the number of hours worked was $8760 - 6979 = 1781$ hours. This in turn implies that the

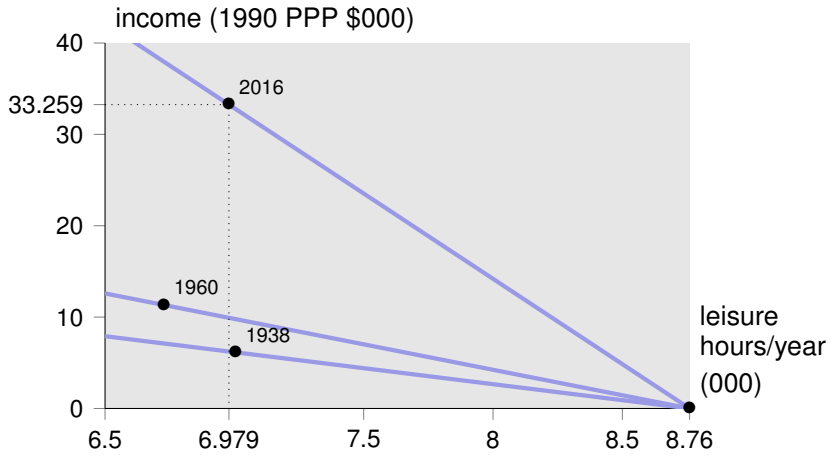


FIGURE 4.7
Application: work and leisure in US (average values)

average wage rate was $33259/1781 = \$18.67$ per hour (in 1990 dollars).

We also know that the consumer could have opted for not working at all. This would have yielded $24 \times 365 = 8,760$ hours of leisure and zero income, the point on the lower right end of the graph. Assuming that the average consumer could have worked as many hours as she wanted to at the going wage rate, we conclude that the consumer's budget line includes points (6.979,33.259) and (8.760,0). By a similar process, we also get the budget lines in 1938 and in 1960. As can be seen, the average American consumer's budget set has expanded over the years.

Specifically, from 1938 to 1960 we observe an increase in wage, corresponding to a steeper feasible set frontier. Moreover, we observe that the average American chose to enjoy fewer hours of leisure, that is, to work for longer hours. In terms of the preceding analysis, we say that, from 1938 to 1960, the wage increase was associated with a substitution effect greater than the income effect: as the wage rate increased, Americans increased the number of hours they work.

By contrast, from 1960 to 2016, we observe an additional increase in the wage rate, but this time the average number of hours of leisure increases, that is, the average number of hours of work decreases. In terms of the preceding analysis, we say that, from 1960 to 2016, the wage increase was associated with a substitution effect smaller than

the income effect: as the wage rate increased, Americans decreased the number of hours they work.

This is a good time to recall that an economic model (just like any other model) is a simplification of reality. There are many, many aspects of industrial and labor relations, politics, law, technology, and so on, which contributed to the evolution depicted in Figure 4.7. Can you think of other factors may have explained the evolution from 1938 tot 2016?

If Figure 4.7 is based on the data underlying Figure 3.1, Figure 4.8 is based on the data underlying Figure 3.2. For the year 2016, we derive the values of income and average wage for the US and Sweden. By our approximation, the average wage rates in the US and Sweden in 2016 were about the same. As a result, the feasible set for an average American was not very different from the feasible set for an average Swede (assuming that labor is the sole income source). However, the representative American selected considerably fewer hours of leisure than the representative Swede.

How can we explain such stark differences in choice between Americans and Swedes, knowing that, in terms of feasible set, they face a similar problem? The preceding analysis of optimal economic decision making (MRS = MRT) suggests that the preferences of Americans are different than the preferences of Swedes. Specifically, Figure 4.8 depicts indifference curves for a representative American and for a representative Swede which are consistent with the observed choice being optimal.

Notice that, for the values actually chosen by the representative agents, the MRS for the American is approximately the same as the MRS of the Swede. This is because, at the optimum, each equates MRS to MRT, and MRT is given by the wage rate, which in turn is approximately the same in the US and in Sweden.

However, the fact that MRS is the same in the US and in Sweden does *not* mean that the preferences of Americans are the same as the preferences of Swedes. To see this, consider point c, where the particular indifference curves in Figure 4.8 cross. At this point, the indifference curve of the American is flatter than the indifference curve of the Swede. At point c, the comparison of MRS is meaningful, for we are considering the same values of leisure and income.

In the present context, a flatter indifference curve means that you care relatively more for the good on the vertical axis. In words, Fig-

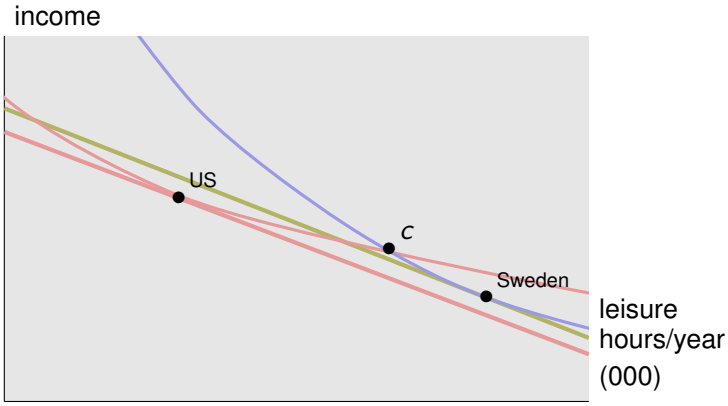


FIGURE 4.8
Application: work and leisure in US, Sweden

ure 4.8 means that Americans care relatively more for income (as opposed to leisure) when compared to Swedes. This is consistent with the observation that, for approximately the same wage rate, Americans work longer hours than the Swedes.

As in the case of Figure 4.7, we must acknowledge that there are many other factors influencing the observed choices in the US and Sweden other than differences in preferences. Can you think of any?

4.3. OTHER HOUSEHOLD DECISIONS

In this and the previous chapter we have considered three examples of decision problems: Alexei's choice between leisure and grade; Maria's choice between food and clothing; and Ana's choice between leisure and income. Even though the feasible set changes from case to case, all of these examples have one thing in common: the optimal solution is given by the equality of marginal rate of substitution and marginal rate of transformation, where the latter may be given by a production function, a price ratio, or a wage rate.

The fact that economists make so much use of marginal rates, and more generally derive optimal solutions by looking at small potential variations in choice variables, is reflected in the general expression **marginal approach** (see also Sections 2.3 and 3.3). There are many other examples of economic decision problems which follow a sim-

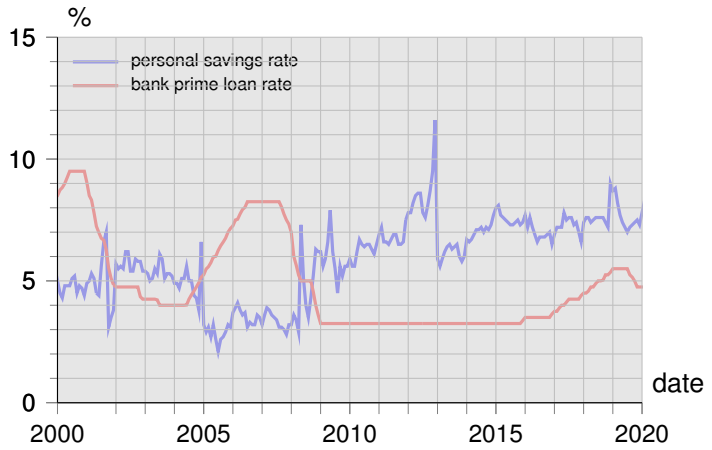


FIGURE 4.9
Interest rate and personal savings rate (source: FRED)

ilar pattern. In this section, we look at three specific examples: savings; risk and insurance; and fertility choices.

SAVINGS

Why do households save? There are multiple reasons, even for a given household. One motivation is to build up a reserve against unforeseen contingencies (what economists refer to as the precautionary motive). A related one is to enjoy a sense of independence and the power to do things. For others, it's a matter of accumulating resources with the view of starting a business, or simply putting the downpayment required for a house or a car. The microeconomics framework we've presented in this and the previous chapter suggests a different perspective, one that economists refer to as **life-cycle optimization** (or the intertemporal substitution motive). Specifically,

> *A household's decision to save can be thought of as a choice between consumption today and consumption in the future.*

In this context, one question of interest is how the trade-off between consumption today and future consumption depends on the interest rate, specifically the rate at which households can turn present savings into future income. Do savings increase when the interest rate

flikr

Retirement planning can be thought of as a trade-off between consumption in the current period and consumption in a future period.

increases? Figure 4.9 plots the evolution of the US aggregate personal savings rate (savings as a percentage of income), as well as the US bank prime loan rate. Can you find a relation between interest rating and savings? From 2000-2010 they seem inversely correlated, whereas from 2010-2020 somewhat positively correlated. Does microeconomic analysis have anything to say about it?

For simplicity, suppose that there are only two periods in a person's lifetime: the period while she is working and the period while she's retired. Suppose the income during the first period is given by I and that the person in question expects to receive no income during her retirement period.

The top panel of Figure 4.10 illustrates this situation. On the horizontal axis we measure consumption today, whereas on the vertical axis we measure consumption tomorrow. If the consumer decides to spend all of her current income on consumption, then consumption today is equal to I, whereas consumption tomorrow is equal to zero. If, at the opposite extreme, the consumer decides not to spend anything on consumption today, then her consumption during the retirement years is given by $I(1 + r_a)$, where r_a is the return on invested savings. In practice things are a little more complicated. First, there isn't one single rate of return to consider: I can invest in bonds, in the stock market, or in other financial assets. Second, there is usually considerable uncertainty regarding the actual value of r_a. But for simplicity let us assume our consumer has a good idea of how much a dollar saved today implies in terms of additional revenue during her retirement years. Finally, any intermediate solution between the extremes of consuming everything and consuming nothing give us

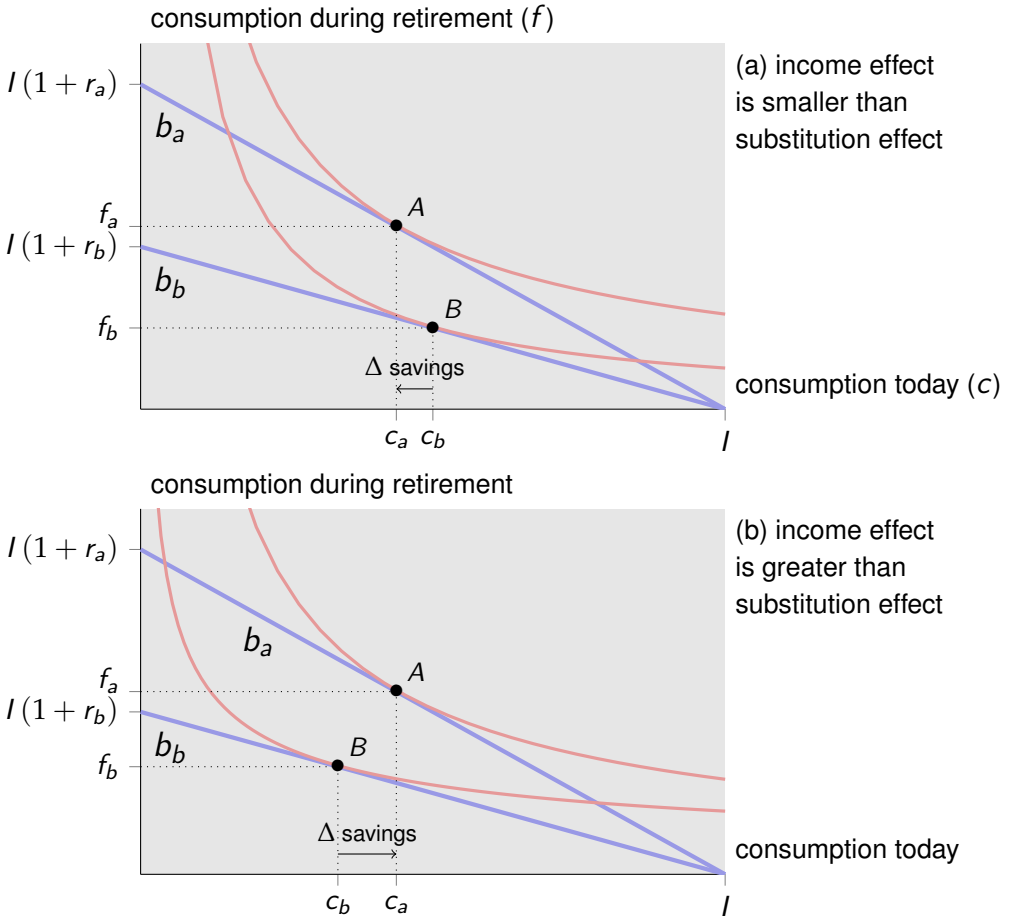


FIGURE 4.10
Effect of a decrease in the interest rate on consumption and savings

the consumer's budget line b_a (very much like the ones we saw for the consumption and labor supply decisions). Given the consumer's relative preferences for consumption today and future consumption, the optimal choice is given by point A, which corresponds to consuming c_a today and f_a during retirement.

Now suppose that the rate at which the consumer can invest her savings drops from r_a to r_b. This implies a shift in the budget line from b_a to b_b. Notice the budget line rotates around the horizontal axis intercept: if the consumer spends all of her current income, then it does not matter what the rate of return is. Given the consumer's relative preferences for consumption today and future consumption, the new optimal point is given by point B, which corresponds to con-

suming c_b today and f_b during retirement. Notice that, on the upper panel of Figure 4.10, $c_b > c_a$. In other words, the drop in the rate of return on invested savings leads to an increase in today's consumption. This makes sense: the opportunity cost of today's consumption is foregone consumption tomorrow. If the rate of return is lower, then the amount of consumption tomorrow I need to forego in order to consume one more unit today is lower, thus current consumption becomes more attractive.

By definition, savings are defined by investment minus consumption. Our consumer has an income of I and consumes c_a in the current period when the interest rate is r_a. It follows that the consumer saves $s_a = I - c_a$. When r drops to r_b, savings drop to $s_b = I - c_b$. Since $c_b > c_a$, we observe a drop in savings given by $c_b - c_a$, a variation that corresponds to the arrow in the top panel in Figure 4.10.

However, as we've seen multiple times, changes in prices — and the interest rate is a price — lead to substitution as well as to income effects. The bottom panel in Figure 4.10 illustrates the case when the income effect is so significant that the overall effect of a drop in the rate of return on invested savings is to *increase* savings, as illustrated by the arrow in the bottom panel of Figure 4.10.

What's going on here? The bottom panel of Figure 4.10 obviously corresponds to a different consumer than the top panel. You can tell this by the different shape of the indifference curves. In the bottom panel the indifference curve going through point B is "flatter" than the indifference curves in the top panel. In the present context, flatter indifference curves correspond to the consumer placing relatively greater value on consumption during retirement. (In the limit, if the indifference curves were completely flat, then consumption during retirement would be all that the consumer cared about.) You can see how a flatter indifference curve implies an optimum farther to the left, that is, a solution with a lower level of consumption today. So, what's happening is that, all things equal — in particular, for a given level of consumption today — the drop in the interest rate implies that the consumer can expect a drop in consumption during retirement. If consumption during retirement is very important for the consumer — as is the case for the consumer in the bottom panel — then the consumer optimally compensates for this drop in future consumption by saving more today. We thus end up with the somewhat surprising conclusion that, as the rate of return on investment sav-

ings decreases, the consumer reduces today's consumption level and increases the level of savings.

So, does a decrease in the interest rate lead to a decrease or to an increase in the savings rate? As often is the case in economics, the answer is — it depends. In the present case, it depends — among other things — on each individual's preferences for consumption today and future consumption. The situation on the bottom panel of Figure 4.10 is more likely to be the exception than the rule. That said, it's definitely a possibility. Empirical studies suggest that the substitution effect is negative as theory would predict. However, based both on studies for developed and developing countries, the total effect tends to be rather small. All in all, this is consistent with the idea that the substitution effect and the income effect are present, have opposite signs, and are approximately of the same order of magnitude, possibly with the income effect being a bit smaller (in absolute value) than the substitution effect. So, perhaps it's not that surprising that we do not find a clear relation between the two time series in Figure 4.9. Moreover, it's clear that there are many factors affecting the savings rate other than the interest rate. On this, the reader is referred to Exercise 4.17.

> *An increase in the interest rate typically leads to an increase in savings. Empirically, this effect is small, possibly because of the income effect of the interest rate increase.*

So far, we've focused on the effect of a change in the price (the interest rate). As in previous sections of this chapter, we are also interested in understanding the effect of an increase in income. Common sense suggests, and empirical evidence confirms, that consumption today and consumption tomorrow are both normal goods. Therefore, an increase in today's income is reflected in both an increase in today's consumption and an increase in tomorrow's consumption. Since tomorrow's consumption is directly related to today's savings, we conclude that an increase in income leads to an increase in savings. To conclude, an extra dollar in today's income implies both an increase in today's consumption and an increase in today's savings. Macroeconomists are particularly interested in this **savings function**, which essentially corresponds to how many cents of an extra dollar in income are turned into savings.

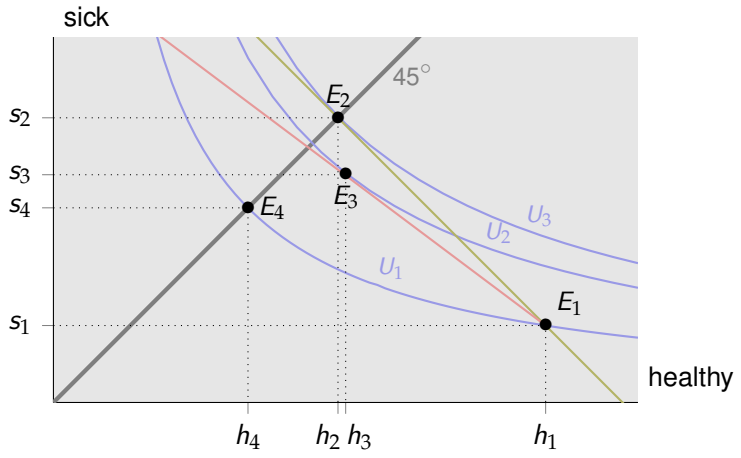


FIGURE 4.11
Risk and insurance

INSURANCE

The way economists model uncertainty and risk is to assume the future is made up of multiple possible states, usually referred to as **states of the world**. For simplicity, let us consider two possible states of the world. In the h state, the consumer is healthy, whereas in the s state she is sick. Suppose moreover that if the consumer is sick then she must pay a large sum to recover her health, so much so that, absent any health insurance, her net income (net of health expenditures) drops from h_1 to s_1.

Figure 4.11 illustrates this situation. On the horizontal axis we measure net income in the h state of the world, whereas on the vertical axis we measure net income in the s state of the world. This may seem a bit confusing, for in the past we considered choices between actual goods (food and clothing, income and leisure time, consumption today and consumption tomorrow). In the present case we consider trade-offs between income in state h and income in state s. The source of possible confusion is that, in reality, only one of these states will turn out to be true (hopefully state h). But a rational agent must be prepared for all eventualities and make choices that cover all possible states.

The line marked as 45° corresponds to the main diagonal. This is the line such the value of h is equal to the value of s. For example, $h_2 = s_2$. In words, points along the 45° correspond to situations

where there is no income risk: future income is the same regardless of the state of the world. Point E_1, the point that describes the consumer's initial situation, is clearly below the 45° line, so it clearly involves risk: if the individual happens to be sick then her net income is considerably lower than if she is healthy.

As before, we assume that the consumer has preferences over the possible states, and that these preferences are described by indifference curves. In the present context, the shape of the indifference curves reflects the consumer's degree of **risk aversion**. In the limit, a **risk neutral** consumer's indifference curves are straight lines, where the slope is such that all points correspond to the same **expected value**. For example, if the consumer is healthy with probability ρ and sick with probability $1-\rho$, then expected income is given by $\rho\, h + (1-\rho)\, s$. To be more specific, suppose that $\rho = 80\%$, so you are sick with probability 20%. Suppose moreover that $h = 200$ and $s = 120$. Then expected income would be $.8 \times 200 + .2 \times 120 = 184$.

Suppose for simplicity that the probability of being sick is equal to the probability of being healthy. (Not a very cheerful example, I know, but one that hopefully simplifies our lives and helps understand the issues.) Then the risk-neutral consumer's indifference curves are straight lines with slope -1. The green line in Figure 4.11 provides an example. If we go to a risk neutral consumer and propose to take away \$1 in the h state to compensate for an extra \$1 in the s state she will shrug her shoulders, as she will be indifferent between these two possible deals. In particular, she will be indifferent between point E_1 and point E_2. Note that point E_2 corresponds to a combination of income levels such that there is no risk (it falls on the 45° line) and expected income is the same as in E_1 (it falls on the same indifference curve of a risk-neutral consumer).

Most consumers that I know are risk-averse, especially when it comes to large sums of income. In terms of choices over states, risk aversion corresponds to convex indifference curves, like the blue curves in Figure 4.11. If a risk-averse consumer were given the option to pick a point from the green line, she would definitely choose E_2, the point that has no risk. In other words, if I am to choose among different combinations of h and s that have the same expected value, then I'd rather go with the one that has no risk, which in this case is point E_2. In fact, at E_2 I reach indifference curve U_3, which corresponds to higher utility than any other point along the green curve.

Unfortunately, one cannot simply say I'd like to be in E_2 rather than E_1. One can, however, buy insurance and get to a combination of h and s that is better than the initial (c_1, s_1) combination. In the context of our framework, insurance consists in renouncing to part of h in exchange for an increase in s. Specifically, I pay a premium p but if I get sick — in other words, if state s happens — then I receive a payment q from the insurance company. This implies that, starting from (h_1, s_1), my "bundle" is now given by $(h - p, s + q)$.

The rate at which the consumer trades off p for q depends on the conditions offered by the insurance company, specifically it depends on the **insurance premium** charged by the insurance company. An example of an insurance policy is given by the red line in Figure 4.11. Notice that the slope of the red line is lower (in absolute value) than thee slope of the green line. The green line corresponds to to constant expected value. If an insurance company were to offer a premium corresponding to the green line than on average the insurance company would make no profit. Since the insurance company must pay costs and make some profit, they offer less q for the same amount of p than the green line (or, they ask for more p for the same q).

Given the insurance policy corresponding to the red line, the consumer's optimal choice corresponds to point E_3. Basically the consumer "buys" a compensation $s_3 - s_1$ in case she is sick. The cost of buying this contingent compensation is given by $h_1 - h_3$. Notice that point E_3 is associated with the indifference curve farthest to the NE (in this case curve U_2) and still within the consumer budget set (which is determined by the red line). In sum, by buying insurance, the consumer moves from utility level U_1 to utility level U_3. It pays to buy insurance!

To conclude this section, we introduce two important concepts which you will likely come across in future economics and finance courses: certainty equivalent and risk premium. Consider again our consumer's outlook in Figure 4.11, assuming that no insurance is bought, that is, assuming the consumer is at point E_1. One question one might ask is how averse to risk this particular consumer is. As we saw earlier, risk aversion corresponds to convex indifference curves. Broadly speaking, the more convex the indifference curves are, the more risk averse the consumer is. Is there a more quantitative way of measuring this? Yes. First, we define the concept of **certainty equivalent**, the payoff level for sure such that the consumer is in-

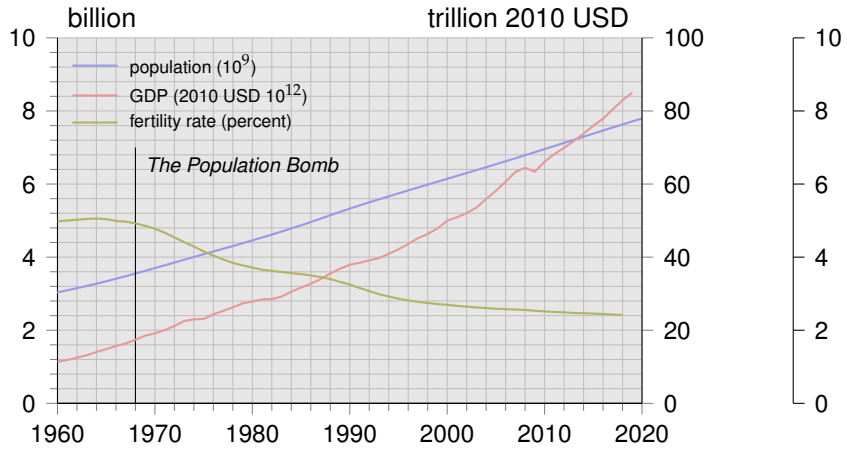


FIGURE 4.12
Population, GDP, and fertility (rightmost scale) at the world level

different with respect to the uncertain outcome (h, s). Specifically, the certainty equivalent corresponding to the uncertain outcome E_1 is given by E_4, the point that lies on the 45° line and on the same indifference curve as E_1. In other words, the consumer is indifferent between the uncertain outcomes (h_1, s_1) and the certain outcome (h_4, s_4). Then $h_4 = c_4$ is the certainty equivalent to (h_1, s_1).

Finally, the **risk premium** is defined as the amount an individual is willing to give up to replace an uncertain outcome with a sure one. In terms of Figure 4.11, the risk premium associated with E_1 is given by $h_1 - h_4$. The more risk averse a consumer is, the greater her risk premium.

FERTILITY

In 1968, a Stanford professor published a highly controversial book, The Population Bomb, where he prophesies that

> The battle to feed all of humanity is over. In the 1970s hundreds of millions of people will starve to death.

This was not an isolated warning. Just a year before, the best-seller Famine 1975! had made similar predictions. Figure 4.12 marks the time when these books was published, as well as the evolution of three key variables: world population, world GDP (constant prices),

and the world average fertility rate. The fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year. At the time when the dire predictions were made, world population was at about 4 billion and increasing rapidly; fertility rates were higher than 5 children per woman; and per-capita GDP (in 2010 prices) was less than $(20 \times 10^{12})/(4 \times 10^{9})$, or simply \$5,000. By 2020, per-capita GDP (in 2010 prices) is about $(85 \times 10^{12})/(7.5 \times 10^{9})$, a little over \$11,000, that is, more than twice the value in the late 1960s. World population has almost doubled (we are now close to 8 billion), whereas the fertility rate dropped to 2.5, about one half of what it was in the late 1960s.

Clearly, the world has plunged into a series of crises (inequality, social unrest, climate change, to name a few), but mass famines were not the main problems of the past few decades. What the doomsayers of the late 1960s missed is that there are adjustment mechanisms which respond to pressures such as rapid population growth. The green revolution, which we dealt with in Section 1.2, was one of them.

Understanding these phenomena is important, lest we blindly project trends and follow the recommendations that come with those projections. *The Population Bomb*, for example, suggested taxes on children, luxury taxes on childcare goods, support for sex-selective abortion (to account for families that have a preference for boys), and even floated the idea of adding "temporary sterilants" to the water supply and staple foods.

What does economics have to say about this? One of the noticeable trends in Figure 4.12 is the sharp decline in the fertility rate in the past half century. In some cases, this resulted from coercion (e.g., China's one-child policy) or other public policies. In most cases, however, it resulted from household decisions. The goal of this section is precisely to better understand fertility rates as an economic household decision. It may seem a bit crass to think of childbearing as a purely economic decision: defining children as an economic good, measuring the price of children, etc. Obviously it's not just an economic decision. However, it is a decision with important economic components and certainly with important economic consequences. Therefore, following the methodological approach of many

Dawn Arlotta

Women's access to education and the job market is frequently associated with a drop in fertility rates.

particular sciences, we narrow our perspective to a economic model of choice with the goal of understanding how a variety of economic factors impact the evolution of the fertility rate.

The microeconomics approach is to model the tradeoffs between having children and consuming other goods. The idea is that having a child implies a series of costs. For starters, there's the mother's personal cost of childbirth. But there are many other economic costs: direct costs such as food, housing, clothing, schooling, etc; and, equally important, the opportunity cost implied by the time spent with children, namely the opportunity cost in terms of foregone labor income.

By now, we know how to represent the choice between two goods. In this regard, there isn't much new about the present application. In Figure 4.13, we measure the number of children (**fertility rate**) on the horizontal axis and consumption on the vertical axis. Since consumption is measured in \$, the "price" of consumption is 1 (it costs \$1 to buy \$1 of consumption). Suppose the household initially has an income of I_1. Then one option is for the household to have zero children and consume I_1. Let p_1 be the "price" of one child. As per the previous paragraph, we should think of p_1 as including both the direct costs as well as the opportunity costs of having a child. Making the simplifying assumption that this per-child cost is the same regardless of the number of children, we conclude that the household is faced with a budget constraint to its consumption and childbearing decision, namely the budget line b_1. In particular, if the household were to spend all of its income in children it would be able to "afford" I_1/p_1 children. Next we assume that the household's preferences can be represented by an indifference curve mapping. And

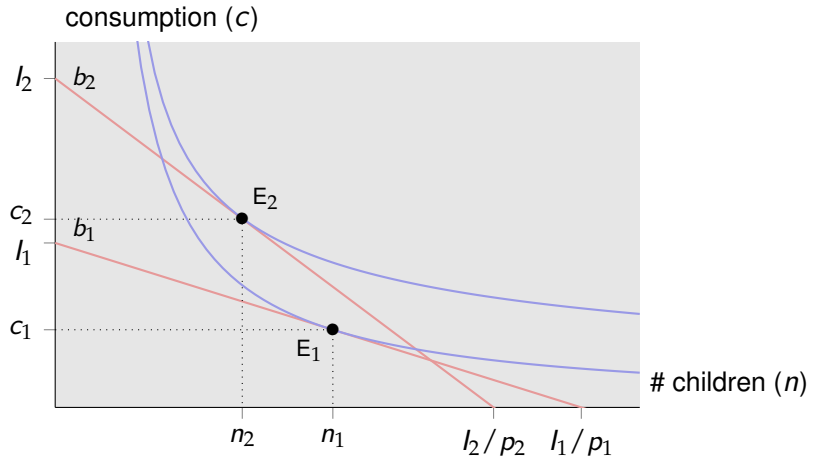


FIGURE 4.13
Optimal choice of family size

finally we find the optimal combination of consumption and number of children, which in this case is given by E_1, a point corresponding to n_1 children and a consumption level c_1.

Figure 4.12 shows that per-capita income doubled since the late 1960s, whereas the fertility rate dropped to a half of what it was half a century ago. A tantalizing conclusion is that children are an inferior good, that is, a good the consumption of which decreases as income increases. In addition to the time-series correlation, cross-family and cross-country evidence also suggests that family size and income are negatively correlated: high income families tend to have few children and, analogously, high income countries tend to have low fertility rates.

However, if you read Chapter 2 you will remember that one of the most important points of methodology to keep in mind is that correlation does not imply causality. In the present context, in addition to an increase in income we must also consider that the "price" of children may have changed in the past half century or so. It did, for two reasons. First, the direct costs with childbearing have increased. Second, and most important, the opportunity cost has increased considerably. The average educational attainment of women increased in most countries of the world, and so have their job market opportunities. This implies that, from a labor market point of view, women have more to lose from childbearing activities. (There is a third factor

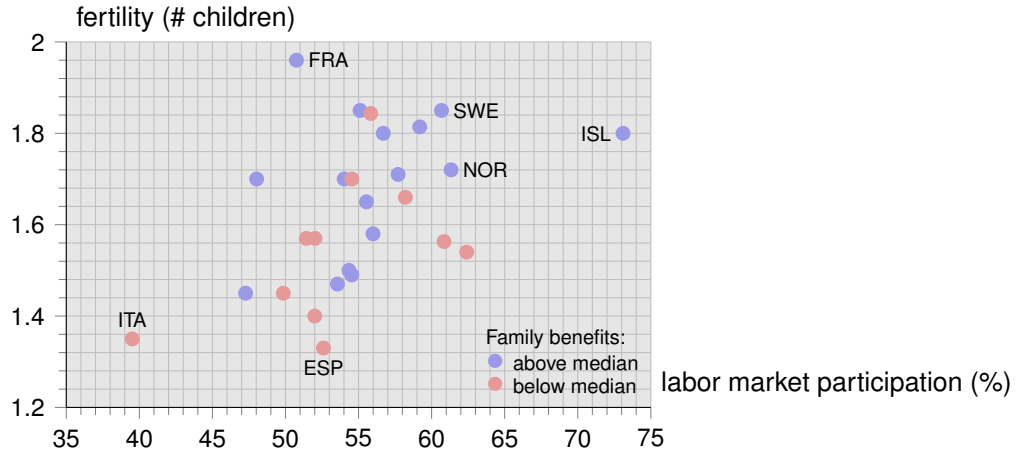


FIGURE 4.14
Women's labor market participation and fertility in 2015. Source: OECD and World Bank

underlying the trend in Figure 4.12, namely the changes in contraceptive technology, which allowed for a reduction in unplanned and/or unwanted pregnancies. Important as this was, it falls out of the focus on Figure 4.13.)

So, if we want to compare a typical household in 2020 to a typical household in 1970 we should consider not only an increase in income but also an increase in the price of children. Figure 4.13 depicts a plausible new equilibrium — point E_2 — which results in both an increase in I and an increase in p with respect to point E_1. Note that at E_2, which might represent the current situation, we observe a drop in n (that is, $n_2 < n_1$) and an increase in c (that is, $c_2 > c_1$), both of which are reflected in the data. Although it is not obvious from the aggregate data, more detailed studies suggest that children are a "normal" good, that is, for most households an increase in income leads to an increase in family size. The problem with Figure 4.12 is that the negative substitution effect of the increase in p more than outweighs the positive effect of an increase in household income.

> *The drop in fertility rates is in part explained by the increase in the opportunity cost of childbearing (and not by the increase in income).*

If the substitution effect of changes in the price of children is so important, then it makes sense to think of public policy as it affects such

price and the trade-offs that follow from it. In the 21st century several European countries suffer from the opposite problem than *The Population Bomb* warned about sixty years ago: Italy, Spain, Portugal, Greece and other countries suffer from very low fertility rates, so low that population size is declining. To be sure, some of the factors underlying the increase in the "price" of children are good news: women have better access to education and the labor market than before. However, there are many other components of this price that can be lowered. Government spending on family benefits, in particular, is likely to contribute to an increase in fertility rate by virtue of decreasing the "price" of children.

Figure 4.14 illustrates some of these points. For a series of OECD countries — mostly European countries but also including US, Canada, Japan and Australia — it plots the labor market participation — i.e., the percentage of women holding jobs — on the horizontal axis; and fertility — i.e., the average number of children per woman — on the vertical axis. Looking at the cloud of points as a whole, there does no seem to be any recognizable pattern. However, if we group the observations by the size of government benefits directed at the family (above median in blue, below median in red) then we do observe a bit of a pattern: Countries where the government provides higher levels of family benefits tend to have higher fertility rates. It is also noticeable that Scandinavian countries such as Sweden, Norway and Iceland, show both higher rates of female labor market participation and higher fertility rates. Of course, there are a lot of other factors. In this sense, it helps to compare countries that are closer to each other, for example France, Italy and Spain. Of these three, the only country with above-mean government support is also the one with (significantly) higher fertility rate. In sum, both the theoretical analysis and the empirical evidence suggest that policy measures which decrease the "price" of children do result in higher fertility rates.

KEY CONCEPTS

budget set | budget line | comparative statics

normal good | inferior good | substitution effect

income effect | law of demand | real income

carbon tax | price taker | labor supply

representative agent | marginal | life-cycle optimization

savings function | state of the world | risk aversion

risk neutral | expected value | insurance premium

certainty equivalent | risk premium | fertility rate

REVIEW AND PRACTICE PROBLEMS

■ **4.1. Budget set.** Consider the choice between quantity of good x (horizontal axis) and quantity of good y (vertical axis).

(a) What is the budget set?

(b) What is the budget line?

(c) What is the slope of the budget line?

(d) What is the economic interpretation for the slope of the budget line?

■ **4.2. Normal and inferior goods.** What is a normal good? What is an inferior good? Is an inferior good inferior for everyone? Why or why not?

■ **4.3. Tuna and beef.** Figure 4.15 represents Margot's choices of tuna and beef after her income changes. Indicate whether the following are true or false.

(a) Beef is an inferior good

(b) Tuna is an inferior good

(c) Tuna is an normal good

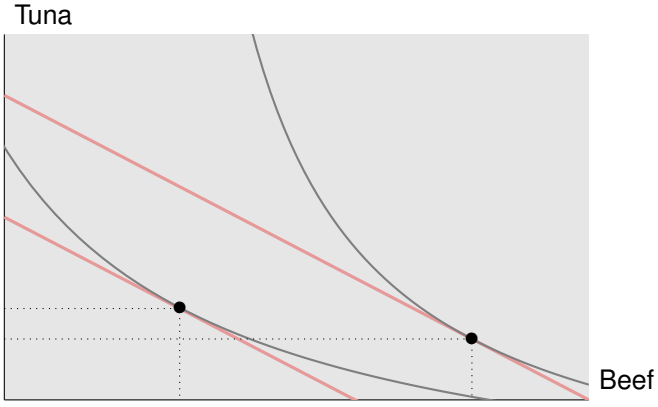


FIGURE 4.15
Margot

■ **4.4. Food and clothing.** The optimal mix between consumption of food and consumption of clothing is given by MRS = p_c / p_f. Explain the meaning of MRS in this context. Explain the economic intuition for the equality MRS = p_c / p_f.

■ **4.5. Maria's food and clothing consumption.** Ten years ago, Maria had an income of 40, which she spent entirely on clothing (18 units) and food (22 units). Currently, Maria has an income of 56, which she spends entirely on clothing (28 units) and food (14 units). Ten years ago, the price of food was $p_f = 1$ and the price of clothing was $p_c = 1$. Today, the price of food is $p_f = 1.75$, whereas the price of clothing is $p_c = 1.12$.

(a) Plot Maria's choices on a graph with quantity of clothing on the horizontal axis and quantity of food on the vertical axis. Indicate Maria's budget constraint in each period as well as her optimal choice.

(b) Suppose that Maria is a rational utility maximizer. Comparing income levels, can we tell whether Maria is better off or worse off at time 2 than at time 1? Why or why not? (Hint: draw indifference curves that are consistent with A and B being optimal choices.)

■ **4.6. Joe's pizza and Coke consumption.** At his current consumption levels, Joe's marginal rate of substitution of pizza slices for cans of Coke is given by 2. (Recall that, as per our convention, this corresponds to plotting pizza on the horizontal axis and Coke on the vertical axis.) The price of a slice of pizza is equal to \$2, whereas the price of a can of Coke is \$1.50. Suppose Joe is currently spending all his income on pizza and Coke and consuming positive amounts of both goods. Would Joe be better off by increasing his consumption of pizza at the expense of Coke; or increase the consumption of Coke at the expense of pizza; or is his current consumption bundle optimal? (You can ignore integer constraints in your answer, that is, assume that Joe can consume fractions of slices of pizza and fractions of cans of Coke.)

■ **4.7. Ann and Bob.** Ann and Bob have the same income level and

face the same prices of goods x and y. The price of x is 4 and the price of y is 8.

(a) At the current consumption level, Ann's MRS is equal to 1. In order to improve her situation, should Ann increase or decrease her consumption of x?

(b) At the current consumption level, Bob's MRS is equal to 0.5. Is Bob's current consumption bundle optimal or suboptimal?

(c) Suppose that, after adjusting their consumption levels, both Ann and Bob choose their optimal levels of x and y. Ann chooses $x = 5$ and Bob chooses $x = 4$. True or false: Ann and Bob have the same MRS at their current consumption levels.

(d) Continuing with the assumptions of the previous question. True or false: If Ann exchanges 1 unit of x for 2 units of y, then both Ann and Bob become better off.

(e) Bob's income increased and his consumption of x changed from 4 to 4.5. True or false: x is an inferior good for Bob.

(f) Suppose Bob's consumption choices are always optimal. We observe that, when the price of x increased from 4 to 6, Bob's consumption of x decreased from $x = 4$ to $x = 3$. True or false: The income effect of the price increase is necessarily negative.

(g) Suppose Ann's consumption choices are always optimal. We observe that, when the price of x increased from 4 to 6, Ann's consumption of x increased from $x = 5$ to $x = 6$. True or false: Ann's behavior necessarily contradicts economic theory.

(h) Suppose Ann's consumption choices are always optimal. We observe that, when the price of x increased from 4 to 6, Ann's consumption of x increased from $x = 5$ to $x = 6$. True or false: The income effect of the price change on Ann's consumption of x must be positive.

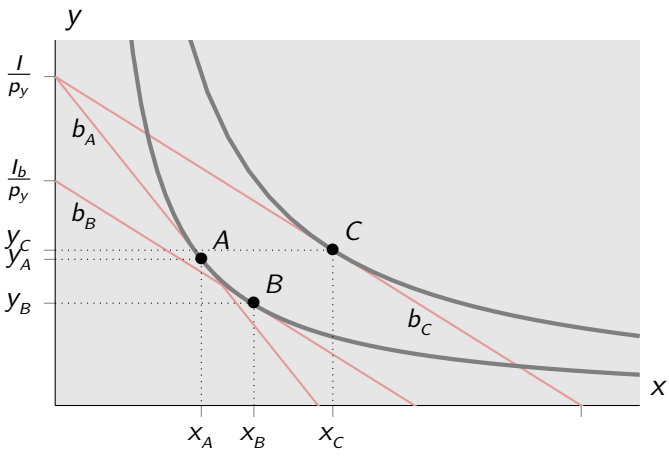


FIGURE 4.16
Income and substitution effects

(i) True or false: Since Ann and Bob have the same income level, they also must have the same level of consumer surplus.

■ **4.8. Income effect and substitution effect.** Consider Figure 4.16, depicting the preferences of a given consumer for goods x and y. As a result of a change in the price of x, the consumer's budget line shifts from b_A to b_C.

(a) What are the consumer's optimal choices before and after the change in p_x?

(b) What are the substitution and income effects on the consumption of x of the change in p_x?

(c) For this consumer and for the given values of x and I: is x an inferior or a normal good?

(d) Explain, qualitatively and quantitatively, the meaning of the income effect.

■ **4.9. Substitution effect.** Show that the sign of the substitution effect on x of a change in the price of x is the opposite of the sign of the price change. What is this property called?

■ **4.10. Perfect complements.** What would the value of the substi-

tution effect be for two goods that are perfect complements? Use a graph to demonstrate your answer.

■ **4.11. France and the US.** The average French person has lower income than the average American, but also more free time than the average American. Why is this so? Which is better in terms of living standards?

■ **4.12. Marginal rate of substitution.** Consider two consumers, a and b, and two goods, x and y. Both consumers face the same prices of x and y and have the same income I. Their optimal choices lead them to purchase x_i of x and y_i of y, where $i \in \{a, b\}$.

(a) What is the relation between the marginal rate of substitution MRS_{xy} for consumer a and the MRS_{xy} for consumer b at their optimal consumption levels?

(b) Suppose now that a and b are not consuming their optimal level. Rather, their consumption levels are such that (1) a and b purchase the same quantity of x and y; and (2) a and b have the same utility level as in the initial case. (For the purpose of this question, ignore the budget constraint.) What is now the relation between MRS_{xy} for consumer a and the MRS_{xy} for consumer b? What does this say about a and b's preference for x and y?

■ **4.13. Perfect substitutes.** True or false (explain your answer). Lei considers two goods x, y to be perfect substitutes: one unit of x is just as good as one unit of y. If $p_x \neq p_y$ then Lei's optimal bundle is a corner solution.

■ **4.14. Kabral green new deal.** Presidential hopeful Ludwig Kabral has promised a tax on carbon-intensive goods. To compensate for the price increases the tax will imply, Kabral has also promised a government income handout. Show graphically how you would determine the value of this handout so that consumers are equally well off as they were before the carbon tax was introduced.

■ **4.15. Labor supply.** What is the equality corresponding to an op-

timal choice between labor income and leisure? What is the intuition for this equality?

■ **4.16. Savings.** The bottom panel of Figure 4.10 depicts the effect of an interest rate decrease on today's consumption (vis-a-vis tomorrow's consumption). Decompose this effect into the substitution and income components.

■ **4.17. Savings rate in 2020.** Visit the FRED site and look for the time series Personal Saving Rate (PSAVERT), as well as the time series 3-Month London Interbank Offered Rate (LIBOR), based on U.S. Dollar (USD3MTD156N). Plot the values for 2019 and 2020. How do they compare to the values in Figure 4.9? How do you explain the variation during 2020?

■ **4.18. Savings.** Consider two different consumers, one who cares more about future consumption, one who cares less about future consumption. Show how their indifference curves in the (c_1, c_2) space differ, where c_1 and c_2 denote consumption today and future consumption, respectively. Show how, given the same budget constraint, these consumers would choose different levels of savings.

■ **4.19. Wages in Seattle.** "When Seattle began raising its minimum wage five years ago, local burger joint Dick's Drive-In experienced an unintended effect. Its employees opted to work fewer hours as their wages rose, a tall order in a tight labor market. 'We thought with higher wages it would be easier to get people to take more hours, but it's been the opposite' " (source). Discuss.

CHAPTER 5

FIRMS

In Chapter 3 we focused on economic decision making at a generic level. In Chapter 4, we covered household decision making (consumption, labor supply, etc). It is now time to focus on economic decisions by firms.

Economists model firms as organizations that transform inputs into outputs. General Motors own a series of factories with a series of machines and employs a number of workers and managers to produce cars. Similarly, New York University may be thought of as an organization that owns buildings and employs faculty and staff in order to offer educational services.

Here's the chapter's roadmap. In Section 5.1, we introduce the concept of a firm's production function, the mapping that describes the transformation of inputs into outputs. Next, in Section 5.2 we focus in one of the firm's important economic choices, namely picking the optimal input mix (workers, machines, materials, energy, etc). Finally, in Section 5.3 we look at the choice of price and output level. In all cases, we apply the basic framework introduced in Chapter 3.

5.1. PRODUCTION FUNCTION

At the risk of oversimplifying, we can think of a firm as a process of transforming inputs into outputs. This is easier to see for a firm that makes actual things. For example, a bagel bakery uses water, flour

and other ingredients, together with machinery (an oven) and labor (someone has to put it all together) to produce tasty bagels. Firms that offer services also go through a similar process. For example, a consulting firm uses hours of labor (many, many hours, I'm told), together with some capital (mainly laptop computers) and materials (paper and paper clips), to produce solid advice to corporations that need it. The firm's **production function** is the mapping that tells us, for a given set of inputs, how much output a firm is able to produce. Normally, this depends on the particular firm, as some firms are more efficient than others at transforming inputs into outputs. It also depends on the quality of inputs, for example skilled versus unskilled labor.

PRODUCTION WITH ONE INPUT

In Section 3.1, we derived Alexei's feasible set when faced with the choice between leisure and grade. We took as given the following relation between hours of study and Alexei's grade:

Study hours	0	1	2	3	4	5	6	7
Grade	0	20	33	42	50	57	63	69

Study hours	8	9	10	11	12	13	14	15+
Grade	74	78	81	84	86	88	89	90

This table relates one input (hours of study) to an output (grade). Normally we associate production functions to firms, but by analogy we can also think of Alexei as having a course-grade production function. Figure 5.1 displays the various points of Alexei's production function. On the horizontal axis we measure input level (in the present case, hours of study), whereas on the vertical axis we measure output (in the present case, course grade). The figure also includes a line that connects the points from the table above, reflecting the assumption that Alexei can also choose fractional values of the input variable "hours of study".

We now define two important concepts based on the production function. First, **average product** (or simply AP) is defined as the ratio between output level and input level. In this case, this corresponds to grade per hour of study. The second, related, concept is **marginal**

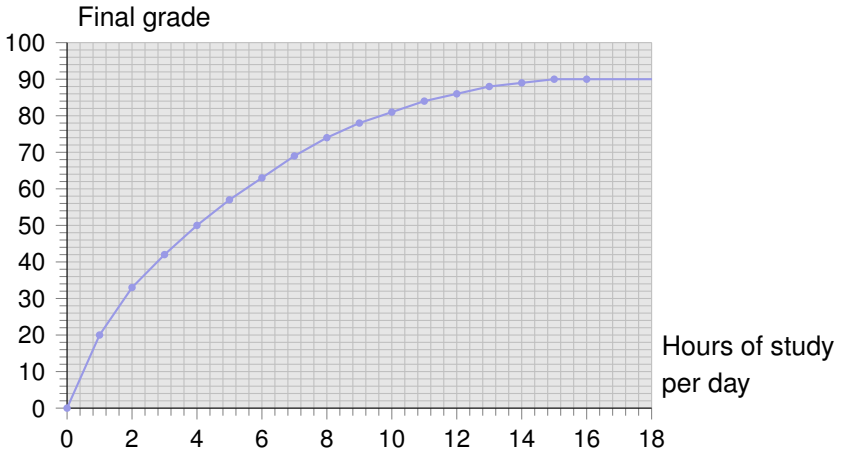


FIGURE 5.1
Alexei's production function

product (or simply MP), defined as the additional output level resulting from a one-unit increase in input level. In this case, this corresponds to grade per additional hour. In general, both AP and MP depend on the input level at which they are computed. Therefore, we can derive the AP and MP functions. This we do in Table 5.1. Suppose, for example, that Alexei is currently studying 6 hours a day. This implies that he expects a grade of 63. His average product is then given by $63/6 = 10.5$. Had Alexei studied for 5 hours instead of 6, be would expect a grade of 57. This implies that the 6th hour of study kicks Alexei's grade up by 6 points. We thus say that marginal product at 6 hours of study is 6 points.

Based on the values of this table, we can construct Figure 5.2, where again the input level is measured on the horizontal axis. One first observation from this figure is that marginal product is decreasing. This corresponds to a very important economics "law", the law of **decreasing marginal returns**. The idea is that each *additional* unit of the input (hours of study in the present example) has a lower contribution than the previous ones. In Section 6.1 we will see that some production functions have increasing MP for low input levels and then decreasing MP for higher input levels. A more general "law" of decreasing marginal returns indicates that the MP of a given input is decreasing for a sufficiently high level of that input. For the present chapter, we will continue to consider the case when marginal returns

TABLE 5.1
Average and marginal product

Hours	Grade	AP	MP
0	0	N/A	N/A
1	20	20.00	20
2	33	16.50	13
3	42	14.00	9
4	50	12.50	8
5	57	11.40	7
6	63	10.50	6
7	69	9.86	6
8	74	9.25	5
9	78	8.67	4
10	81	8.10	3
11	84	7.64	3
12	86	7.17	2
13	88	6.77	2
14	89	6.36	1
15+	90	6.00	1

are uniformly decreasing.

There are a number of justifications for decreasing marginal returns. One of the most important ones is sequencing of actions. Suppose that I study better during the morning, say from 8am to 12pm, not so well after lunch, and very poorly at night. If I decide to study only for two hours a day, then I would study in the morning, when those hours of study have a greater impact (and absent other considerations against studying in the morning). If, instead of two hours, I decide to study for six hours, then I will optimally study four hours in the morning and two in the afternoon, knowing that the afternoon hours will not be as productive as the morning ones. In this context, the marginal effect of the sixth hour of study (in the afternoon) is lower than the marginal effect of the first hour (in the morning).

Another explanation, one that we will explore later in the book, is related to production with multiple inputs. Consider, for example, the production function of restaurant meals. It requires two inputs,

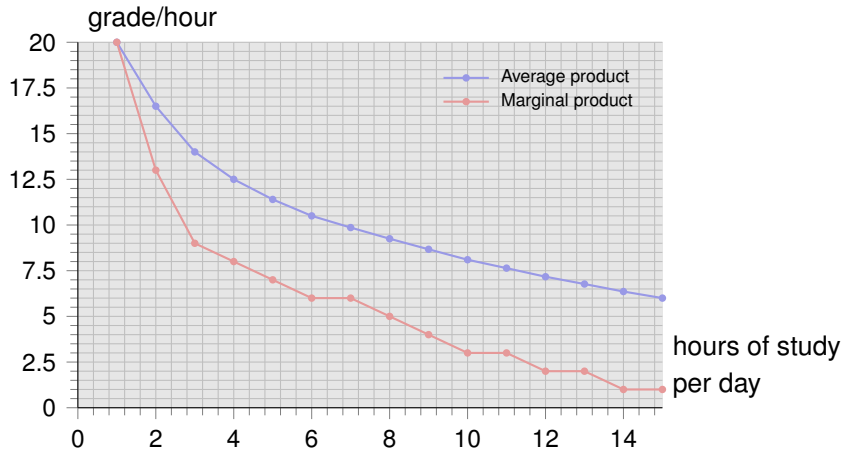


FIGURE 5.2
Average and marginal product

kitchen space (in square feet) and workers. Fixing the input "kitchen space", you can see how the contribution of an additional worker would decline as more workers are added. In fact, at some point, the marginal product of a worker might actually be negative! "Too many cooks spoil the broth," so the saying goes.

> *There are multiple justifications for decreasing marginal product, including optimal sequencing and fixed production factors.*

Figure 5.2 shows that, in addition to marginal product, average product is also decreasing. There is an economic intuition for this. At one hour of study, MP and AP are the same (since both the total and the incremental input levels are equal to one hour). Because of decreasing marginal returns, MP at two hours of study is less than MP at one hour of study, which in turn is equal to AP at one hour of study. In words, this means that the second hour contributes to grade less than the average hour up to that level. This implies that that second hour of study effectively lowers the average. More generally, if MP is lower than AP, then an additional hour of study effectively lowers AP, which in turn implies that AP is decreasing.

> *Average product is greater than marginal product. Both are decreasing in output level.*

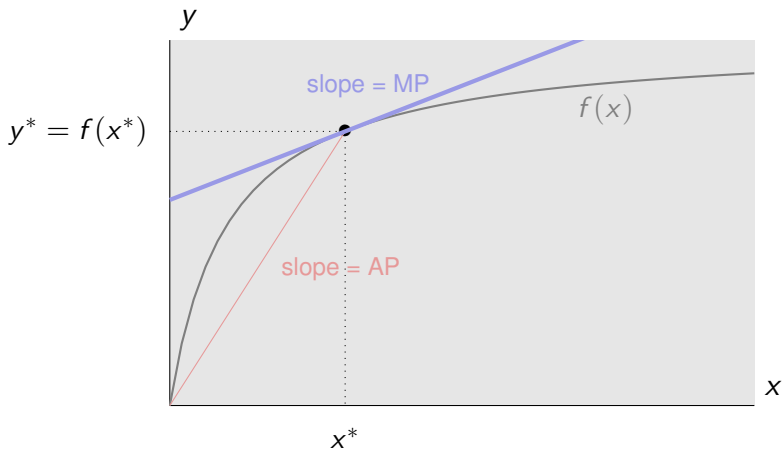


FIGURE 5.3
Properties of production function

To conclude this section, Figure 5.3 plots a generic production function. There is one input, x, and one output, y. As in the case of Alexei's grade production function, we see that the relation between x and y is a **concave** function. A concave production function corresponds to a decreasing MP mapping. In fact, when we have a continuous production function such as $y = f(x)$ in Figure 5.3, MP is given by the slope of the tangent to $f(x)$; and the tangent becomes flatter as x increases. (As we will see in Section 6.1, many production functions are convex at $x = 0$ and then become concave as the production function in Figure 5.3, so to be rigorous the present production function is not exactly generic.)

The relation between AP and MP is also illustrated in Figure 5.3. AP is defined by the ratio y/x. In graphic terms, this corresponds to the slope of the segment that extends from the origin to (x^*, y^*), for a generic input level x^*. As can be seen, this slope is greater than the slope of the tangent (that is, MP is less than AP). Moreover, the slope of the (x^*, y^*) segment is lower the greater the value of x^* (that is, AP is decreasing). In sum, for production functions like the one in Figure 5.3, average product is greater than marginal product and both average and marginal product are decreasing in output level.

TABLE 5.2
Production with two variable inputs

$K \downarrow L \rightarrow$	1	2	3	4	5	6
1	100	141	173	200	223	244
2	141	200	244	282	316	346
3	173	244	300	346	387	423
4	200	282	346	400	447	489
5	223	316	387	447	500	547
6	244	346	423	489	547	600

PRODUCTION WITH MULTIPLE INPUTS

Normally firms use more than one input. When that is the case, the production function may be written as $f(x_1, ...x_n)$, where x_i stands for the quantity of input i. For the purpose of this section, we consider two inputs: capital and labor. This is not to say that other inputs are not relevant: no matter how many ovens and oven operators you have, you cannot make bagels without flour. It's just that, for the purpose of illustrating the main principles, it suffices to consider two inputs. Moreover, in many examples (e.g., consulting services) these are indeed the main inputs into production (in other words, paper and paper clips are a small fraction of the consulting firm's operations). We follow the convention of denoting the quantity of the capital and labor inputs by K and L, respectively.

When there is more than one input, we cannot represent the production function in a two-dimensional graph. One alternative is to display the value of $f(K, L)$ for each combination of K and L on a double-entry table. Table 5.2 considers one particular example. Each row corresponds to a different value of K, from 1 to 6. Each column corresponds to a different value of L, also from 1 to 6. The value of each cell is the output value corresponding to each combination of inputs. For example, 2 units of capital and 3 units of labor yield an output of 244. Before continuing, notice that the values in Table 5.2 satisfy the property of decreasing marginal returns. For example, if capital is set at $K = 3$, then the incremental output gain from each one-unit increase in labor input is given by 173, 71, 56, 46, 41, 37.

One interesting fact about Table 5.2 is that multiple combinations

of K and L may yield the same output level. For example, $K = 6$ and $L = 1$ yield the same output as $K = 2$ and $L = 3$. Figure 5.4 takes this idea one step further and plots, on a graph with K on the vertical axis and L on the horizontal axis, a series of isoquants. An **isoquant** is a line on the (L,K) map such that all points correspond to the same output level. Notice the close parallel with indifference curves, which we introduced in Section 3.2. Indifference curves connect points yielding the same utility enjoyed by an economic agent (consumer, worker, etc). Isoquants, by contrast, connect points yielding the same output level. For example, the $q = 224$ isoquant in Figure 5.4 includes point A ($K = 3, L = 2$) as well as point B ($K = 1, L = 6$). As can be seen from Table 5.2, these two alternative combinations yield the same output level, namely $q = 224$. Similarly, points C ($K = 6, L = 2$) and D ($K = 3, L = 4$) belong to the same isoquant, this time the $q = 346$ isoquant.

The parallel between isoquants and indifference curves can be taken one step further. In Section 3.2, we introduced the concept of marginal rate of substitution, the rate at which an economic agent is willing to give up one good in order to obtain an additional unit of another good. Graphically, the MRS corresponds to the absolute value of the slope of the indifference curve containing each point under consideration. Similarly, the **marginal rate of technical substitution (MRTS)** measures how much extra K the firm needs when it loses one unit of L so as to keep the same output level; or, alternatively, how much capital a firm can save by employing an additional unit of labor so as to keep the same output level.

The shape of a production function's isoquants indicates the degree to which the inputs are substitutes or complements. Consider the production function of commercial flights. At the risk of simplifying the problem, let us say you need one pilot and one plane in order to offer one flight. In this context, given that an airline owns one plane, having more pilots won't help; you still can only offer one flight. Given that the airline employs one pilot, having more than one plane won't help either; you still can only offer one flight. The pilot-plane example corresponds to the extreme of **perfect complements**. Production functions with these features are sometimes referred to as **Leontief production functions**. In this case, isoquants are L-shaped as in the bottom panel of Figure 5.8. Once again, there is a parallel with indifference curves, where two goods may also be perfect comple-

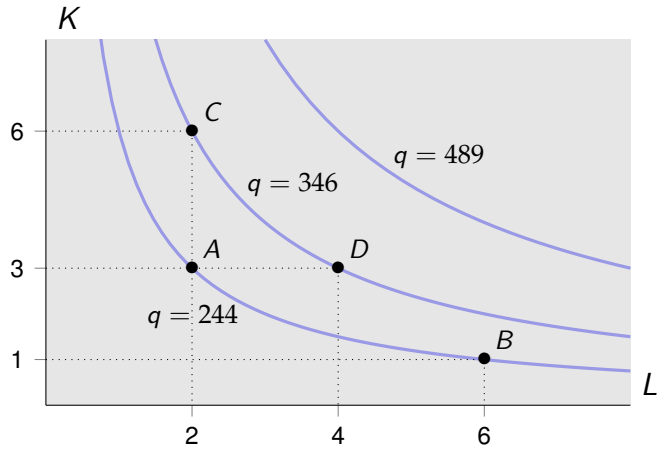


FIGURE 5.4
Isoquants

ments. Examples include peanut butter and jelly, cars and tires, and so on. See also Exercise 3.9.

At the opposite end, consider McDonald's production function. Suppose the fast-food chain uses both Texas and Nebraska beef as inputs. Moreover, for the purpose of this example, suppose that beef is the only ingredient into burgers (I am aware this is a strong assumption, but please bear with me). At the risk of offending the great states of Texas and Nebraska, it seems reasonable to assume that the quality of beef in these two states is similar. Therefore, the quantity and quality of McDonald's burgers depends on the total quantity of beef, not on the particular proportions of beef from Texas or Nebraska. We thus have a case when the inputs are **perfect substitutes**. Perfect substitute inputs lead to straight isoquants (as in the top panel of Figure 5.8): one unit of output (burger) can be obtained with one unit of Texas beef and zero units of Nebraska beef; or one unit of Nebraska beef and zero units of Texas beef; or any combination therein. More generally,

> *The closer substitutes (resp. complements) two production inputs are, the closer the isoquants are to straight lines (resp. L-shaped lines).*

5.2. INPUT MIX

Over the years, across countries and across industries we see significant variation in the capital-labor input mix. Take for example auto manufacturing. Comparing a GM factory from the 1960s to a Tesla factory of the 2010s, we observe a significant increase in the capital/labor ratio. What determines the optimal mix of labor and capital inputs? What is the effect of changes in the interest rate, the wage rate, technical progress (e.g., artificial intelligence), and so forth? These are some of the questions that economists address by using the framework developed in this chapter.

In the present context, a firm's optimal problem can be approached in two different ways. First, for a given cost level, determine the input mix that maximizes output level. Alternatively, for a given output level, determine the input mix that minimizes cost. We stress "in the present context" because there are many other choice problems a firm must consider. One of them, output pricing, will be considered in the next section.

Consider first the output maximization problem, which turns out to be very similar to Alexei's optimal choice of hours of study (Chapter 3) as well as Maria's optimal consumption mix (Chapter 4). Let C be the firm's total input expense:

$$C = w\,L + r\,K$$

where w is the cost of one unit of L (wage rate) and r is the cost of one unit of K (cost of capital). For a given value of C, we define an **isocost** line as a line that connects all input combinations that cost C. Different values of C corresponds to a different isocost lines. An isocost line is essentially the same as a budget line. Recall that the latter consists of combinations of goods x and y that cost I, where I is consumer income. The y-axis intercept is given by I/p_y, whereas the x-axis intercept is given by I/p_x. Similarly, the intercept of the isocost line on the L axis is given by C/w, where w is the unit cost of labor; and the intercept of the isocost line on the K axis is given by C/r, where r is the unit cost of capital. It follows that the slope of an isocost line is given by $-w/r$. Different isocost lines correspond to horizontal shifts, that is, they all have the same slope.

The firm's optimal input mix is illustrated in the top panel of Figure 5.5. Specifically, m^* is the input mix that maximizes the firm's

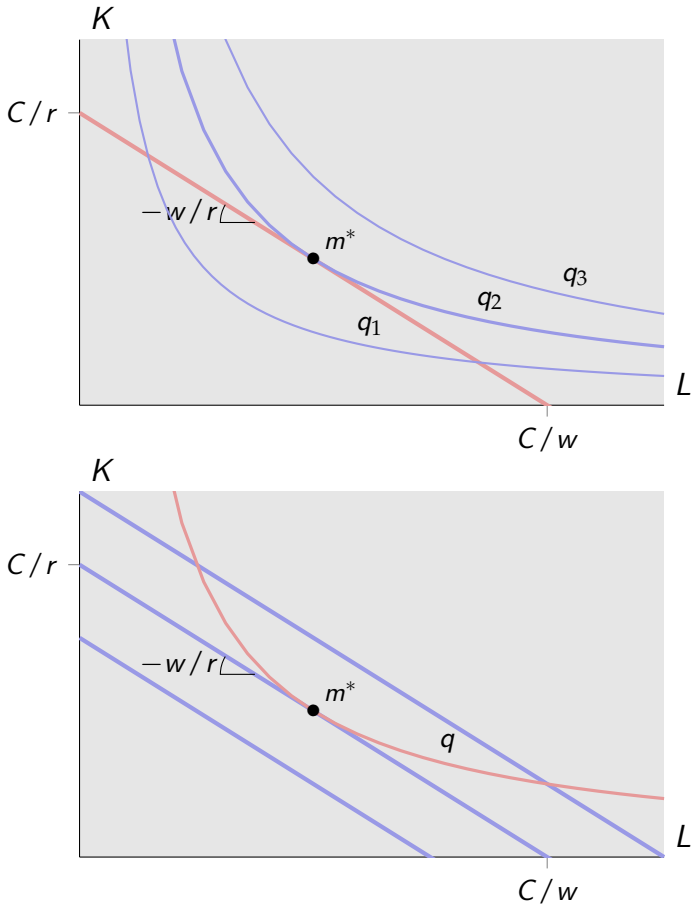


FIGURE 5.5
Optimum input mix (top) and cost minimization (bottom)

output level for a given total input budget C. Since the absolute value of the slope of the isoquants is given by the MRTS and the absolute value of the slope of the isocost line is given by w/r, we conclude that the optimal input mix is such that MRTS = w/r. The intuition for this optimality rule is similar to what we found when discussing the consumer's marginal rule: If MRTS were different than w/r then the firm could do better: for the same input budget, it would be able to obtain a higher output. The argument is similar to that in Chapters 3 and 4.

The second approach to a firm's optimal input mix is to derive the minimum cost possible for a given output level. The bottom panel of Figure 5.5 illustrates this process. Consider a given output level q and its associated isoquant q. As mentioned earlier, there are multi-


Alden Jewell and Steve Jurvetson

A Plymouth plant in the 1960s and a Tesla plant in the 2010s. Can you tell the differences?

ple isocost lines, each corresponding to a different cost level C. The bottom panel in Figure 5.5 depicts several of these isocost lines. The optimal input mix is given by the point on the desired isoquant q that is associated with the lowest isocost line, that is, the one closest to the origin. In the bottom panel of Figure 5.5, this is given by the input combination m^*, the point where an isocost line is tangent to the isoquant.

> *The following two problems lead to the same input mix: (a) maximize output for a given cost level; and (b) minimize cost for a given output level.*

The two panels in Figure 5.5 look similar, and there is a reason for that. Regardless of whether we seek the highest output level attainable with a budget C or the lowest cost C consistent with output q, we are led to the same rule: at the optimum input mix, the marginal rate of technical substitution is equal to the input cost ratio, that is, MRTS = w/r. This is analogous to the by now famous equality typeset in a very large font size, namely MRS = MRT.

DECLINING COST OF CAPITAL

One of the more noticeable trends in modern economies, beginning with the Industrial Revolution, is the rapid decline of the cost of capital as a production input. In recent years, this trend has been very noticeable in digital industries. For example, Figure 5.6 documents the steep decline in cost of computing over the past decades. Up until 1940, the cost of computation was approximately constant. Since

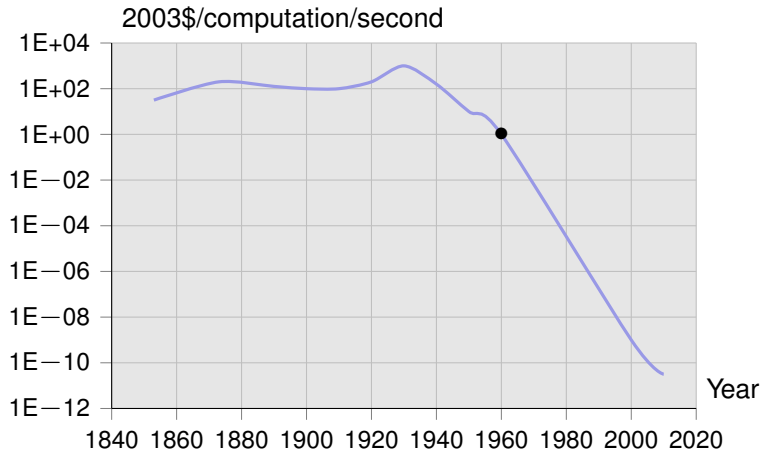


FIGURE 5.6
Computation cost over time (source)

then, it has declined at an exponential rate. To be specific, the cost of a standard computation has declined at an average annual rate of 53% per year over the period 1940–2012! The exclamation mark reflects both the number 53 and the length of the period (72 years).

More generally, the cost of capital inputs keeps declining. Figure 5.7 illustrates the effect of a drop in the cost of capital inputs, from r_1 to r_2. Suppose that a given firm continues to operate with the same input budget C. This is not entirely realistic: we would expect the firm to re-optimize its input and output decisions, leading probably to a different level of resources spent on acquiring inputs. However, for the purpose of illustrating the impact of a change in input costs, we will stick to this simplifying assumption.

A lowering of the cost of capital from r_1 to r_2 implies that the C isocost curve pivots around the L axis. Specifically, the L-axis intercept remains at C/w, whereas the K-axis intercept increases from C/r_1 to C/r_2. If initially the optimum was given by m_1, the new optimum is now given by m_2. As expected, the new optimal solution corresponds to a higher output level, an increase from q_1 to q_2. Also as expected, the amount of capital used in production increases from K_1 to K_2. It is not clear in general what to expect regarding labor input levels. In Figure 5.7, the value of L remains unchanged following the decrease in the cost of capital. However, this need not be the case in general: As we will see next, the effect of a change in the cost

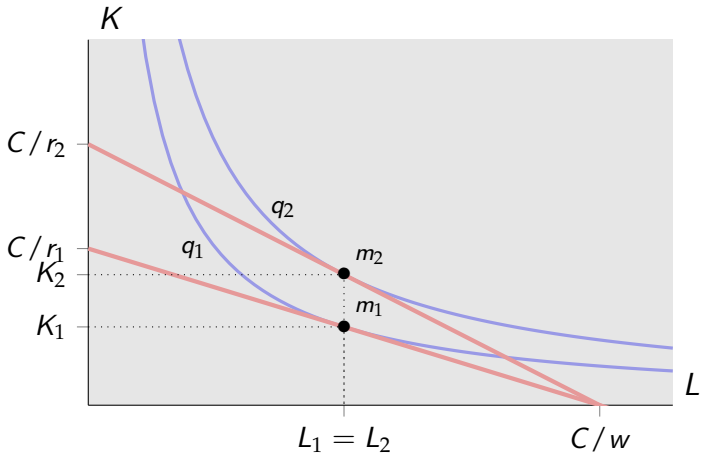


FIGURE 5.7
Lower cost of capital

of capital on the use of labor as a production input depends greatly on the degree of substitutability between capital and labor, which in turn is reflected in the shape of the isoquant curves.

Consider first the extreme case when capital and labor inputs are perfect substitutes. For example, one supermarket checkout counter can be manned by either a person or an automatic checkout machine. The top panel in Figure 5.8 illustrates this case. As mentioned earlier, when inputs are perfect substitutes, isoquants are straight lines. Suppose that, initially, the cost of labor is given by w whereas the cost of capital is given by r_1. For a given level of total input costs C, we have an isocost line stretching from C/r_1 on the vertical axis (K) to C/w on the horizontal axis (L). Since the isoquants are straight lines, we do not have a tangency point as in previous cases. Rather, the optimal solution is a "corner" solution, in the present case given by input mix m_1. In other words, with input costs w and r_1, the firm minimizes cost (or maximizes output) by using labor as the only input. Suppose that the cost of capital drops from r_1 to r_2, as shown in the top panel of Figure 5.8. Then the optimal input mix remains the same. In fact, since the firm uses no capital inputs, the change in the cost of capital has no effect on cost level or output level. However, there is a threshold level of the cost of capital beyond which the firm completely flips its input choice from all labor and no capital to all capital and no labor. For example, if the cost of capital is given by r_3 then, with the

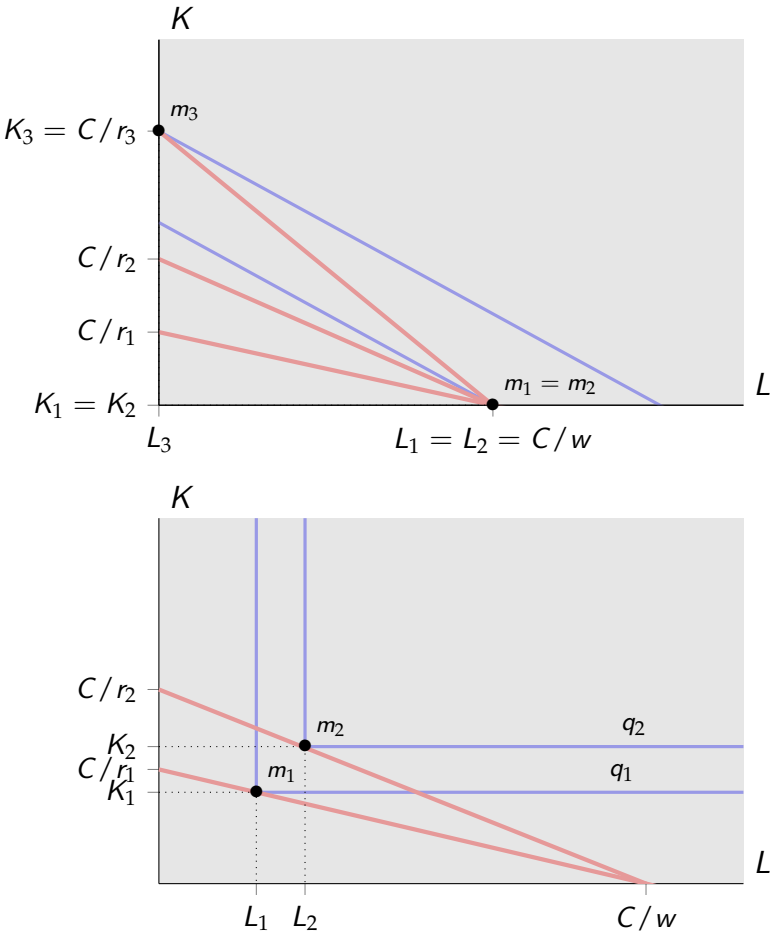


FIGURE 5.8
K and L: perfect substitutes (top) and perfect complements (bottom)

same total input budget C, the firm is able to produce a higher output level by using only capital than by using only labor. (Can you determine the level of cost of capital at which the firm flips its input mix?)

Consider the opposite extreme: perfect complements. For example, the operation of an MRI machine requires three technicians and this proportion is not flexible. The perfect complements case is illustrated in the bottom panel of Figure 5.8. Initially, the cost of labor is w and the cost of capital is r_1. For a given level of total input costs C, we have an isocost line stretching from C/r_1 on the vertical axis (K) to C/w on the horizontal axis (L). Since the isoquants are L shaped, we do not have a tangency point as in previous cases. Rather, the op-

Box 5.1: Delivery drones

In October 2019, United Parcel Service (UPS) was awarded a certification that allows it to use drones on medical campuses. The certification allows UPS to fly drones beyond the visual line of sight in order to deliver health care supplies to various hospitals. UPS hopes this will be the first step to being able to deliver to homes and rural areas. According to UPS, delivery by drone is cheaper than the cost of a person driving a car.

The FAA has already granted a certificate to Wing, the drone-delivery unit of Google. However, the two certifications are different. Wing is allowed to use only one pilot and one drone at a time, while UPS is allowed to use several pilots and numerous drones simultaneously. Other countries have also begun drone deliveries of vital medical supplies. Zipline, for example, distributes blood in Rwanda using drones, whereas Swoop Aero delivers vaccines and other medical supplies in the Pacific.

What impact will drone technologies have on jobs? As often is the case, the most likely scenario is that the new technologies will both destroy jobs and create new jobs. Specifically, many truck delivery operations will be discontinued, and so many truck drivers will lose their jobs. At the same time, many drone driving jobs will be created.

timal solution is at the kink of the L-shaped isoquant, that is, input mix m_1. In other words, with input costs w and r_1 the firm minimizes cost (or maximizes output) by using the fixed proportion of labor and capital given by the equipment's requirements. Suppose that the cost of capital drops to r_2. The isocost line corresponding to total cost C pivots around the L-axis intercept, that is, the L axis intercept remains constant, whereas the vertical intercept is now given by C/r_2. As the bottom panel of Figure 5.8 illustrates, the new optimum for a firm with an input budget C corresponds to input mix m_2. Although input levels are different, the proportion of capital and labor remains the same, that is, it remains at the proportion required by the equipment's requirements. We thus conclude that a drop in the cost of capital leads to both a greater use of capital and a greater use of labor.

The two panels in Figure 5.8 correspond to extreme situations. If

inputs are perfect substitutes, then a decrease in the cost of capital will eventually lead to a drop in the use of labor inputs — in fact, a rather drastic drop from labor-only production to capital-only production. At the opposite end, if inputs are perfect complements, then a decrease in the cost of capital leads to greater use of both capital and labor inputs. Generally speaking, when we talk about the impact of a new technology on jobs, this is the critical question that needs to be addressed: to what extent is the new technology a substitute or a complement to labor inputs. We next turn to a particularly important type of new technology, Artificial Intelligence (AI).

AI, ROBOTS AND JOBS

The above discussion on the relation between capital and labor inputs might be summarized as follows:

> *The impact of technology on jobs depends largely on the degree of substitutability between capital and labor inputs.*

What does this all imply regarding the impact of AI and robots on employment? The first general point is that one cannot generalize: In some cases, new AI technologies are a complement to labor, thereby increasing labor demand and labor productivity. For example, medical support systems allow doctors to treat more patients and to do a better job with each patient (i.e., reach a quicker and more accurate diagnosis). In other cases, robots are clearly labor substitutes, thereby eliminating jobs. For example, supermarket checkout machines, ATM machines, and production-line robots are nearly perfect substitutes for labor.

But even when new technologies replace existing jobs it's not clear that, overall, they create unemployment. If history is a good indicator, technological progress leads to the elimination of jobs but not to an increase in the unemployment rate. The reason is that new jobs are created as old jobs are destroyed. This is not a universally accepted opinion, I should add. Albert Einstein, for example, believed that the massive increase in unemployment during the Great Depression was largely due to the increase availability of capital. In 1933 he stated that

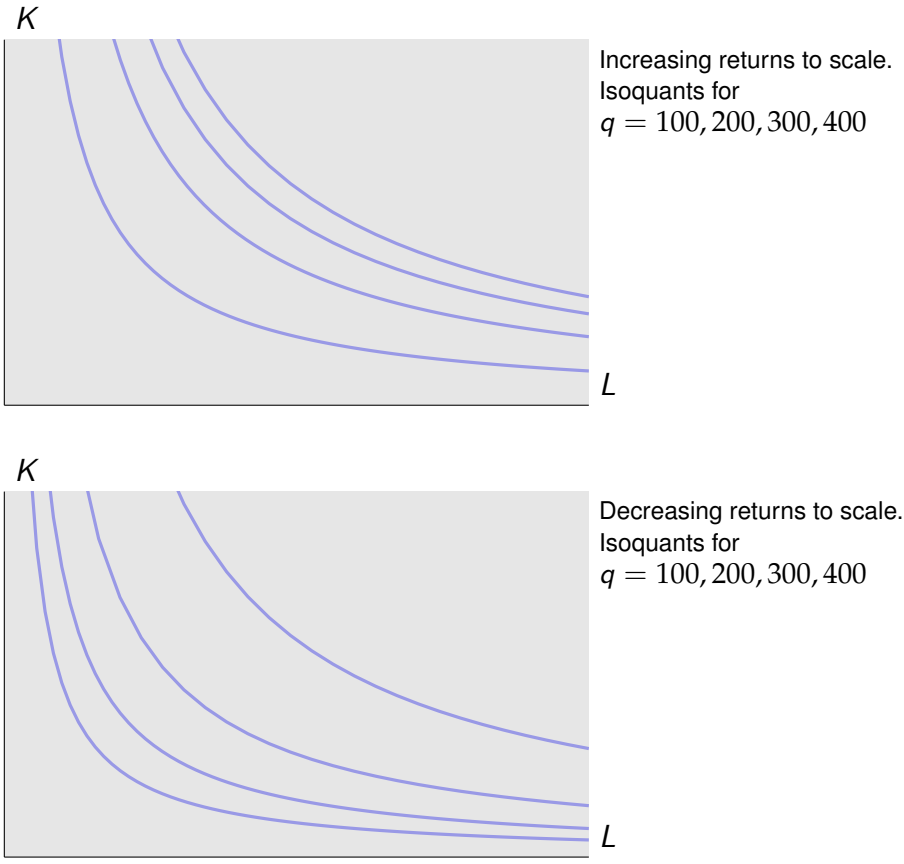


FIGURE 5.9
Returns to scale: increasing returns to scale (top) and decreasing returns to scale (bottom)

> It cannot be doubted that ... the improvement in the apparatus of production through technical invention and organization has decreased the need for human labor, and thereby caused the elimination of a part of labor from the economic circuit.

In my opinion, Einstein was better at physics than at economics.

RETURNS TO SCALE

Earlier in this chapter (and in Chapter 3), we introduced the law of decreasing marginal returns: as you add more of a given input, you typically get a lower and lower additional output. One of the rea-

sons for this pattern is that we are holding all other factors constant. Try, for example, adding more and more cooks (labor input) into one single kitchen (capital input).

What if we change *all* inputs at the same time, and in the same proportion? The answer to this question characterizes a firm's **returns to scale**. There are basically three different possibilities: increasing, constant, or decreasing returns to scale.

We say that a production function exhibits **increasing returns to scale** (IRS) if, when input levels are doubled, output more than doubles. In terms of isoquants, this implies that isoquants corresponding to constant output increases are "closer" at higher quantities of both inputs. This is illustrated in the top panel of Figure 5.9.

Firms subject to IRS are able to produce large output levels at a low cost. This implies that one firm in isolation is more efficient at producing a given output level q than many firms producing smaller output levels q' that add up to q. This situation is referred to as **natural monopoly**. One example of natural monopoly is given by electric utilities. For example, Wolf Creek Generating Station, the sole nuclear power plant in Kansas, has a capacity of 1,200 MW. The total cost of offering this capacity would be greater if instead of one plant we had two plants each supplying 600 MW, or twelve plants each supplying 100 MW.

What causes IRS? One first factor is the presence of indivisibilities: some factors of production are only available in large sizes. For example, it's difficult if not impossible — but certainly uneconomical — to produce a small nuclear power plant. Another source of IRS is given by specialization (already discussed in Section 1.2). As production scale increases, workers can specialize and focus on tasks that match their skills. Also, firms can use specialized machinery. Can you think of examples?

The opposite of increasing returns to scale is — you guessed it — decreasing returns to scale. We say that a production function exhibits **decreasing returns to scale** (DRS) if, when input levels are doubled, output increases by a factor of less than 2. In terms of isoquants, this implies that isoquants corresponding to constant output increases are "farther apart" at higher quantities of both inputs. This is illustrated in the bottom panel of Figure 5.9.

What causes DRS? An important factor is what we might refer to as **management complexity**. Suppose that GE increases by ten-fold

in number of plants, lines of business, etc. Even a great CEO like Jack Welch would have a hard time managing such a gigantic firm. A similar problem is the difficulty of communicating through larger organizations and the emergence of "corporate red tape", as I may attest based on my experience as a GM intern. Similarly, if Boeing wanted to double its size to scale it would need to double all inputs, including specialized engineers, some of which are very hard to find.

Finally, it can also be the case that, as we double a firm's inputs, its output exactly doubles. We refer to this case as **constant returns to scale** (CRS). In terms of the isoquant map, this is the case when isoquants corresponding to a constant output increment are equidistant.

PRODUCTIVITY

The term **productivity** is used frequently to describe a firm's performance or the performance of its production factors. Unfortunately, it means different things to different people and as a result the term productivity may be a source of confusion.

One first important concept is that of average labor productivity, or simply **labor productivity**. This is defined by $q\,p/L$, where q is number of units produced, p is the price at which each unit is sold, and L is the number of workers. For simplicity, suppose that price is equal to 1, that is, $p = 1$ (in the next section we deal with the issue of product pricing). Then labor productivity is simply q/L. Consider the firm's production function corresponding to the top panel of Table 5.3. (This is the same as Table 5.2, and is reproduced here for your reading convenience.) If the firm has $K = 2$ units of capital and employs $L = 4$ units of labor, then labor productivity is given by $282/4 = 70.5$. Were the firm to increase labor inputs to $L = 5$ units of labor, labor productivity would fall to $316/5 = 63.2$. You should have expected labor productivity to decline. As we have seen before, declining MP implies declining AP, and when we fix the quantity of one input (e.g., capital), the marginal product of any other input declines as we use more of it.

A second important property of labor productivity is that it is increasing in K. For example, if we keep labor inputs at $L = 4$ but increase K from 2 to 3, then labor productivity increases from 70.5 to $346/4 = 86.5$ This is important: as we compare labor productivity

TABLE 5.3
Two production functions with different levels of total factor productivity

$K \downarrow L \rightarrow$	1	2	3	4	5	6
1	100	141	173	200	223	244
2	141	200	244	282	316	346
3	173	244	300	346	387	423
4	200	282	346	400	447	489
5	223	316	387	447	500	547
6	244	346	423	489	547	600

$K \downarrow L \rightarrow$	1	2	3	4	5	6
1	200	282	346	400	446	488
2	282	400	488	564	632	692
3	346	488	600	692	774	846
4	400	564	692	800	894	978
5	446	632	774	894	1000	1094
6	488	692	846	978	1094	1200

across firms or across sectors, we must take into account the relative levels of capital in each firm or sector. Even if we were to correct for inflation and other relevant factors, we would likely find that average labor productivity at a Tesla factory in 2020 is substantially higher than average labor productivity at a Plymouth factory in 1960. It's not so much the fact that Tesla workers are more skilled than Plymouth workers or that Tesla is better managed than GM (Plymouth's parent company), rather that Tesla workers are combined with substantially more capital in 2020 than Plymouth workers were in 1960.

In this sense, a better measure of firm performance is how well it does *with a given set of production factors*. Suppose that the bottom panel of Table 5.3 corresponds to a different firm producing the same product as the top panel. A firm that works according to the top production function and employs 2 units of labor and 3 units of capital produces an output of 244. With the same inputs ($K = 3, L = 2$), the firm operating according to the bottom production function produces an output of 488, twice as much as the firm on the top panel.

We would then say that the bottom firm's total factor productivity is twice that of the top firm's. Specifically, **total factor productivity** (TFP) measures a firm's efficiency in the use of production inputs: it measures how much output a firm produces relative to other firms *controlling for input levels*.

These definitions and distinctions are important for a variety of reasons. For example, in Chapter 13 we will talk about international migration as a source of economic opportunity. Typically, workers in developing countries move to developed countries with a view to improve their economic condition. In terms of production functions, developed countries differ from developing countries in two ways. First, developed countries have a greater abundance of capital. Second, developed country firms tend to have greater total factor productivity. A simplified description of a firm in a developing country would be the blue cell in the top panel of Figure 5.3, whereas a firm in a developed country would correspond to the red cell in the bottom panel. The same worker in the developed country has a much higher average and marginal productivity, partly because of the capital mix difference, partly because of the difference in TFP. You can see the attractiveness of migrating to a developed country.

5.3. OUTPUT LEVEL AND PRICE

So far we have been looking at a firm's decisions regarding its inputs, in particular how to optimally combine inputs in order to produce a certain output level and minimum cost. But how should a firm determine its output level? Assuming that the firm faces a given downward-sloping demand that relates price and demand for the firm's output, we can rephrase the problem as: How should a firm determine its price? In this section we focus on the problem of optimal choice of price (or output level).

ICE-CREAM PRICING

Consider a specific numerical example, in fact, one that is, as they say in Hollywood, "inspired by true events." Rui, a young undergraduate economics major, once got a summer job selling ice-cream in Philadelphia. (There was such a student. He took my microeco-

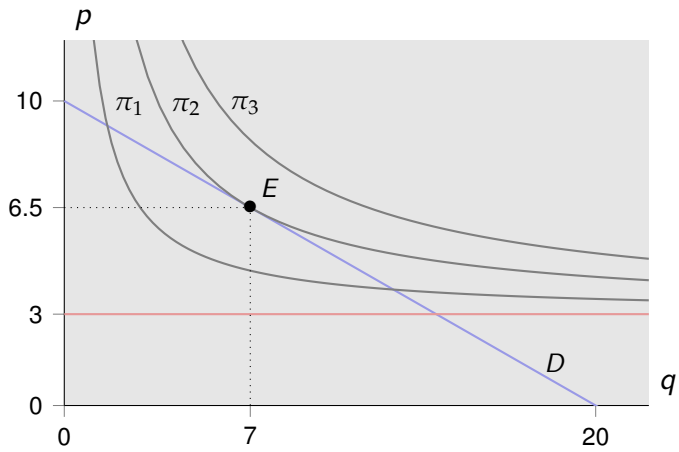


FIGURE 5.10
Optimal choice between p and q

nomics class. After returning from Philly, he told me how very useful the microeconomics class had been when selling ice-cream. So — pay attention to what comes next!)

Rui operates his truck in a specific neighborhood of Philly, where he is the only vendor. After a few days of experimenting with different prices, Rui estimates that demand is given by $q = 20 - 2\,p$, where q is quantity demanded and p is price. We will go through the details of consumer demand in Chapter 6. For now, suffice it to say that the demand curve faced by a firm relates the price it sets to the quantity demanded by consumers, that is, the maximum number of units the firm is able to sell at that price. We can also express the demand curve in inverse form. In the present case, inverse demand is given by $p = 10 - q/2$ (which is equivalent to $q = 20 - 2\,p$ solved for p). Figure 5.10 illustrates the ice-cream demand curve faced by Rui. Rui's costs are as follows. Each hour he must pay $F = \$15$ for the truck rental. In addition, he must pay the ice-cream factory $c = \$3$ per unit sold. (Think of a unit as a box of 12 ice-cream bars.)

Given all this information, the question at hand is: what price should Rui set? Suppose Rui wants to maximize profit, which is given by

$$\pi = (p - c)\,q - F$$

Figure 5.10 plots a series of three **isoprofit** curves. An isoprofit curve is like an indifference curve, with the difference that, instead of

Jake Cvnningham

Ice cream truck at Columbus Circle, New York. If you managed the truck, how would you price the ice cream?

consumer utility, it connects pairs (p, q) corresponding to the same profit level. Isoprofit curves are downward sloping like indifference curves. The idea is that a firm can increase profit either by increasing price or by increasing sales. In other words, price and output are substitute "inputs" in "producing" profit.

As in the previous chapters, we have a problem of constrained optimization. The firm's preference is to achieve an isoprofit curve as far from the origin as possible. The firm's constrain is that its choice of p and q must fall on the demand curve. In other words, the demand curve corresponds to the frontier of the firm's feasible set.

As in the previous chapters, the firm's optimal choice corresponds a point where an isoprofit curve is tangent to the demand curve. In Figure 5.10, this corresponds to point E with coordinates $q = 7$ and $p = 6.5$. Also as in the previous chapters, the firm's optimal choice is given by the equality $MRT = MRS$. What do these rates correspond to in the present case? The marginal rate of transformation is nothing but the slope (in absolute value) of the inverse demand curve, that is, $|\Delta p/\Delta q|$. The slope of the demand curve indicates the trade-off that the firm must face when balancing a price target with a sales target. If the firm wants to increase price, then it must accept selling a lower output level. Conversely, if the firm sets a higher sales target (that is, a higher value of q) then it must also set a lower price to go with it.

The firms's marginal rate of substitution is a little more difficult to understand. The value of MRS indicates how much of a price decrease the firm is willing to accept in exchange for a one-unit increase in quantity sold. Since $\pi = (p - c)\, q - F$, when the firm increases q by one unit its profit increases by $p - c$. For example, suppose that

current price is $p = \$8$, unit cost $c = \$3$, unit sales $q = 4$, and fixed cost $F = \$15$. Then profit is given by $(8-3) \times 4 - 15 = 5$. Suppose q were to increase by one unit to $q = 5$. Then profit would increase to $(8-3) \times 5 - 15 = 10$, an increase of $5 = 8 - 3 = p - c$. Moreover, when the firm decreases p by one unit its profit declines by q. Continuing with the same numerical example, if p drops from $p = 8$ to $p = 7$ (and keeping q constant), profit drops from 5 to $(7-3) \times 4 - 15 = 1$, that is, profit drops by $5 - 1 = 4 = q$.

Putting it all together, we conclude that the firm's marginal rate of substitution is given by $MRS = (p-c)/q$. The greater the price-cost margin, that is, the greater $p - c$, the more the firm is willing to increase q and lower p (steeper isoprofit curve). Conversely, the greater the current output level, q, the less the firm is willing to increase q and lower p (flatter isoprofit curve). Finally, we conclude that the rule for optimal price setting (MRT = MRS) is that

$$\left|\frac{\Delta p}{\Delta q}\right| = \frac{p-c}{q}$$

or alternatively

$$\frac{p-c}{q} = \frac{1}{\left|\frac{\Delta q}{\Delta p}\right|} \tag{5.1}$$

In words, if demand is very sensitive to price changes (that is, if the slope $|\Delta q/\Delta p|$ is very high), then the seller optimally chooses a low margin $p - c$ (for a given value of q). This is intuitive: if a small price decrease leads to a large demand increase, then the seller should decrease price and enjoy the large Δq benefit at a relatively low cost from decreasing p by Δp.

Figure 5.11 illustrates this idea. Specifically, we consider two different demand curves. Demand curve D_1 is relatively flat. This means that quantity demanded is very sensitive to price changes: a small change in price leads to a large change in quantity demanded. (This may seem a little confusing: Usually we think of a flat function as one where the dependent variable is not very sensitive to changes in the independent variable. The source of confusion is that sometimes we consider p the dependent variable but most times we consider q, the variable on the x axis, as the dependent variable. If you are furious about this, please don't blame me, blame Alfred Marshall, whose idea it was to represent p on the vertical axis. That said,

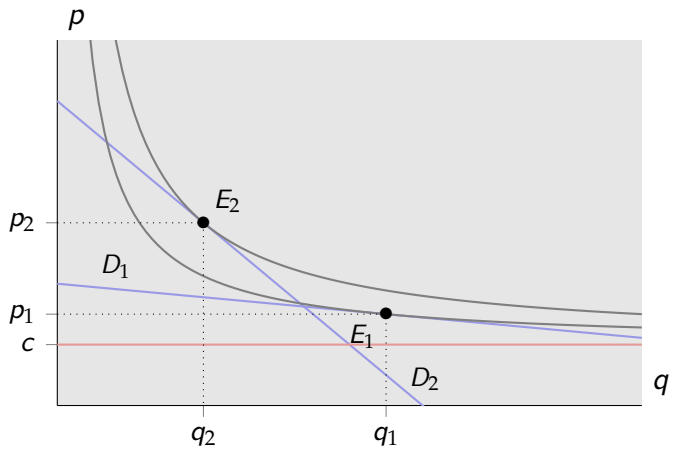


FIGURE 5.11
Demand sensitivity to price and optimal price

as we will see in Chapters 6 and 7, there is a "method" to Marshall's "madness".) In contrast to D_1, demand curve D_2 is relatively steep. This means that quantity demanded is not very sensitive to price changes: a small change in price leads to a small change in quantity demanded. As Figure 5.11 shows, optimal price is higher when demand is given by D_2, that is, when demand is less sensitive to price changes.

MARGINAL REVENUE AND MARGINAL COST

"There is more than one way to peel an orange," so they say, and this particular "orange" (optimal pricing) is sufficiently important to warrant additional approaches. Based on the information regarding demand and costs, Rui assembles the values listed in Table 5.4. The first two columns correspond to the demand curve $q = 20 - 2\,p$ (for a series of values of p). The third column shows total revenue for each price. This is simply price times quantity (first column times second column). The fourth column shows total cost: 15 plus 3 times the number of units sold (as given by the second column). The fifth and sixth columns will be discussed in detail below. Finally, the seventh column shows profit, the difference between the third and the forth columns.

Given all this information, what price should Rui set? Before continuing, notice that, since price and output are related by the de-

TABLE 5.4
Ice-cream pricing example

price	demand	total revenue	total cost	marginal revenue	marginal cost	profit
10.0	0.0	0.0	15.0			-15.0
9.5	1.0	9.5	18.0	9.5	3.0	-8.5
9.0	2.0	18.0	21.0	8.5	3.0	-3.0
8.5	3.0	25.5	24.0	7.5	3.0	1.5
8.0	4.0	32.0	27.0	6.5	3.0	5.0
7.5	5.0	37.5	30.0	5.5	3.0	7.5
7.0	6.0	42.0	33.0	4.5	3.0	9.0
6.5	7.0	45.5	36.0	3.5	3.0	9.5
6.0	8.0	48.0	39.0	2.5	3.0	9.0
5.5	9.0	49.5	42.0	1.5	3.0	7.5
5.0	10.0	50.0	45.0	0.5	3.0	5.0
4.5	11.0	49.5	48.0	-0.5	3.0	1.5

mand curve (as shown in the first two columns of Table 5.4), choosing the optimal price is equivalent to choosing the optimal output level. That is, even though the seller is assumed to set price and consumers choose quantity as a function of price, we can think of the seller as choosing the optimal quantity it wants consumers to buy and then setting the corresponding price. In what follows, we treat the seller's decision as that of selecting an output level. Note also that, given the particular demand curve we consider, the sequence of declining prices in Table 5.4 corresponds to output increasing by units of 1 from row to row. This need not always be the case, but it makes our life considerably easier.

So, to rephrase the earlier question: what level of unit sales should Rui optimally target? Economists like to think about these questions by reasoning in terms of incremental, or marginal, decisions (cf Section 2.3). Specifically, let us first ask the question: is it better to sell one unit than to sell none (assuming the truck rental fee has already been paid)? Is it better to be in the first row (price equal to 10, zero sales), or the second one (price equal to 9.5, one unit of sales)?

In order to answer this question, we compute marginal revenue and marginal cost. The value of **marginal revenue** is shown in the fifth column of Table 5.4. For example, when setting price at 9.5,

Rui is able to sell one unit. Compared to selling zero units (price equal to 10), this corresponds to a marginal revenue of 9.5, which is the difference between 9.5 (total revenue from selling one unit) and 0 (total revenue from selling no units). By the same token, the marginal revenue from selling 3 units instead of 2 is equal to $7.5 = 25.5 - 18$; and so forth. Similar to marginal revenue, we can also compute the values of marginal cost. Specifically, the marginal cost of selling one unit is given by $3 = 18 - 15$. As can be seen in Table 5.4, this is also the marginal cost for all other units. (We will return to the important concept of marginal cost in Chapter 6.)

How do the concepts of marginal revenue and marginal cost help determine the optimal sales target? When considering the choice between selling zero units and selling one unit, Rui compares a marginal revenue of 9.5 with a marginal cost of 3. Since 9.5 is greater than 3, it is better to sell one unit than to sell none.

Next we compare selling two units to selling one. The marginal revenue of the second unit is 7.5, whereas the marginal cost is only 3. Rui is therefore better off by selling two units than by selling only one. Continuing with this reasoning, we conclude that it is optimal to sell 7 units (by setting a price equal to 6.5). In fact, at this output level, a further increase to 8 would imply a marginal revenue of only 2.5, whereas the marginal cost would be 3.

The fact that a price of 6.5 and a sales target of 7 correspond to the optimal solution could also be gotten by simply looking at the rightmost column: the value of profit is maximal precisely where price equals 6.5. However, the marginal revenue versus marginal cost reasoning helps derive an important rule in economics: the level of output should be chosen so that the value of marginal revenue is as close to marginal cost as possible. The ice cream example is a bit special in that we must choose an integer output level. More generally, if we can choose a continuous value, then optimality implies that output level be chosen so that marginal revenue is equal to marginal cost.

At the optimal output level, marginal revenue equals marginal cost.

This may seem strange: if we want to maximize profit, then surely we want the difference between revenues and costs to be as high as possible. The solution to this apparent paradox is that one thing is

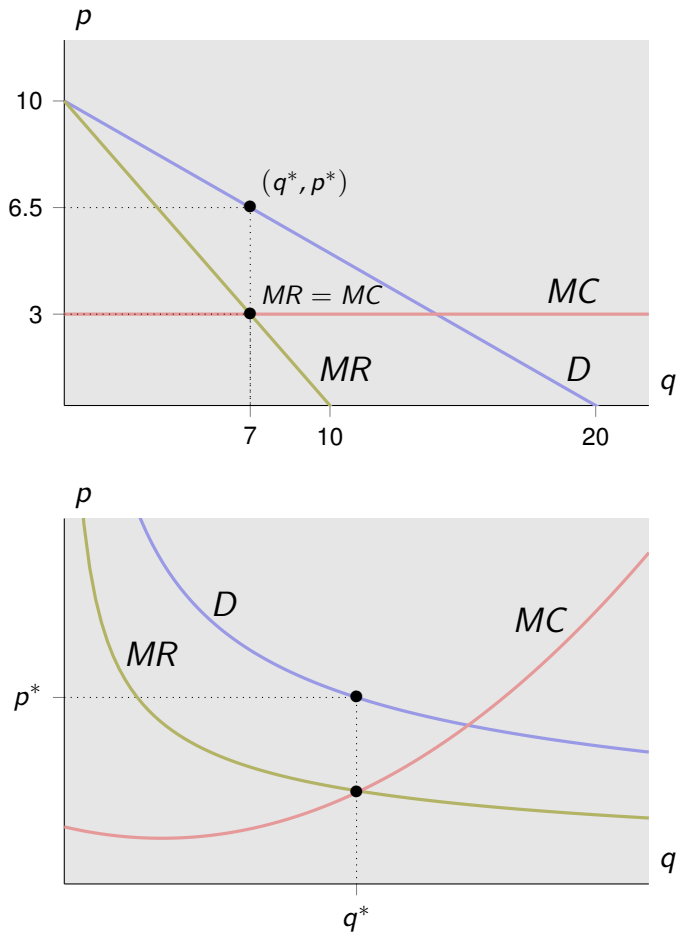


FIGURE 5.12
Optimal pricing: ice-cream case (top) and general case (bottom)

the difference between revenues and costs; and a different thing is the difference between marginal revenue and marginal cost.

Figure 5.12 illustrates the marginal revenue-marginal cost approach to optimal pricing. The demand curve and the marginal cost curves are the same as in Figure 5.10. The novel element in Figure 5.12 is the marginal revenue curve, which we plot from the values in Table 5.4. The value of q at which marginal revenue is equal to marginal cost is $q = 7$, the value we previously determined as the optimal choice of q. Once we have the optimal value of q, we can determine the optimal p by looking up the point on the demand curve corresponding to $q = 7$. As expected, we get $p = 6.5$.

The ice-cream example is a little special in that we assumed con-

stant marginal cost and a linear demand. The bottom panel on Figure 5.12 considers a more general case.

DEMAND ELASTICITY

How high a price should a seller set? It depends! Specifically, it depends on how sensitive demand is to price. We can see this in Equation (5.1), which shows that, for a given q, the higher the slope (in absolute value) of the demand curve, $|\Delta q/\Delta p|$, the lower the optimal margin $p - c$. More generally, optimal pricing requires the knowledge of how sensitive demand is to price changes. We next turn to this task.

Suppose that world oil demand decreases by 1.3 million barrels a day when price increases from \$50 to \$60 dollars per barrel (that is, the slope of the world oil demand is .13 million barrels per \$1 change in the oil barrel price). Would you consider the demand for oil to be very sensitive or not very sensitive to changes in price? Consider a second example: The demand for sugar in Europe decreases by 1 million tons per day when average retail price increases from €.80 to €.90 per kilo (that is, the slope of Europe's sugar demand is 10 million tones per €1 change in the price of a sugar ton). Would you consider the demand for sugar to be very sensitive or not very sensitive to changes in price?

You're reaction to these questions might be: I have no idea! There is a reason for this: most people have no idea whether a million barrels is a lot or not. More generally, it's hard to say if a given slope is large or small unless you are very familiar with the industry in question and the units with which p and q are measured. To make matters even more complicated, comparing the demand for sugar in Europe with the worldwide demand for oil in terms of price sensitiveness implies comparing apples and oranges (so to speak). Again, the problem is that, by measuring the slope of the demand curve, we are stuck with units: barrels, dollars, kilos, euros, and so on.

To address these concerns, economists frequently make use of the concept of **price elasticity of demand** (or simply elasticity), which is normally denoted by the Greek letter ϵ. Elasticity is defined as the percent change in demand divided by the percent change in price:

$$\epsilon = \frac{\%\ \Delta \text{ quantity}}{\%\ \Delta \text{ price}}$$

The percent change in q is given by Δq (the variation in q) divided by q (the value of q). Therefore,

$$\epsilon = \left(\frac{\Delta q}{q}\right) / \left(\frac{\Delta p}{p}\right) \tag{5.2}$$

Finally, we can rewrite this as

$$\epsilon = \left(\frac{\Delta q}{\Delta p}\right) \left(\frac{p}{q}\right) \tag{5.3}$$

Let us go back to the ice-cream example. From Table 5.4, we know that when $p = 6.5$ we get $q = 7$; whereas when $p = 6$ we get $q = 8$. Consider then a change in price from 6.5 to 6. In terms of the above notation, we get $\Delta p = 6 - 6.5$ and $\Delta q = 8 - 7$. Therefore, from (5.2) we can estimate the value of elasticity at $p = 6.5$ as

$$\epsilon = \frac{\frac{8-7}{7}}{\frac{6-6.5}{6.5}} = \frac{1 \times 6.5}{-0.5 \times 7} = -\frac{6.5}{3.5} \approx -1.86$$

In fact, we know from Figure 5.10 that $\Delta q / \Delta p = -2$ (when q drops from 20 to 0, p increases from 0 to 10). Therefore, we can also estimate the value of ϵ when $p = 6.5$ from Equation 5.3:

$$\epsilon = -2 \, \frac{6.5}{7} \approx -1.86 \tag{5.4}$$

Estimating the value of the price elasticity of demand effectively amounts to estimating the demand curve. As we will see in Section 6.2, this can be a tricky business. So, if someone gives you an estimate of ϵ, you should accept it with a healthy dose of skepticism.

Table 5.5 lists estimates of ϵ for various products. Notice that all values are negative, reflecting the fact that demand curves are (nearly always) downward sloping.

One note before we conclude this subsection: There is nothing in economic theory that implies a specific functional form for market demand. Commonly used functional forms include: (a) linear demand (slope is the same for all p but elasticity varies with p), and (b) constant-elasticity demand (elasticity is the same for all p but slope varies with p). Figure 5.13 illustrates these two possibilities.

TABLE 5.5
Examples of elasticity values

Product and market	Elasticity
Norwegian salmon in Spain	-0.8
Norwegian salmon in Italy	-0.9
Coffee in the Netherlands	-0.2
Natural gas in Europe (short-run)	-0.2
Natural gas in Europe (long-run)	-1.5
US luxury cars in US	-1.9
Foreign luxury cars in US	-2.8
Basic cable TV in US	-4.1
Satellite TV in US	-5.4
Ocean shipping services (worldwide)	-4.4

ELASTICITY GALORE

When we talk about elasticity *tout court* we mean the price elasticity of demand. However, there are other elasticity concepts that economists frequently consider. First, we have the **income elasticity of demand**, normally denoted by ϵ_y and defined as

$$\epsilon_y \equiv (\Delta q/q)/(\Delta y/y)$$

where y is income level. The elasticity ϵ_y measures the sensitivity of quantity demanded with respect to a change in consumer income (both measured as percent changes).

Second, we have the **cross-price elasticity of demand**, normally denoted by ϵ_{ij}, which is defined as

$$\epsilon_{ij} \equiv (\Delta q_i/q_i)/(\Delta p_j/p_j)$$

where i refers to good i and j refers to good j. The elasticity ϵ_{ij} measures the sensitivity of quantity demanded of good i with respect to a change in the price of good j (both measured as percent changes).

Economists have a plethora of names to classify products according to the values of the demand elasticities. Table 5.6 lists the main entries into this jargon set. First, based on the value of the price elasticity of demand, we say that a demand is elastic if the absolute value

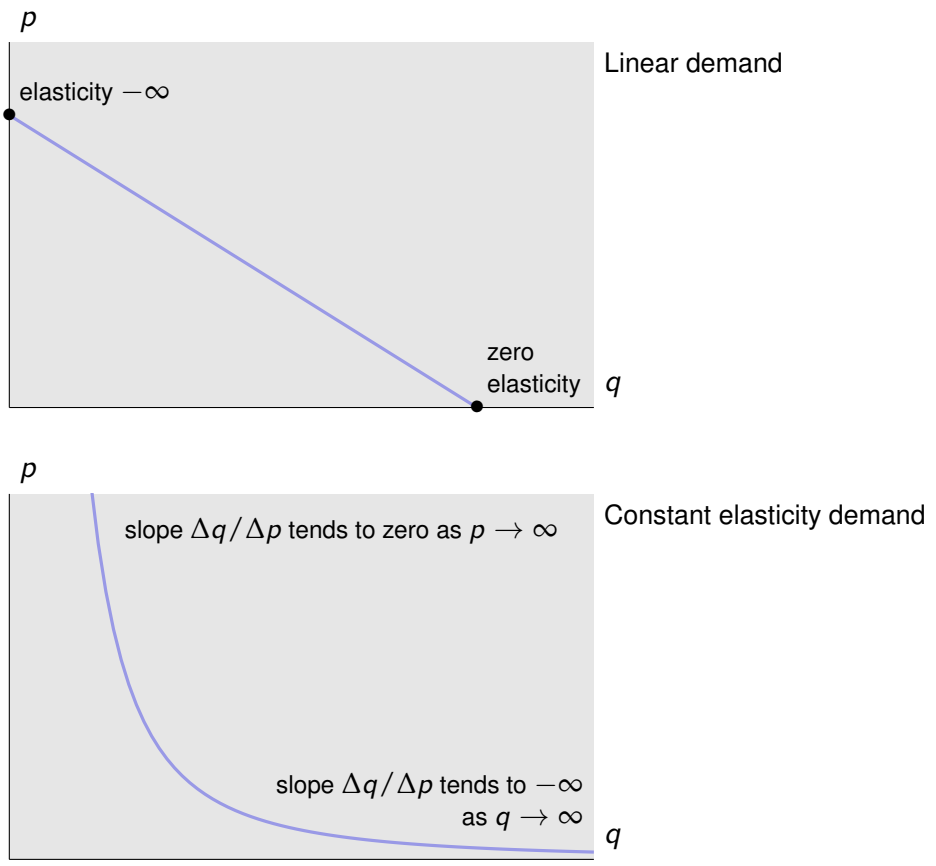


FIGURE 5.13
Linear demand (top) and constant-elasticity demand (bottom)

of the demand elasticity is greater than 1. Conversely, if the absolute value of the demand elasticity is less than 1 we say the demand is inelastic. As Table 5.5 suggests, an example of an elastic demand curve is cable TV, whereas coffee provides an example of an inelastic demand. However, since the value of elasticity may vary with price, it's possible that a demand is elastic for high price levels and inelastic for low price levels.

Before we move on to other elasticity concepts, a word of caution: Demand curves are typically downward sloping. For this reason, we sometimes use the absolute value of the price elasticity of demand. We then say that demand is elastic if "elasticity" is greater than one. Strictly speaking, this not correct. We should instead say that demand is elastic if the *absolute value* of elasticity is greater than one.

TABLE 5.6
Elasticity value and product characteristics
Notation: ϵ = price elasticity, ϵ_{ij} = cross-price elasticity, ϵ_y = income elasticity

condition	nature of demand
$\lvert\epsilon\rvert > 1$	demand is *elastic*
$\lvert\epsilon\rvert < 1$	demand is *inelastic*
$\epsilon_{ij} > 0$	goods *i* and *j* are *substitutes*
$\epsilon_{ij} < 0$	goods *i* and *j* are *complements*
$\epsilon_{ij} = 0$	goods *i* and *j* are *independent*
$\epsilon_y < 0$	the good is *inferior*
$\epsilon_y > 0$	the good is *normal*
$0 < \epsilon_y < 1$	the good is a *necessity*
$\epsilon_y > 1$	the good is a *luxury*

You should keep in mind that economists are not always very precise in this regard.

Regarding the cross-price elasticity, here are some examples to illustrate each possibility: Coke and Pepsi are substitute products; cars and tires and complement products; Firestone tires and Ben&Jerry ice cream are independent products.

Finally, with respect to the income elasticity of demand, two of the terms in Table 5.6 should be familiar from Chapter 4: A good is called an inferior good if consumers buy less of it when income increases. This implies that $\Delta q < 0$ following $\Delta y > 0$, which in turn implies ϵ_y is negative. Whether a good is normal or an inferior depends on the particular consumer and its income level. For most people, spam would be an example of an inferior good. Also, just as a given demand may be elastic for some price levels and inelastic for other ones, so the income elasticity of demand varies with income level. \$50 bottles of wine are a normal good for me. I dream of the day when my income is so high that \$50 bottles of wine will be an inferior good for me. Finally, as the name suggests, most goods are normal goods. For example, if your income increases you are likely to buy more trips to Hawaii, thus trips to Hawaii would be a normal good.

ELASTICITY RULES

Equipped with the concept of elasticity, we are now ready to revisit the problem of optimal pricing. Recall from Equation 5.1 that

$$\frac{p-c}{q} = \frac{1}{\left|\frac{\Delta q}{\Delta p}\right|}$$

Multiplying both sides by q/p (which is legit if $p > 0$) we get

$$\frac{p-c}{p} = \frac{1}{\left|\frac{\Delta q}{\Delta p}\right| \times \frac{p}{q}}$$

Since $|\Delta q/\Delta p| \times \frac{p}{q} = -\Delta q/\Delta p \times \frac{p}{q} = -\epsilon$, the above may be re-written as

$$\frac{p-c}{p} = \frac{1}{-\epsilon} \tag{5.5}$$

or simply

$$m = \frac{1}{-\epsilon} \tag{5.6}$$

where

$$m \equiv \frac{p-c}{p} \tag{5.7}$$

denotes the firm's **margin**. In words,

> *If a firm is pricing optimally, then its margin equals the inverse of the price elasticity (in absolute value).*

Figure 5.14 provides graphical intuition for the so-called **elasticity rule** given by (5.6). Consider a price change from p' to p'', that is, a price change of Δp. Since the seller's profit is given by $(p-c)\,q$, this price increase leads to a gain given by area G, which in turn is given by $\Delta p \times q''$. The price increase also leads to a decrease in sales, from q' to q''. This corresponds to a loss of $(p'-c) \times -\Delta q$, which corresponds to area L. We place a minus sign before Δq because, as price increases from p' to p'', quantity decreases from q' to q''. In this way, the area L, a positive value, corresponds to a profit loss.

The condition that the gain from a price increase is greater than the loss corresponds to $G > L$, which in turn is equivalent to

$$q\,\Delta\,p > (p-c)\,(-\Delta\,q)$$

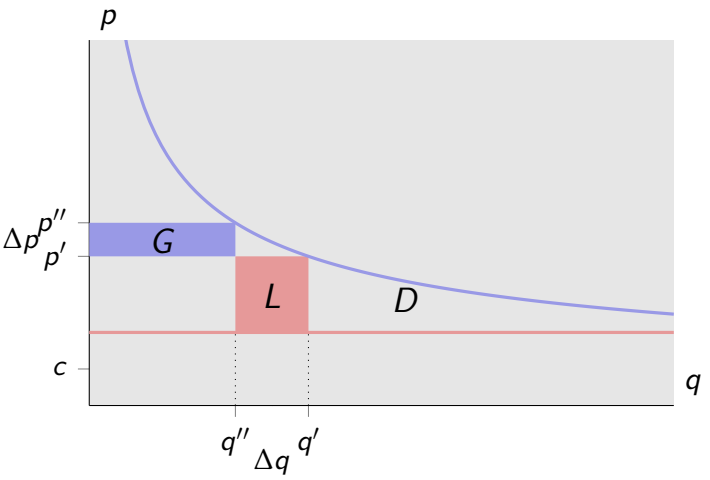


FIGURE 5.14
Optimal pricing: elasticity rule

This can be rearranged to get

$$-\frac{q}{p}\frac{\Delta p}{\Delta q} > \frac{p-c}{p}$$

and finally

$$m < 1/(-\epsilon)$$

In other words, the seller should increase the price if $m < 1/(-\epsilon)$. By a similar argument, the seller should decrease price if $m > 1/(-\epsilon)$. It follows that, if the seller is setting an optimal price, then it must be that $m = 1/(-\epsilon)$, the elasticity rule.

Let us return to the ice-cream pricing example. We didn't use the elasticity rule to find p^*, but nevertheless the elasticity rule holds at $p = p^*$ (and keep in mind that I underlined "at $p = p^*$"). In fact, at $p = 6.5$, margin is given by

$$m = \frac{6.5 - 3}{6.5} = .5385$$

As shown in Equation (5.4), at $p = 6.5$ elasticity is given by $-2 \times 6.5/7$. It follows that

$$\frac{1}{-\epsilon} = \frac{1}{-2 \times 6.5/7} = .5385$$

Bingo! We get the same .5385 value!

There are multiple ways of expressing the elasticity rule. One that can be particularly useful corresponds to re-writing Equation (5.6) through a series of steps:

$$\begin{aligned} \frac{p-c}{p} &= \frac{1}{-\epsilon} \\ p-c &= \frac{p}{-\epsilon} \\ p\left(1+1/\epsilon\right) &= c \\ p &= \frac{c}{(1+1/\epsilon)} \\ p &= \left(\frac{\epsilon}{1+\epsilon}\right) c \end{aligned} \tag{5.8}$$

This version of the elasticity rule is particularly helpful if, given the values of ϵ and c, we want to determine optimal p. All we need to do is to apply (5.8).

There are also multiple ways of expressing the difference between price and cost. Specifically, a common alternative to margin m is given by markup k, defined as

$$k \equiv \frac{p-c}{c} \tag{5.9}$$

The elasticity rule corresponding to the firm's markup is given by

$$k = \frac{1}{-\epsilon-1}$$

(Practice: derive this rule from Equation 5.6.)

As an illustration, consider the following example. A pharmaceutical company is launching a new drug which is protected by patent. It's estimated that the price elasticity of demand is constant and given by -1.5. The seller's cost is \$10 per 12-dose package (our unit of account). What's the profit-maximizing price? From (5.8), we get

$$p = \frac{-1.5}{1+(-1.5)} \times 10 = 3 \times 10 = 30$$

What are the values of margin and markup at the optimal price? From (5.7) and (5.9), we get

$$\begin{aligned} m &= \frac{30-10}{30} = \frac{2}{3} \\ k &= \frac{30-10}{10} = 2 \end{aligned}$$

respectively. Finally, let us check that the elasticity rules hold. From the right-hand sides of (5.6) and (5.8) we get

$$\begin{aligned} 1/-e &= 1/1.5 = \frac{2}{3} \\ 1/(-e-1) &= 1/(1.5-1) = 2 \end{aligned}$$

respectively. As expected, we get the values of m and k previously computed.

MARGINAL REVENUE AND MARGINAL COST (REPRISE)

Earlier we argued that, at the optimal output level, marginal revenue is equal to marginal cost. Marginal revenue is given by the revenue obtained from selling an additional output unit. We will now express marginal revenue in terms of the demand elasticity. If the firm increases output level by one unit, it receives a revenue of p from selling that additional unit. However, the firm must decrease price in order to increase sales by one unit. Specifically, the demand curve slope $\Delta p/\Delta q$ indicates how much price must change in order for q to increase by one unit. If the firm does change p by $\Delta p/\Delta q$, this implies a revenue loss of $q\,\Delta p/\Delta q$, that is, a price difference $\Delta p/\Delta q$ applied to all q units sold. Putting the two effects together, we conclude that marginal revenue is given by

$$MR = p + q\,\Delta p/\Delta q \tag{5.10}$$

Since $\Delta p/\Delta q < 0$, we conclude that $MR < p$, that is,

> *Marginal revenue is lower than price*

Graphically, we can see this in both panels of Figure 5.12.

Finally, the $MR = MC$ rule implies that

$$p + q\left(\frac{\Delta p}{\Delta q}\right) = MC$$

which is equivalent to

$$p - MC = -q\left(\frac{\Delta p}{\Delta q}\right)$$

which in turn is equivalent to (assuming $p \neq 0$)

$$\frac{p - MC}{p} = -\left(\frac{\Delta p}{\Delta q}\right)\frac{q}{p}$$

which corresponds to the previously derived Equation 5.5.

ADDITIONAL NOTES ON ELASTICITY AND PRICE

What if $-1 < \epsilon < 0$? Applying the elasticity rule (for example, Equation 5.8), we get a negative value for p, which does not make much sense (how does a firm maximize profit by selling its only product at a negative price?). Let's think about the economics of the situation. If ϵ is less than 1 in absolute value, then an increase in price leads to an increase in revenue: the decrease in quantity is very small compared to the increase in price. Since an increase in price implies a decrease in quantity (small as it may be), it also implies a decrease in cost (for cost is increasing in output). We thus conclude that, if ϵ is less than 1 in absolute value, then an increase in price leads to an increase in revenue and a decrease in cost; it thus leads to an increase in profit. It follows that, whenever $-1 < \epsilon < 0$, it is optimal for the seller to increase price. It can never be optimal for a seller to operate on a segment of its demand curve where $|\epsilon| < 1$, that is, where demand is inelstic.

In practice, we do observe goods with inelastic demand (see Table 5.5 for examples). Does this imply a violation of the elasticity rule? Maybe yes, maybe not. Consider for example ConEdison, the electrical utility serving New York City. Consumer demand for electricity is inelastic, that is, $-1 < \epsilon < 0$; still, ConEdison does not increase price as the elasticity rule would suggest. The reason is not that ConEdison would not want to increase price, rather that regulation prevents it from doing so.

Consider now the case of milk sold in Manhattan. This is another example of a good with inelastic demand. Absent price regulation, as in electricity supply, why isn't the price of milk higher? This time the reason is that, while the market price elasticity is less than 1 (in absolute value), the demand elasticity *faced by each seller* is considerably greater than 1 (in absolute value). In fact, to the extent that milk is a relatively homogeneous product, a small price increase by a small producer would reduce its demand to zero.

Finally, if the market demand for milk is inelastic, one might ask why don't milk sellers get together and jointly increase price (so that buyers have no alternative but to buy a similar quantity at a higher price). This time the reason is that such an agreement would most likely be illegal, as we will see in Section 8.2.

KEY CONCEPTS

production function | average product | marginal product | decreasing marginal returns | concavity | isoquant | marginal rate of technical substitution (MRTS) | perfect complements | Leontief production function | perfect substitutes | isocost | returns to scale | increasing returns to scale | natural monopoly | decreasing returns to scale | management complexity | constant returns to scale | productivity | labor productivity | total factor productivity | isoprofit | marginal revenue | price elasticity of demand | income elasticity of demand | cross-price elasticity of demand | margin | elasticity rule

REVIEW AND PRACTICE PROBLEMS

■ **5.1. AP and MP.** What is average product (AP)? What is marginal product (MP)?

■ **5.2. Alexei (reprise).** In Section 3.1, we derived Alexei's feasible set in the leisure-grade space. How does MRT in this context relate to the concept of marginal product introduced in Section 5.1?

■ **5.3. Diminishing marginal returns.** What is the law of decreasing marginal returns? What is the economic intuition for such a law?

■ **5.4. Kim's taco truck.** Kim owns a food truck which she usually parks near NYU. Each day, she must decide how many hours to work. Based on past experience, Kim estimates that the number of tacos sold is greater the greater the number of hours the truck is "open." Specifically, Table 5.7 shows the estimated relation.

TABLE 5.7
Kim's taco truck production function

Number of hours	Number of tacos
0	0
1	18.0
2	31.6
3	37.4
4	40.7
5	42.7
6	44.2
7	45.2
8	46.0
9	46.1
10	46.1

(a) For each value of hours open, determine Kim's average sales (i.e., number of tacos per hour) as well as Kim's marginal sales (tacos per additional hour).

(b) What is the relation between number of hours and marginal sales? What is the relation between marginal sales and average sales?

(c) Plot the values of hours (x) and number of tacos (y). Draw a line through these points. Is the relation between y and x linear, concave or convex? How do your answers relate to the questions in (b)?

(d) What is the economic meaning of the answers to (b) and (c)?

■ **5.5. Substitutes vs complements inputs.** Consider the following production processes. In each case, indicate if inputs are closer to perfect substitutes or closer to perfect complements. Justify your answer.

(a) Pilots and planes in air travel services.

(b) Machines or human work used to dig earth in order to build a dam.

(c) Nebraska beef or Texas beef used in making burgers.

(d) Shovels and workers digging a hole.

■ **5.6. Isoquants and indifference curves.** What is the relation between isoquants and indifference curves?

■ **5.7. Marginal rate of technical substitution.** What is the marginal rate of technical substitution?

■ **5.8. Optimal input mix.** What is the condition for an optimal input mix? What is the economic intuition for this condition?

■ **5.9. Input mix.** Figure 5.15 illustrates a firm's input mix choice.

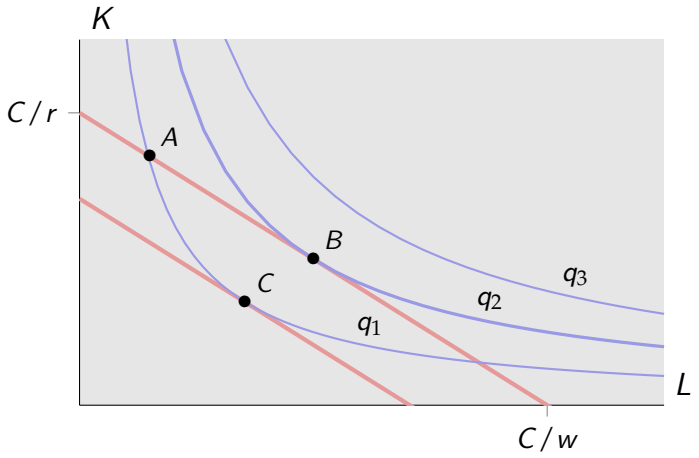


FIGURE 5.15
Optimum input mix (top) and cost minimization (bottom)

(a) Explain the intuition for convex isoquant curves.

(b) Suppose the firm is currently at point *A*. Making reference to the figure, show that, with respect to *A*, the firm can produce more output with the same cost or spend less in order to produce the same output level.

(c) What is value of marginal rate of technical substitution (MRTS) when the firm chooses an optimal input mix?

■ **5.10. Radiology services.** Given the current knowledge of AI applied to radiology, the following combinations of radiologists and annual spending in AI (in $ million) lead to an output level of 15,000 tests per year: (5,0), (3,1), (2,2), (1,4).

(a) Plot these points on a graph with # radiologists on the horizontal axis and AI spending on the vertical axis. Assuming that intermediate input combinations (e.g., 30% of (5,0) and 70% of (3,1)) are possible and lead to the same output level as the adjacent points, draw the isoquant corresponding to an output level of 15,000. (In other words, connect the points to produce the isoquant.)

(b) Suppose that a radiologist costs \$700,000 per year (including benefits). What is the cost-minimizing combination of radiologists and AI spending to achieve $y = 15,000$?

(c) Plot the isocost curve that passes through the optimal point derived in the previous answer. To do so, notice its slope (in absolute value) is given by the ratio of price of radiologists (\$.7 million) and "price" of AI spending (\$1 million per million of expenditure). Notice also that the isocost line in question must pass through the point derived in the previous answer.

(d) Show that the cost-minimizing combination corresponds to the point where the slope of the isoquant is closest to the slope of the isocost curve.

■ **5.11. Technology and jobs.** Whether a new technology decreases or increases employment in a given industry depends largely on the nature of the technology. Explain.

■ **5.12. Technology and unemployment.** Historically, new technologies have destroyed jobs, but technical progress has not increased the unemployment rate. Comment.

■ **5.13. Returns to scale.** When do we say that a production function exhibits increasing returns to scale?

■ **5.14. Migration.** When a worker with a certain skill level migrates from a developing country to a developed country, his marginal productivity increases (as does his salary). How do the production functions in Table 5.3 help understand this phenomenon?

■ **5.15. Kabral's.** Kabral's is a famous fast-food chain. It has been estimated that if Kabral's were to double all of its inputs it would be able to produce more than twice the current output level. However, it has also been observed that, when increasing the labor force (one of the various inputs), the additional output created by each new

worker is lower and lower.

(a) What do we call these properties of Kabral's production function?

(b) Can the above two properties hold for the same production function?

■ **5.16. Returns to scale.** Consider the production function represented in Table 5.2.

(a) Does this production function exhibit increasing, decreasing or constant returns to scale?

(b) Does the production function exhibit decreasing marginal returns?

■ **5.17. Ice cream.** Over the past years, the price of ice cream has varied between \$3 and \$6 per pound. Lisa's weekly expenditure on ice cream is higher in weeks when the price is lower. What can you say about Lisa's price elasticity of demand for ice cream?

■ **5.18. Netflix demand elasticity.** The price elasticity of demand for Netflix is -1.24. Is demand elastic or inelastic? Explain. Given this elasticity, if Netflix increases its price, will consumer expenditure also increase? Explain.

■ **5.19. T-Mobile.** It is estimated that, if T-Mobile were to increase the price of its basic plan by 10 percent, demand would decline by 20 percent. What is the value of the price elasticity of demand? Suppose that T-Mobile's current margin (price minus unit variable cost divided by price) is equal to 25 percent. What should T-Mobile do: increase price, decrease price, or keep it constant?

■ **5.20. Orange tail.** Suppose that Orange tail, an Australian-based vineyard, sells in two different markets: Australia and the US. It is estimated that the price elasticity of demand in the US is -4, whereas the price elasticity of demand in Australia is -2.

(a) Why would the value of the price elasticity of demand be higher (in absolute value) in the US?

(b) If Orange tail wants to maximize total profits, should the US price be higher or lower than the Australia price? (Hint: this is a trick question; the answer depends on the cost of producing and delivering to the US vis-à-vis the cost of producing and delivering to Australia.)

(c) Based on the previous answers, explain in words some of the main factors determining the relation between domestic prices and export prices.

■ **5.21. MCL.** MCL produces a small toy drone. Based on historical data, demand at two different price levels is estimated as follows: When $p = 10$, demand is given by $q = 35$. When $p = 11$, demand is given by $q = 28$.

(a) Determine the value of price elasticity of demand.

(b) Suppose that unit cost of production is $c = 2$ (and does not vary with output level). Assuming that the price elasticity of demand is constant, determine the profit-maximizing price.

(c) MCL is considering exporting to market M. Suppose that the transportation cost is negligible, so that the cost of serving market M is the same as the cost of serving the domestic market. The price elasticity of demand in market M is estimated to be -3. Determine the profit-maximizing export price.

(d) Assuming that MCL sets the domestic price so as to maximize profits, determine the domestic market margin (in percentage terms).

■ **5.22. Monsanto's Roundup™.** Roundup, the trademarked name of glyphosate, a chemical herbicide developed and patented in the 1970s, was Monsanto's leading product for decades. In the late 1990s, it became the best-selling agricultural chemical of all time and an enormously profitable product for the company. Glyphosate-based herbicides produced net sales for Monsanto of $2.4b in 2001 alone, nearly half the Mosanto's total.

This success was the result of several factors. One was a conscious strategy to reduce price in the US, where patent protection gave Monsanto an effective monopoly until September 2000. (Prices were lower outside the US, where patents expired earlier.) Between 1995 and 2000, Monsanto reduced the price by an average of 9% a year. When volume increased by an average of 22% a year, revenue and profits exploded. Table 5.8 displays the values of prices and unit sales, both in the US and overseas. Figure 5.16 plots the various time series.

Another factor in Roundup's success was the increasing popularity of conservation tillage, an environmentally friendly method of farming in which crops are planted without first plowing the fields. With less plowing, there is less loss of topsoil and moisture. The problem is weeds. Instead of plowing them under, farmers eliminate weeds before planting by applying a nonselective herbicide such as Roundup. Analysts suggest that conservation tillage is sensitive to the price of herbicides, an important component of its cost.

A third factor was the development of herbicide-tolerant crops. Monsanto's Roundup Ready corn was approved in 1998, and soybeans followed shortly thereafter. Monsanto argued that Roundup and Roundup Ready seeds were complementary products, with price reductions in one increasing demand for the other.

Even as patents expired, Monsanto was able to maintain high market shares. In Brazil, for example, Monsanto's patent expired in 1981, yet its 2001 market share was 81%. High market share, in turn, allowed Monsanto to exploit economies of scale and work its way down the learning curve.

(a) Provide an estimate of the US price elasticity of demand for Roundup. Be clear about the assumptions your estimate is based upon.

(b) Based on your estimate of the price elasticity of demand, do you think Monsanto's price decrease caused an increase in Monsanto's profits? (Hint: recall that profit equals revenue (i.e., $p \times q$) minus cost. You will have to make an assumption regarding the value of unit cost.)

TABLE 5.8
Roundup's price and sales (US and overseas)

	Price ($ per gallon)		Quantity (millions of gallons)	
Year	US	Overseas	US	Overseas
1995	45	21	13	25
1996	44	20	16	30
1997	40	18	20	40
1998	35	16	28	54
1999	33	15	33	64
2000	28	14	40	73
2001	25	15	45	72
2002	23	14	39	55

Source: Bear Stearns proprietary data, with thanks to Frank Mitsch.

(c) Monsanto has been selling Roundup for decades. If the price decrease did indeed cause an increase in profits, why didn't Monsanto do it before the mid-late 1990s?

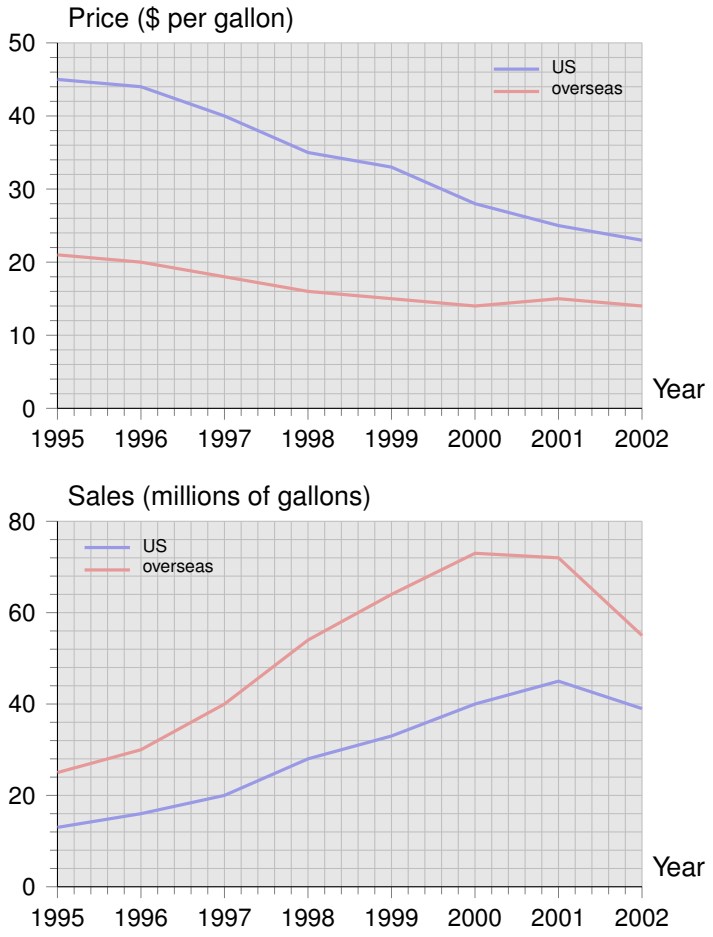


FIGURE 5.16
Roundup's price and sales (US and overseas)

Justin Watt

PART III

MARKETS

CHAPTER 6

SUPPLY AND DEMAND

In Chapter 2, we mentioned that economics is not just a behavioral science but also a social science. The behavioral element was patent in Part II of this book, devoted to the study of economic decision making. Parts III and IV introduce a different dimension of economics analysis, namely the study of the interaction between economic agents. In particular, Part III focuses on markets, the economic institution par excellence. We begin in this chapter with the study of firm and market supply, focusing first on the firm's cost function. Section 6.2 deals with the other side of supply and demand, focusing first on the important concept of consumer willingness to pay.

6.1. COST FUNCTION AND SUPPLY

Up until now, we have characterized a firm by its production function $F(K, L)$. A more frequent, alternative characterization is given by the firm's cost function. The firm's **cost function**, typically denoted by $C(q)$, shows the least total cost of inputs that the firm needs to pay in order to produce output q; that is, the cost of producing q assuming the firm does so efficiently. In other words, the cost function presupposes that the firm chooses its optimal input mix (see Section 5.2).

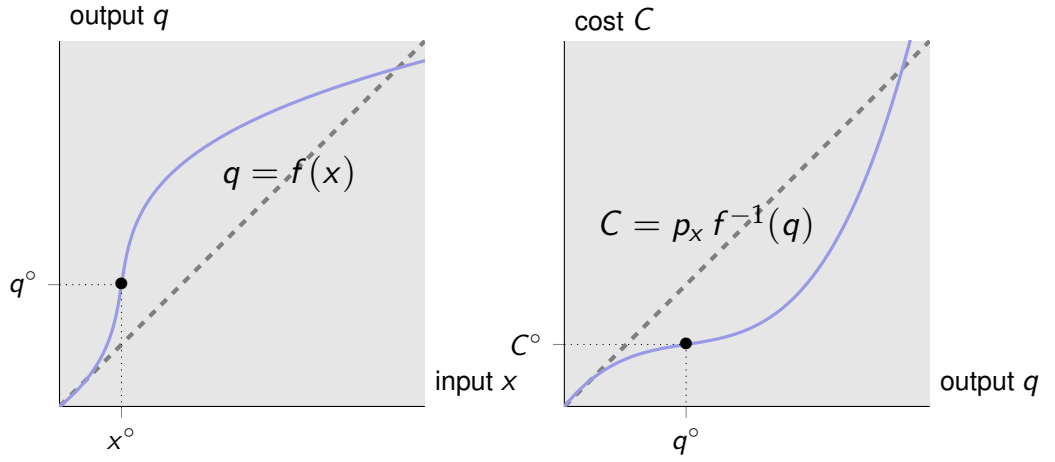


FIGURE 6.1
From production to cost function (assuming firm uses one input x which costs p_x per unit)

FROM PRODUCTION FUNCTION TO COST FUNCTION

In order to get a better idea of the relation between a firm's production function (introduced in Chapter 3) and its cost function, it helps to consider the one-input case. The left panel of Figure 6.1 depicts a firm's production function when there is one input x and one output y. In Chapter 3, we stressed that marginal product is typically declining, that is, the production function is concave. The top panel of Figure 6.1 considers a more general case, the case when, for low levels of x, the production function is convex.

The justification for the convex portion of the firm's production function is that at low levels of inputs (e.g., labor) an increase in input levels allows for efficiencies (e.g., division of labor) to the point that output increases more than proportionately with respect to input. For example, suppose that you need to dig up two holes on the sidewalk of Washington Square in order to fix a pipe. (If you were at NYU anytime from 2014–2019, this would have been a very common sight and we're glad we're done with it—knock on wood.) If only one worker (say, Flavio) is assigned to the job, then he is going to take a long time to do it: each time he fills a bucket inside the hole, he needs to come out of the hole and empty the bucket in a large container. Suppose however that there are two workers, Flavio and Anna. Then one of the workers (say, Anna) can stay outside of the

hole and take care of the job of carrying the bucket from Flavio and empty it in the large container. In this way each of the two workers specializes in one task and their joint contribution is greater than what they would accomplish if each were working separately.

While a production function may be convex for low levels of input, eventually the law of decreasing marginal product likely kicks in and the production function becomes concave, as shown on the top panel of Figure 6.1. Specifically, for $x > x^\circ$ we see that $f(x)$ is a concave function.

Since there is only one input, the cost function is relatively easy to derive. (Actually, not necessarily easy, but certainly easier than in the multiple-input case.) Suppose the firm wants to produce q units of output. Since $q = f(x)$, this requires $x = f^{-1}(q)$ input units, where f^{-1} is the inverse function of f. For example, if $q = \sqrt{x}$, then $x = q^2$, that is, $f(x) = \sqrt{x}$ and $f^{-1}(q) = q^2$.

Since the firm must pay p_x per input unit, it follows that the cost of output level q is given by $C(q) = p_x x = p_x f^{-1}(q)$. This cost function is plotted on the right panel of Figure 6.1. The shape of the inverse function f^{-1} corresponds to "flipping" f about the 45° line (the dashed line). Since C equals f^{-1} times a scalar (p_x), the shape of C is the same as the shape of f^{-1}. (In this particular case we assume $p_x = 1$ for simplicity. We can always change money units so that this is the case.)

Since C corresponds to flipping f about the main diagonal and f is convex for $q < q^\circ$, it follows that C is concave for $q < q^\circ$. Conversely, f is concave for $q > q^\circ$, whereas C is convex for $q > q^\circ$. In other words,

> *If a firm's one-input production function is concave (resp. convex), then the corresponding cost function is convex (resp. concave).*

In the multiple input case, the cost function is defined as the lowest cost the firm must incur in order to produce output q including all possible input combinations that lead to q. Specifically, consider the case when there are two inputs, K and L. Then we look for the lowest isocost curve that includes a point in the isoquant q^* (a specific value of q), as we did in Section 5.2. The cost level corresponding to such isocost is the value of $C(q^*)$. If we do so for every possible value q then we have the cost function $C(q)$.

The optimal input mix may vary as we vary the level of output q. For example, if you have a very small farm then it does not pay to own a tractor. If you have a very large farm, however, then the capital/labor mix is likely to tilt in the direction of capital intensity. In other words, when the firm's production function includes multiple inputs, the relation between the production function and the cost function is not as clear-cut as in the one-input case. However, the idea remains that, if the production function is concave, then the cost function is likely convex.

MARGINAL COST AND AVERAGE COST

As mentioned earlier, the firm's **cost function**, typically denoted by $C(q)$, shows the least total cost of inputs that the firm needs to pay in order to produce output q. In other words, $C(q)$ is the cost of producing q assuming that the firm does so efficiently. The cost function $C(q)$ leads to a series of related cost concepts:

- **fixed cost** (FC): the cost that does not depend on the output level.
- **variable cost** (VC) that cost which is not fixed.
- **total cost** (TC): the sum of fixed cost and variable cost.
- **average cost** (AC) (also known as "unit cost"): total cost divided by output level.
- **average fixed cost** (AFC): fixed cost divided by output level.
- **average variable cost** (AVC): variable cost divided by output level.
- **marginal cost** (MC): the cost of one additional unit. In other words, the total cost of producing $q+1$ units minus the total cost of producing q units of output.

Two notes before continuing. First, strictly speaking, the above definition of MC correspond to the concept of incremental cost. The rigorous definition of marginal cost is the *derivative* of total cost with respect to the output level. Second, in order to distinguish total cost from variable or fixed cost, sometimes we denote total cost by TC. In other words, TC is simply C. Similarly, in order to distinguish average total cost from average variable or average fixed cost, we

Neil Turner

Krispy Kreme doughnut factory. The shape of a firm's cost function depends on the shape of the firm's production function, which in turn depends on the technology that transforms inputs into outputs.

sometimes denote average total cost by ATC. In other words, ATC is simply AC.

The particular structure of a firm's cost function depends on its technology. Here are some examples:

- bagels: modest fixed cost (space), relatively constant marginal cost (labor and materials)
- electricity generation: large fixed cost (plant), initially declining marginal cost (large plants are more efficient, and many plants have startup costs)
- music CDs: large fixed cost (recording), small marginal cost (production and distribution)

As an example, Table 6.1 presents a specific cost function. For each output level (first column) the fourth column shows the total cost. This can be split into fixed cost (second column), that is, the portion of the cost that does not depend on output level, and variable cost (third column).

Marginal cost, as mentioned earlier, is given by the cost of one additional unit. Since we do not have the value of total cost unit by unit, we estimate marginal cost by dividing incremental cost by incremental output level. For example, we estimate the marginal cost at $q = 10$ to be given by $(39.2 - 30.0)/(10 - 0) = .92$. Strictly speaking, marginal cost is the derivative of cost with respect to output level, that is, it corresponds to an infinitesimal change in q. Also, as in other cases there is some arbitrariness in the choice of $C(q+1) - C(q)$ or $C(q) - C(q-1)$ as the difference we use in order to estimate marginal cost at q.

TABLE 6.1
Cost function

q	*FC*	*VC*	*TC*	*MC*	*AFC*	*AVC*	*ATC*
0	30	0.0	30.0				
10	30	9.2	39.2	0.92	3.0	0.92	3.92
20	30	14.8	44.8	0.56	1.5	0.74	2.24
30	30	20.4	50.4	0.56	1.0	0.68	1.68
40	30	29.6	59.6	0.92	0.75	0.74	1.49
50	30	46.0	76.0	1.64	0.6	0.92	1.52
60	30	73.2	103.2	2.72	0.5	1.22	1.72
70	30	114.8	144.8	4.16	0.43	1.64	2.07

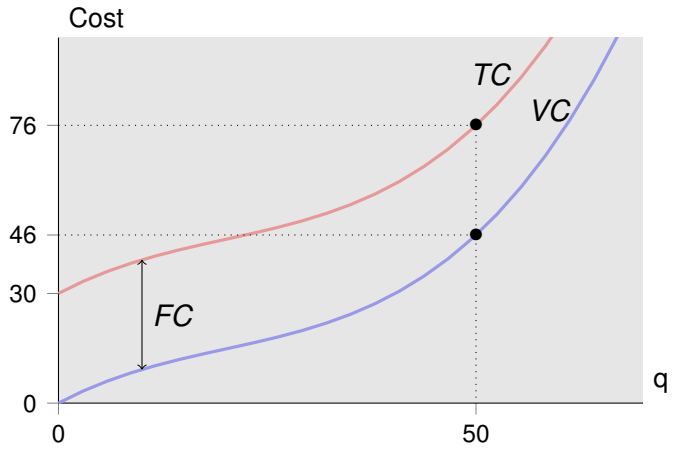


FIGURE 6.2
Total cost function

Average cost, as mentioned earlier, is given by the ratio between total cost and output level. For example, if $q = 40$, then average cost is given by $59.6/40 = 1.49$. The value of average cost can be divided into average fixed cost and average variable cost. Continuing with $q = 40$, we have $AVC = 29.6/40 = .74$ and $AFC = 30/40 = .75$. Notice that $AC = AFC + AVC$.

Assuming that the firm can choose any value of q (that is, not just multiples of 10 as in Table 6.1), Figures 6.2 and 6.3 depict the various cost function concepts. Figure 6.2 includes total cost and variable cost as a function of output level q. Figure 6.3 includes marginal cost, average cost (divided into average fixed cost, average variable

cost and average total cost).

Focusing first on Figure 6.2, we see that if $q = 50$, then $VC = 46$ and $TC = 76$. If instead $q = 0$, then $VC = 0$ (by definition) and $C = 30$, knowing that $C(0) = FC$. Focusing now on Figure 6.3, we observe an interesting property relating the marginal and average cost curves:

- when MC is below AVC ($q < q_1$), AVC is falling
- when MC is above AVC ($q > q_1$), AVC is rising
- when MC is below ATC ($q < q_2$), ATC is falling
- when MC is above ATC ($q > q_2$), ATC is rising

As a result, the MC curve crosses the AVC and the ATC curves at their respective minima. (There is a close parallel between these relations and the relation between AP and MP discussed in Section 5.1.)

Frequently (and in Figure 6.3) the average cost function is U-shaped. This results from the tension between two "forces" (as it were). To the extent that the firm has positive fixed costs, the greater the output level, the lower the average cost. In other words, a higher output level allows the firm to spread the fixed cost over more units. This effect is responsible for the declining portion of the U (that is, the left part of the average cost function).

There is, however, another effect. As we saw in previous chapters, marginal product tends to decline beyond a certain input level (imagine adding a 14th worker to work on digging up a hole on the sidewalk of Washington Square). In term of the cost function, declining marginal product corresponds (broadly speaking) to an increasing marginal cost curve. If marginal cost increases at a fast rate, eventually it becomes higher than average cost, at which point average cost becomes increasing. This is responsible for the increasing portion of the U of average cost.

FIRM SUPPLY

Knowing how much it costs to produce output q, we now turn to the decision of which value q to choose. As an illustration, consider a very simple example, that of a small, price-taking t-shirt factory. By price-taking we mean that the output price (as well as the input prices) are taken by the firm as fixed (that is, as given). The idea is

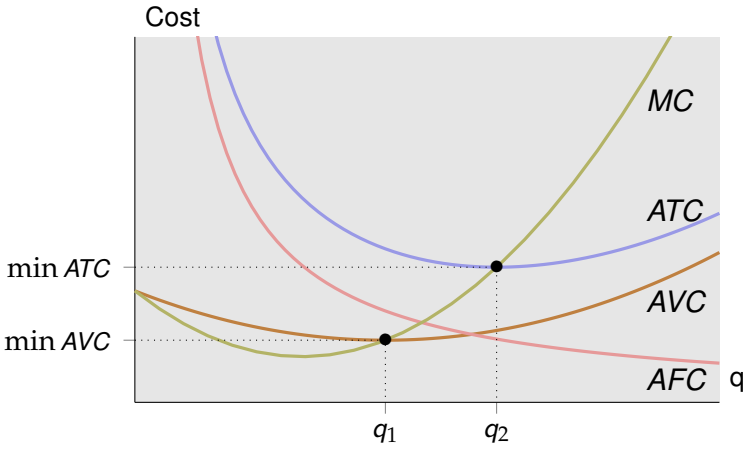


FIGURE 6.3
Derived cost functions

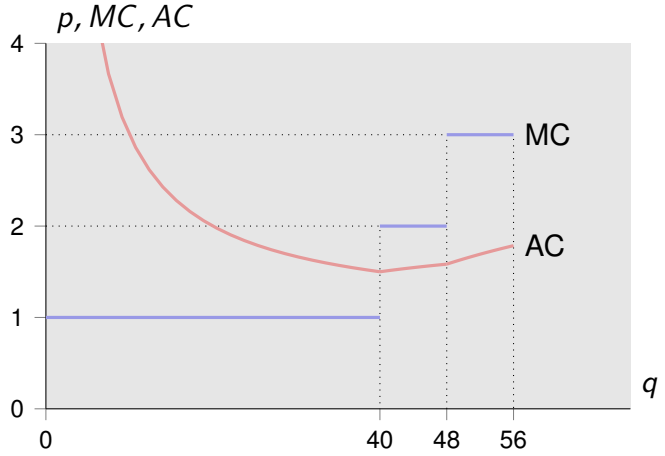


FIGURE 6.4
T-shirt factory marginal cost and average cost

that the firm is so small that its decision of how much output to sell, or how much to purchase of each input, does not have an impact on the respective market prices. (Similarly, as a consumer, you are most likely a price taker: no matter how many lattes you drink at Starbucks (within reason) the price is not going to change. If you drank something like 13 million lattes then Starbucks might start thinking about charging a different price, but it's unlikely you will buy or drink 13 million lattes.)

Suppose that, in order to produce t-shirts, a manager leases one

machine at the rate of \$20 per week. The machine must be operated by one worker. The hourly wage paid to that worker is as follows: \$1 during weekdays (up to 40 hours), \$2 on Saturdays (up to 8 hours), and \$3 on Sundays (up to 8 hours). (Lest you think this is an unfair wage, keep in mind this factory operates in Kabralstan, where the local dollar is worth \$10 US.) Finally, suppose that the machine, which is operated by the worker, produces one t-shirt per hour. Assuming that current output (q) is 40 t-shirts per week, we have that:

- The fixed cost is given by the machine weekly lease. We thus have $FC = \$20$.
- The variable cost is given by 40 t-shirts times one hour per t-shirt times \$1 per hour, which equals \$40.
- The average cost is $(20 + 40)/40 = \$1.50$.
- The marginal cost is \$2. In fact, producing the 41st t-shirt in a given week would imply asking the worker to work on Saturday, which would be paid at the hourly rate \$2; and producing a t-shirt requires one hour of work.

These cost values were computed for a particular output level. However, both average cost and marginal cost depend on the output level. By computing the values of marginal cost and average cost for each output level, we get the marginal cost and average cost functions (as before). Figure 6.4 depicts these functions for the particular case of the T-shirt factory. The more general case is given by Figure 6.5.

What is the use of all of these cost concepts? Suppose that Benetton, the sole buyer of t-shirts from our small factory, is offering a price of $p = \$1.80$ per t-shirt. Moreover, Benetton is willing to buy at that price as many t-shirts (within reason) as the factory wants to sell (that is, the t-shirt factory is a price-taking firm). Given this offer, should the factory operate on Saturday?

At the current output of $q = 40$ t-shirts a week, average cost is given by \$1.50 (see above). This means that, at $p = \$1.80$, the factory is making money. It might seem that, for this reason, it pays to operate on Saturdays as well: "if you are making money at the current output level, produce more and you will make more money." As it turns out, this is the wrong way to think about it. What is relevant for the decision of whether or not to operate on Saturdays is the

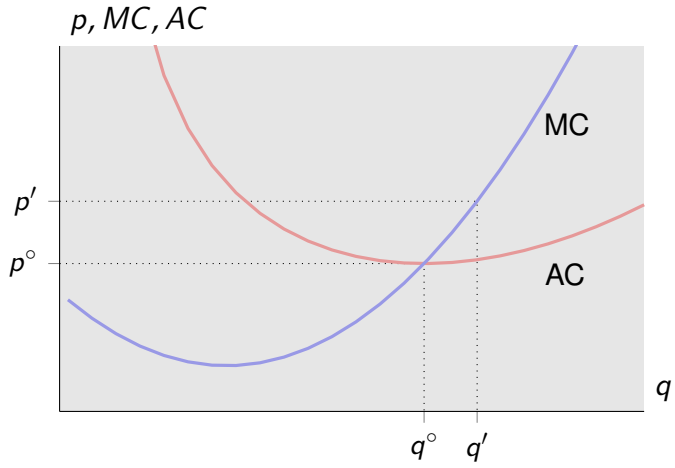


FIGURE 6.5
Marginal cost and average cost: general case

comparison between price and *marginal* cost, not the comparison between price and average cost. And since marginal cost of operating on Saturdays is \$2, whereas the selling price is only \$1.80, it does not pay to produce and sell a 41st unit.

In other words, although the factory is making money at output level $q = 40$ (because price is greater than average cost), profits would be lower if output were increased (because price is lower than marginal cost). To put it differently, the factory makes money on average but would lose money at the margin if output were increased. By "lose money at the margin" I mean lose money by producing an additional (a marginal) output unit.

Suppose now that Benetton (still the sole buyer) offers a price $p =$ \$1.30 per t-shirt. No matter what the output level is, price falls below average cost. (Check this.) That is, no matter how much the factory produces, it will lose money. In fact, $p < AC$ implies that $p \times q < AC \times q$, that is, revenues ($p \times q$) are less than total cost ($AC \times q = C$). It follows that the optimal decision would be not to produce at all. (This comparison is based on the assumption that the firm has still not paid for the weekly machine lease; more on this later.) To summarize,

> *marginal cost is the appropriate cost concept to decide how much to produce; average cost is the appropriate cost concept to decide whether to produce at all.*

Specifically, if price is above marginal cost, then the firm should increase output; and if price is below marginal cost, then the firm should decrease output level. Consider again the t-shirt factory example. If the firm reduces output to $q = 39$, then it saves \$1. Since this is lower than price, the firm should not decrease output level (the revenue loss is greater than the cost saving). If instead the firm increases output to $q = 41$, then it spends an additional \$2 on labor costs. Since this is greater than price, the firm should not increase output level (the increase in cost is greater than the increase in revenue). We conclude that $q = 40$ is the optimal output level, assuming the firm is active. Since price is greater than average cost at $q = 40$, we conclude that $q = 40$ is indeed the firm's optimal output level when $p = 1.8$.

The t-shirt factory example is a bit special in that there are only two factors of production and there isn't much flexibility in production. Moreover, there is a discontinuity in the value of marginal cost at $q = 40$. In general, the marginal cost and average cost functions would be continuous functions, or nearly continuous functions, as shown in Figure 6.5. In this figure, p° denotes the minimum of the average cost function. For prices below this minimum, a price-taking firm would prefer not to produce at all. For values of p greater than p°, the optimal output level for a price-taking firm is given by the marginal cost function. For example, if $p = p'$, then the optimal output level is given by q'. The reason why $p = MC$ is optimal is that, were p different from MC, the firm could do better: if $p > MC$, then an output increase increases profit; if $p < MC$, then an output decrease increases profit. More generally, a price-taking firm's **supply function** is given by the marginal cost function for values of price greater than the minimum of average cost.

Optimal supply by a price-taking firm is a particular instance of a more general rule of optimal behavior: Suppose that, as we assume throughout the book, the firm wants to choose output level so as to maximize its profit (or, if you will, so as to maximize firm value). Profit is given by revenues minus costs. The marginal approach to

optimal behavior, which appeared in all chapters from Chapter 2 to Chapter 5, asks the following question: given the currently planned output level, what happens to firm profits if the firm decides to increase output by one unit? As we saw in Section 5.3, the change in firm profit resulting from a one-unit increase in output is given by $MR - MC$. Moreover, at the optimal output level $MR = MC$. As we saw earlier, marginal revenue is lower than price. Specifically, Equation 5.10 states that MR is given by

$$MR = p + q\,\Delta p/\Delta q$$

Since $\Delta p/\Delta q \leq 0$, it follows that $MR \leq p$.

Consider now the case of a price-taking firm like our t-shirt factory. As we showed earlier, a price-taking firm is so small that its decision of how much output to sell has no impact on p. In terms of our mathematical notation, this corresponds to the limit case when $\Delta p/\Delta q = 0$ (my change in q has no effect on p). This implies that $MR = p$. Finally, $MR = MC$ implies $p = MC$, which is precisely the equality corresponding to the firm's supply function. To put it differently, in Section 5.3 we derived the elasticity rule of optimal pricing. One version of this rule is that the margin (price minus marginal cost, divided by price) should equal the inverse of the price elasticity of the demand faced by the firm (cf Equation 5.6). As mentioned above, a price-taking corresponds to the limit case when a change in q has no effect on p; or, conversely, a small change in p has an infinite effect on q. This implies that the demand elasticity faced by a price-taking firm is equal to $-\infty$. It follows that the inverse of the elasticity is zero, which in turn implies that the optimal margin is equal to zero, that is, price equal to marginal cost.

Figure 6.6 illustrates the above points. Optimal output is given by the point where price equals marginal cost. Specifically, assuming that current price is p^*, optimal output is given by $q = q^*$. Suppose that the firm were to set $q = q_1 < q^*$ instead. Then the firm would be leaving money on the table: each of the units from q_1 to q^* costs less than p^* to produce (marginal cost is lower than p^*). Therefore, the firm is missing out on profitable sales. Suppose that the firm were to set $q = q_2 > q^*$ instead. Then the firm would again be leaving money on the table: each of the units from q^* to q_2 costs more than p^* to produce (marginal cost is greater than p^*). Therefore, the firm

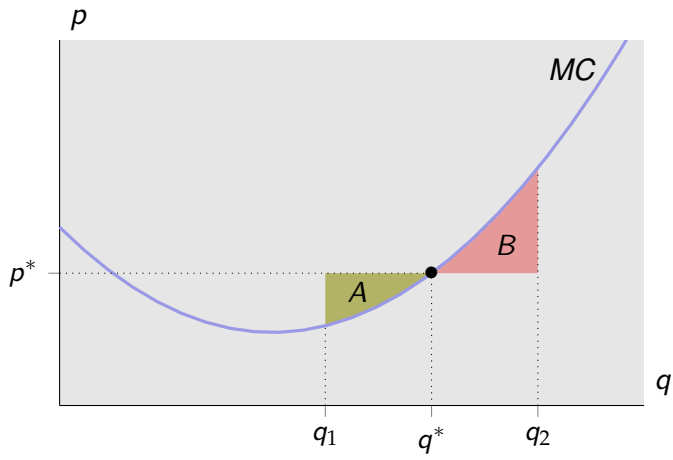


FIGURE 6.6
Optimal output choice by a price-taking firm

is engaging in unprofitable sales: reducing output from q_2 toward q^* would lead to a higher profit level.

In the special case of the t-shirt factory, to the extent that marginal cost varies in a discontinuous way, we may end up in a solution where price falls between two values of marginal cost. Specifically, for $q = 40$, the marginal cost that is saved by reducing output by one unit is \$1, whereas the marginal cost that needs to by paid to increase output to $q = 41$ is \$2.

SHORT RUN AND LONG RUN

Continuing with the t-shirt factory example. Suppose that Benetton's announcement that they are only willing to pay \$1.30 arrived on Monday morning, after the factory manager had already committed to lease the machine for the week. What should the firm do?

To the extent that the fixed cost has already been paid, it is effectively a sunk cost: no matter what the firm does this week the \$20 will need to be paid. As we saw in Section 2.3, sunk costs should be ignored in optimal decision making. The decision of whether or not to operate (and, if so, how much to produce) should be taken irrespective of the value of fixed cost.

In terms of cost functions, this means that, in the short run, the relevant average cost concept is that of average variable cost. The

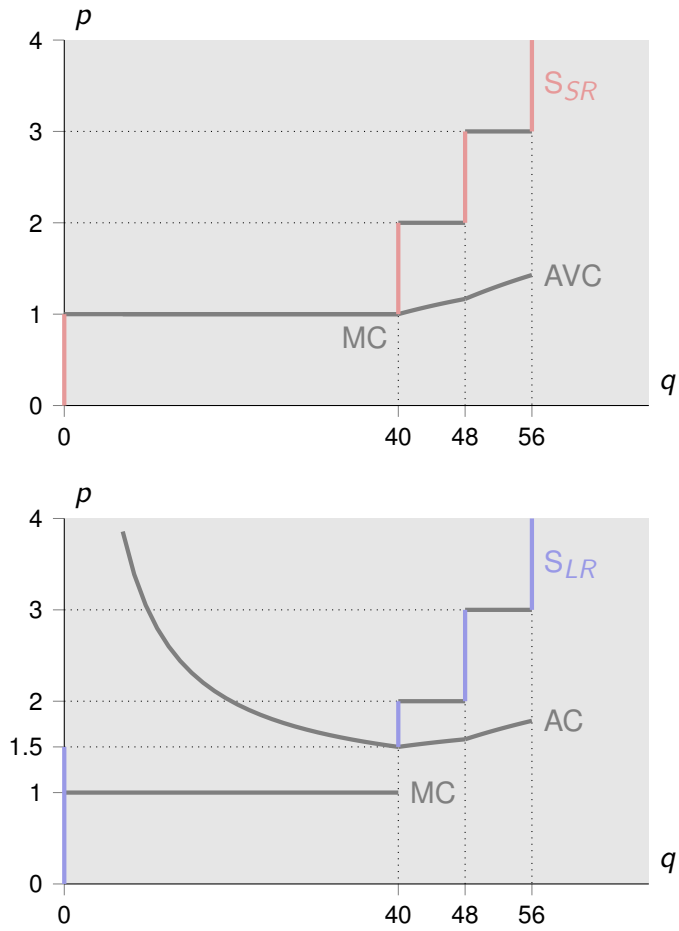


FIGURE 6.7
T-shirt factory short-run (top) and long-run (bottom) supply function

top panel in Figure 6.7 shows the t-shirt factory's average variable cost curve. As can be seen, its minimum is at \$1. It follows that, if Benetton offers \$1.30, then the firm should accept the offer and produce $q = 40$. We thus conclude that, in the short-run, the factory's supply curve is given by the marginal cost curve for price values above \$1 (the minimum of the average variable cost curve). This is shown in the top panel of Figure 6.7, which depicts the firm's **short-run supply curve**.

In the long run, nothing is fixed. In particular, the firm must decide whether or not to renew the machine lease. In this context, assuming the \$1.30 price remains valid, the firm is better off by simply shutting down. More generally, the bottom panel in Figure 6.7 shows

the firm's **long-run supply curve**.

A more general case is depicted in Figure 6.8. This case is more general in the sense that we do not have "jumps" as in the t-shirt factory example. It is still somewhat special in that we assume that the firm only has one technology available (and thus one possible cost structure). In this context, the only relevant difference between the short-run and the long-run is whether fixed costs have been paid or not. (In other words, more generally we could assume that, in the long run, the firm has the option of changing its technology, which, as we have seen before, corresponds to a production function f, which in turn corresponds to a cost function C.)

The short-run supply curve is given by the the portion of the supply curve lying above the minimum of the average variable cost (AVC). This corresponds to the red and blue portions of the marginal cost curve. The long-run supply curve, in turn, corresponds to the portion of the supply curve lying above the minimum of average cost (AC). This corresponds to the blue portion of the marginal cost curve.

The above discussion also helps clarify the economics' notion of short run and long run. The **short run** is defined as the period of time during which some factors of production are fixed. In the t-shirt factory example, the machine lease lasts for a week, and so the relevant period to define the short run is one week. Naturally, in other industries the period corresponding to the short run differs. In fact, in most industries it's likely to be considerably longer than one week. The **long run**, by contrast, is the period of time required for all inputs to be variable.

INVERSE SUPPLY

For readers with a STEM background, the supply function is a difficult graph to read. Usually we plot functions with the independent variable on the horizontal axis and the dependent variable on the vertical axis. For example, the function $y = f(x)$ has x on the horizontal axis and y on the vertical axis.

The firm supply function is given by $q = S(p)$, where p is on the vertical axis and q on the horizontal axis. This can be confusing, but hopefully you will get used to it. Moreover, while the supply curve gives q (horizontal axis) as a function of p (vertical axis), we can

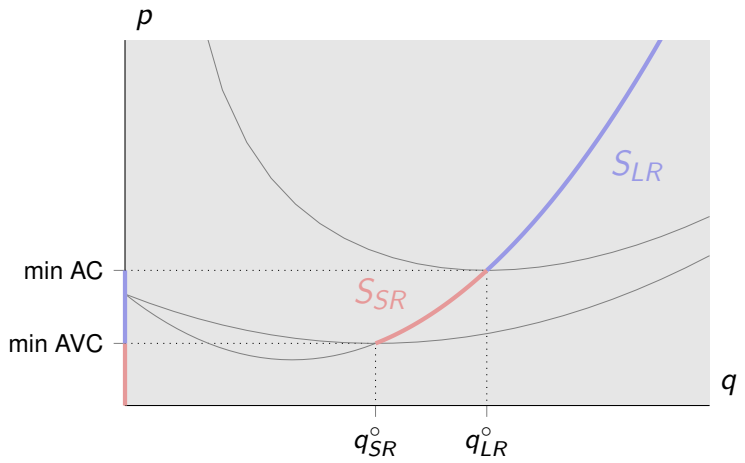


FIGURE 6.8
Supply by price taking firm

also read the curve the other way around: for a given q (horizontal axis), what is the value of p (vertical axis) on the supply curve? This corresponds to the inverse of the supply curve. We don't usually refer to the supply curve in this way, but it may help to think about it for a minute.

The firm's supply curve is determined by the equality $p = MC$. Therefore, the inverse supply curve is nothing else but the marginal cost curve! In other words, $S^{-1}(q)$ is nothing but $MC(q)$. What is then the meaning of the inverse supply function? For a given value of q, the inverse supply function (which is really the marginal cost function) gives me the lowest price that the firm would require to sell that output unit. In fact, if the firm chooses q optimally then I know that if p is lower than $MC(q)$ then that particular qth unit will not be supplied, whereas, if p is greater than $MC(q)$ then that particular qth unit will be supplied. In sum,

> *The supply curve may be read in two different ways. First, the direct way: for a given price, the supply curve corresponds to the output level that the firm is willing to supply. Second, the inverse way: for a given output unit, the (inverse) supply curve corresponds to the lowest price such that the firm would want to supply that unit.*

SUPPLY CURVE AND SUPPLY FUNCTION

One final word on terminology. A price-taking firm's decision of how much to supply is determined, as we've seen, by the going price at which the firm can sell. However, there is a host of other factors that influence the firm's decision. For example, if the cost of a particular input decreases, then the firm's marginal cost shifts downwards, which in turn results in a higher optimal output level *for the same given price*.

In this context, it is helpful to distinguish the **supply function**, which includes all factors influencing a firm's decision, from the **supply curve**, where the single independent variable is price. Formally, the supply function is given by $S_f(p \mid x_1, x_2, ...)$, where p is price and $x_1, x_2, ...$ represent input costs and other factors which influence a firm's decisions. The supply curve, in turn, corresponds to $S(p) = S_f(p \mid \overline{x}_1, \overline{x}_2, ...)$, where $\overline{x}_1, \overline{x}_2, ...$ represent specific values of the variables $x_1, x_2, ...$ When representing the supply curve on a (q, p) graph we implicitly assume specific values of $x_1, x_2, ...$ If the value of any of these variables changes, then the value of the supply function $S_f(p \mid x_1, x_2, ...)$ changes accordingly. In terms of the (q, p) graph, we observe a shift in the supply curve $S(p)$.

MARKET SUPPLY

Having derived the firm's supply curve, we now turn to the market supply curve. The market supply is given by the (horizontal) sum of all firms' supply curves. In other words, for each possible price p, we determine each firm's supply $q_i(p)$; and the market supply is simply the sum of these values: $q_1(p) + q_2(p) + ...$

Consider the values in Table 6.2. The second, third and fourth columns give the value of supply by firms A, B and C. (Note that the assumption of price-taking firms is rather strong in a market with only three firms. We're considering a small number of firms to keep it simple. Normally, the markets where the price-taking assumption holds would include a considerably larger number of sellers.) For each price level (first column), we compute market supply by adding each firm's supply. For example, if $p = 3$ then market supply is equal to $7 + 4 + 1 = 12$.

Alternatively, we may have estimated individual firm marginal

TABLE 6.2
From firm supply to market supply

	Quantity supplied			
Price	Firm A	Firm B	Firm C	**Market**
1	3	2	0	5
2	5	0	0	8
3	7	4	0	11
4	9	5	2	16
5	11	6	3	20

TABLE 6.3
Individual firm marginal cost (and supply) functions

Firm	MC	inverse MC	min AC
1	$-\frac{1}{2}+\frac{1}{2}q$	$1+2p$	1
2	$-1+q$	$1+p$	3
3	$2+q$	$-2+p$	5

cost curves (and thus supply functions). For example, consider the values in Table 6.3. Each row corresponds to a different firm. The first column indicates the firm's marginal cost schedule. For example, Firm 1's marginal cost is given by

$$MC(q) = -\tfrac{1}{2}+\tfrac{1}{2}q$$

We are also told that the minimum of the Firm 1's average cost is given by 1. What is then Firm 1's supply curve? Recall that the supply curve corresponds to the marginal cost curve but is read as q as a function of p, whereas the MC curve reads as cost as a function of q. So, in order to obtain the firm's supply curve we need to set $p = MC$ and invert the marginal cost function:

$$\begin{aligned} \text{(inverse) supply curve (i.e., } MC \text{ curve):} \quad & p = -\tfrac{1}{2}+\tfrac{1}{2}q \\ \text{(direct) supply curve:} \quad & q = 1+2p \end{aligned}$$

The latter expression may be found on the third column of Table 6.3 and corresponds to Firm 1's supply curve (for values of p greater than 1, the minimum of its average cost).

Figure 6.9 shows Firm 1's supply curve (noted q_1). For values of p lower than 1, Firm 1 supplies zero (better just shut down). For

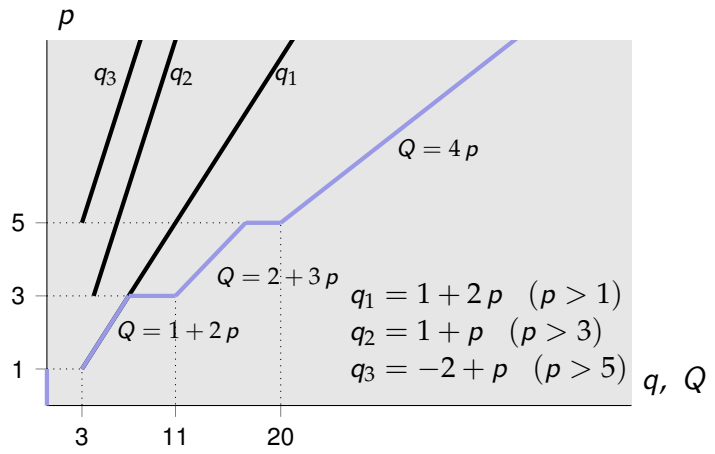


FIGURE 6.9
Market supply

values of p greater than 1, Firm 1 supplies $q = 1 + 2\,p$. By a similar process, we can also derive and graph the other firms' individual supply curves:

$$\begin{aligned} q_1 &= 1 + 2\,p \\ q_2 &= 1 + p \\ q_3 &= -2 + p \end{aligned}$$

There is one added complication: each individual firm's supply only kicks in when price is greater than the minimum of their average cost (which we can find on the fourth column of Table 6.3). So, for p less than 1 no firm supplies at all. For p greater than 1 but lower than 3, only Firm 1 supplies, in which case market supply Q is given by $Q = q_1$. For p greater than 3 but less than 5, both Firms 1 and 2 are active, in which case $Q = q_1 + q_2$. Finally, for $p > 5$, all firms are active and market supply is given by $Q = q_1 + q_2 + q_3$. Figure 6.9 shows market supply Q as a blue line with multiple segments. For $p < 1$, $Q = 0$. For $1 \leq p < 3$, $Q = q_1 = 1 + 2\,p$. For $3 \leq p < 5$, $Q = q_1 + q_2 = 2 + 3\,p$. Finally, for $q \geq 5$, $Q = q_1 + q_2 + q_3 = 4\,p$.

A third possible case corresponds to firms that are subject to capacity constraints. As an illustration, consider the case of electricity generation in California. Table 6.4 lists the main generation plants as of 2000 (listed alphabetically). This includes a variety of types of plants: hydroelectric, nuclear, natural gas, etc. Different technolo-

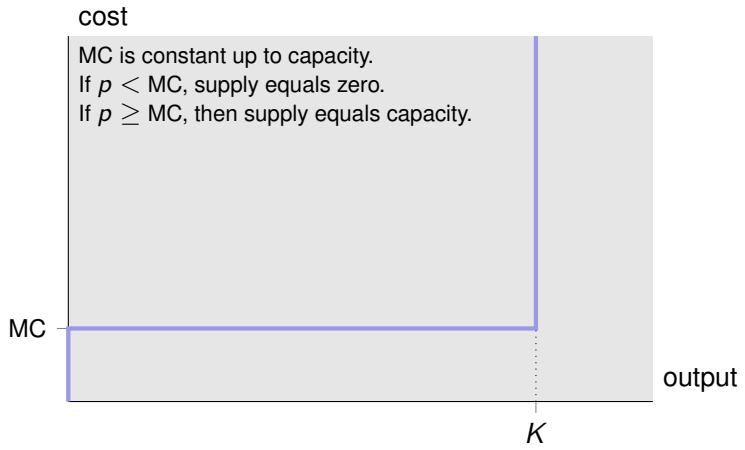


FIGURE 6.10
Firm supply with capacity constraints

gies have different cost structures. For example, hydroelectric plants have a very low variable cost (no fuel is required) but a high fixed cost.

As an approximation, we may assume that marginal cost is constant up to capacity, that is, marginal cost is equal to average variable cost. In graphic terms, this corresponds to a marginal cost function as in Figure 6.10. For any value of output lower than the firm's capacity K, marginal cost is constant and given by MC. At $q = K$, marginal cost shoots up to infinity, reflecting the impossibility of producing more than capacity. In this context, the difference between the various plants is that they correspond to different electricity generation technologies, which in turn correspond to different values of K and MC.

The supply function of firms with a cost structure as in Figure 6.10 is simple: if price is below MC, then supply zero; if price is greater than MC, then supply up to capacity. What about market supply? As mentioned earlier, market supply is given by the (horizontal) sum of all individual supply curves. In the present context, we proceed as follows:

- Order all plants by marginal cost level, from lowest to highest.
- For each price, determine the set of plants with marginal cost lower than that price.
- Add up the capacity levels of all such plants.

TABLE 6.4
California electricity generation plants

		Variable Costs			Fixed Costs	
Unit name	Capacity (MW)	Fuel cost ($/MWH)	Var O&M ($/MWH)	Total ($/MWH)	O&M ($/Day)	Start cost ($)
ALAMITOS 3-6	1900	48.00	1.50	49.50	20,000	34,000
ALAMITOS 7	250	83.00	1.50	84.50	0	8,000
BIG CREEK	1000	0.00	0.00	0.00	40,000	0
CONTRA COSTA 4&5	150	58.00	0.50	58.50	8,000	16,000
CONTRA COSTA 6&7	700	54.00	0.50	54.50	8,000	16,000
COOLWATER	650	58.00	0.50	58.50	4,000	12,000
DIABLO CANYON 1	1000	7.50	4.00	11.50	75,000	15,000
EL SEGUNDO 1&2	400	60.00	1.50	61.50	2,000	8,000
EL SEGUNDO 3&4	650	54.00	1.50	55.50	4,000	12,000
ELLWOOD	300	96.00	0.50	96.50	0	0
ENCINA	950	56.00	0.50	56.50	4,000	18,000
ETIWANDA 1-4	850	56.00	1.50	57.50	16,000	20,000
ETIWANDA 5	150	85.00	1.50	86.50	16,000	20,000
HELMS	800	0.00	0.50	0.50	40,000	0
HIGHGROVE	150	68.00	0.50	68.50	0	0
HUMBOLDT	150	65.00	0.50	65.50	0	0
HUNTERS POINT 1&2	150	66.00	1.50	67.50	2,000	8,000
HUNTERS POINT 4	250	98.00	1.50	99.50	2,000	8,000
HUNTINGTON BEACH 1&2	300	52.00	1.50	53.50	2,000	8,000
HUNTINGTON BEACH 5	150	75.00	1.50	76.50	2,000	8,000
KEARNY	200	105.00	0.50	105.50	0	0
LONG BEACH	550	72.00	0.50	72.50	4,000	4,000
MANDALAY 1&2	300	53.00	1.50	54.50	2,000	8,000
MANDALAY 3	150	75.00	1.50	76.50	2,000	8,000
MOHAVE 1	750	17.00	2.50	19.50	30,000	30,000
MOHAVE 2	750	17.00	2.50	19.50	30,000	30,000
MORRO BAY 1&2	335	54.00	0.50	54.50	10,000	20,000
MORRO BAY 3&4	665	50.00	0.50	50.50	10,000	20,000
MOSS LANDING 6	750	45.00	1.50	46.50	10,000	26,000
MOSS LANDING 7	750	45.00	1.50	46.50	10,000	26,000
NORTH ISLAND	150	85.00	0.50	85.50	0	0
OAKLAND	150	74.00	0.50	74.50	0	0
ORMOND BEACH 1	700	52.00	0.50	52.50	16,000	26,000
ORMOND BEACH 2	700	52.00	0.50	52.50	16,000	26,000
PITTSBURGH 1-4	650	56.00	0.50	56.50	10,000	38,000
PITTSBURGH 5&6	650	50.00	0.50	50.50	10,000	38,000
PITTSBURGH 7	700	82.00	0.50	82.50	10,000	38,000
POTRERO HILL	150	85.00	0.50	85.50	0	0
REDONDO 5&6	350	56.00	1.50	57.50	16,000	24,000
REDONDO 7&8	950	52.00	1.50	53.50	16,000	24,000
SAN BERNADINO	100	72.00	0.50	72.50	0	0
SOUTH BAY	700	60.00	0.50	60.50	2,000	8,000

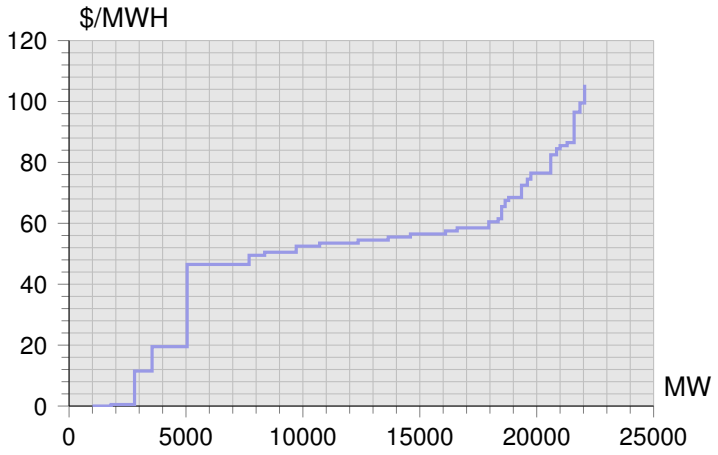


FIGURE 6.11
Market supply when each firm has a capacity constraint

- The total value obtained in this way corresponds to the market supply at that price.
- Doing this for all price levels, we obtain the market supply function.

Figure 6.11 shows the result of this process. The first segment of the supply curve corresponds to hydroelectric plants such as Big Creek. These are plants with very low marginal costs (maybe even zero), which explains why the supply curve is close to the horizontal axis. The medium segment of the supply curve corresponds to nuclear power plants such as Diablo Canyon. There are several plants like Diablo, all with relatively similar marginal cost levels. This in turn leads to a relatively "flat" portion of market supply: for a relatively small change on price, many new plants come in line, thus producing a large increase in supply. Finally, the high price segment corresponds to fuel-burning plants such as Kearny. There are multiple fuel-burning technologies and fuel types. Moreover, these plants tend to have relatively small capacity. This results in a portion of the supply curve that is relatively steep, that is, it takes a considerable increase in price to induce some of these plants to come in line.

In the previous sections we examined the foundations of market supply. We now turn to the foundations of market demand. Specifi-

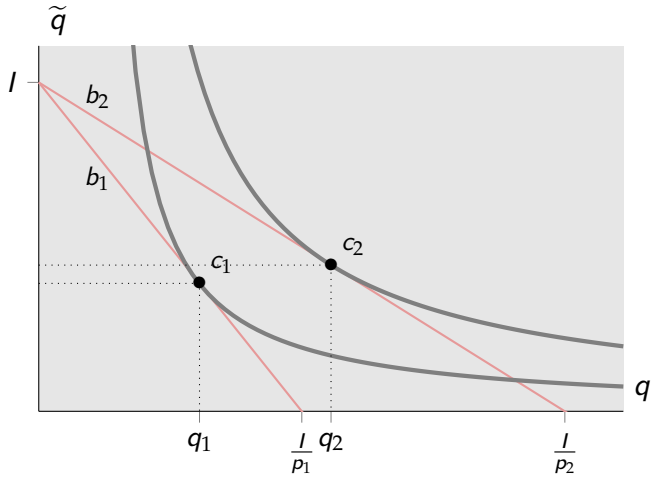


FIGURE 6.12
Consumer demand

cally, the goal is to present the basic elements from which the market demand curve is derived. We also touch on the issue of estimating the demand curve based on historical data.

6.2. WILLINGNESS TO PAY AND DEMAND

In Chapters 3 and 4, we saw numerous examples where an agent (a consumer, a worker, a student) optimizes the trade-off between two goods. Consider now Margarida's choice between consumption of a good q and consumption of all other goods, which we denote by $\widetilde{q}$. Let the price of q be given by p. As to the price of $\widetilde{q}$, assuming we measure $\widetilde{q}$ as the amount spent in all goods other than q, its price is simply given by 1 (it costs exactly \$1 to spend \$1 in $\widetilde{q}$). Finally, let income be given by I.

Figure 6.12 illustrates this problem. Suppose that initially the price of q is given by p_1. Then Margarida's budget line is given by the line marked b_1. This is a line with intercept I on the $\widetilde{q}$ axis and I/p_1 on the q axis. Given Margarida's preferences, we conclude that her optimal choice is given by c_1, which corresponds to consuming q_1 of q.

Suppose now that we cut p by 50%. Since the intercept on the q axis is given by I/p, we have a rotation in Margarida's budget

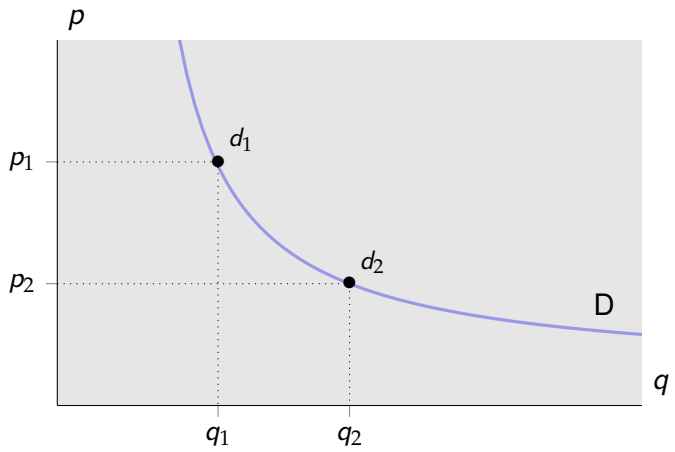


FIGURE 6.13
Consumer demand

line around the vertical intercept $(0, I)$ and such that the horizontal intercept is twice as far from 0 as the initial one. In other words, $I/p_2 = 2I/p_1$. Given Margarida's preferences, we conclude that her new optimal choice is given by c_2, which corresponds to consuming q_2 of q.

We now have two observations regarding Margarida's behavior. When $p = p_1$, she chooses to purchase (and consume) q_1 units of q. When $p = p_2$, she chooses to purchase (and consume) q_2 units of q. We can plot these points in Figure 6.13, where we continue to plot q on the horizontal axis but now we plot price, p, on the vertical axis.

We could repeat this exercise (change the value of p, determine Margarida's optimal choice c, transfer the corresponding value of q from Figure 6.12 to Figure 6.13, together with the value of p) for many values of p. The result would be a relation between p and q like the line in Figure 6.13. This we call Margarida's demand curve for q. Specifically, an individual's **demand curve** for good q, denoted $D(p)$, gives their choice of q when price is given by p.

I already mentioned this in Section 6.1 (in the context of the supply curve) and will do it again: The consumer demand curve is given by $q = D(p)$, where p is on the vertical axis and q on the horizontal axis. This can be confusing, so keep that in mind.

INVERSE DEMAND CURVE

In Chapters 3 and 4, we saw that points c_1 and c_2 in Figure 6.12 are derived from the MRS = MRT condition. The value of MRT reflects Margarida's *ability* to trade-off consumption of q for consumption of $\widetilde{q}$. It's simply given by the price ratio. In the present context, since the price of $\widetilde{q}$ is (by normalization) equal to 1, the price ratio is simply the price of q, that is, p.

The value of MRS, in turn, reflects Margarida's *willingness* to trade-off consumption of q for consumption of $\widetilde{q}$. Generally speaking, MRS measures how much the individual is willing to give up of what's on the vertical axis in order to obtain one additional unit of what's on the horizontal axis. In the present case, we measure consumption of "not q" on the vertical axis ($\widetilde{q}$), and this we measure in \$. Therefore, in the present context, MRS measures how much money (how many \$) Margarida is wiling to give for one additional unit of q. For this reason, in the present context MRS corresponds to Margarida's **willingness to pay** for q.

Also in the present context, the optimality condition MRS = MRT comes down to MRS = p. In other words, at Margarida's optimal solution, her willingness to pay for an extra unit of q (MRS) is exactly equal to the price of q (MRT). This makes sense: if Margarida's willingness to pay for q were different from p, then she could do better. Specifically, if MRS is greater than p then Margarida is better off by getting more of q. Conversely, if MRS is lower than p then Margarida is better off by getting less of q.

Let us now turn to Figure 6.13. As explained earlier, for a given value of p, an individual's demand curve, denoted $D(p)$, gives their choice of q. But this function $D(p)$ can also be read in the reverse: for a given value of q, $D^{-1}(q)$ gives a particular value of p. What is the meaning of this value of p? As we saw in the previous paragraphs, Margarida's optimal behavior implies that p equals her willingness to pay for q, so $D^{-1}(q)$ is Margarida's willingness to pay for the qth unit. More generally, the values of D^{-1} correspond to Margarida's **inverse demand curve**.

> *For each unit of an individual's consumption plan, the inverse demand curve, denoted $D^{-1}(q)$, gives its willingness to pay for such unit.*

For example, suppose that Raj's daily demand for coffee is given by $q = 10 - 2\,p$. This means that, if $p = 3$, then Raj would be willing to purchase $10 - 2 \times 3 = 4$ cups of coffee. From the direct demand curve (or simply "demand curve"), $q = 10 - 2\,p$, we can derive Raj's inverse demand by solving it with respect to p. We get $p = 5 - \frac{1}{2}\,q$.

We can now answer questions such as: How much is Raj willing to pay for a second cup of coffee each day? We get the answer by plugging $q = 2$ into the inverse demand expression: $5 - \frac{1}{2} \times 2 = \$4$. How much is Raj willing to pay for a fourth cup of coffee each day? Again, we can get the answer by plugging $q = 4$ into the inverse demand expression: $5 - \frac{1}{2} \times 4 = \$3$.

Note that, for $p = 3$, we could have saved ourselves the above computational work: We already knew that, at $p = 3$, Raj demands 4 cups of coffee. Therefore, it must be the case that Raj is willing to pay \$3 for the 4th cup of coffee.

DEMAND CURVE AND DEMAND FUNCTION

One final word on terminology. A consumer's decision of how much to buy is determined, as we've seen, by the good's price. However, there various other factors that influence the consumer's decision. For example, if the good is a normal good and the consumer's income increases then the consumer purchases more of the good *even if price does not change*.

In this context, it is helpful to distinguish the **demand function**, which includes all factors influencing a consumer's decision, from the **demand curve**, where the single independent variable is price. Formally, the demand function is given by $D_f(p \mid x_1, x_2, ...)$, where p is price and $x_1, x_2, ...$ represent income, price of substitute products, and other factors that influence a consumer's decisions. The demand curve, in turn, corresponds to $D(p) = D_f(p \mid \overline{x}_1, \overline{x}_2, ...)$, where $\overline{x}_1, \overline{x}_2, ...$ represent specific values of the variables $x_1, x_2, ...$

When representing the demand curve on a (q, p) graph we implicitly assume specific values of $x_1, x_2, ...$ If the value of any of these variables changes, then the value of the demand function $D_f(p \mid x_1, x_2, ...)$ changes accordingly. In terms of the (q, p) graph, we observe a shift in the demand curve $D(p)$.

TABLE 6.5
From individual to market demand

	Quantity demanded			
Price	Individual A	Individual B	Individual C	**Market**
1	4	9	16	29
2	2	6	13	21
3	0	3	10	13
4	0	0	7	7
5	0	0	4	4

MARKET DEMAND

In Section 6.1 we saw how to get from individual firm supply curves to the market supply curve. Something similar happens with demand curves: we derive the market demand curve by adding up (horizontally) all individual consumers' demand curves.

Market demand is downward sloping for two reasons: First, as price decreases, existing consumers demand more of the good. Second, as price decreases, new consumers "enter" the market and contribute to market demand. (There is some similarity here with respect to the reasons why the supply curve is increasing.)

As mentioned in Section 4.1, the **law of demand** establishes that the substitution effect is always negative, that is, the substitution effect of a price increase is negative (or, conversely, the substitution effect of a price decrease is positive). Sometimes people interpret the law of demand as meaning that the demand curve is downward sloping. However, that is not necessarily the case: if the income effect of a price change is sufficiently large, then demand curves can be positively sloped (and the good in question is called a Giffen good).

The same ideas apply to the market demand curve: It is normally downward sloping, and frequently we (somewhat unprecisely) refer to this as the law of demand. In this sense, the "law of demand" is more an empirical regularity than a logical proposition.

Finally, note that factors which influence the demand of one or many consumers (e.g., income levels) also influence market demand.

As an illustration of how market demand can be obtained from individual demand curves, consider the values in Table 6.5. Each row corresponds to a different price, from 1 to 5. Columns 2 to 4 show the

quantity demanded by three different individuals (A, B and C). Finally, Column 5 gives total market demand, the sum of all individual demands.

Normally, the market is made up of more than three consumers (more like three thousand or three million). In this context, working with individual demand curves for each of three million consumers is not practical. What we can do, however, is to start from individual demand for certain *types* of consumer, and then derive the market demand based on the number of consumers of each type. This is particularly helpful when we have information about population demographics. In the next subsection, I develop an example of such aggregation process.

EXAMPLE: DEMAND FOR MINIVANS

Suppose we want to estimate the demand for minivans at the state level, that is, for each of the 50 US states. Suppose that the demand for minivans for a typical US household depends on whether the household includes children under 18 or not. Specifically, suppose it was estimated that the demand curves of a household without children (q_0) and of a household with children (q_1) are given by

$$\begin{aligned} q_0 &= .8 - \tfrac{1}{50}\, p \\ q_1 &= 1 - \tfrac{1}{80}\, p \end{aligned}$$

Figure 6.14 plots these demand curves. Note that for positive prices p, the values of q_0 and q_1 are less than 1. It may seem odd for a household to purchase a fraction of a minivan. The correct interpretation is that the values of q_i $(i = 0, 1)$ measure the probability that a household of a given type purchases a minivan.

For a specific household, many factors come into play when deciding whether to purchase a minivan. It would be very difficult to predict the choice of any particular household. However, as we consider market demand, which corresponds to thousands of households, by virtue of the **law of large numbers** we will be able to predict the aggregate number of purchases reasonably well. For example, if a household of type a buys with probability 38% and there are 200 such households, then I expect that, in the aggregate, $.38 \times 200 = 76$ minivans will be purchased.

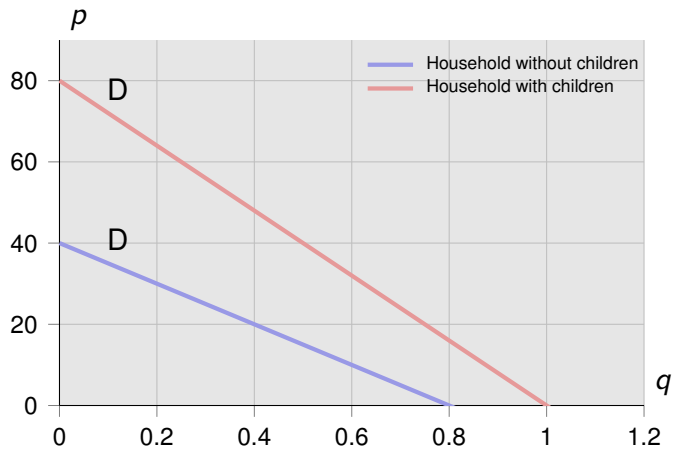


FIGURE 6.14
Household demand for minivans

TABLE 6.6
2000 US Census: families and children, by state

Concept	New Mexico	West Virginia
Households (thousand)	466.5	504.1
Households without children (thousand)	231.5	291.0
Households with children (thousand)	235.0	213.1
Households with children (%)	50.4	42.3

Assuming (for simplicity) that there are only two types of buyer (households with children and households with no children), we are ready to derive each state's market demand. Consider specifically the states of New Mexico and West Virginia. (For simplicity, we restrict the analysis to New Mexico and West Virginia. The analysis can be extended to all other states.) From the 2000 Census, we obtain the values in Table 6.6. In oder to derive the total demand for minivans, we compute the product of the demand curve by households with no children times the number of households with no children and to this we add the product of the demand curve by households with children times the number of households with children.

One trick we must take into account is that, for high values of p, the demand by households with no children is equal to zero, in which case only the second product above applies. Specifically, by looking

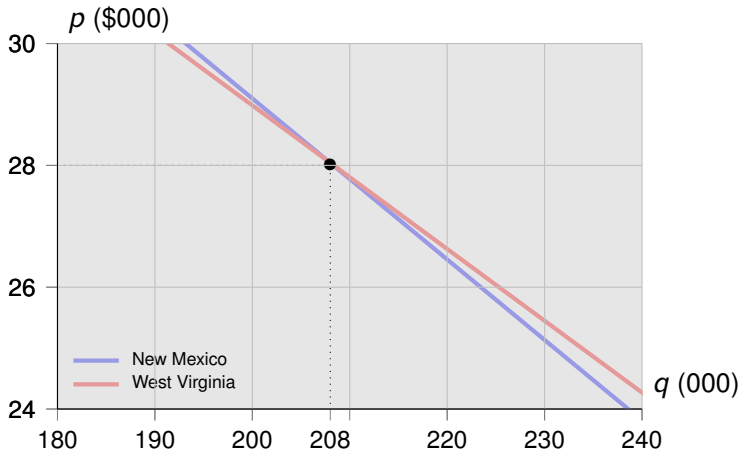


FIGURE 6.15
Market demand for minivans

at Figure 6.14 we see that, if $p > 80$, then both types demand zero. If p falls between 40 and 80, then type 1 has positive demand but type 0 has zero demand. Finally, if p is less than 40 then both types have positive demand. Taking this into consideration, we derive the market demand in New Mexico as

$$Q_{NM} = \begin{cases} 0 & p > \$80 \\ 235.0 \times (1 - p/80) & \$40 < p \leq \$80 \\ 231.5 \times (.8 - p/50) + 235.0 \times (1 - p/80) & p \leq \$40 \end{cases}$$

whereas for West Virginia we get

$$Q_{WV} = \begin{cases} 0 & p > \$80 \\ 213.1 \times (1 - p/80) & \$40 < p \leq \$80 \\ 291.0 \times (.8 - p/50) + 213.1 \times (1 - p/80) & p \leq \$40 \end{cases}$$

Figure 6.15 plots the resulting market demand curves. For simplicity, we restrict to the \$24,000-\$30,000 price range, where most minivans are priced. Notice that, overall, the demand in New Mexico is not very different than the demand in West Virginia. At first this may seem surprising, considering that there are 504 thousand households in West Virginia and only 467 thousand in New Mexico. However, because the percentage of families with children is higher in New Mexico than in West Virginia, the totals end up being similar.

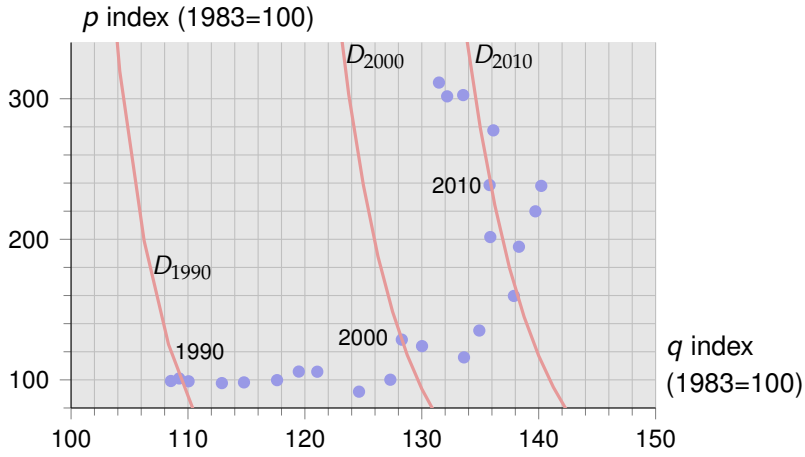


FIGURE 6.16
Example: demand for gasoline

Another interesting observation is that, at a price of $28,000, total demand is the same in New Mexico and West Virginia. However, the market demand in New Mexico is steeper (that is, less sensitive to price changes) than the demand in West Virginia. This makes sense: to the extent that there are more households with children in New Mexico, we expect New Mexico households to be more "dependent" on minivans, and so their demand less sensitive to price changes.

DEMAND ESTIMATION

In the previous exercise (statewide demand for minivans) we started from given demand curves for a typical household (with or without children). Where do these demand curves come from? In an ideal world, firms would know the demands for their products. In practice, it's not so easy. One reason is that it's hard to get reliable market data: how much was bought by whom and at what price.

Another difficulty with demand estimation is that it's inherently difficult to tease out the effect of price from the effect of other variables, especially when the latter might be changing at the same time as price (or, even worse, when they are not known to us).

Consider Figures 6.16 and 6.17. Both plot annual data of prices and quantities. Figure 6.16 corresponds to the US gasoline market, whereas Figure 6.17 corresponds to NY Mets (a baseball team) ticket

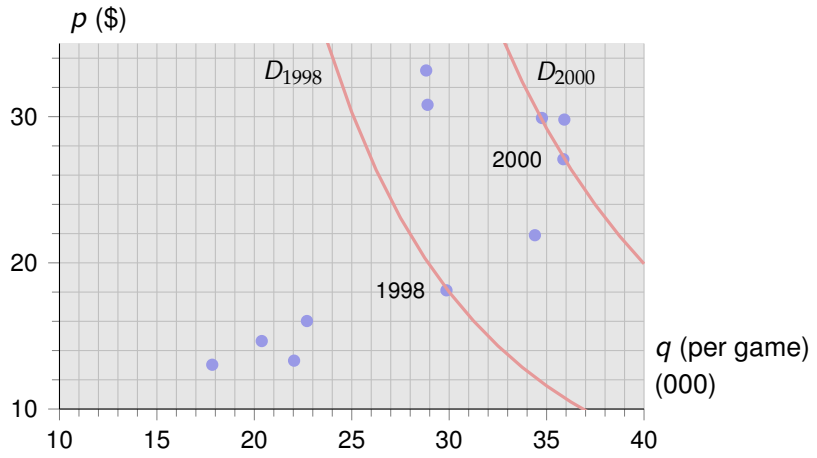


FIGURE 6.17
Example: demand for NY Mets tickets

sales. If one eyeballs the historical observations, a pattern emerges: years when prices were higher are also years when quantity sold was higher. One may naively suppose that the demand for gasoline and the demand for Mets tickets are upward sloping. This would be great news for the Mets, who could easily solve their recurring problem of empty seats during many of the season's games: simply raise prices until the park is full!

Alas, a historical positive relation between price and quantity does not mean that demand is positively sloped. (As mentioned in Section 2.1, correlation is not the same as causality.) What happens is that over time the demand curve has shifted (and, to some extent, the supply curve too, but primarily the demand curve). And this results in a series of points that look more like a supply curve than a demand curve, but is really neither one nor the other.

The point is that estimating the demand curve from historical data is a tricky business. To see this, consider Figure 6.18, which shows a series of demand curves and supply curves over a number of periods and a series of observations (data points). Suppose that the demand curve is fixed at D_3 (i.e., over time demand remains at D_3). As the supply curve shifts between S_1 and S_2, we observe equilibrium points A and D. Based on these, we are able to correctly identify the shape of the demand curve. Suppose instead that the supply curve is fixed at S_1. As the demand curve shifts between D_3 and D_4,

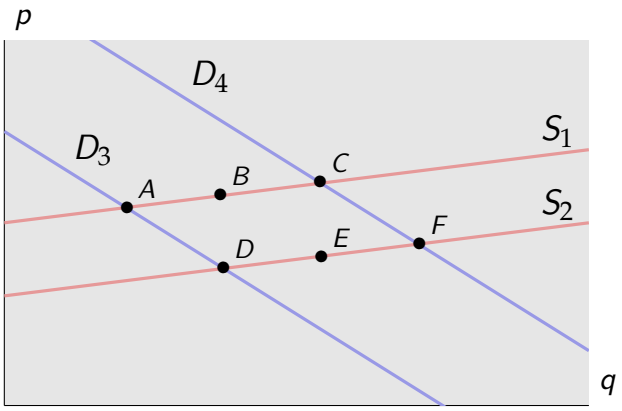


FIGURE 6.18
The identification problem

we observe equilibrium points A and C. Based on these, we are able to correctly identify the shape of the supply curve.

The problem is that, in practice, market data such as that found in Figures 6.16 and 6.17 result from a combination of demand-curve and supply-curve shifts; and if we are not careful, we may end up failing to identify either the demand or the supply curve. I have colleagues who provide this service for a reasonable fee, but you should be aware of the main challenges in estimating the demand curve from actual data, including the problem of both S and D shifting around. Econometricians refer to this as the **identification problem**.

While I don't expect you to become an expert in the identification problem, it helps to look at a specific example: estimating the slope of the demand for gasoline. From August 23 to August 31, 2005, the states of Louisiana and Mississippi suffered a major natural disaster: Hurricane Katrina. New Orleans and other parts of the South experienced winds as strong as 174 mph. More than 1,800 human lives were lost. In addition to human loss, Katrina also implied considerable economic costs. At an estimated $125 billion in damage, Katrina is considered the costliest Atlantic hurricane ever. In particular, a large chunk of the US gasoline refining capacity was affected by the hurricane. In other words, Katrina implied a major supply shock to the US gasoline market.

Figure 6.19 shows two time series: US gasoline prices (left scale) and an index of supply disruption (right scale). Time t represents the

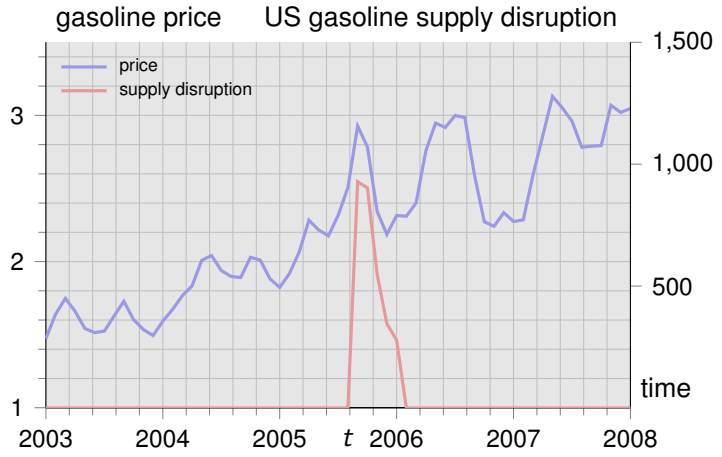


FIGURE 6.19
Gasoline supply and prices around hurricane Katrina

onset of Katrina: August 23, 2005. We notice an immediate spike in supply disruption. It corresponds to the many refineries in Louisiana that were hit by the hurricane. We also note a spike in price during the period of supply disruption. The idea of demand identification is to take advantage of this sudden shift in the supply curve to estimate the slope of the demand curve. The underlying assumption is that, while demand was affected by the hurricane (e.g., many drivers in Louisiana were unable to drive), the impact of Katrina on supply was considerably higher than the impact on demand. In terms of Figure 6.18, the events of Katrina corresponds to a shift in supply keeping demand constant, something like points A and D. This allows us to estimate the slope of D_3.

> *Solving the supply-demand identification problem requires observing variables that shift one curve but not the other.*

Once we've estimated the slope of the demand curve, we can go back to the left panel of Figure 6.16 and plot the various demand curves over the years. It's not that a higher price implies a higher quantity demanded, as the correlation between p and q might suggest. Rather, what happens is that several factors (especially consumer income) shift the demand schedule over the years (as can be seen in Figure 6.16). Considering that the supply curve did not change as much as the demand curve did, the points where supply equals demand (the

Piqsels

Over the years, as the price of gasoline increased in the US, total sales of gasoline increased as well. This positive correlation does not imply that the demand for gasoline is positively sloped, rather that there were other factors (namely income) shifting the demand for gasoline to the right at the same time as price increased.

data values we keep a record of) show a positive correlation as seen in Figure 6.16.

Figure 6.17 (ticket sales at the NY Mets) shows a similar pattern. In this case, the shifts in the demand curve year after year are likely caused by team performance. Specifically, if the Mets perform well in year t, then we observe a rightward shift in the demand for tickets (including season tickets) in year $t+1$. Seeing how the team increases in popularity, the Mets management decides to increase ticket prices. In terms of observable data, we see an increase in price and an increase in number of ticket sales.

As we mentioned in Section 2.1, a correlation between two different variables (price and quantity, in this case) does not necessarily imply a causal relation. It's not that an increase in p causes an increase in q. Rather, a third variable (team popularity in the Mets case) causes a shift in demand and supply, which in turn leads to both an increase in p and an increase in q.

ALTERNATIVE PATHS TO ESTIMATING DEMAND

Statistical analysis is not the only avenue for demand estimation. An alternative approach is to obtain data by means of surveys. One problem with this method is that we are never sure how accurate the responses are going to be: until your own money is at stake you don't have an incentive to think hard. For example, in Consumer Reports' 2018 Automotive Fuel Economy Survey Report, we learn that

- 85% of Americans agree that "Automakers should continue to improve fuel economy for all vehicle types."

- 78% of Americans agree that "Making larger vehicles such as SUVs or trucks more fuel-efficient is important."
- 74% of Americans agree that "Increasing average fuel economy from 25 miles per gallon (mpg) today to 40 MPG by 2025 is a worthwhile goal."

However, according to the International Energy Agency average fuel efficiency of US cars is about 27.4 miles per gallon, whereas France, Germany and the UK show values of 44.4, 40.0 and 40.6, respectively. If fuel efficiency is so important to US drivers, why don't they switch to more fuel efficient cars (which do exist in the US market)? In sum, one big problem with surveys is that consumers don't always "walk the talk".

Still another approach to estimating demand is to do experiments in markets. Thus mail-order businesses used to send out catalogs to different customers in which some of the prices are different. If you charge different prices to different consumers in the same ZIP code, you are able to test the effect of changing price. The idea is that, within a given ZIP code, many demographic characteristics (income, education, etc) tend to be similar, so that the price difference is the main difference between buyers. With the advent of the Internet, these catalog strategies no longer work as well as they did before. Moreover, these experiments run the risk of alienating customers: What if you find out you got the high price?

Finally, if you do not have historical data to estimate demand or the resources to experiment with price changes, you should at least have an idea of whether demand is more or less sensitive to price changes depending on the characteristics of the good in question. In that spirit, here are some rules of thumb that might help in this process: First, demand for luxuries tends to be more price sensitive than demand for necessities. Compare, for example, food and Armani suits.

Second, demand for specific products (e.g., the iPhone) tends to be more price sensitive than demand for a category as a whole (smartphones). Why is this so? Because when the price of a specific product rises, people are willing to buy fewer units. Some of this reduction leads to purchases of other products in the same category (e.g., Samsung phones), some to a reduction in the category as a

whole (smartphones). Only the latter induces price-sensitivity of the category as a whole.

Finally, demand is less sensitive to price changes in the short run than in the long run. A good example is gasoline demand. Can you see why? Suppose, for example, that the government plans to levy a 100% tax on gasoline for the next three years. In the next day or week, consumers would probably still drive their cars, but in the longer term their demand for gas could change for many reasons: they might buy more fuel-efficient cars, carpool, or take the bus or train to work; perhaps some would work from home. As a result, the quantity of gasoline demanded at the new price would gradually decrease.

> *The following demand curves tend to be more sensitive to price changes: luxuries (vs necessities); specific products (vs category); long run (vs short run).*

ESTIMATING THE DEMAND FOR FACEBOOK

Consider the specific example of Facebook. Facebook users do not pay to use Facebook, so it's impossible to use historical p and q data to estimate the demand curve. Is there a demand curve? As we saw earlier, we can "read" the demand curve as q as a function of p or, in inverse form, p as a function of q. You may not know what your willingness to pay for Facebook is, but surely there is one. Sometimes, when I ask the question "How much would you be willing to pay to have a Facebook account" (or an Instagram account or a TikTok account), people tell me "I have no idea". This is not true. You do have an idea. Is it more than one billion dollars? Probably not. So, we already know that your willingness to pay for a Facebook account is less than one billion dollars! You do have *some* idea.

Can we get a more precise estimate by asking Facebook users? In the previous subsection we learned the pitfalls of estimating valuations by asking people (how do you know they will tell the truth?). But suppose that, in addition to asking for a number, you also ask for a commitment on the part of the user, so that they have some skin in the game. Specifically, suppose that I ask Facebook users "How much would you be willing to *receive* in order to *stop* using Facebook?" Suppose moreover that it is understood that the answer is

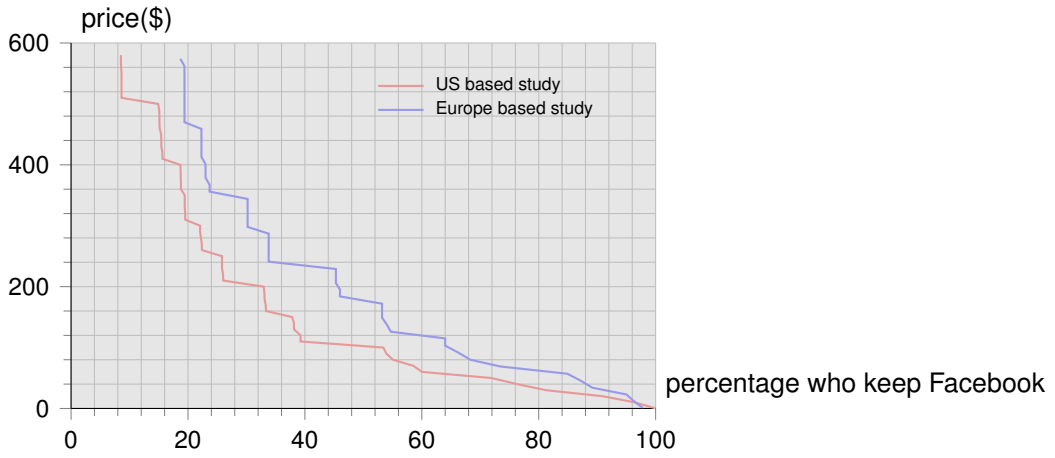


FIGURE 6.20
Demand for Facebook

also a promise: After all of the answers are in, the experimenter will announce the "price" of turning off Facebook, and every user who announced a valuation lower than that "price" receives the "price" and turns off Facebook as promised.

This type of experiment has been performed a number of times. The idea is that, if users are rational economic agents, then their answer should be equal to their willingness to pay. Why? Suppose that my willingness to pay (or my best estimate thereof) is equal to $50. What if I say that I would only turn off Facebook for $100? Then if the announced price is $90, I will effectively be excluded from the offer, for 100 is greater than 90. I could have gotten $90 for something that would only cost me $50 (turning off Facebook). What if instead I say that I would turn off Facebook for $30? Then there is the risk that the price is $40, in which case I am paid $40 for something that will cost me $50 (turning off Facebook). In sum, my best bet is actually to be honest.

Figure 6.20 shows the result of two such surveys (source and source). On the vertical axis we measure the offer proposed to each consumer (dollars paid if user accepts to deactivate its account for a period of four weeks). On the horizontal axis we measure the results, specifically the probability that the offer is *rejected*. Why do we plot the rejection probability? Because demanding Facebook corresponds to rejecting the offer to de-activate the account. In other words, to use

Facebook is equivalent to not de-activating Facebook. It's an awkward double negative but it's an accurate one.

Based on the average responses, we can then estimate the inverse demand for Facebook. As expected, the demand is downward sloping: the more you pay users to quit Facebook, the fewer keep their Facebook account active. Note that the two curves correspond to different samples (one in the US and one in Europe) and follow slightly different experiments. Given that, it's remarkable how similar the results are.

KEY CONCEPTS

cost function
cost function
fixed cost
variable cost
total cost
average cost
average fixed cost
average variable cost
marginal cost
supply function
short-run supply curve
long-run supply curve
short run
long run
supply function
supply curve
demand curve
willingness to pay
inverse demand curve
demand function
demand curve
law of demand
law of large numbers
identification

REVIEW AND PRACTICE PROBLEMS

■ **6.1. Cost function.** What is the firm's cost function?

■ **6.2. Production function and cost function.** What is the relation between a firm's production function and cost function when there is only one input?

■ **6.3. U-shaped average cost function.** What is the economic intuition for a U-shaped average cost function?

■ **6.4. Cost curves.** Draw a graph showing the average total cost, average variable cost, and marginal cost curves for a typical competitive firm (as shown in the present chapter). Indicate three price levels on this graph: a price, labeled p_3, that results in the firm making positive profits; a price, labeled p_2, that results in the firm breaking even; and a price, labeled p_1, that results in the firm making negative profits that are lower (in expected value) than fixed costs.

■ **6.5. Marginal cost and average cost.** True, false or uncertain: "When *MC* is above *AVC*, *AVC* is rising." Justify your answer.

■ **6.6. Supply function.** Define a firm's supply function.

■ **6.7. Marginal cost and average cost.** "Marginal cost is the appropriate cost concept to decide how much to produce, whereas average cost is the appropriate cost concept to decide whether to produce at all." Explain.

■ **6.8. Output and shut-down decisions.** Consider a firm with the cost function depicted in Figure 6.21. For each of the following propositions, state if they are true, false, or uncertain. (By uncertain we mean that, with the available information, one cannot determine whether the proposition is true or false.) Justify your answers.

(a) By setting q^*, the firm incurs a loss equal to the area A.

(b) Conditional on being active, q^* is the optimal output level.

(c) The firm is better off by shutting down.

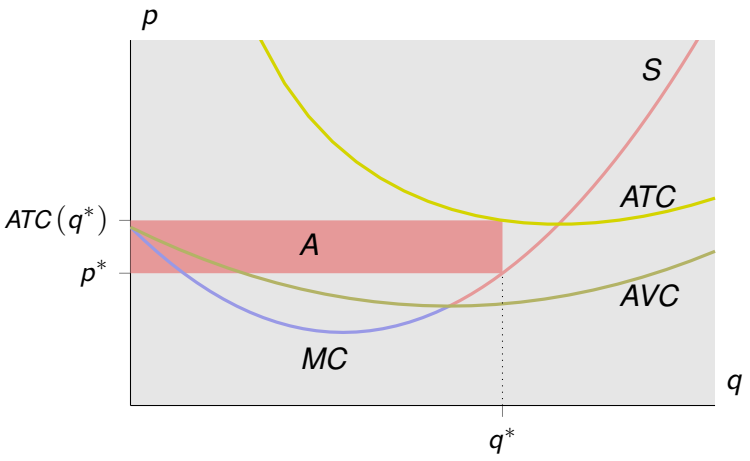


FIGURE 6.21
Shut-down decisions (cf Exercise 6.8)

(d) The firm should produce at the output level such that average total cost is minimized.

(e) In the short run, the firm should produce at the output level such that average variable cost is minimized.

■ **6.9. Short-run supply.** What do we mean by the firm's short-run supply curve?

■ **6.10. Firm supply and industry supply.** A firm's marginal cost curve is given by $MC(q) = 1 + \frac{1}{2}q$. The minimum of the firm's average cost is given by 2.5.

(a) Plot the firm's marginal cost function.

(b) Derive the expression of the firm's supply curve.

(c) Determine the firm's optimal output level when $p = 4$.

(d) Determine the firm's optimal output level when $p = 2$.

(e) Suppose that the industry in question comprises 200 firms like the one above. Derive the industry supply curve.

■ **6.11. Short run and long run.** What is, from an economics point of view, the difference between the short run and the long run?

TABLE 6.7
Oil producing countries

Country	Prod. capacity*	Marginal cost**
USA	15.0	54.6
Saudi Arabia	12.0	10.6
Russia	10.8	35.8
Iraq	4.5	15.3
Iran	4.0	11.9
China	4.0	67.5
Canada	3.7	52.1
United Arab Emirates	3.1	34.1
Kuwait	2.9	3.5
India	2.5	46.7

* Million barrels a day. Source: U.S. Energy Information Administration
** US$ per barrel. Source: Asker, Collard-Wexler, De Loecker (2019)

■ **6.12. Oil supply function.** Table 6.7 lists the world's top ten oil-producing countries. For the purpose of the present exercise, suppose that (a) these are the only oil producing countries, (b) each country acts as an independent player/firm, and (c) the marginal production cost is constant up to capacity. For example, the US must pay $54.6 to produce the first barrel or any other barrel up to 15 million in a given day.

Assuming that each firm/country acts as a price taker, derive and plot the supply curve. Specifically, suppose that each firm/country produces up to capacity if and only if the ongoing price is above their cost.

■ **6.13. Steel market supply.** Suppose there are two technologies for producing steel. Technology 1 corresponds to a fixed cost of 450, a marginal cost of 8, and a production capacity of 120. Technology 2 corresponds to a fixed cost of 62, a marginal cost of 13, and a production capacity of 35. Currently, there are 2 firms using Technology 1 and 10 firms using Technology 2. Assuming all firms behave as price takers, derive the industry short-run supply curve.

■ **6.14. Labor supply.** As seen in Section 6.1, the firm's supply curve is an increasing function of price. Consider a different type of supply curve: the labor supply curve.

(a) Show that the labor supply curve may be negatively sloped. (Hint: revisit the microeconomic foundations of labor supply, first presented in Section 4.2.)

(b) Suppose that, as empirical evidence suggests, the income effect on leisure of an increase in wage is (a) very small for high levels of leisure and low levels of income; and (b) very large for low levels of leisure and high levels of income. What does this imply in terms of the shape of the labor supply function?

■ **6.15. Willingness to pay.** Define a consumer's willingness to pay (WTP). How does it relate to the consumer's MRS? How does it relate to price?

■ **6.16. Inverse demand.** What do we mean by the inverse demand curve?

■ **6.17. Opera tickets.** Yunok's (yearly) demand for opera tickets is given by $q = 4 - .02\,p$, where q is the number of opera tickets and p the price of an individual ticket in \$. How much is Yunok willing to pay for a second opera ticket?

■ **6.18. Ali burgers.** There are two types of consumers of Ali burgers: type a consumers have demand given by $q_a = 10 - p$; and type b have demand given by $q_b = 20 - 2\,p$. There are 1,000 type a consumers and 400 type b consumers.

(a) Plot the individual demands of types a and b.

(b) Determine the market demand for Ali burgers as well as its inverse.

■ **6.19. Golden delicious.** There are two types of buyers of apples (the fruit, not the computer). Type a buyers have a demand given by $q = 6 - p$, where q is quantity in pounds per week and p is price in

dollars per pound. Type b buyers, in turn, have a demand given by $q = 10 - p$ (same units as type a demand).

(a) Derive each type's inverse demand curve and plot them on the same graph.

(b) How do type a and type b differ in their willingness to pay for a second pound of apples?

(c) Suppose that oranges cost \$4 per pound. How much is a type a willing to pay for the "marginal" unit they buy? (If an individual buys, for example, three pounds, then the "marginal" unit is the third pound of apples.) How much is a type b willing to pay for the "marginal" unit they buy?

(d) Based on your answers to the two previous questions, can we say that type b have a greater willingness to pay than type a buyers? Justify your answer.

■ **6.20. Oranges.** The demand for oranges in Kabralstan has remained constant for years. The variations in price and output from year to year correspond to shifts in the supply function, which in turn is primarily affected by varying weather conditions. Table 6.8 shows the last ten years of annual data on the Kabralstan orange industry.

(a) Plot the values of price and output in the usual way (i.e., with price on the vertical axis). Try to plot the values as accurately as possible.

(b) Estimate the demand curve as a linear function. Hint: draw a straight line through the points and find the intercepts on the axes.

■ **6.21. Law of Demand.** True, false or uncertain (justify your answer): The Law of Demand indicates that the demand curve is downward sloping.

■ **6.22. Slope of market demand.** Consider the values in Table 6.5. Show that the slope of each individual demand curve is constant. Determine the slope of the market demand curve for each price level. Why does the slope of demand curve increase as price increases?

TABLE 6.8
Orange price and output in Kabralstan

Year	Price	Output
2009	3.3	72
2010	3.8	59
2011	2.4	81
2012	2.3	74
2013	3.1	69
2014	2.7	73
2015	3.0	71
2016	3.5	66
2017	2.9	72
2018	3.2	66

■ **6.23. Positively sloped demand.** True or false (justify): Over the past ten years, the price of x has increased year after year, whereas quantity sold has increased too. This implies that the demand for x is positively sloped, that is, x is a Giffen good.

■ **6.24. Monsanto (reprise).** Refer back to Exercise 5.22. Using the events at Monsanto and Roundup as an illustration, explain the difference between a shift in the demand curve and a movement along the demand curve. Identify occurrences of each in the demand for Roundup.

CHAPTER 7

EQUILIBRIUM AND EFFICIENCY

Having introduced the supply and demand framework (Chapter 6), this chapter puts it to work. The goal is to understand how price and output level are determined in competitive markets (the law of supply and demand); how price and output levels are affected by exogenous events (e.g., a new tax, a natural disaster, a change in the price of an input or of a substitute product); and what properties such market equilibrium has. The chapter is divided into several parts: Section 7.1 introduces the concept of competitive markets and develops the framework of comparative statics (the analysis of how exogenous shocks affect price and output level). Section 7.2 defines the important concepts of producer and consumer surplus. It also includes an important result in microeconomics, The First Welfare Theorem. Finally, Section 7.3 deals with public policy that interferes with the market mechanism (e.g., rent control).

7.1. COMPETITIVE MARKETS

In previous chapters, we referred several times to competitive markets, stressing the feature of many sellers on the supply side and many buyers on the demand side. At this point it will help to provide a more precise definition of what we mean by **competitive markets**. First, we assume that all firms produce the same product (as in commodity markets); that is, we make the **homogeneous product**

assumption. This implies that firms compete head to head on price, the only relevant variable. Moreover, firms are so small that no particular firm has an effect on price. In other words, firms are **price takers**.

Second, we assume **well-defined property rights**. At this point, this may not seem a very important point but, as we will see later, it turns out to be quite crucial. For now, suffice it to say that property rights over Planet Earth are not well defined: we all own the planet and nobody owns the planet, and this is one of the reasons why pollution and climate change are a big problem and an unregulated free-market solution won't solve it. We'll get back to this in Chapter 9.

Third, we assume that all agents (firms and consumers) are well aware of all prices and product characteristics and contract conditions. No hidden fees and so forth. Formally, we assume **perfect information**.

How reasonable are these assumptions? More so in some cases than in others. The characteristics of many commodity industries seem to match (at least approximately) the assumptions of the competitive model. More generally, the idea is to think of the perfect competition model as a benchmark that particular industries can be compared to.

That said, there are many industries where the above assumptions clearly do not hold. Internet search does not have a multitude of small-size, price-taking sellers: it's Google and little else. Recent developments notwithstanding, the car manufacturers and car drivers have not taken into account the enormous harm that gasoline engines inflict on the planet, a violation of the property rights of present and future generations. And no consumer that I know (including myself) has ever read the "terms of agreement" in any website; we simply click on "I agree". It is therefore clear that we do not have perfect information regarding prices and product characteristics and contractual terms and conditions.

In Chapters 8, 9 and 10 we will deal with each of the above departures from the model of competitive markets. In this chapter we will stick with the reference point provided by competitive markets.

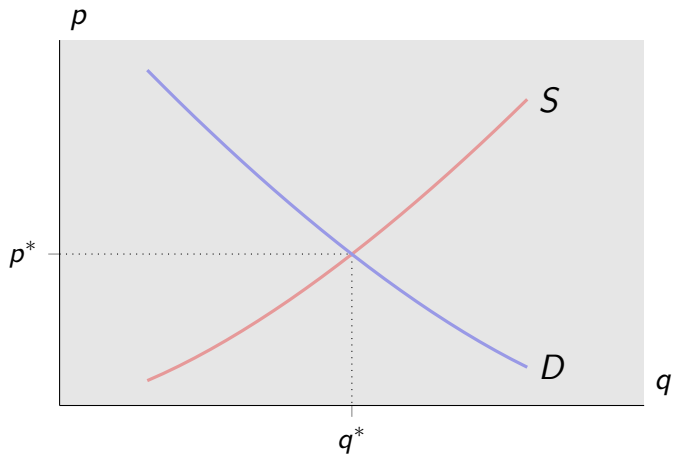


FIGURE 7.1
The market mechanism

THE MARKET MECHANISM

Figure 7.1 shows the basic diagram of supply and demand. We will repeat this figure numerous times throughout the rest of the book, so it's good that you get well acquainted with it. Recall that, as per Alfred Marshall, we measure price on the vertical axis and quantity (or output) on the horizontal axis.

As mentioned in Chapter 6, it helps to distinguish between the supply function and the supply curve; and between the demand function and the demand curve. In the supply-and-demand chart (Figure 7.1), price and quantity are treated as endogenous variables, that is, variables to be determined. In fact, the whole point of the model is to study the determinants of p and q. All of the other variables included in the supply and demand functions are set at fixed values, that is, the particular supply and demand curves represented in Figure 7.1 correspond to particular values of those variables. If we change these values (as we will later), then we have a shift in either the supply curve or the demand curve or both.

The central idea of the model of supply and demand is that the price of a product is the result of the interaction between buyers (demand) and sellers (supply). We refer to the point at which the supply and demand curves intersect as the **market equilibrium**. In Figure 7.1 this is given by point (q^*, p^*), where the supply curve crosses the demand curve. We thus say that p^* is the equilibrium price and q^* the

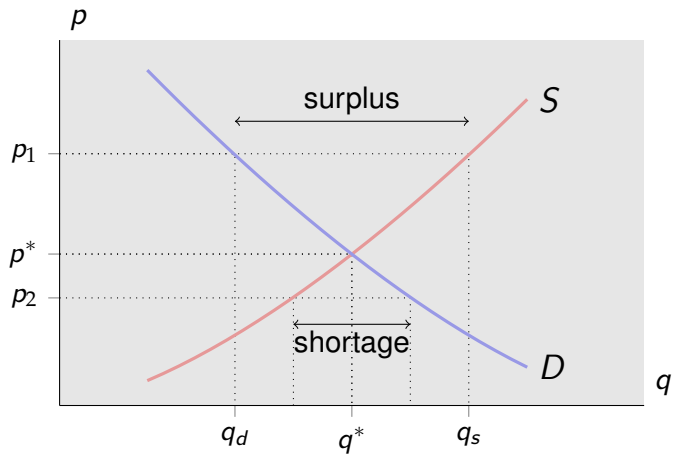


FIGURE 7.2
Excess supply and excess demand

equilibrium output level.

We say this outcome is an equilibrium in the sense that none of the market participants have an incentive to change their behavior: buyers are buying what they want at that price (the point is on the demand curve) and sellers are selling what they want (the point is on the supply curve).

If the price were higher than the equilibrium price, then fewer people would want to buy than to sell. We would be in a situation of **excess supply**. This is illustrated in Figure 7.2, where price p_1 is higher than the equilibrium price p^*. If we were in this situation, then the excess of sellers would tend to drive the price down. The idea is that disgruntled sellers (that is, sellers who are unable to sell) would look for buyers and offer a lower price than the buyer is currently paying.

Conversely, if the price were lower than the equilibrium price, then fewer people would be willing to sell than to buy. We would be in a situation of **excess demand**. This is illustrated in Figure 7.2, where price p_2 is lower than the equilibrium price p^*. If we were in this situation, then the excess of buyers would cause the price to increase. The idea is that disgruntled buyers (that is, buyers who are unable to buy) would look for sellers and offer a higher price than the seller is currently selling for.

The tendency of price to move in the direction of the equilibrium

Jeremy Kemp

Chicago Board of Trade corn pit (1993). When price deviates from the market clearing price, disgruntled buyers or disgruntled sellers make revised offers that push price in the direction of the equilibrium price.

price, also known as **market-clearing price**, is frequently referred to as the **law of supply and demand**. In other words,

> *Price tends to move in the direction of the equilibrium price (where supply equals demand).*

The law of supply and demand is not a law in the sense common to natural and exact sciences. However, the analogy can be useful. Consider, for example, the system formed by a pendulum hanging from a ceiling. Such system has an equilibrium: the vertical position. This is the point where the downward gravitational force is exactly compensated by the upward pull exerted by the string (by Newton's third law). Whenever the pendulum is not in the vertical position, a net force points in the direction of the rest point. (Not to worry, I will not be asking physics questions in the final.) By analogy, we can think of supply and demand as "forces" that push price up or down depending on whether the current price is below or above the equilibrium price. The equilibrium price, in turn, is the "rest point" of the system, the situation where the net force acting on price is zero.

As an example, consider the gold market. The top panel in Figure 7.3 shows the time series of gold price, on a monthly frequency, since 1970. Over the years, the price of gold has fluctuated considerably. This does not imply that price has been different from the equilibrium price, that is, the variations in price do not imply that we've been off equilibrium for decades. What happens is that, over time, both the supply of gold and the demand for gold are subject to shifts due to a variety of factors, which in turn implies that the equilibrium values of p and q change.

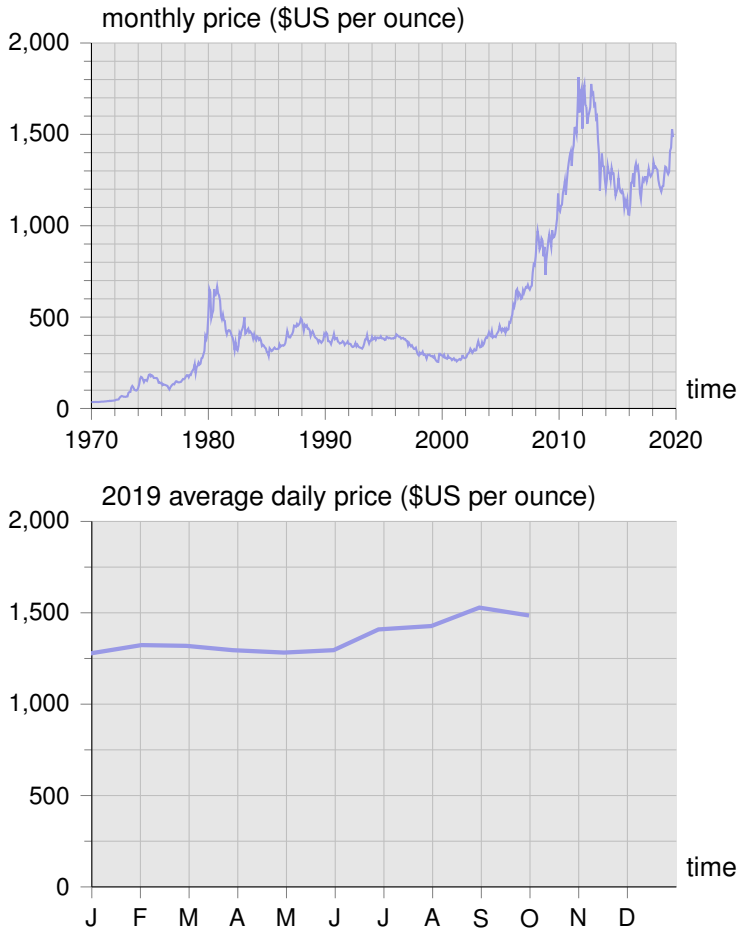


FIGURE 7.3
Monthly gold prices (top panel, source: Gold Hub); and daily gold prices (bottom panel, source: Quandl)

The bottom panel of Figure 7.3 shows the daily price of gold during 2019. This time we see considerably less variation, which suggests that demand and supply have been relatively stable during the year 2019, i.e., $1,500 per ounce is the price such that market demand balances market supply. (Real time data shows some within-day price variation, but not much.) On October 25, 2019, for example, the going price of gold was 1513.45 dollars per ounce. If for some reason many sellers had set an ask price of 1600, then there would have been too few buyers willing to buy at that price (excess supply). It would then have been in some sellers' interest to reduce the ask. This is the equivalent of the gravitational force in the pendulum

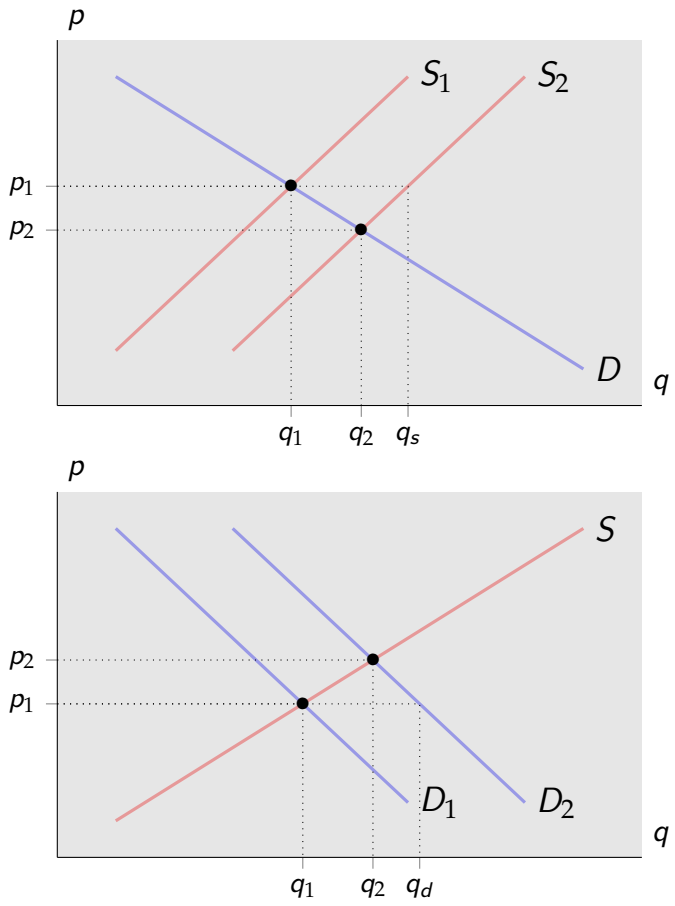


FIGURE 7.4
Supply (top) and demand (bottom) shift and changes in market equilibrium

example: if price is above the equilibrium price, then the "natural" market forces tend to bring it down to the market-clearing level. The same applies to situations when price is lower than its equilibrium level.

As the gold example suggests, in the real world there are many exogenous factors (production technology, input costs, tastes, income, and so forth) shifting the supply and demand curves at all times. For this reason, the equilibrium point itself is constantly changing. In this sense, it is not very appropriate to talk about equilibrium as a "rest point." Nevertheless, finding the equilibrium is a helpful way of understanding in which direction we expect price will move. We next turn to this issue.

COMPARATIVE STATICS

Often we are concerned about changes in market conditions. If the demand or supply curve shifts due to changes in various underlying factors, then a new equilibrium price is established. The term **comparative statics** is used by economists to describe the exercise of estimating the new market equilibrium resulting from a change in an exogenous factor. We do this by shifting the supply or demand curves and noting the resulting change in the equilibrium price and quantity. The most basic principles of comparative statics are that

> *(a) A rightward shift of the demand curve leads to an increase in quantity and an increase in price.*
> *(b) A rightward shift of the supply curve leads to an increase in quantity and a decrease in price.*

(For the opposite shifts in demand or supply, just change the signs.) So, if I ask you what effect will event Y have on price and quantity in market X, the question to ask yourself is what Y implies in terms of shifts in the demand and supply curves of good X. For example, suppose that the price of raw materials falls. As illustrated in the top panel of Figure 7.4, this implies that S shifts from S_1 to S_2 (a downward shift in the supply curve). If price were to stay at its original level p_1, then we would have a situation of excess supply. Therefore, price adjusts to the new and lower equilibrium level, p_2. Suppose instead that consumer income increases. As illustrated in the bottom panel of Figure 7.4, this corresponds to a rightward shift in D, from D_1 to D_2. If price were to stay at its original level p_1, then we would have a situation of excess demand. Therefore, price adjusts to the new and higher equilibrium level, p_2.

EXAMPLE: TAIWAN'S 1999 EARTHQUAKE

Consider a real-world example: the September 1999 earthquake in Taiwan. What impact would you expect it to have on the world market for DRAM (dynamic random access memory), both in terms of price and in terms of quantity? Before answering this question, two important pieces of information: First, the relevant market for

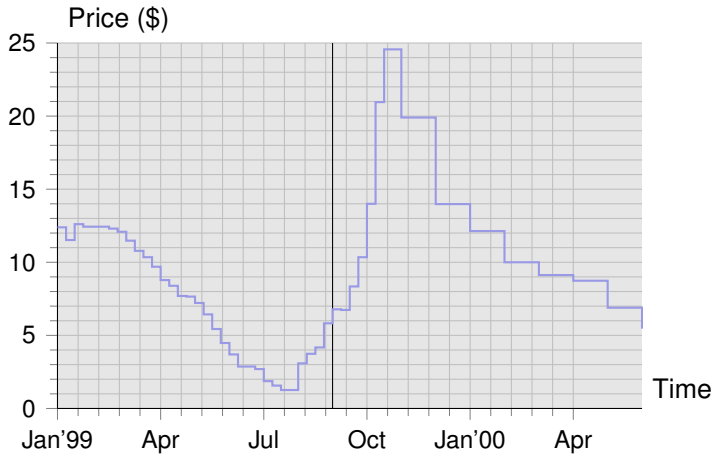


FIGURE 7.5
Taiwan earthquake: price level over time (source: *Financial Times* and author's calculations)

DRAM is the world. Second, Taiwan is one of the world's leading producers, accounting for about 10% of world output.

An earthquake is likely to shut down a series of factories (it did), which implies a northwest (or leftward) shift in the supply curve, like the shift from S_2 to S_1 in the top panel of Figure 7.4. The shift in supply leads to an increase in price and a decrease in quantity.

Figure 7.5 shows the world price of DRAM around the date of the Taiwan earthquake. Just before the earthquake, prices were around $7. Just after the earthquake, in a matter of days, prices sky-rocketed to values as high as $25. This seems a little too much, considering that only a fraction of Taiwan's factories were affected, and Taiwan in turn represents less than 10% of world supply. One possible interpretation is that the earthquake also induced a sharp increase in speculative demand (brokers or computer manufacturers who stockpiled in anticipation of further price increases). This interpretation is consistent with the fact that prices declined considerably in the months after the initial spike.

SOME RULES OF THUMB

Before continuing, here are some rules of thumb that may help in the process of comparative statics. First, it's important to distinguish be-

tween shifts in the supply (or demand) curve and movements along the supply (or demand) curve. Consider the top panel in Figure 7.6. For illustration purposes, think of it as reflecting the supply of copper. Three periods are considered, from 1 to 3. At time 1, the supply curve is given by S_1 and price is given by p_1. It follows that the quantity supplied is given by q_1. Now suppose that, at time 2, an increase in demand by Chinese manufacturers pushes price up to p_2. The supply function is still the same, so we have a *movement along* the supply curve, leading to a higher quantity supplied, q_2. Finally, at time 3 a new copper mine is discovered. This shifts the entire supply schedule from $S_1 = S_2$ to S_3. China continues to push demand outward, so that the new equilibrium point is at E_3. The result is that, even though price did not change, we have an increase in quantity supplied, this time caused by an *shift in the supply curve*. (It is a bit of a fluke that the shift in demand and supply curves leads to a change in q and a zero change in p. I consider this case for illustration purposes only.) In sum, the change from E_1 to E_2 corresponds to a movement along the supply curve, whereas the change from E_2 to E_3 corresponds to a shift of the supply curve (as well as a shift in the demand curve). The rule is simple: if it's the price that changes, we have a movement along the curve; if it's something else that changes, we have a shift of the curve itself.

The same applies to the demand curve. This is illustrated in the bottom panel of Figure 7.6. For illustration purposes, think of D as the demand for Coke. Initially, demand is at D_1 and price is given by p_1, resulting in a quantity demanded equal to q_1. Suppose that, at time 2, the Coca-Cola Company decides to jack up price to p_2. Assuming that demand remains the same as at time 1, we have a movement along the demand curve, bringing quantity demanded down to q_2. Finally, suppose that, at time 3, PepsiCo decides to decrease the price of Pepsi. I know this is not your case, but there are consumers who do not have very strong feelings regarding Pepsi or Coke. Given that, the demand for Coke shifts to the left to D_3, the result of a big consumer shift from Coke to Pepsi. Now, even if the price of Coke remains the same ($p_3 = p_2$), we will observe a decrease in the quantity demanded of Coke, a decrease that results from the leftward shift in the demand for Coke.

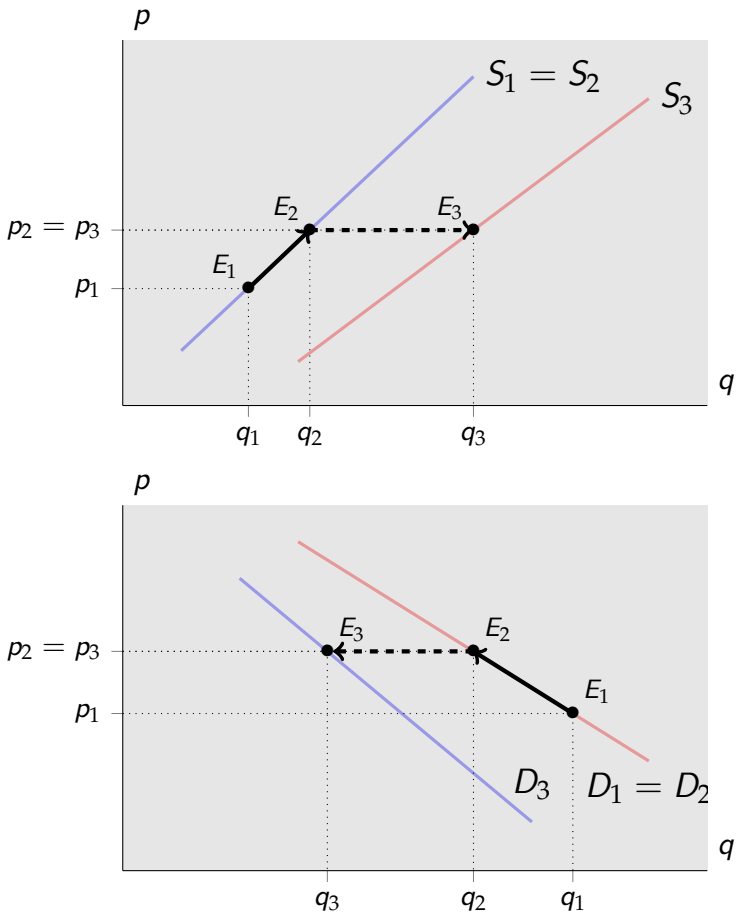


FIGURE 7.6
Shifts in supply (top) and shifts in demand (bottom). Movements along curves are marked with solid arrows, whereas shifts in curves are market with dashed arrows.

Movements along the supply (resp. demand) curve of x, while other factors remain the same, corresponds to changes in the price of x. Shifts in the supply (resp. demand) curve of x result from changes in factors other than the price of x.

Figure 7.7 illustrates another important rule of thumb. Let us start with the top panel. When we say that there is an increase in supply, or that the supply function expands, we mean that the supply curve shifts in the south east direction, for example from S_1 to S_2. This shift in the supply function can be thought of as a movement to

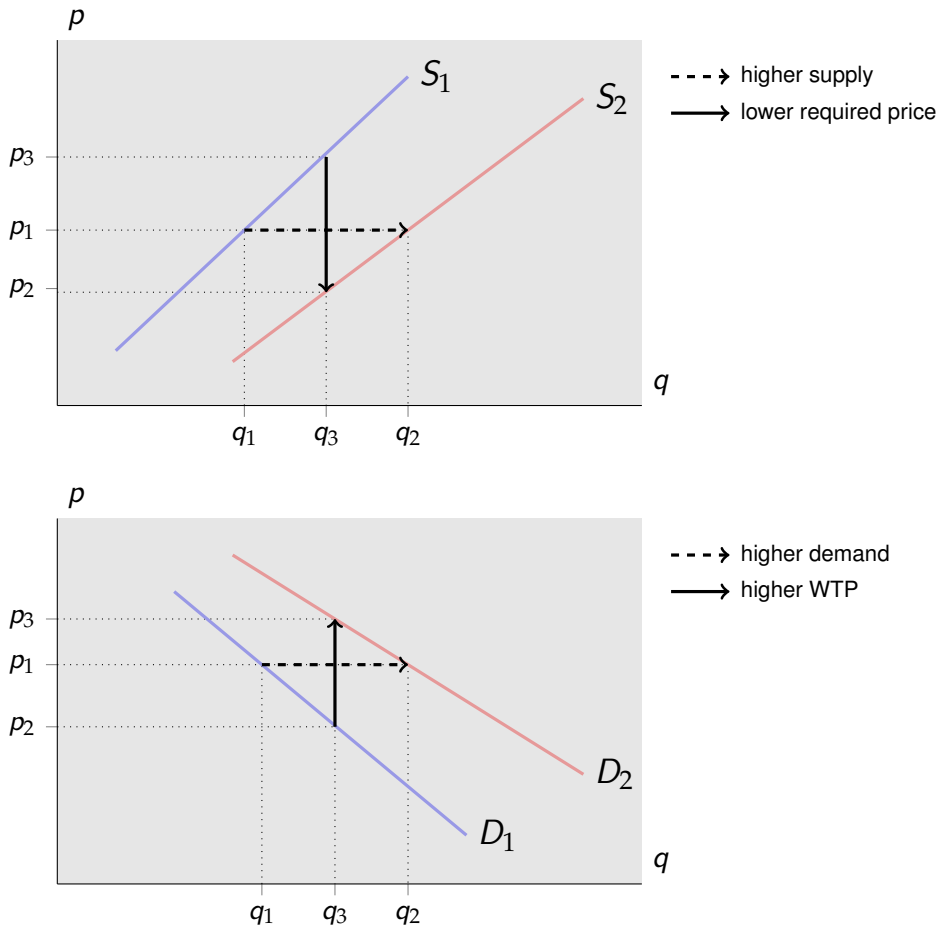


FIGURE 7.7
Shifts in supply (top) and shifts in demand (bottom)

the right or a downward movement. I know, this seems confusing: a downward shift of the supply function corresponds to an increase in supply! Hopefully the confusion disappears if we pay closer attention to what is actually happening. Let us first consider a rightward movement, which is easier to interpret. For example, a new firm enters the market or an existing firm builds a new factory or goes on a hiring spree. All of these changes imply that, for a given price, the market is willing to supply a higher total quantity. This makes a lot of sense.

Consider now the case when one of the suppliers' inputs becomes cheaper. For example, due to technological progress the cost of robots declines, or the government lowers import tariffs on steel (one of the

firm's inputs). This implies that the lowest price that each supplier requires to supply a given output unit is now lower. Recall that the firm's supply curve (and thus the market supply curve) reflects the firm's marginal cost. If marginal cost is lower, then the height of the firm's supply curve is lower. This in turn corresponds to an expansion in supply. In fact, if there is a reduction in the lowest price that a firm requires to supply, it follows that, for a given price, the firm is willing to supply more (check S_2 vs S_1).

The same is true for shifts in the demand curve, as illustrated in the bottom panel of Figure 7.7. Consider, for example, the demand for movie tickets at the only movie theater in Hill Valley, CA. If a bunch of people move to Hill Valley, then we have a shift of the demand curve to the right: for a given theater ticket price, more people will come to the movies. Alternatively, suppose that the theater owner invests on a major uplift of the theater's facilities and starts exhibiting really popular movies. Then, even if the number of residents of Hill Valley does not change, their willingness to pay for a theater ticket increases. This corresponds to an upward shift of the demand curve. Similarly to a rightward shift, this upward shift corresponds to an expansion of the demand curve. In sum, an expansion of the demand curve may be interpreted as an increase (rightward shift) of the (direct) demand curve; or as an increase (upward shift) of the inverse demand (i.e., willingness to pay).

Once you get into the mechanics of comparative statics, it should come naturally to interpret real-world events as shocks to demand and supply curves, which in turn lead to adjustments in price and transaction volumes. Consider some recent events in the honey industry, as described in Box 7.1. The left column includes a series of quotes from a *Wall Street Journal* article on the honey industry. The right column, in turn, includes a series of comments on how to interpret these events in terms of the model of supply and demand.

COMPARATIVE STATICS: THE ANALYTICAL APPROACH

Sometimes we are able to estimate the shape of the supply and the demand curves. In these cases, we may be able to go beyond the qualitative approach considered up to now and actually put a number on the prediction of what happens to price and quantity. Consider the following example from the gasoline market. The supply

Box 7.1: Events in the honey industry.

How a news article on the honey industry reflects many of the concepts introduced in this chapter (source: Cyril Morong).

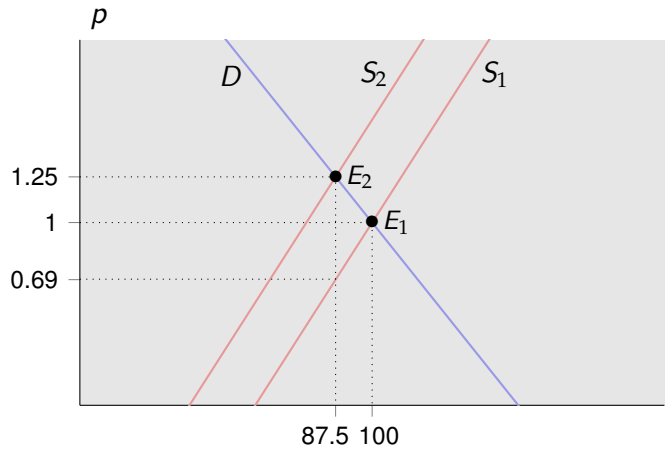
Article quote	Comment
Honey prices are starting to sting. Global honey prices are at their highest levels in years, due to a new wave of consumer demand for natural sweeteners ...	Demand increased because tastes or preferences increased, the opposite happening for sugar.
... and declining bee populations that are hampering mass production.	Supply decreases.
In addition, it is being used more as an ingredient in shampoos, moisturizers and other personal-care products that companies market as naturally made.	Another increase in demand due to tastes.
U.S. retail prices averaged $7.66 a pound in May, up 9% from a year earlier. Those prices have risen by about two-thirds in the last decade. Americans consumed 596 million pounds of honey in 2017, or an average of nearly two pounds per person — up 65% since 2009.	If demand shifts right, then we expect both price and quantity to increase
It has been touted by celebrities — including tennis star Novak Djokovic — for its health benefits and numerous scientific studies have shown it can help heal wounds, ulcers and burns.	Maybe this is part of the reason why tastes increased.
Global honey production has been relatively stable over the past five years.	But if supply shifted left, that could cancel out the demand increase and leave quantity the same.
In the U.S., honey production peaked in 2014 and has fallen 15% since then.	If supply shifted more to the left than demand shifted to the right, total Q falls — maybe the increased American quantity means less for consumers elsewhere.

and demand functions (p in dollars, q in million gallons per day) are given by

$$\begin{aligned} Q_D &= 150 - 50\,p \\ Q_S &= 60 + 40\,p \end{aligned}$$

BestGraphics_Com

Once you get into the mechanics of comparative statics, it should come naturally to interpret real-world events as shocks to demand and supply curves which lead to adjustments in price and transaction volumes.



$$D: \quad q = 150 - 50\,p \qquad p = 3 - q/50$$

$$S_1: \quad q = 60 + 40\,p \qquad p = \tfrac{q-60}{40}$$

$$S_2: \quad q = 60 + 40\,(p - .5625) \qquad p = \tfrac{q-37.5}{40}$$

FIGURE 7.8
Practice: gasoline tax

The initial market equilibrium results from the equality of supply and demand:

$$\begin{aligned} 60 + 40\,p &= 150 - 50\,p \\ p &= (150 - 60)/(40 + 50) = 1 \\ q &= 60 + 40 = 100 \end{aligned}$$

So, the initial equilibrium price is \$1 per gallon and a total quantity of 100 million gallons is sold.

Now suppose the government imposes a tax of $t = 56.25$ cents per gallon. Specifically, suppliers now receive the sale price but must pay 56.25 cents per gallon sold to the tax authority. It follows they get a net price of p minus 56.25 cents. This implies that the new supply

curve is given by

$$Q_S = 60 + 40\,(p - .5625)$$

The idea is that firm supply is determined by the net price the firm receives. Even though consumers pay p at the pump, each gas station must pay 56.25 cents to the tax authority, thus netting $p - .5625$. So, instead of $Q_S = 60 + 40\,p$, the original supply curve, we get a new supply curve where net price $p - .5625$ substitutes for p. The new market equilibrium (with a 56.25 cents/gallon tax) is given by

$$\begin{aligned} 60 + 40\,(p - .5625) &= 150 - 50\,p \\ p &= (150 - 60 + 22.5)/(40 + 50) = 1.25 \\ q &= 60 + 40\,(p - t) \\ &= 60 + 40\,(1.25 - .5625) = 87.5 \end{aligned}$$

Figure 7.8 illustrates the above calculations. We conclude that, as a result of the tax, producers get less, consumers pay more, and the government collects $.5625 \times 87.5 = \$49.21875$ billion in taxes.

COMPARATIVE STATICS: THE NUMERICAL APPROACH

On September 14, 2019, drone attacks sparked fires at two Saudi Aramco oil facilities in Abqaiq (about 37 miles southwest of Dhahran). As a result, Saudi Arabia's Interior Ministry announced that the government would shut down half of its national oil production. Roughly 5 million barrels of oil per day, or 5% of global crude production, were suddenly taken off the market.

Assuming that each country has constant marginal cost up to capacity and that each country is a price taker, we derive the supply curve marked S_1 on the top panel in Figure 7.9. (Exercise 6.12 goes through this process in greater detail.)

Suppose (for simplicity) that, as a result of the September 2019 attack, Saudi Arabia stops producing oil altogether. What impact would we expect that to have on the oil price? One way to answer the question is to compute the new market supply curve. Clearly, it's shifting to the left, but by how much? If the oil price is less than Saudi Arabia's cost, then quantity supplied is not affected. If the oil price is greater than Saudi Arabia's cost, then quantity supplied decreases by the amount of Saudi Arabia's capacity. The top panel in Figure

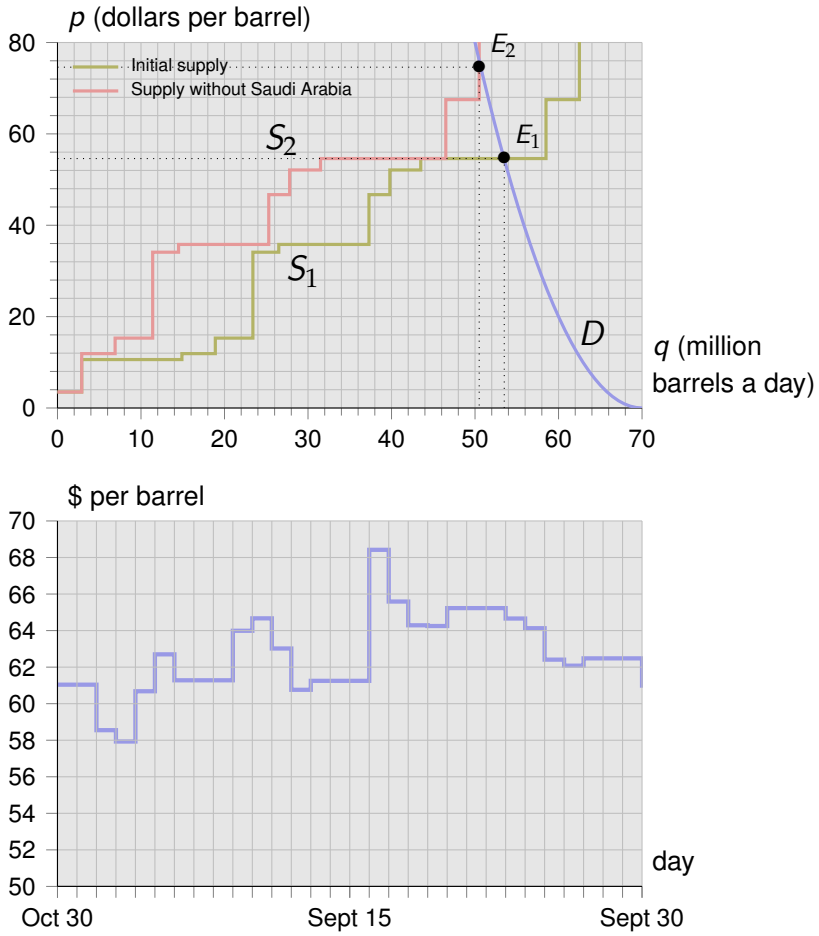


FIGURE 7.9
Application: oil market

7.9 depicts the new market supply of oil, S_2, following this reasoning. Assuming that demand is given by D, then the market equilibrium moves from E_1 to E_2. The bottom panel in Figure 7.9 shows the actual daily spot price during the month of September 2019. As expected, price did increase after the September 14 attack. (Prices are only quoted during weekdays. Since the attack took place on a Saturday, the first price observed after the shut-down was that for Monday, September 16.)

Loïc Manegarium

In October 2019, Saudi Arabia oil output was halved as some of its facilities were attacked by drones.

EFFECT ON PRICE AND EFFECT ON VOLUME

By now, we know how shifts in supply and demand lead to variations in quantity and price. An additional question is whether the shifts in supply and demand lead primarily to movements in price or primarily to movements in quantity. In other words, going beyond the sign of the changes in p and q, we are now also interested in the size of such changes.

If you work through an example using the supply and demand diagram, you'll see that the impact on price or quantity depends on the slopes of the supply and demand curves. Specifically, the effect of a shift in the supply curve depends on the slope of the demand curve. (This sounds a little strange, but it's true because the demand curve hasn't shifted, so the change in equilibrium is a movement along the demand curve.) If the demand curve is steep, then a shift in supply results primarily in a change in price. By contrast, if the demand curve is flat, then a shift in supply results primarily in a change in quantity. For shifts in demand, the impact depends on the slope of the supply curve. The four panels in Figure 7.10 illustrate the four possible cases (demand or supply shifts with elastic or inelastic supply and demand, respectively). Can you think of examples that fit each of these cases? (See Exercise 7.3 for more on this.)

> *The more sensitive demand (resp. supply) is to changes in price, the more the effect of a supply (resp. demand) shift will be felt on output as opposed to price.*

Thus a key ingredient to any market analysis is an assessment of the

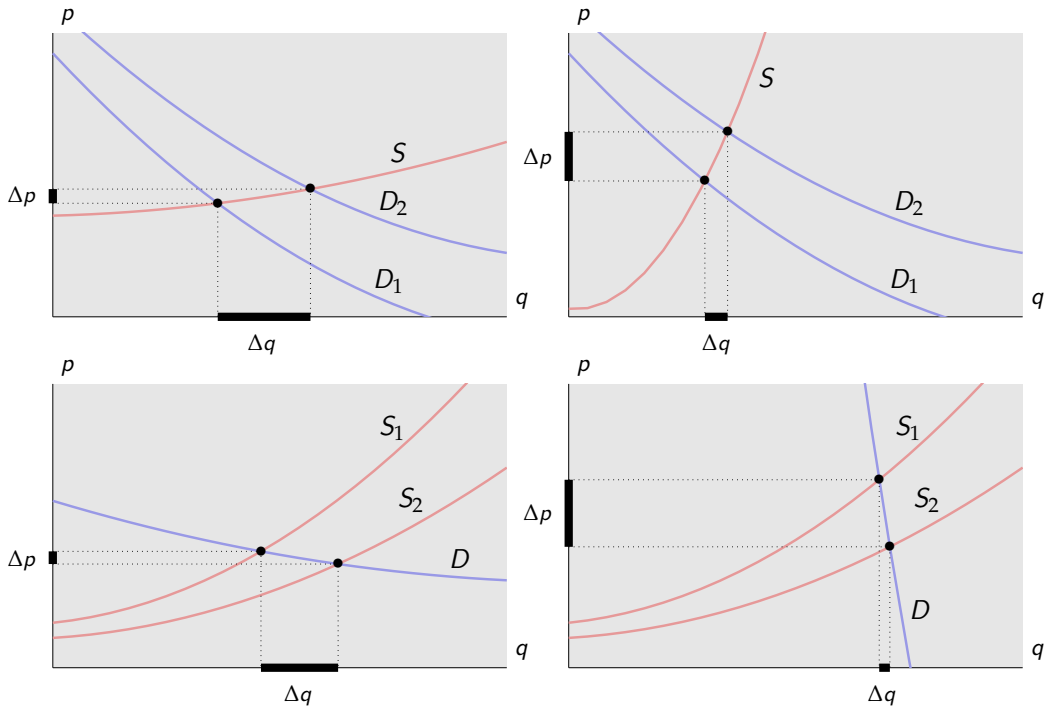


FIGURE 7.10
Price effect and output effect. Top panels: shift in demand. Bottom panels: shift in supply. Left panels: price sensitive supply (top), price sensitive demand (bottom). Right panels: rigid supply (top), rigid demand (bottom).

slopes of the supply and demand curves: how sensitive the decisions of buyers and sellers are to changes in price. Consider the California electricity market. The capacity of local power plants can't be changed much without building new ones. Moreover, the high-voltage lines to bring in power from other states have limited capacity. Hence the supply curve is very steep (vertical?) and the impact of an increase in demand (the result of growth of the California economy) is reflected almost entirely in the price. In fact, during 2000 and 2001, a combination of increasing demand and limited supply sent wholesale prices up by a factor of 8 or 9!

To conclude the discussion on price effects vs volume (or quantity) effects, let us go back to the case of gold. Figure 7.11 shows the daily values of gold price and trade volume. One particularly notable feature of the data is that the volume of trade is considerably more volatile than price. Why? One possible explanation in terms of the

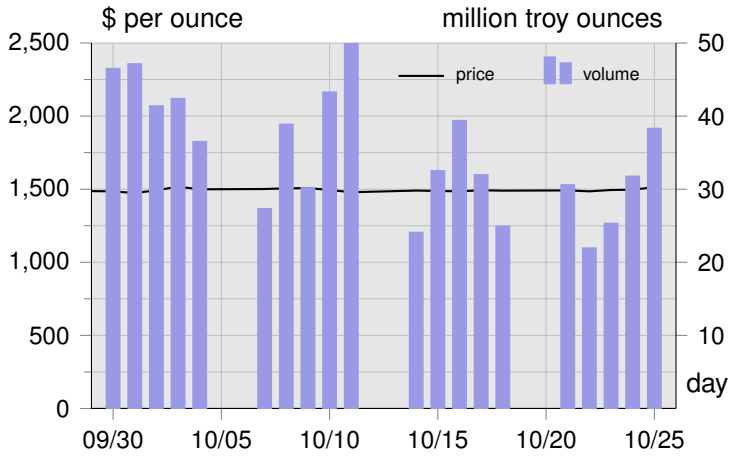


FIGURE 7.11
Price and volume of gold during October 2019
(sources: CME Group for volume, Quandl for price)

supply and demand framework is that both the supply and demand curves are very sensitive to price (very "flat"), so that small shocks to either schedule lead to major movements in volume of trade but not in price.

Figure 7.12 illustrates this possibility. Notice that the vertical price scale varies from 1400 to 1600. Therefore, the supply and demand schedules are considerably "flatter" than they look at first. Suppose there is a shift in the demand schedule from D_1 to D_2. This is a relatively small shift. In terms of vertical distance, we are talking about a drop in \$40 per ounce, a relatively small fraction of the \$1500 initial equilibrium price. However, to the extent that the supply curve is very sensitive to price changes, the shift in the demand curve produces a dramatic movement in the equilibrium value of q. Specifically, at E_2 the volume of trade is given by 18 million troy ounces, a considerable drop from the initial 30 million.

7.2. GAINS FROM TRADE AND EFFICIENCY

In this section, we define the concepts of producer and consumer surplus. We also discuss how they can be estimated and how they can help understand the concept of value, in particular value in use. We then come to one of the central results in microeconomics, namely

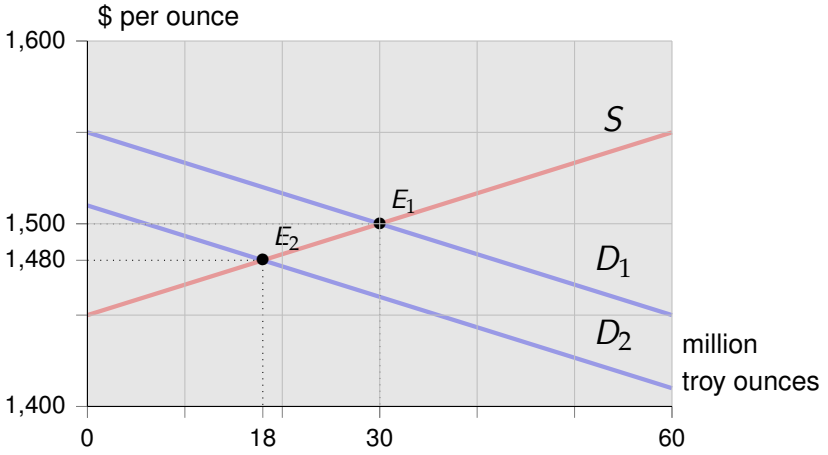


FIGURE 7.12
Price and volume of gold

that in competitive markets efficiency is maximized when p and q are at equilibrium values.

PRODUCER SURPLUS

In Chapter 6, we saw that price-taking firms optimally set an output level such that price equals marginal cost. Suppose that this were not the case. Specifically, suppose that price is greater than marginal cost, that is, $p > MC$. If that were the case, then by selling an extra unit the firm would receive an extra revenue of p and pay an extra cost MC, which implies that the firm would make an extra profit of $p - MC$ on that unit. If the firm can increase its profit with respect to the current output level, then it is not choosing an optimal output level. It follows that $p > MC$ cannot be an optimal solution. A similar argument applies to $p < MC$, which in turn implies that it must be $p = MC$ at the optimal output level.

The fact that the firm sells up to the point when $p = MC$ does *not* mean that the firm is selling all of its output at cost. Specifically, suppose that $q = q^*$ when $p = p^*$, where p^* is the going market price. To the extent that marginal cost is increasing in output level, each unit that the firm sells up to $q = q^*$ is sold at a price greater than marginal cost. This is illustrated in the top panel of Figure 7.13, where we see that MC is below p for all values of q lower than q^*.

(This need not be the case always, that is, it is theoretically possible that the first units sold by the firm have a marginal cost greater than sale price.) Specifically, the first unit is sold at a (variable) profit $p^* - MC(1)$, where $MC(1)$ is the marginal cost of the first unit. The second unit is sold at a (variable) profit $p^* - MC(2)$, where $MC(2)$ is the marginal cost of the second unit. And so forth.

If we add all of these individual-unit profit values, then we obtain the firm's overall variable profit. Specifically, the firm's **producer surplus** is equal to the firm's variable profit, the sum of the variable profit of all units sold. Graphically, in the top panel of Figure 7.13 the firm's variable profit corresponds to the area limited below by the the MC curve and above by the price level.

Since the producer surplus corresponds to the firm's variable profit, we can also measure it as the product of (price minus average cost) times output:

$$\left(p^* - AVC(q^*)\right)\, q^* = p^*\, q^* - VC(q^*)$$

where q^* is the output corresponding to p^* and AVC the average variable cost. In terms of the top panel of Figure 7.13, this corresponds to the area of a rectangle with height $p^* - AVC(q^*)$ and length q^*. It follows that the area of this rectangle is equal to the area between MC and p, that is, the area $A + B + C$ is equal to the area $B + D$.

Just as we aggregate individual supply functions to obtain the market supply function, we can also aggregate each firm's surplus to obtain the market producer surplus. This is illustrated in the bottom panel of Figure 7.13. As we can see,

> *The industry producer surplus is given by the area limited below by the market supply curve and above by the price level, ranging from zero to the value of supply corresponding to the going price.*

(Note that I use the notation Q for industry output so as to distinguish it from q, the individual firm's output. In a competitive market, we would expect there to be many sellers and the value of Q to be measured in larger units than the value of q.)

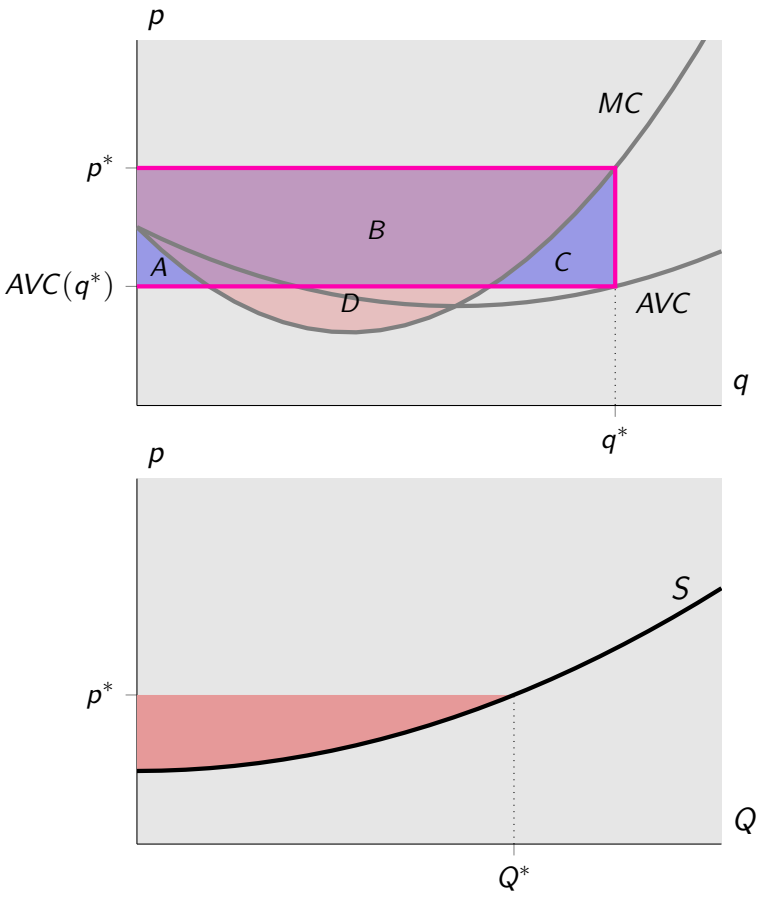


FIGURE 7.13
Firm producer surplus (top) and market producer surplus (bottom)

CONSUMER SURPLUS

Suppose that before going to watch a movie you stop at a pizzeria and place your order. Pizza comes at a dollar a slice (I know, I should update this example). Imagine the maximum price you would be willing to pay for one pizza slice. Perhaps three dollars, especially if you are very hungry and there is no alternative eatery in the neighborhood. Consumers don't usually think about this explicitly; all they need to know is that they are willing to pay *at least* one dollar for that pizza slice. But, for the sake of argument, let us suppose that the maximum you would be willing to pay is three dollars.

How about a second slice of pizza? While one slice is the minimum necessary to survive through a movie, a second slice is an op-

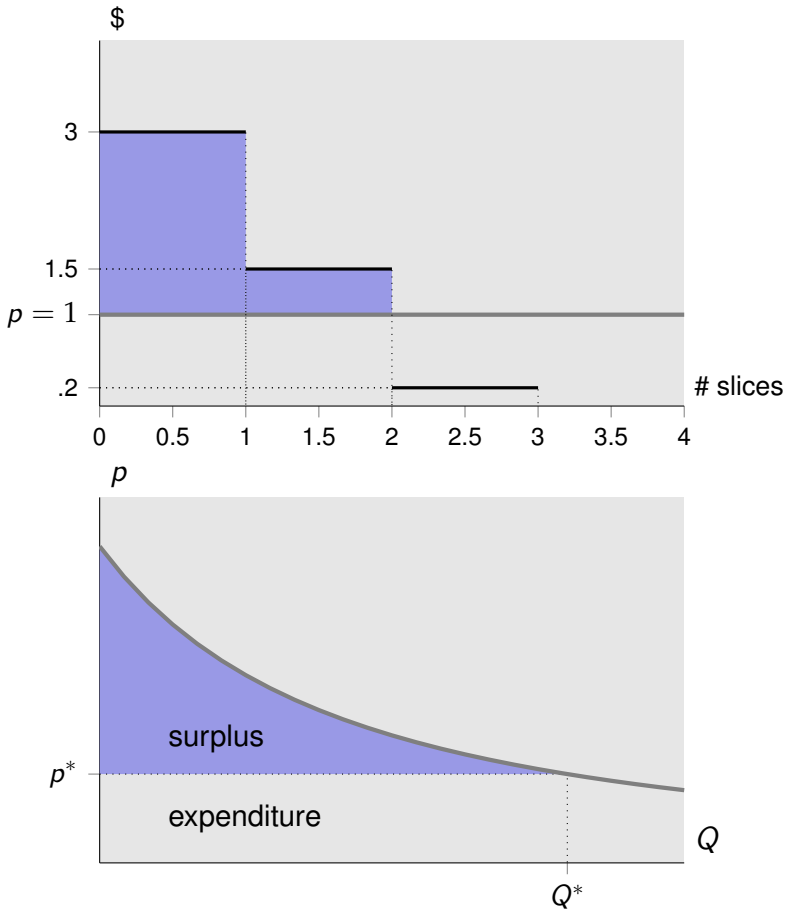


FIGURE 7.14
Consumer surplus: pizza consumer (top), market (bottom)

tion. It makes sense to assume you would be willing to pay less for a second slice than for the first slice; say, one dollar and 50 cents. What about a third slice? For most consumers, a third slice would be superfluous. If you are going to watch a movie, you might not have the time to eat it, anyway. If you were to buy a third slice, you would probably only eat the toppings and little else. You wouldn't be willing to pay more than, say, 20 cents.

Putting all of this information together, we have your demand curve for pizza. The top panel in Figure 7.14 illustrates this. On the horizontal axis, we have the number of pizza slices you buy. On the vertical axis, we measure the **willingness to pay**, that is, the maximum price (in dollars) at which you would still want to buy.

As discussed in Chapter 6, there are two things we can do with a demand curve. First, knowing what the price is (one dollar per slice), we can predict the number of slices bought. This is the number of slices such that willingness to pay is greater than or equal to price. Or, to use the demand curve, the quantity demanded is given by the point where the demand curve crosses the line $p = 1$. In the present case, this corresponds to two slices.

A second important use of the demand curve is to measure the consumer's willingness to pay. You would be willing to pay up to three dollars for one slice of pizza. That is, had the price been \$3, you would have bought one slice of pizza. Happily, you only paid \$1 for that first slice. Since the pizza is the same in both cases, you are \$3−\$1 = two dollars better off than you would be had you bought the slice under the worst possible circumstances (or not bought it at all).

Similarly, you paid 50 cents less for the second slice than the maximum you would have been willing to pay. Your total surplus as a consumer is thus \$2+50c = \$2.50, two dollars from the first slice and 50 cents from the second one. In other words, buying two slides of pizza for \$1 each generated value for you as a consumer, specifically the equivalent of \$4.50 of gross value or \$2.50 of net value (for you spend \$2 in the process).

This net value has a name: we call it **consumer surplus**. It is defined as the difference between willingness to pay and price actually paid. Recall, from Chapter 6, that willingness to pay is simply the value of the inverse demand curve (i.e., the value of p for a given value of q). It follows that *consumer surplus is given by the difference between the inverse demand curve and price*. Adding this up for all units purchased by the consumer, we have the area limited above by the consumer's inverse demand curve and below by price.

Just as we aggregate individual demand functions to obtain the market demand function, we can also aggregate each consumer's surplus to obtain the market consumer surplus. This is illustrated in the bottom panel of Figure 7.14, where market demand is represented by a continuous line.

Consumer surplus is given by the area under the (inverse) demand curve and above the price paid by the consumer, ranging from zero to

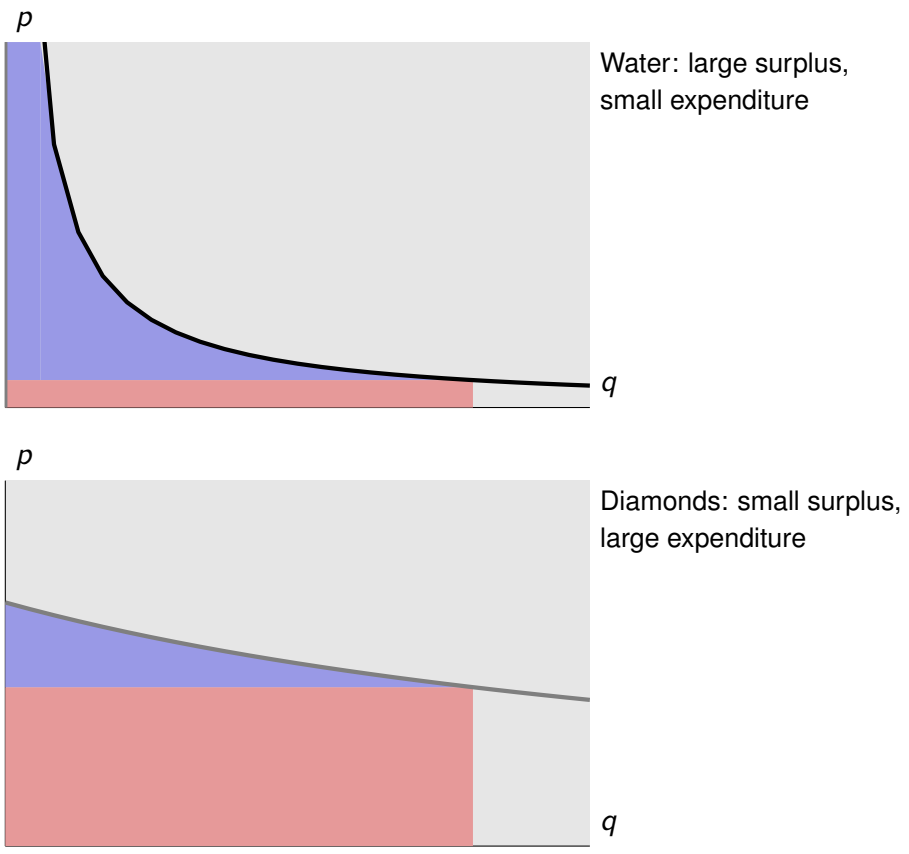


FIGURE 7.15
Application: water and diamonds

Q, the total quantity demanded.

Specifically, if price is p^*, then quantity demanded is Q^* and consumer surplus is given by the shaded area.

THE PARADOX OF VALUE

We first introduced the paradox of value in Section 2.3. We now revisit it in a more formal way. To refresh your memory, the water-diamonds paradox stems from the question, Which of the two has greater value: water or diamonds? The answer is that it really depends on what notion of value you consider (market value or value in use).

Figure 7.15 helps understand the distinction. On the top panel we have the market for water. The willingness to pay for water is very, very high when it comes to the first units you consume. You can survive without watering your lawn, maybe without showering, but I can assure you cannot survive without drinking water. Fortunately for us (in the US), water is relatively abundant, so that the market price is small. We thus live in an equilibrium where the total expense on water (red-shaded area) is relatively small compared to the (user) value created by consumer purchases (total of red- and blue-shaded areas).

By contrast, the demand for diamonds (bottom panel) is relatively more flat. If you were to ask consumers to pay a lot for diamonds eventually they would substitute something else for diamonds (jade?). Moreover, the market value of diamonds is very high, that is, they are sold for a very high price. It follows that the total expense in diamonds (red-shaded area) is relatively large compared to the (user) value created by consumer purchases (total of red- and blue-shaded areas).

In other words, the **market value** of diamonds is higher than the market value of water, but the **value in use** of water is higher than the value in use of diamonds. To put it in one sentence, I'd rather live without diamonds than without water, but I'd rather own DeBeers than ConEdison.

ESTIMATING CONSUMER SURPLUS

How do you find the value of consumer surplus, really? I get this question a lot. It's easy to understand where producer surplus comes from. After all, it's just variable profit, a concept we're all familiar with (at least in theory). Producer surplus, or profit, is the value that sellers create for their shareholders.

When it comes to consumers, there is no accounting profit to speak of and no shareholders to distribute it to. Still, consumers do create value (for themselves) when they pay less than what they would be willing to pay. If you feel happy when you made a purchase, one reason is that you just made a "profit", that is, you just created net value (the difference between your willingness to pay and price).

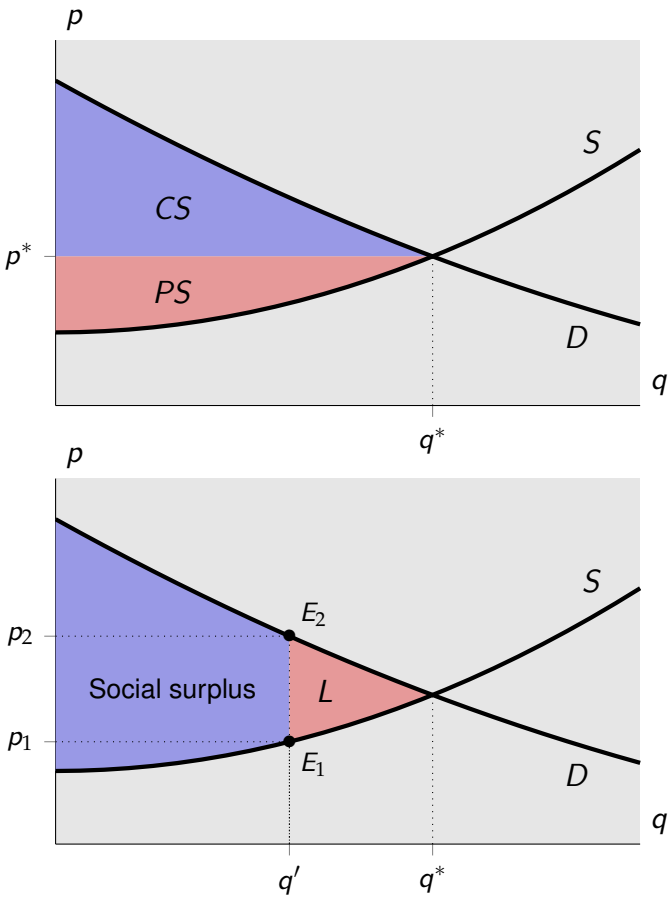


FIGURE 7.16
Efficient (top) and inefficient (bottom) output level

Can you put a number on the consumer's "profit"? Yes: the difference between willingness to pay and price is a specific dollar value. Can you estimate this dollar value? To the extent that you can estimate a consumer's or the market demand curve, you can invert it to find willingness to pay, and so compute the value of consumer surplus. In Section 6.2 we discussed the pitfalls of estimating market demand. They also apply when it comes to estimating consumer surplus.

GAINS FROM TRADE

We now come to one of the central results in microeconomics. One may agree or disagree with the material in this section, but one can-

not underplay the importance that it has had in economic and political thought for the past two centuries or so. Before getting into the result itself, we discuss one of the central concepts in economics, namely the concept of gains from trade (from which the concept of efficiency is derived).

Perhaps it's not immediately obvious, but trade creates value, that is, creates surplus. If trade is voluntary, this has to be true, or people wouldn't do it. Consider a specific example: Jane is a big fan of apples (the fruit, not the computer). She would be willing to pay up to \$10 for a pound of golden delicious. It costs Old McDonald 50 cents per pound to grow apples, and the current sale price is \$3 per pound. In this situation, when Jane buys her first pound of golden delicious she makes a "profit" of $10 - 3 = \$7$, which we refer to as consumer surplus. Old McDonald, in turn, makes a variable profit of $3 - .5 = \$2.5$ from selling one pound of golden delicious to Jane, a profit we refer to as producer surplus. All in all, the transaction creates a total value of \$9.5, the difference between Jane's value for the one pound of golden delicious and Old McDonald's production cost.

The crucial point is that the moment Old McDonald produces this particular pound of apples he does not create as much value as when he sells it to Jane, whose valuation equals \$10, far more than it costs Old McDonald to produce it. Naturally, when growing apples the farmer has in mind that there are consumers like Jane who value the fruit highly; but without trade such value is not realized.

The top panel of Figure 7.16 generalizes the concept. For buyers, the (inverse) demand curve represents their willingness to pay. The difference between the demand curve and market price (area CS) is thus surplus to buyers. Similarly, the (inverse) supply curve measures the price at which sellers are willing to sell. The difference between price and the supply curve (area PS) is thus surplus to sellers.

Total surplus generated by trade, the sum of areas A and B, measures the increase in economy-wide value that results from production and trade: going back to our example, it measures how much better the economy is with the existence of golden delicious apples and the fact that there is a market where they can be traded, i.e., a means for transferring this particular product from those who have it to those who value it.

THE FIRST WELFARE THEOREM

Why do economists (and many politicians) wax lyrical about markets? One reason (and there are other perhaps more compelling ones) is that competitive markets are efficient, meaning that

> *In a competitive market, the equilibrium levels of output and price correspond to the maximum total surplus.*

To economists, this is a sufficiently important and striking result that it has won the designation **First Welfare Theorem**. To rephrase the previous wording, the First Welare Theorem states that *gains from trade are maximized at the competitive equilibrium.*

The opening paragraph in this subsection makes an allusion to the concept of **efficiency**. As justice is to law and health to medicine, efficiency is a central concept in economics, in particular microeconomics. We may distinguish different types of efficiency. The first version, **allocative efficiency**, requires that resources be allocated to their most efficient use. We may then rephrase the First Welfare Theorem by stating that competitive markets are efficient in this sense that resources are properly allocated. Any output level different from the market level q^* would result in a lower total surplus (i.e., in lower gains from trade). In other words, it would result in an inefficient allocation of resources.

The possibility of an inefficient outcome is illustrated by the bottom panel of Figure 7.16. To continue with the example of the market for apples, suppose that only q' pounds of golden delicious are transacted. There are various reasons why trade volume is q' rather than q^*. One reason is that a regulator dictates a price ceiling p_1. Another reason is that a regulator dictates a price floor of p_2. This may not make a lot of sense, but as we will see in the next section there may be reasons to do so. For now, it's worth keeping in mind that efficiency does not necessarily imply optimality. In other words, there may be reasons why we as a society prefer an allocation that is not efficient but is better along some other dimension.

If, because of a price ceiling p_1 or because of a price floor p_2, market output is artificially kept at a level q' lower than the equilibrium (and efficient) level q^*, then there are a number of disgruntled buyers and sellers who would be willing to trade but do not do so because

the price is either too high or too low. Specifically, suppose that we are in E_1. Then there are a series of buyers (those with valuations corresponding to the demand curve from q' to q^*) who would be willing to pay more than the sellers would ask but won't do so because the price is "artificially" kept at p_2. Suppose instead that we are in E_2. Then there are a series of sellers (those with marginal cost corresponding to the supply curve from q' to q^*) who would be willing to sell for less than the buyers would be willing to pay but won't do so because the price is "artificially" kept at p_2.

In both cases (in equilibrium E_1 and in equilibrium E_2), total output equals q', which is lower than the (unregulated) market equilibrium and efficient level q^*. In total, area L measures the loss of value (i.e., loss in total surplus or loss in gains from trade) due to the inefficient output level. We refer to this area as the **deadweight loss** due to the deviation from the (unregulated) market equilibrium. So, another way to rephrase the First Welfare Theorem is to state that, in a competitive market, deadweight loss is minimized at the unregulated market equilibrium.

EXAMPLE: EUROPEAN AIRLINE DEREGULATION

The European airline industry provides a useful illustration of the First Welfare Theorem. Until the early 1990s, European airline markets were highly regulated. For example, if you wanted to travel from Rome to Paris, you only had two options: Alitalia or AirFrance. Moreover, there was no competition between these state-owned airlines: fares were set by an open agreement between the governments of Italy and France. As a result, airfares were expensive. Very expensive. A 1987 study estimated that, controlling for flight distance, Europeans had to pay between 34 and 65 cents per mile, about three times as much as Americans.

In 1992, the European Union (EU) Regulation 2408/92 dictated that, by 1997, any European carrier could offer service on any intra-European route. Gone the cartel agreements, the number of airlines and flights expanded during the 1990s and 2000s. By 1990, the number of European flights per week was just under 60,000. By 2000, the number was already greater than 100,000. Inevitably, the supply expansion had an effect on prices. By 2010, for similar 600-mile flights, Europeans were paying 11 cents per mile, whereas Americans were

paying 23 cents per mile. A quarter of a century earlier (in 1986, to be precise) these fares were 52 and 15 cents per mile, respectively.

To summarize, in the 24 years from 1986 to 2010, we estimate European fares (for 600-mile flights) dropped from about 52 to about 11 cents per mile, whereas in the US the fares increased from 15 to 23 cents! Since 2010, matters have become even worse for Americans, on account of a major consolidation of US airlines. More on this in Chapter 8.

Figure 7.17 illustrates the above narrative. The top panel describes the market equilibrium during the 1980s. Due to bilateral cartel agreements, fares were set at p_1 (high level) and the number of flights and passengers was q_1 (relatively small level). By contrast, the bottom panel describes the market during the late 1990s. As a result of the 1992 liberalization policy, the number of airlines and flights on most European routes increased. The number of passengers flown increased from q_1 (top panel) to q_2 (bottom panel). In this new equilibrium (E_2), fares are given by p_2, a lower value than p_1.

Liberalization of the European airline industry increased market efficiency. First, we have the area C in the top panel of Figure 7.17, which corresponds to the deadweight loss from "missing trades", that is, passengers who would be willing to pay more than it costs to carry them but not as much as the airlines were asking them to pay.

In addition to allowing, say, British Airways to fly from Paris to Rome, the European liberalization process also allowed new airlines to spring up. Ryanair, EasyJet, and many other newly-created low-cost airlines increased the competitive pressure. As the name suggests, these airlines are considerably more "lean" (that is, have considerably lower marginal cost) which allows them to offer lower fares. In terms of the graph on the bottom panel of Figure 7.17, entry by low-cost airlines may be represented by a shift of the supply curve from S to S'. This shift implied an additional drop in fares and an increase in the volume of passengers flown; and an additional increase in total surplus, measured by area D.

In addition to entry by "leaner" producers, the shift from S to S' may also be explained by the effort that incumbent airlines had to make to keep up with competition from low-cost airlines. Economists refer to this efficiency source as **productive efficiency**, which we may define as the proximity of a firm's cost to the truly

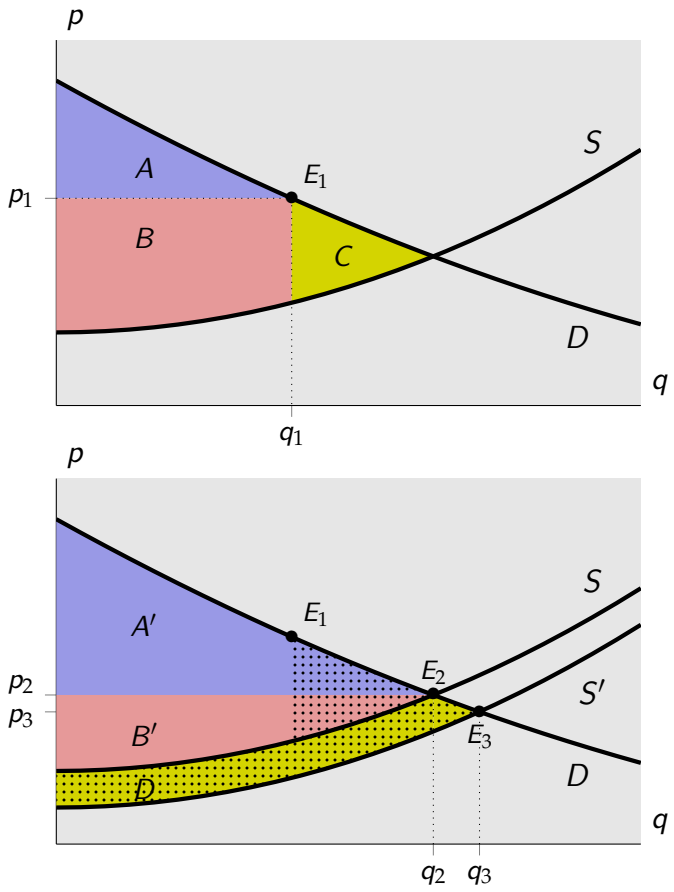


FIGURE 7.17
Effects of airline deregulation. The dotted area measures the efficiency increase from deregulation.

lowest possible cost. Admittedly, this is not a very rigorous definition: Up until now, we have assumed that firms choose the best combination of production inputs so as to produce output q at the lowest possible cost. Well, this is one of those cases when theory and practice don't necessarily coincide. Many firms, especially firms subject to little competition, may become "lazy" and produce in a way that does not minimize production cost (think CEO perks, shorter hours, cutting corners, etc). In other words, firms not subject to competition frequently show lower levels of productive efficiency. Harvey Leibenstein referred to this phenomenon as **X-inefficiency**.

Wikimedia

European airline liberalization brought fares down by about 80%.

THE INVISIBLE HAND

The First Welfare Theorem may be rephrased with reference to the famous (or infamous) "invisible hand" of the marketplace, one of the many pioneering ideas developed by Adam Smith. Though buyers and sellers may have disparate and conflicting preferences and abilities, the price mechanism ensures that those consumers who are willing (and able) to pay the most for each good get it, and those firms for whom it is cheapest to produce those goods produce it. Moreover, in the equilibrium of a competitive market there are no remaining consumers whose willingness to buy one additional unit is greater than what it would cost any firm in the economy to produce it. That is, *all trades such that willingness to pay is higher than cost take place.*

We usually don't think about it this way, but it's a truly phenomenal achievement: a decentralized, virtually costless system (the price system) manages the allocation of multiple resources among millions of agents in an efficient way (in the sense of allocative efficiency). Unlike central planning, which requires a very "heavy" structure to collect and process information, the price system accomplishes the efficient allocation of resources in a very simple, "lean" way. Specifically, all that each buyer has to do is answer the question: Is my willingness to pay for x greater than price? If so, then I will buy, if not then I won't. Similarly, all that each seller has to do is answer the question: Is my cost (i.e., willingness to sell) of x lower than price? If so, then I will sell, if not then I won't. The beauty of it is that this rule is both optimal for the individual buyer, the individual seller, and optimal for society as a whole *insofar as we're interested in maximizing gains from trade*.

This is what Adam Smith meant by the "invisible hand of the marketplace." We may agree or disagree with the accuracy and relevance of the idea. However, we cannot understate the importance that it has had in economic thought, and in political thought as well, for more than two centuries. Within the field of economics, these ideas were developed and popularized in the 20th century by economists such as Frederich Hayek and Milton Friedman. Under these and related authors, the First Welfare Theorem became part of the larger edifice of economic and political thought that includes liberalism, individualism and libertarianism. What these currents of thought have in common is their accent on individual freedom, including individual economic freedom, often in opposition to the role of government as a market regulator or as an agent of solidarity.

SURVIVAL OF THE FITTEST

When discussing the effects of liberalization of the European airline industry, we saw that putting an end to the bilateral cartels brought fares down (and increased the number of flights). In terms of the "invisible hand" narrative, this was the sign to European travelers with mid-level willingness to pay that it was OK to fly. In fact, their willingness to pay was considerably higher than the marginal cost of carrying them. Therefore, the increase in volume of air traffic created value.

We also saw that an additional source of value was the entry of low-cost airlines such as Ryanair and easyJet. One thing I did not mention but played an important role was the exit of a variety of (not so efficient) airlines, such as SwissAir or Sabena (Belgium's national airline). In other words, an additional benefit from increased competition is the selection of more efficient producers. In this sense, more than Adam Smith's "invisible hand", the appropriate metaphor seems to be Charles Darwin's "natural selection" (only the more efficient firms survive). As Warren Buffett aptly put it, "only when the tide goes out do you discover who's been swimming naked." In the present context, this might be rephrased as "only when the tide of perfect competition takes place do you discover which firms are not clothed with the garb of productive efficiency." And no, I don't expect this sentence to help me towards a Pulitzer prize, but you get the idea.

WHAT THE FIRST WELFARE THEOREM DOES NOT SAY

Maximizing allocative and productive efficiency is no doubt a good thing. However, a few observations or caveats are worth highlighting. First, the First Welfare Theorem is a statement about efficiency rather than equity, that is, it concerns the size of total surplus, not its distribution. In particular, note that in calculating total surplus we value consumer and producer surplus equally. Presumably, we attach value to profits because they are eventually returned to the firm's shareholders. However, inasmuch as shareholders tend to be wealthier than consumers, many would argue that firm profits ought not to be weighted as much as consumer surplus. For example, institutional arrangements or regulations that raise consumer surplus by the equivalent of $20 million and decrease firm profits by $25 million may be judged to improve welfare even at a cost of $5 million in terms of total surplus.

Another important note is that the First Welfare Theorem (as stated above) is about static efficiency, that is, the optimal allocation of resources given the current set of products and production technologies. To continue with the airlines examples: Competitive markets lead to the efficient number of flights, but do they also lead to the right level of investment in new transportation technologies, or investment in new energy sources? It is difficult to measure these dynamic effects, even more difficult to compare them to measures of static efficiency. Unfortunately, this creates a bias: economist focus too much on efficiency largely because they can measure it. Unfortunately, this is not an innocuous bias.

Last but certainly not least, an important caveat is that the First Welfare Theorem applies to competitive markets, which, as outlined earlier in the chapter, correspond to some fairly strong assumptions. When producers or consumers are large enough to affect market prices; or when products are differentiated; or when there is less than perfect information about price and quality; or when entry into the industry is restricted; or when property rights are not properly established — then the First Welfare Theorem does not necessarily hold.

Given all of these caveats, one may ask the question: Why pay any attention at all to the First Welfare Theorem? If we are to be rigorous, there isn't any truly competitive market in the world, so isn't all of this much ado about nothing? One possible defense of the economics

approach is that the competitive market model provides a reference point: To the extent that a real-world market is close to a competitive market, one might say that efficiency is close to maximized under equilibrium conditions. In his famous 1877 novel, Anna Karenina, Russian writer Leo Tolstoy famously noted that

> All happy families are alike; each unhappy family is unhappy in its own way.

As we will see in the next three chapters, there are many reasons why real-world markets are not quite the competitive market described earlier in this chapter. Still, it is helpful to understand the behavior of competitive markets, the "happy family" of economics. But there's more: Even the characterization of competitive markets as a "happy family" is open to debate. One must remember that efficiency is only a partial, at times very partial, performance measure.

Parts IV and V of this book deal with the above two observations. Part IV focuses on market failures, that is, markets which, for one reason or another, are not competitive markets. As we will see, this typically implies that the market equilibrium is not efficient. Part V, in turn, explores optimality dimensions that go beyond efficiency (equality, opportunity, etc).

NON-MARKET LOGIC

Among the many assumptions underlying the First Welfare Theorem and the role of the invisible hand of the marketplace is the assumption that economic agents are individual, logic, selfish maximizers who only respond to extrinsic, material motivation. No one believes this is entirely true, but most accept it as a useful starting point. But is this a good approximation? As usual, the answer is that "it depends", specifically, it depends on the particular setting.

Consider the following study based on Israeli daycare centers. A common 21st century problem in daycare services is that parents are often late to pick up their children at the end of the day. At a number of Israeli daycare centers, late arrivals used to be punished with a cold stare or a similar form of social censure. But seeing how parents continued to arrive late, some daycare centers agreed to test a new policy, namely to charge a ten shekel fine for lateness (about $3 at the

time). The results of this experiment were quite surprising (at least to some). Instead of reducing lateness, the fines led to an increase in the frequency of late pickups: on average, the rate doubled with respect to treatment group (that is, the group of daycare centers not imposing fines).

One possible explanation for this pattern is that, before the fine was introduced, most parents were on time because they felt that it was the right thing to do, or because they were concerned with the social punishment they suffered from the daycare staff if they were late. By contrast, once the fine is introduced, many parents think of lateness as a possibility they can "buy" by paying the fine. In other words, once there is a "market" for lateness, parents no longer see punctuality as a moral obligation.

One important learning point from this experiment is that incentives, in particular market incentives, are not the sole source of extrinsic motivation. In fact, the introduction of market incentives may **crowd out** other sources of incentives: as we increase monetary incentives, we decrease incentives based on our sense of decency. To put it differently:

> *Human behavior in a social context is determined by a variety of "logics" in addition to the logic of the market.*

We return to this issue at other points in the book. (This Israeli day care center has proven a rather controversial one in the economics profession. The reader might be interested in a methodological criticism and the authors' response to it.)

7.3. PRICE CONTROLS

Efficiency is not the only goal society should be concerned with. There may be many good reasons why governments take actions that effectively disturb the "natural" equilibrium of an otherwise competitive market. In this section we consider four particularly important cases: taxation, rent controls, minimum wage, and price gouging.

TAXES

There are many reasons why governments levy taxes and there are many different types of taxes. Historically, taxes were first and foremost a form of raising income to cover government expenditures. In this context, it may be useful to estimate the efficiency cost of raising \$1 of revenue. This we do next. Specifically, let us return to the example considered in Section 7.1, a tax on gasoline consumption. To recap, the supply and demand functions (p in dollars, q in million gallons a day) are given by

$$\begin{aligned} Q_D &= 150 - 50\,p \\ Q_S &= 60 + 40\,p \end{aligned}$$

The initial (pre-tax) market equilibrium results from the equality of supply and demand:

$$\begin{aligned} 60 + 40\,p &= 150 - 50\,p \\ p &= (150 - 60)/(40 + 50) = 1 \\ q &= 60 + 40 = 100 \end{aligned}$$

So, initial equilibrium price is \$1 per gallon and a total quantity of 100 million gallons is sold.

Now suppose the government imposes a tax of $t = 56.25$ cents per gallon. Specifically, suppliers now receive the sale price but must pay 56.25 cents per gallon sold to the tax authority. It follows that they receive a net price of p minus 56.25 cents. This implies that the new supply curve is given by

$$Q_S = 60 + 40\,(p - .5625)$$

The new market equilibrium (with a 56.25 cents/gallon tax) is given by

$$\begin{aligned} 60 + 40\,(p - .5625) &= 150 - 50\,p \\ p &= (150 - 60 + 22.5)/(40 + 50) = 1.25 \\ q &= 60 + 40\,(p - t) \\ &= 60 + 40\,(1.25 - .5625) = 87.5 \end{aligned}$$

All this we saw in Section 7.1. We may now ask: what is the excess burden (that is, the loss in allocative efficiency) created by the tax?

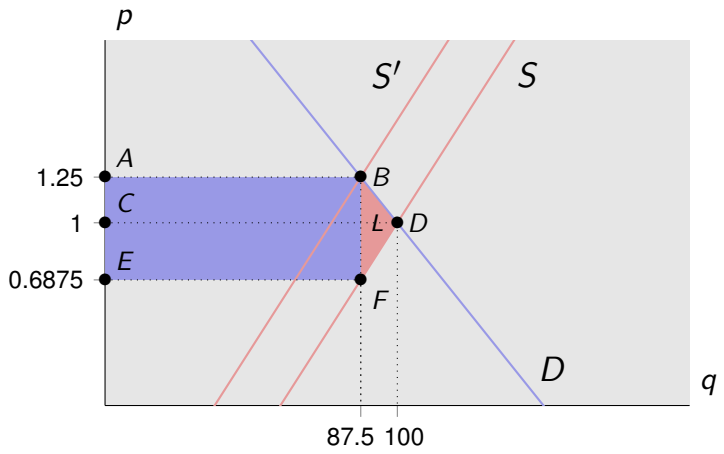


FIGURE 7.18
Practice: gasoline tax and deadweight loss

Figure 7.8 illustrates the answer to this question. As a result of the tax, buyers lose part of their surplus and sellers, too, lose part of their surplus.

Part of these losses in surplus are compensated by the gain to the tax authority. To the extent that these funds are used to benefit buyers and sellers (e.g., better infrastructure or a better mass transit system), we should not include them as efficiency losses. However, there is a part of the loss in total surplus which is not compensated by an increase in tax revenues, namely the area L in Figure 7.18.

Since both the demand and supply curves are linear, the deadweight loss corresponds to the area of a triangle. Specifically,

$$L = \tfrac{1}{2} \times (100 - 87.5) \times .5625 = 3.515625$$

We can also compute the loss in consumer surplus due to the tax. Consumers lose the area given by the trapezoid [ABDC], which is given by

$$\tfrac{1}{2} \times (87.5 + 100) \times (1.25 - 1) = 23.4375$$

Regarding producer surplus, we have a loss of given by the area of the trapezoid [CDFE], that is

$$\tfrac{1}{2} \times (87.5 + 100) \times (1 - .6875) = 29.296875$$

As to the government, a tax of 56.25 cents generates a tax revenue given by the area of the [ABFE] rectangle, that is,

$$87.5 \times 0.5625 = 49.21875$$

Gains and losses must add up. Specifically, the loss in total surplus must equal tax revenue plus deadweight loss. Let's check

$$23.4375 + 29.296875 = 52.734375$$
$$49.21875 + 3.515625 = 52.734375$$

There are certainly good reasons to levy a tax; or, more generally, to take actions which move us away from the competitive market equilibrium. That said, it's important to know this comes at a cost, namely a cost in terms of efficiency loss. In the present case, the loss is given by $L = 3.515625$, which represents a little over 7% of the tax revenue. Another important observation regarding the gasoline tax is that, while it is nominally paid by the seller, its effect is felt both by seller and buyer. In fact, the loss in surplus is about the same for seller and buyer. This and other points regarding taxation will be examined in greater detail in Section 12.3.

IMPORT TARIFFS

Trade creates value. This is, to a great extent, the central theme of this chapter. In particular, international trade creates value. Much of the growth experienced by China and other economies in the past decades can be attributed to the value created by international trade.

In this context, an **import tariff** (or an **import quota**) can have a value-destruction effect. Can we measure this? Essentially, the value destroyed by trade restrictions corresponds to the deadweight loss from departures from the competitive equilibrium. Consider the bottom panel of Figure 7.16. Suppose the supply corresponds to exports from China to the US, whereas the demand corresponds to US demand for these imports. Absent any trade regulation, the equilibrium level of exports/imports is given by q^*. Suppose, however, that an import tariff is set such that consumer price increases to p_2. Alternatively, suppose that an import quota is set such that not more than q' can be imported. Regardless of the specific nature of the policy, we observe a decrease in imports and thus a reduction in the number of

trades. These were all trades for which the willingness to pay by US consumers was higher than the production cost by Chinese manufacturers. When we add these up we come to the area L, a dollar value measuring the "lost trades" due to the import tariff or import quota.

If import tariffs destroy value, why are there import tariffs at all? First, sometimes import tariffs are part of a broader game played by countries. Specifically, tariffs may serve as a tool for "punishing" a foreign country for what it has done or has failed to do. Second, an import tariff drives foreign producers out of the domestic market, which in turn opens the way for less efficient domestic producers. Thus domestic consumers pay a higher price (and many trades are "lost") but in return domestic jobs are created or saved. This may be a very inefficient way of creating or maintaining jobs at home, but it's one governments may opt to, especially if subject to intense lobbying by the protected domestic industry.

The issue of **lobbying** is sufficiently important to justify a brief digression. Economic policy is part of overall government policy and the rationale for specific measures is to be found in the process of policy-making rather than the economic efficiency calculations considered in this chapter. A particularly important aspect of the policy-making process is the **special interests** paradigm. An import tariff on steel, for example, implies an enormous benefit for a small number of agents (domestic steel producers) and a small cost for a large number of agents (domestic consumers of products which incorporate some steel). The incentive for a domestic steel company to lobby for a tariff is thus high, whereas an individual consumer's incentive to lobby against a tariff is low. This results in an unbalanced political process whereby special interests are given disproportionate weight.

If you think about it, this phenomenon (the benefit is concentrated in a small number of agents, the cost is spread among a large number of agents) is more general and applies to other instances of public policy. In the next section, we consider another specific example of special interests and the effect they might have on market regulation.

RENT CONTROL

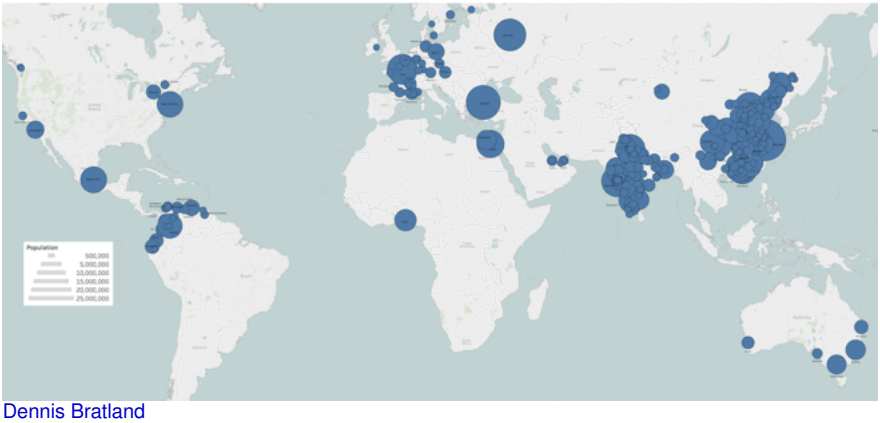
A well known 1990 survey of economists found that 93.5% (the highest%age of any question) was in agreement or qualified agreement with the statement that, "A ceiling on rents reduces the quantity and

quality of housing available." The argument regarding quantity is simple: Suppose that the bottom panel of Figure 7.16 represents the rental housing market. Suppose that the government sets a maximum price of p_1 (in the present context, the price corresponds to the rent). Then the supply of rental dwellings drops from q^* to q'. The argument regarding quality is not as straightforward, but the idea is that if landlords earn less from renting out a building, then the incentives to maintain the building are commensurably lower.

Notwithstanding this broad agreement regarding the negative effects of rent control, the policy is still very common in many cities throughout the world. As of 2019, there were approximately 200 cities in the United States with some type of rent regulation. Moreover, a variety of jurisdictions were considering or implementing new rent regulation.

There are a number of arguments in favor of rent regulation. The most common one is that rent control helps the poor, which is particularly important at a time of rising income inequality. This is a highly debatable argument, as we will see below in this section and later in Chapter 12. A second argument, less based on economics and more based on social and psychological considerations, is that we should recognize the legitimate interest of long-term tenants in remaining in their homes. Even if a house is rented, it is still a family home, and its tenants have a reasonable expectation of remaining in it on terms similar to those they have enjoyed in the past. A third, related, argument is that there is a social interest in diverse and stable neighborhoods. For example, some complain that most artists had to leave New York's Greenwich Village as rents skyrocketed to unaffordable levels, and that the Village lost a lot following that exodus.

There have been many empirical studies on the effects of rent controls; the evidence is mixed. One problem with many studies is the usual problem with empirical social science: distinguishing between correlation and causality in a world where lots of things change at the same time. For this reason, a sudden change in legislation which took place in Massachusetts provides a useful testing ground. In November 1994, landlords succeeded in placing an initiative on the Massachusetts ballot to ban rent control statewide. In November 1995, the proposal was approved statewide: 51% in favor, though in the cities that had rent control (Boston, Brookline, and Cambridge) the vote was overwhelmingly against. One study shows that, not sur-



Map of cities with population over 500,000 that have some form of rent control or rent regulation.

Dennis Bratland

prisingly, rents increased following the repeal of rent control. Moreover, both the quantity and the quality of rental housing supplied increased (as predicted by the basic economics of supply and demand).

One year before Massachusetts, another important ballot was (also narrowly) approved: San Francisco repealed an *exemption* on rent control, that is, it moved in the opposite direction of Massachusetts by *extending* the reach of rent regulations. Specifically, all multi-family structures with four units or less, built in 1979 or earlier, became subject to rent control (whereas before 1994 they were exempt from rent control). Like Massachusetts, the change in legislation provides a unique window on the effects of rent regulation. A study looking at very granular data (basically at the unit level) reaches the following conclusions: First, the probability that a beneficiary of rent control remains in their unit is about 20% higher than the control group. This difference in persistence rates is particularly significant for older tenants and tenants who had lived in their rent-controlled unit for longer. Second, through this persistence effect, rent controls contribute to racial diversity. The reason is that minorities are disproportionately represented among rent-control tenants. Third, the switch to rent control also had an effect on the supply side. The law allows landlords to convert a building into a condo, thus removing its units from the rental market. In fact, there was a 15% decline in available rentals among the previously rent-control-free units. This decline in supply likely led to a long-term increase in rents (following the basic forces of supply and demand). Moreover, the newly converted units attracted in-migrants with income levels about 18% higher than previous tenants.

Overall, the evidence vindicates both the arguments in favor and against rent control (and in fact the study has been used as supporting evidence for both sides of the argument). The immediate effect is, to a great extent, the intended effect: keeping poorer and minority tenants in the neighborhood. However, the long-term effects likely work against those that the policy is supposed to protect. To some extent, rent controls benefit the present generation of disadvantaged people but hurt those who come later.

MINIMUM WAGE

Similar to rent control, minimum wage policies tend to be big dividers, both across the political spectrum and between economists and non-economists. The neoclassical economics argument is essentially the same as the argument against rent control (in this regard, neoclassical economics is rather boring): By setting a minimum wage, the equilibrium quantity of labor decreases, thus creating a deadweight loss corresponding to hires that should take place but do not take place. However, unlike the case of rent controls (which largely confirm the economics prediction), the evidence on minimum wage is largely at odds with the prediction based on the bottom panel of Figure 7.16.

One particularly well-known study looked at employment in New Jersey and Pennsylvania. In 1992, the minimum wage in New Jersey increased from \$4.25 to \$5.05 per hour, while in the adjacent state of Pennsylvania it remained at \$4.25. For an economics researcher, this provides a unique opportunity to identify causality by means of a **difference-in-differences** research design. The idea is to compare the changes in employment in two "identical" establishments, one on each side of the border. If the two establishments are sufficiently close to the border, then the case can be made that the minimum wage is the only relevant difference in the environments they face. Moreover, by comparing *changes* in employment rates we control for a host of factors that might have affected employment rates and are not related to minimum wage. The study concludes that New Jersey's increase in minimum wage slightly *increased* or had no effect on employment in New Jersey restaurants (the set of establishments considered in the study), which is at odds with what the supply-and-demand model would predict.

A number of subsequent studies, using different data sets or different methodologies or both, reached conclusions closer to the neoclassical economics prediction: an increase in minimum wage leads to a decrease in employment. However, it is remarkable how the surprising result from the 1992 New Jersey case has been extended to other states and years. For example, a recent study shows that increases in minimum wage in New York state have had no effect on employment. New York state (among other states) has committed to push the state minimum wage to $15. Currently, it's set at $12.50. Meanwhile, other states (such as Pennsylvania) have stuck to the federal level of $7.25 (which in turn has remained constant for many years). Similarly to New Jersey in the 1990s, this new study finds no losses in employment at New York state restaurants close to the Pennsylvania border when compared to their cross-the-border counterparts.

Additional research into specific establishments suggests businesses cover higher labor costs by taking a hit to profits, improving productivity or simply raising prices. This in turn suggests that the industry may not be as close to the competitive market reference point as the efficient markets view suggests. We will return to this in the next chapter.

PRICE GOUGING

In the wake of unexpected negative supply shocks (or positive demand shocks), prices tend to surge to abnormally high levels. Many efficient-markets economists find such price hikes normal and in fact efficient: it's the law of supply and demand at work. By contrast, most of the world accuses sellers of price gouging and clamors for laws protecting buyers from unfair pricing. For example, in the aftermath of Hurricane Sandy, which struck the US in October 2012, New Jersey authorities filed civil suits accusing seven gas stations and one hotel of **price gouging**. Meanwhile, Libertarian TV personality John Stossel was inviting his viewers to "hug a price gouger today." The contrast could not be greater.

A more recent example is given by the COVID-19 pandemic. Figure 7.19 (source) shows the online price of 3M masks sold during the first months of 2020. Specifically, the figure plots the ratio between the price set throughout 2020 and the average price set by Amazon

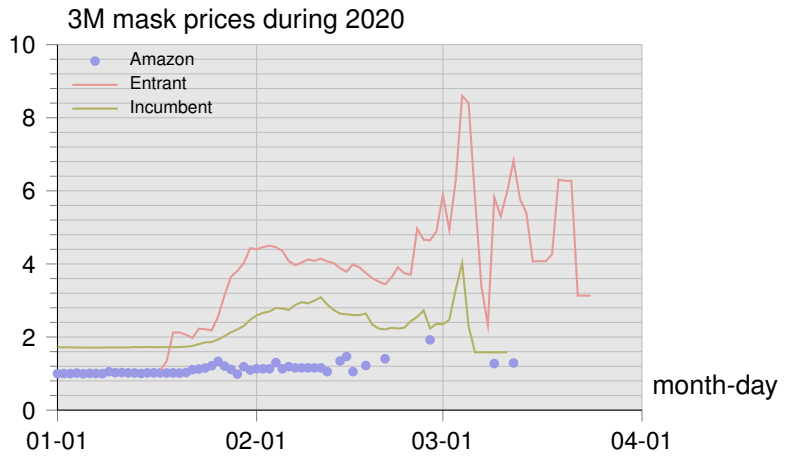


FIGURE 7.19
Price ratio by type of seller (ratio with respect to Amazon's 2019 average price).
Note: Amazon data as scatter plot to reveal stockouts

during 2019 (a natural reference point for prices during a non-crisis period). Three groups of sellers are considered: Amazon, who is both seller and the platform "host" of other sellers; "incumbent" sellers, that is, sellers who already sold before January 15, when the first US case was announced; and "entrant" sellers, that is, sellers who began selling after January 15. Several features are noticeable. First, despite the enormous spike in demand caused by COVID-19 fears, Amazon barely increased its price. In addition to legal concerns (price gouging is illegal in most US states), there are also reputational concerns: the last thing Amazon needs is to be called a price gouger and be the target of a public boycott campaign. Amazon sells millions of different products; it would make no sense to risk those revenue streams for the prospect of a small gain in selling masks.

Second, sellers other than Amazon increase prices considerably. For entrant sellers, the average price ratio can be as high as 8 (that is, an eight-fold increase with respect to pre-pandemic prices). Underneath this average there is considerable variation, including sellers setting prices 30 or 40 times higher than Amazon.

Third, there is a significant difference between the price patterns for "incumbent" and "entrant" sellers, which suggests that the reputation argument works not just for Amazon but also for continuing sellers, who have something to lose from being given the "price

gouger" label.

Last but not least, notice that (not surprisingly) the sellers setting lower prices run out of stock more quickly. In other words, after mid February it is little consolation to say that Amazon sets a low price, for they are simply out of stock. In a certain sense, it's as if they set an infinite price.

If you ask anyone on the street what they think about price gouging, their first reaction will likely be "it's just not fair." It's not fair to charge more than $300 for something that just a few weeks ago cost less than $10. An economist might reply "how do you know the seller's cost did not increase a lot too? More importantly, suppose that I only have one mask and that there are two interested buyers. The best way to decide whom to sell the mask to is whoever is willing to pay the most, and that's what a high price does: it separates those who need the mask from those who *really* need it."

You can see the potential flaw in the argument. Under many circumstances, using willingness to pay as a measure of need may make sense. In an emergency situation, it might be a stretch. Joe is a billionaire and already has five masks at home. Strictly speaking he does not need an extra one, but who knows. And $300 is nothing to him. Across the street, a nurse who works with COVID-19 patients desperately needs a mask but simply cannot afford the $300 required to buy it on Amazon. It's not fair!

There is, however, a much stronger economics argument in favor of allowing very high prices: incentives. Let us go back to the example at the beginning of the section: It's October 2012 and Hurricane Sandy has just hit New Jersey. Gas stations have very low stocks and begin to ration by increasing gas prices. The governor declares a state of emergency and, with that, price gouging ("unconscionably" high prices) is deemed illegal. New Jersey Governor Chris Christie enacted a price ceiling and threatened a "zero-tolerance" approach to violators. A big shift in the supply curve together with a price cap leads to an enormous excess demand. Car drivers line up for hours to fill up, which they may or may not succeed in doing.

Suppose instead that Christie allowed for prices to increase. Then, clever entrepreneurs would think of ways of filling up large trucks in Philadelphia and drive them to New Jersey. With gas at $10 a gallon, it pays to do so. With gas at $3 per gallon, it does not. In sum, to the extent that the supply elasticity is high (e.g., supply is sensitive to

price changes), the efficiency costs of a price ceiling can be significant.

As often is the case, there are trade-offs. There is something to be said for the efficiency role of the invisible hand of the marketplace (price). But there are many situations, including emergency situations, when markets are simply not competitive or when efficiency is not the most important imperative (or both).

KEY CONCEPTS

competitive markets | homogeneous product | price taker

well-defined property rights | perfect information

market equilibrium | excess supply | excess demand

market-clearing price | law of supply and demand

comparative statics | producer surplus | willingness to pay

consumer surplus | market value | value in use

First Welfare Theorem | efficiency | allocative efficiency

deadweight loss | productive efficiency | X-inefficiency

crowd out | import tariff | import quota | lobbying

special interests | difference-in-differences | price gouging

REVIEW AND PRACTICE PROBLEMS

■ **7.1. Vitamin C.** Vitamin C is a generic vitamin that is produced by many companies: brand names are not very important, entry is easy. A good friend (a world-renowned orthopedic surgeon from New Jersey) tells you that he is about to publish in *The New England Journal of Medicine* (a highly respected and widely quoted medical journal) a study indicating that a daily dose of 500 mg of vitamin C tends to improve the muscle tone and increase the physical stamina of adults, with no adverse side effects. Though a very good doctor, she is woefully ignorant about the basic workings of markets and wants to know what is likely to happen (in the short run and in the long run) to the price of vitamin C, to the quantity sold, to the profits of the producers, and to the number of firms that produce it. Summarize what you would tell her.

■ **7.2. Comparative statics: aspartame, oil.** For each of the following, use a supply and demand diagram to deduce the impact of the event on the stated market. Would you expect the impact to be primarily on price or quantity? Feel free to mention issues that you don't think are captured by a traditional supply and demand analysis.

(a) Event: The FDA announces that aspartame may cause cancer. Market: Saccharin. (Note: aspartame and saccharin are low-calorie sweeteners.)

(b) Event: Oil price increases. Market: California electricity.

■ **7.3. Comparative statics: price and quantity effects.** Consider following events and markets:

- Event: OPEC reduces oil output. Market: oil.
- Event: Unusually rainy winter in New York City. Market: umbrellas in NYC.
- Event: Soccer Champions League final in Madrid. Market: Madrid hotels.
- Event: Unusually low catch of sole fish. Market: sole fish.

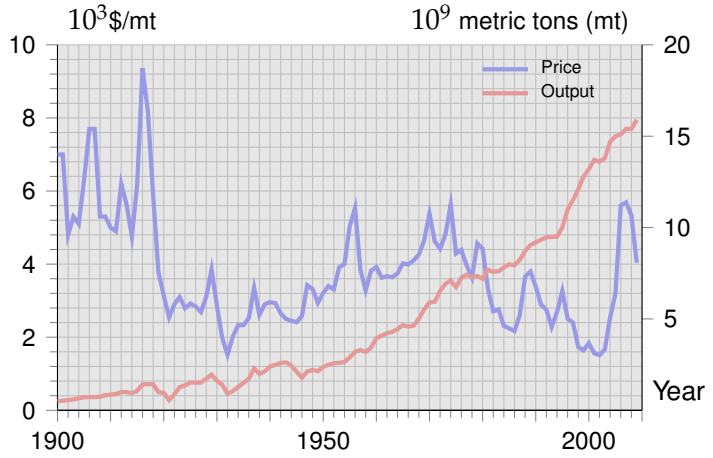


FIGURE 7.20
Copper: price and output, 1900–2010 (source: US Geological Survey)

Which of the four corresponds to the four cases considered in Figure 7.10?

■ **7.4. Copper.** As Figure 7.20 shows, over the last century the volume of copper transacted has increased substantially, while price has declined slightly except for the first years of the current century. This is a feature of many primary commodities: their prices have tended to go down over time, though during the early 21st century there were some signs of a change in the trend. How do you explain these trends?

■ **7.5. Kidney transplants.** Suppose that, in a given state (let's call it state X), a few recent kidney transplant malpractice suits have led to punitive damage awards of unprecedented levels. What impact do you expect this to have in the market for kidney transplant services in state X? To the extent that you can, and making the necessary assumptions as you go along, indicate the expected effects on price and quantity; the relative magnitude of these effects; and any possible differences between short-run and long-run effects.

■ **7.6. T-shirt printing.** The custom T-shirt printing business has many competitors, so that the perfect competition model may be considered a good approximation. Currently the market demand curve

is given by $Q = 120 - 1.5\,p$, whereas the market supply is given by $Q = -20 + 2\,p$.

(a) Determine the market equilibrium

Suppose there is a T-shirt craze that increases demand by 10% (that is, for each price, demand is now 10% greater than it was before the craze).

(b) Determine the new demand curve.

(c) Determine the change in equilibrium quantity.

(d) If your answer to the previous question is different from 10%, explain the difference in values.

Now go back to the initial demand curve and suppose there is an increase in the cost of blank T-shirts, an essential input into the business of selling custom T-shirts. Specifically, for each unit by each supplier, the production cost goes up by 10%.

(e) Determine the new supply curve.

(f) Determine the change in equilibrium price.

(g) If your answer to the previous question is different from 10%, explain the difference in values.

■ **7.7. Sales tax.** Consider an industry with market demand $Q = 550 - 20\,p$ and market supply $Q = 100 + 10\,p$. Determine the equilibrium price and quantity. Suppose the government imposes a tax of \$6 per unit to be paid by consumers. What is the impact on equilibrium price and quantity? What if the sales tax is paid by the seller instead of the buyer?

■ **7.8. Sales tax with steeper demand.** Consider again Exercise 7.7. Suppose that demand is instead given by $Q = 280 - 2\,p$.

(a) Show that the equilibrium levels of p and q are the same as in the initial equilibrium of Exercise 7.7.

(b) Determine the impact of a \$6 sales tax in terms of the price effectively paid by buyers and sellers.

(c) Compare the results in (b) to those in Exercise 7.7. Explain the economic intuition.

■ **7.9. Car prices in Europe.** Sales taxes on car purchases in Europe vary from 0% to more than 200%. The UK is one of the countries with lowest taxes, whereas Denmark is one of the countries with highest taxes.

(a) In which countries do you expect consumer prices to be the highest?

(b) In which countries do you expect pre-tax consumer prices to be the highest?

By law, if a consumer buys a car in country x and then registers the car in country y, the consumer receives a refund from the tax paid in country x and then pays the corresponding tax in country y.

(c) What is the optimal car buying strategy for a European who does not mind to purchase abroad?

■ **7.10. Gold prices.** What causes gold prices to fluctuate?

■ **7.11. Producer surplus.** Define producer surplus.

■ **7.12. Willingness to pay and consumer surplus.** What is the relation between willingness to pay and consumer suprlus?

■ **7.13. Internet usage.** Suppose the market demand for internet usage, with q in minutes and p in dollars-per-minute, is given by $q = 1000 - 500\,p$. Suppose that the initial price was \$.40 per minute, and the new price is \$1.00 per minute. What is the change in consumer surplus? Show your work.

■ **7.14. Paradox of value.** What is the paradox of value?

■ **7.15. Market value and value in use.** What is the difference between market value and value in use?

■ **7.16. Copper.** Suppose the demand for copper is given by $q =$

$6 - 2\,p$, whereas the supply of copper is given by $q = 2 + 2\,p$.

(a) Determine the equilibrium values of p and q.

(b) Determine the value of consumer surplus.

(c) Suppose copper is produced in Peru and consumed in the United States. A tariff of $t = 1$ is imposed on copper imports from Peru to the US. Assume the tax is paid by the Peruvian seller. Determine the new values of equilibrium price paid by US consumers and quantity.

(d) What effect does the import tariff have on consumer surplus?

(e) Determine the government revenue generated by the import tariff.

(f) Determine the deadweight loss implied by the import tariff.

■ **7.17. XPTO sunglasses.** The demand for XPTO sunglasses is given by $D(p) = 100 - 2\,p$ and the supply curve is given by $S(p) = 3\,p$.

(a) Compute the equilibrium price and equilibrium quantity of XPTO sunglasses.

(b) Sketch both the demand and supply curves on the same graph (be sure to label your axes correctly).

(c) Determine the value of consumer surplus and producer surplus at the equilibrium values.

Suppose all sunglasses are imported from China. Suppose also that the government imposes an import tariff of \$10 per unit.

(d) Determine the new equilibrium values of price and quality.

(e) Determine the tariff's impact on consumer surplus, producer surplus, and total surplus.

■ **7.18. The pickle problem.** Listen to the podcast, *The Pickle Prob-*

lem (or read the transcript). How does it relate to the First Welfare Theorem presented in Chapter 7?

■ **7.19. Estimating consumer surplus.** How can we estimate consumer surplus?

■ **7.20. Smith and Darwin.** What would Adam Smith and Charles Darwin have to say about competitive markets?

■ **7.21. Fundamental Theorem.** What does the Fundamental Theorem state? Equally important, what does it *not* state?

■ **7.22. Minimum wage in Seattle.** Watch the CNBC news story, *How rising wages impacted Seattle*. How does it reflect the arguments in favor and against minimum wage?

Alfred Palmer

PART IV

MARKET FAILURE

CHAPTER 8

MARKET POWER

In a competitive market, firms are small relative to the market. In fact, in Part III we considered the extreme case when firms are so small that the demand curve they face appears to be flat. In other words, from each firm's point of view, demand is extremely sensitive to price changes: the tiniest change in price would lead to the greatest change in output (from their own small-firm perspective).

In behavioral terms, hat, in competitive markets, firms are price takers. This was the case, for example, with the small t-shirt factory considered in Section 6.1. There we saw that price-taking firms set output levels such that marginal cost is equal to price. In other words, in competitive markets the resulting equilibrium price corresponds to the marginal cost of producing each firm's qth unit.

However, it's fair to say that in the real-world most firms are price makers, not price takers. Apple, to take a somewhat extreme example, is certainly not a price taker: Who decides the price of an iPhone 11? Largely, it's Apple, not the market. Wireless companies such as Verizon may also have a say, but these are certainly not price takers.

In this chapter, we consider the case when firms are sufficiently large so that their individual behavior has an impact on market outcomes. We begin by considering the sources and effects of market power, considering both the case of monopoly (one seller) and the case of oligopoly (a few sellers). We also report on recent trends in market power. Next, we look at the main public policy instruments directed at curbing market power. The chapter concludes with a sec-

tion on the 21st century tech giants.

8.1. SOURCES AND EFFECTS OF MARKET POWER

Whenever firms have power to set price (that is, whenever they are not price takers), we say there is market power. The degree of market power depends on industry structure (e.g., how many competing firms there are) as well as on the nature of demand (in particular, how sensitive demand is to price changes). In terms of industry structure, one extreme corresponds to **monopoly**, that is, the case when there is only one seller (and many buyers on the demand side). For example, Electricité de France is a monopoly supplier of electricity to French households. Another industry structure prone to market power is that of **oligopoly**, the case when there is a small number of competitors. Sometimes, there are a few, similar sized, competitors. For example, the art auction market is dominated by Christie's and Sotheby's. In other cases, there is a **dominant firm** and a bunch of smaller ones. For example, in the market for online searches "giant" Google competes against a series of smaller (sometimes niche) search engines.

MONOPOLY

How do monopolists become monopolists? One source of monopoly power is intellectual property. For example, in the 1980s Pfizer patented the medical drug atorvastatin, which it sold under the brand name Lipitor. The **patent** expired in 2011 (patents typically last for twenty years). Until then, Pfizer was a monopoly supplier of atorvastatin. A related source of an intellectual property right leading to monopoly is given by **copyright**. Disney, for example, has the exclusive right over the movie and the musical *Lion King*. No matter how good my singing and dancing abilities may be, I am not allowed to compete against Disney with my own Broadway production of *Lion King* (unless Disney gives me permission, which I doubt they will). Unlike patents, copyrights last for many decades.

But you don't need government protection in order to become a monopolist: **trade secrets** also do the job. For example, Google's search engine is not patented. Why don't other firms copy Google's

Photo by Karolina Grabowska from Pexels

Patent protection is a common source of monopoly power.

algorithm? Because they don't know how it works. Similarly, the legendary secret formula for Coca-Cola, regarded by some as the world's best-kept secret, is located in a high-security vault in Atlanta.

Still another source of monopoly (or quasi-monopoly) power is given by **network effects**. Many people use the Microsoft Windows operating system primarily because most other people use Windows as well. It's not that I particularly like Windows (I don't), but if most of the world is stuck on Windows, then I might as well choose Windows as well. This provides Microsoft a degree of market power that it would not have absent these network effects.

On the demand side, market power is determined by the degree of price sensitivity. As illustrated by Figure 5.11, if demand is very sensitive to price changes, then the seller's optimal price is relatively low. In this sense, it does not matter whether the seller is a monopolist or not. The fact that demand is so sensitive to price suggests that, de facto, the seller is not a monopolist: If demand is so sensitive to price changes, it must be that consumers have alternatives to the product sold by the putative monopolist.

OLIGOPOLY

Competitive markets ("many" sellers) and monopoly (one seller) are two extreme cases of industry structure. Most real-world markets fall somewhere in-between: more than one but fewer than "many" competitors. For all their (extreme) differences, monopolists and small, price-taking firms have one thing in common: neither needs to be concerned with competitors. Monopolists have no competitors, and

		Firm 2: 5	Firm 2: 4	Firm 2: 3
Firm 1	5	7.5 7.5	12 0	7 0
	4	0 12	6 6	7 0
	3	0 7	0 7	3.5 3.5

FIGURE 8.1
Pricing game

price takers are small enough that their actions have no effect on other price takers. By contrast, oligopolists must take into account their rivals' actions. We thus enter (again) into game theory territory.

BEST RESPONSES AND NASH EQUILIBRIUM

In Section 2.2, we introduced the first elements of game theory. To refresh your memory, we saw that a **game** is a model which combines four elements: **players**, **rules**, **strategies**, and **payoffs**. We also saw how you can represent simultaneous-moves two-player games as a matrix game: one player picks a row while another player picks a column. Finally, we presented a special type of game, the prisoner's dilemma. This game has the feature that both players have a **dominant strategy** but the resulting outcome is the worse for both players. The climate change game played by China and the US was presented as an example.

Consider now the game represented in Figure 8.1. It describes the pricing game played by two competing firms. Each firm can set a high (5), medium (4) or low (3) price. Unlike the climate change game introduced in Section 2.2, no player has a dominant strategy in the pricing game in Figure 8.1 (check). As such, we cannot analyze ("solve") the game in the way we analyzed the prisoner's dilemma. Instead, we proceed by introducing a new concept: best responses.

> *A player's* **best response** *(or simply BR) is a mapping indicating its optimal choice* for each possible choice by the rival player.

The term "response" can be a bit confusing, for we are not talking about players moving one after the other. Think of best response as my optimal choice if I *believe* or *expect* the other player to choose a certain action. Specifically, in the present pricing game Firm 1's best response is as follows: if Firm 2 sets $p = 5$ (that is, if Firm 1 expects Firm 2 to set $p = 5$), then Firm 1 should set $p = 4$. In fact, setting $p = 4$ gives Firm 1 a profit of 12, whereas $p = 5$ leads to 7.5 and $p = 3$ leads to 7. By the same token, if Firm 2 sets $p = 4$ or $p = 3$, then Firm 1's best response is to set $p = 3$. Firm 2's best response is similar.

Equipped with the best-response mappings, we are now ready to derive our prediction of the outcome of the play of the game. The most common way of doing this is to derive the equilibrium of the game. Specifically,

> *A* **Nash equilibrium** *(or simply NE) of a game is a combination of strategies (one for each player) such that no player can improve its payoff by* unilaterally *changing its strategy.*

The concept of Nash equilibrium is closely related to the concept of best responses. By definition, a given combination of strategies (a for Player 1 and b for Player 2) forms a Nash equilibrium if and only if a is optimal for Player 1 given that Player 2 chooses b; and b is optimal for Player 2 given that Player 1 chooses a. Another way to state this is that a is Player 1's best response to Player 2's choice of b and b is Player 2's best response to a. We thus conclude that (a, b) forms a NE if and only if both a and b belong to the players' best responses.

In other words, we find the game's Nash equilibrium (NE) by the "intersection" of the two players' best responses, that is, a combination of choices by Firm 1 and Firm 2 such that Firm 1 does its best given what Firm 2 does and vice-versa. In the present context, this corresponds to both firms setting a low price, i.e., $p = 3$.

So far so good: the NE of the pricing game suggests that, while the number of competitors is very small (only two), competition may lead them to set a low price, presumably a price close to their production cost. In other words, even though the number of competitors

is small, the outcome looks similar to that of a competitive market: there isn't much market power. The problem is that when the number of players is small and their interaction frequent, then there is scope for collusion among competitors, that is, firm behavior that effectively leads them to set high prices ($p = 5$ in the present case).

From a game theory point of view, this presents a puzzle: We just saw that, if Firm 1 expects Firm 2 to set $p = 5$, then Firm 1 is better off by setting $p = 4$. So how can it be that firms collude by setting $p = 5$? In game theory jargon, how can $p = 5$ be part of an equilibrium? The answer is that, in the real world, the game that firms play is different from the game in Figure 8.1. This is true in many dimensions, but a particularly important one is that firms typically interact over many periods.

REPEATED GAMES AND COLLUSION

A **repeated game** is game theory's way of modeling on-going interaction between players. As the name suggests, a repeated game is simply a game obtained from repeating a one-shot game (like the one in Figure 8.1). For example, suppose that two gas stations set prices daily and that the matrix in Figure 8.1 reflects daily payoffs. Acknowledging that the two gas stations compete day after day, consider the following tacit agreement: set $p = 5$ as long as in the past both firms set $p = 5$, and set $p = 3$ otherwise. That is, if any firm "deviates" from the tacitly agreed-upon $p = 5$, then firms "plunge" into a "price war", that is, set $p = 3$ thereafter.

In this proposed equilibrium of the repeated game each firm earns a profit of 7.5 in each period (assuming they start with $p = 5$ in the first period). Is this really an equilibrium? Wouldn't firms have an incentive to undercut their rival? By doing so, a firm would earn a profit of 12 in the current period. However, beginning next period, firms would switch to $p = 3$ for ever, leading to a profit of 3.5 per period. Effectively, firms compare the following two alternative profit streams:

(a) cooperate: 7.5, 7.5, 7.5, ...
(b) defect: 12, 3.5, 3.5, ...

Depending on how important the current period is with respect to the future, "cooperation" (that is, setting a high price) may be the best

response and (5,5) a NE. Specifically, if firms interact very frequently, then the short-term gain (12) is of little significance with respect to the long-term losses.

To conclude the analysis of the repeated game, notice that we assumed there are only two players. If instead there were many gas stations vying for market share, then the temptation to lower prices would likely be greater. The idea is that, if all gas stations set a high price, then each gets a small market share, but if one of them undercuts the competition, then it enjoys a big boost in terms of market share. In sum,

> *If the number of firms is small and firms interact frequently, then it may be an equilibrium for firms to set high prices.*

If high prices are an equilibrium and if firms are better off by setting high prices, then we should expect them to collude. There is only one problem: While firms are better off, consumers are worse off. Consumers would much rather if firms played the low price equilibrium. Moreover, as we saw in Section 7.2, the case can be made that, overall, society is worse off when firms collude by setting high prices. For these reasons, a formal agreement to set high prices is illegal (in fact, a crime in the US). Not that this stops firms from forming secret cartels or colluding tacitly (i.e., without explicit communication). We will return to this in Section 8.2.

To conclude this section, I note that, although we reached the above repeated-game results in the context of collusion between competing oligopolists, the principle is sufficiently important to deserve special mention:

> *Repeated interaction between players may lead to equilibrium outcomes (e.g., cooperation) that would not be equilibrium outcomes if the underlying game were played only once.*

I cannot emphasize enough how general and important this point is: A multitude of tacit agreements in society, including many social norms and what economists refer to as "relational contracts," are enforced not so much by the rule of law as they are by the repeated interaction among society members. If I go to a coffee shop tomorrow,

order breakfast and then walk out without paying, thus violating either the law or a social norm or both, it's unlikely the coffee shop will sue me in court. However, it's almost certainly the case that the coffee shop will not let me in the their establishment again (a "punishment" strategy in the coffee-shop repeated game akin to setting a low price in the pricing game). More generally, we can think of our society's institutions as a means to convert a prisoner's dilemma (where all society members play their *myopic* dominant strategy and all receive a low payoff) into a cooperative equilibrium (where each member sacrifices their short-term gain for the sake of an overall societal gain). End of digression.

OLIGOPOLY: PREEMPTION BY CAPACITY EXPANSION

In the mid 1970s, DuPont, one of the world's largest chemical corporations, engaged in a curious strategy in the titanium dioxide industry: it build production capacity well in excess of its needs. As a result, in a relatively short period of time, DuPont's market share increased from about 30 to more than 50 percent. Box 8.1 provides additional details. What sense does it make for a firm to build more capacity than it needs? In order to understand the nature of DuPont's strategic move, consider the following production capacity game. There is an incumbent firm that must decide whether to build a "normal" capacity level or a larger capacity level (which essentially amounts to excess capacity, that is, capacity that is not actually used). And there is a potential competitor who must decide whether to enter and challenge the incumbent or rather stay out.

Consider first the case when the two players move simultane-

		Entrant: stay out	Entrant: enter
Incumbent	low K	0 40	10 25
	high K	0 30	-10 20

FIGURE 8.2
Production capacity game with simultaneous moves

Box 8.1: DuPont and the TiO_2 market.

Titanium dioxide (TiO_2) is a white chemical pigment employed in the manufacture of paint, paper and other products to make them whiter or opaque. The primary raw material for the production of TiO_2 is either ilmenite ore or rutile ore.

By 1970, there were seven firms in the industry: a large firm, DuPont, and six smaller ones. During the 1960s, DuPont used mainly ilmenite, whereas its rivals used mainly rutile. In 1970, a sharp increase in the price of rutile ore created a significant cost advantage for DuPont with respect to its rivals: at 1968 ore prices, Dupont had a cost advantage of 22%; at 1972 prices, this advantage averaged 44%. Moreover, stricter environmental regulation meant that several of DuPont competitors would have to incur large costs in order to continue production.

DuPont found itself with a competitive advantage in several dimensions. First, its production process used a cheaper input than most of its rivals. Second, its production process complied better with environmental standards. Third, because of the cost advantage, the firm was in better financial shape, thus better positioned to expand capacity.

A Task Force was formed at DuPont to study how to turn these advantages to the firm's greater benefit. The result was the strategy of expanding capacity at a pace sufficient to satisfy all of the growth in demand in the ensuing years. The idea was that *by expanding rapidly, DuPont would discourage expansion (or entry) by rival firms.* It was the Task Force's conviction that deterrence of competitive expansion was necessary if DuPont was to establish a dominant position: according to the plan, DuPont's market share would increase from 30% in 1972 to 56% in 1980 and perhaps 65% in 1985. (cont. next page)

ously. The game then corresponds to the matrix game depicted in Figure 8.2. The incumbent's best response is to set low K (i.e., low production capacity) regardless of what the entrant does (i.e., regardless of what the incumbent expects the entrant to do). In other words, low K is a dominant strategy for the incumbent. As for the entrant, the best response is to enter if the incumbent chooses low K and stay out if the incumbent chooses high K. Since low K is a dominant strat-

Box 8.1: DuPont and the TiO_2 market (cont.)

World demand, which had expanded at a whopping 7.7% per year from 1962 to 1972, barely changed from 1972 to 1982. Partly for this reason, partly as a result of Dupont's strategy, various rival firms abandoned expansion plans or simply scrapped existing capacity. By 1985, five of the firms competing with DuPont in the domestic market had exited: three by acquisition, one by complete cessation of operations, and one by shutting down its US plants.

DuPont never reached the 65% target, but, starting from less than 30% its domestic market share surpassed the 50% mark by the early 1980s. Dupont's motto may be "miracles of science." However, its rise to dominance in the TiO_2 industry was more of a "miracle of strategy."

egy for the incumbent, we conclude that (low K, enter) is the game's NE. In fact, whenever one of the players has a dominant strategy, the easy way to find the NE is to find the other player's best response to such dominant strategy.

SEQUENTIAL-MOVE GAMES

As mentioned in Section 2.2, a game combines a set of players, rules, strategies and payoffs. So far, we have considered games where the rule is very simple: both players make its choices simultaneously. This need not be interpreted literally: The relevant point is that each player makes their choice with no knowledge of the other player's choice.

In some cases, however, one of the players clearly has the chance to observe the other player's move before making a choice. Specifically, suppose that the game is played sequentially: the incumbent moves first and, having observed the incumbent's move, the small potential competitor then decides whether to enter and challenge the incumbent or rather to stay out. This order of moves seems consistent with the idea that DuPont was a larger firm, had more cash in hand, and was not under the pressure of having to retrofit its capacity (cf Box 8.1).

The best way to analyze a game with sequential moves is to represent it as a **tree game**. This we do in Figure 8.3. The root node of

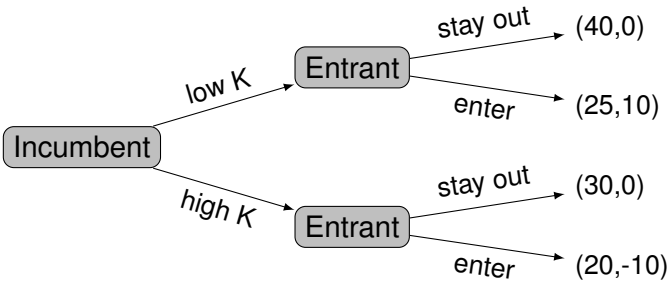


FIGURE 8.3
Production capacity game with sequential moves

the tree corresponds to the first choice made in the game, in this case by the incumbent. Each branch coming out of this node corresponds to possible choices by the incumbent: low K or high K. Each possible choice by the incumbent leads to a node occupied by the second player, the entrant. As before, the entrant may choose to stay out or to enter. We follow the convention that the first number in the end nodes corresponds to the first player's payoff, whereas the second number corresponds to the second player's payoff.

Solving a tree game is in some way easier than solving a matrix game. Basically we follow the **forward reasoning** principle. First, we put ourselves in the shoes of the entrant and answer the question, "If the entrant were placed in this situation (i.e., on this node) what would it choose"? To answer this question we simply compare the entrant's payoff from entering with the payoff from staying out. If the incumbent chooses low K, then the entrant gets 0 if it stays out and 10 if it enters. It is therefore better off by entering. Similarly, if the incumbent chooses high K, then the entrant gets 0 if it stays out and -10 if it enters. It is therefore better off by staying out.

We can now put ourselves in the shoes of the incumbent. Anticipating the entrants's behavior (enter if and only if the incumbent chooses low K), the incumbent is better off by setting high K. We thus conclude that the NE of the game corresponds to the strategies (high K, stay out) by the incumbent and the entrant, respectively. (For aficionados only: Strictly speaking, the look forward, reason backward procedure leads to what's known as a subgame perfect NE. The set of subgame perfect NE is a subset of the set of NE.)

The comparison of the simultaneous and sequential move games

leads to another important game-theory principle: the value of **commitment**.

> *By committing to a course of action, a player may achieve a better outcome than by keeping its options open.*

This may seem a bit contradictory: If you ask anyone on the street, I would expect most people to say that it's always better to keep your options open. Not so, a game theorist would say: Committing to a course of action, thus reducing the set of options available, may be a better course of action to the extent that it induces other players to change their course of action. In the capacity game, by choosing high K, the entrant effectively "kills" potential competition. This comes at a cost, namely the cost of investing in capacity beyond what would be efficient (in terms of cost minimization). Ex-post (that is, having observed that the entrant stayed out), the incumbent might regret not having the option to choose low K: after all, a payoff of 40 is better than a payoff of 30. However, such regret would be misplaced: the reason the entrant decided to stay out in the first place was precisely that the incumbent committed to high K.

To summarize the past two subsections, we note that if the number of competitors is small (oligopoly), then there is scope for behavior that creates, maintains or increases positions of market power. This may happen through collusion, whereby oligopolists agree explicitly (secret cartel) or implicitly (tacit collusion) to set higher prices than independent competition would imply. Market power may also result from the behavior of dominant firms that discourages potential competition or kills existing competition. In other words, small numbers (of competitors) tends to lead to market power, and market power tends to lead to higher prices. In the next section, we look into the implications of market power and high prices.

EFFECTS OF MARKET POWER

Figure 8.4 illustrates the effects of market power. The top panel depicts the equilibrium of a competitive market, whereas the bottom

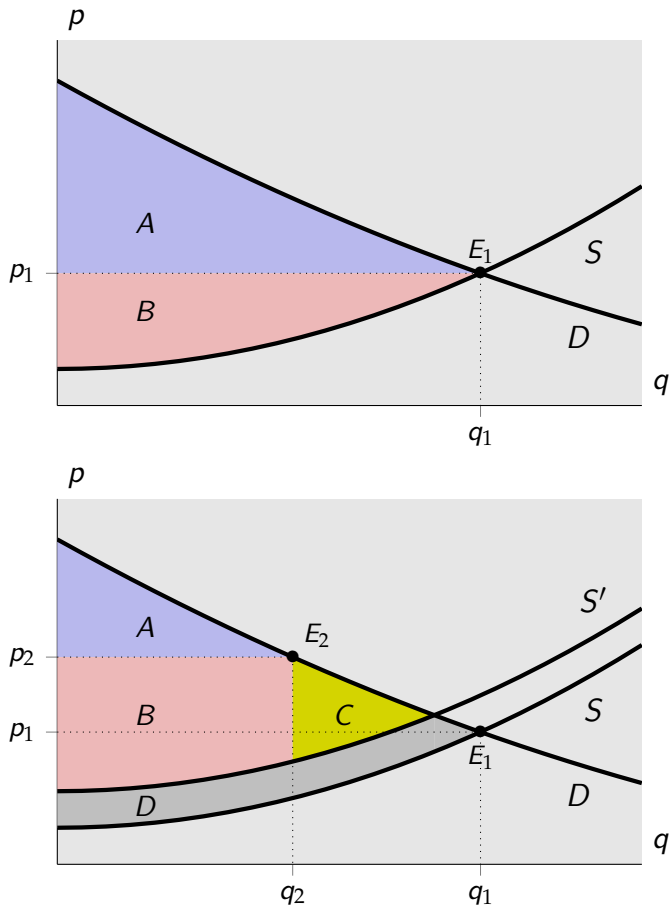


FIGURE 8.4
Effects of market power

panel depicts the outcome under market power. An important component of the First Welfare Theorem (cf Section 7.2) is that firms are price takers and set price equal to marginal cost. If, by contrast, firms are price makers and set price above marginal cost, as we saw in the previous subsections, then the theorem fails to hold. Specifically, on the bottom panel of Figure 8.4 we see price is set to p_2, which is greater than p_1, the equilibrium price under competitive conditions. A first implication is that there are trades which fail to take place, that is, there are consumers whose willingness to pay is greater than cost, but no trade takes place because price is greater than marginal cost (and so consumers don't make a purchase). All in all, this adds up to area C on the bottom panel. This corresponds to the **deadweight loss** from price distortions, that is, from a price level different than

the competitive market price level (cf Sections 7.2 and 7.3).

But there is more: As the bottom panel of Figure 8.4 suggests, and similar to what we saw in Section 7.2, one of the effects of market power is that it reduces the competitive pressure to be cost efficient. This in turn implies that sellers (or the seller, if there is only one) have higher marginal costs. This is illustrated on the bottom panel of Figure 8.4 by a higher marginal cost curve, which in turn eliminates an additional area of total surplus under competitive markets, area D. In sum, the switch from a competitive equilibrium to one with market power shrinks total surplus from $A + B$ on the top panel to a much smaller $A + B$ on the bottom panel.

In addition to a lower total surplus, we also note that its division into firm profits and consumer surplus becomes considerably more favorable to sellers. All in all, consumers are the greatest victims of market power. As can be seen, consumer surplus under market power (area A on the bottom panel) is considerably lower than under competitive markets (area A on the top panel).

TRENDS IN MARKET POWER

The significant trend toward greater concentration and greater market power is one of the most worrying features of the US economy during the current century. By greater concentration, we mean that in a given industry there are fewer sellers, so that even if we are not in a monopoly situation, we are closer to a monopoly situation. How did we get to greater industry concentration? Partly, by means of mergers and acquisitions. For example, from 2008 to 2013, Delta Airlines merged with Northwest Airlines, United Airlines with Continental Airlines, and American Airlines with US Airways, overall lowering the number of major US-based airlines.

In parallel with this general increase in concentration, we also observe significant increases in markup levels. Figure 8.5 shows the evolution of US average markups (price minus unit cost divided by unit cost, as we saw in Section 5.3). During the last decades of the 20th century, it hovered around 30 percent. By 2015, we have reached average markups of 60 percent!

It is hard to establish a causal relationship between the increases in concentration and the increases in prices. It is particularly difficult to do so with aggregate data. Careful industry-level analysis sug-

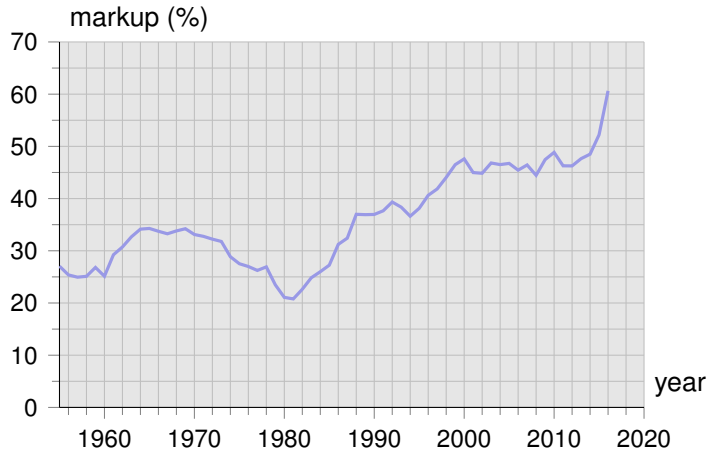


FIGURE 8.5
Evolution of average markups in US industries (source).

gests that part of the increase in markups is due to the emergence of digital firms with high fixed cost and low marginal cost (e.g., Microsoft or Google). However, the secular increase in concentration and in prices is observed even if we restrict to more "traditional" industries.

As a specific example, consider housing construction. The top panel of Figure 8.6 documents the increase in concentration in the US house construction industry: In 2006, six firms typically controlled a local construction market; ten years later, that number was reduced to 4. The bottom panel of Figure 8.6 shows that construction costs of single-family homes increased from less than $150,000 in 1998 to almost $300,000 in 2015. Some of this cost increase may be accounted for by an increase in average house size (which changed a bit in the past ten years), but most of it corresponds to more expensive construction.

A related trend is that, for a given number of competitors, we observe an increasing overlap in ownership. Specifically, many investment funds own shares in multiple competitors within the same industry. Table 8.1 lists the top 10 largest shareholders of the top 4 US airlines. It is remarkable how much of the ownership of airlines is concentrated in investment funds. It is also remarkable that several investment funds (those highlighted in color) own shares in all four major airlines. Several other ones own shares in two or three

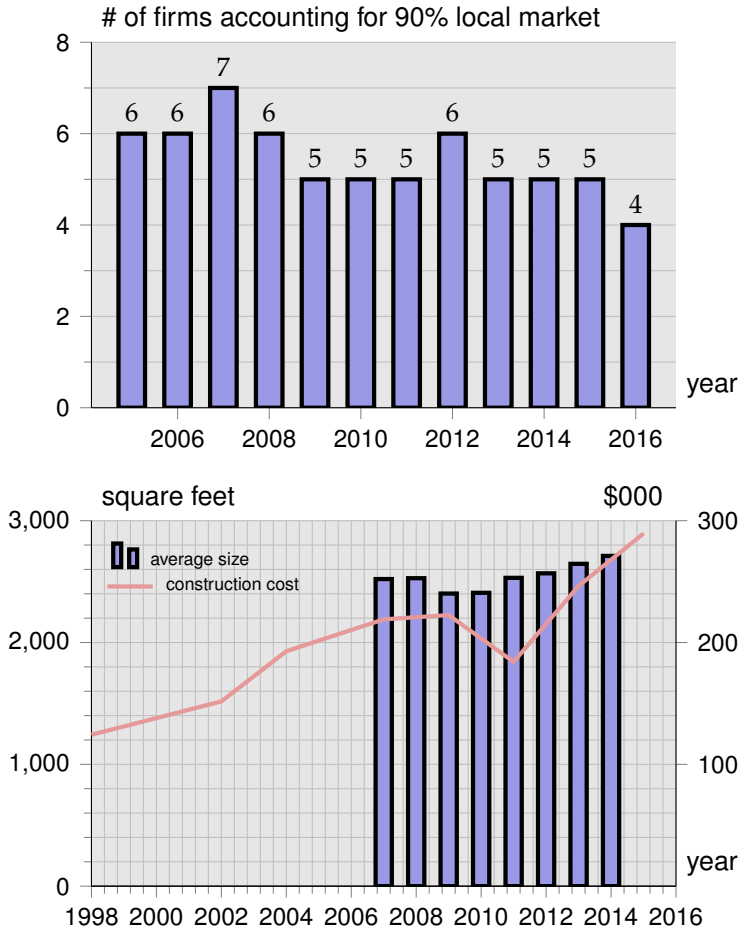


FIGURE 8.6
Single-family homes

of the top four. Investment funds, and consultants writing on their behalf, claim that they are simple passive investors and that investing in multiple firms within a given industry is a way of reducing risk (and thus offer better results to their clients). However, there is some evidence that when, for some unrelated reason, institutional investors increase their ownership of multiple competitors, market prices increase and firm values increase. Moreover, there is some anecdotal evidence that shareholders have an influence on industry managers in the direction of increasing prices and decreasing output. For example, it has been reported that portfolio managers with ownership in multiple competitors in the oil and gas industry arranged meetings with industry executives with the purpose of press-

TABLE 8.1
Largest shareholders of the top 4 US airlines (source)

Delta	(%)	Southwest	(%)	American	(%)	United	(%)
Berkshire	8.25	PRIMECAP	11.78	T. Rowe Price	13.99	Berkshire	9.20
BlackRock	6.84	Berkshire	7.02	PRIMECAP	8.97	BlackRock	7.11
Vanguard	6.31	Vanguard	6.21	Berkshire	7.75	Vanguard	6.88
State Street	4.28	BlackRock	5.96	Vanguard	6.02	PRIMECAP	6.27
J.P. Morgan	3.79	Fidelity	5.53	BlackRock	5.82	PAR Capital	5.18
Lansdowne	3.60	State Street	3.76	State Street	3.71	State Street	3.45
PRIMECAP	2.85	J.P. Morgan	1.31	Fidelity	3.30	J.P. Morgan	3.35
AllianceBernstein	1.67	T. Rowe Price	1.26	Putnam	1.18	Altimeter	3.26
Fidelity	1.54	BNY Mellon	1.22	Morgan Stanley	1.17	T. Rowe Price	2.25
PAR Capital	1.52	Egerton Capital	1.10	Northern Trust	1.02	AQR	2.15

ing the latter to reduce output and thus increase profits ("pump less and profit more"). While there are multiple other examples of this sort, the actual effect of common ownership on market competition remains a contentious issue.

INDUSTRY FOCUS: HEALTH CARE

It seems clear that there is a correlation between greater concentration and higher prices. It is difficult to distinguish between correlation and causality. For this purpose, it helps to focus on a particular industry. In this section, we focus on health care, which represents an increasing share of the economy. In the US, health expenditures accounted for about 17 percent of GDP. This is strikingly high, considering that in comparable European countries health expenditures are only about 10 percent of GDP. Why do Americans spend so much on healthcare? One possible answer is that the quality of US healthcare is higher than in other equally developed countries. However, common outcome measures suggest that the difference in healthcare quality between the US and other developed countries is not that great, especially considering the gap in health expenditures.

There is no one single reason why Americans spend so much on healthcare, but one explanation on which economists generally agree is market power. The hospital industry provides a good example. A series of mergers have taken place since 2000. Many of these mergers

Pixabay

US health expenditure corresponds to about 17 percent of GDP, whereas comparable European countries only spend about 10 percent of GDP.

do not include direct local competitors, which partly explains why they have been authorized by government agencies. Do they, however, contribute to higher prices? Prices have indeed increased, and recent research suggests that these price increases are probably related to the increased concentration of hospital ownership. From an empirical point of view, we are faced with the common problem of distinguishing correlation from causality. Could the correlation correspond to reverse causality? For example, it could be that some hospitals became better, were able to increase prices, and thus become more attractive targets for a merger, which in turn leads to the association of a merger with higher prices (even though there is no causal effect of mergers on prices).

Typically, hospitals belong to hospital systems, and mergers correspond to bringing together different hospital systems. One possible strategy to avoid the above statistical problem is to focus on smaller hospitals within each system. The idea is that these hospitals, which are not the "crown jewel" of each system, are unlikely to be the motive for a merger between two different systems. We can thus estimate the causal effect on hospital service prices of merging different hospitals. Recent research following this strategy leads to the results summarized in Figure 8.7. The sample of hospitals is divided into three groups: merged hospitals that are separated by 30 to 90 minutes of travel time, merged hospitals separated by more than 90 minutes of travel time, and non-merged hospitals.

Notice that the analysis does not include hospitals competing in the same local market. As such, we would expect no effect on prices: after all, the hospitals we consider are not competing in the same

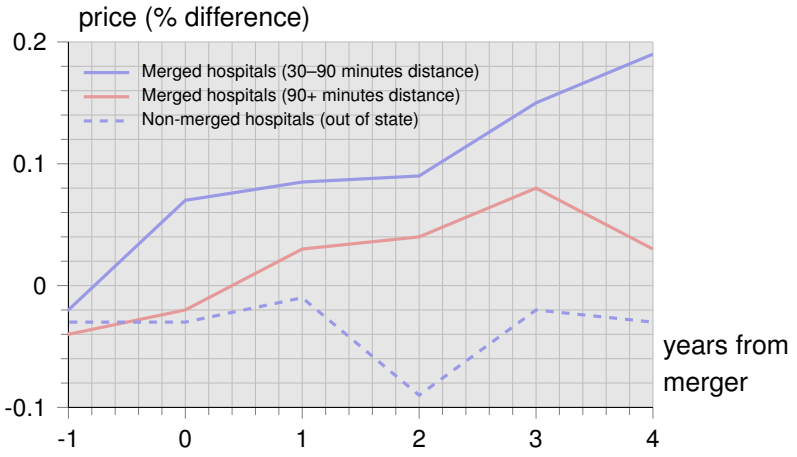


FIGURE 8.7
Hospital mergers (difference in differences analysis)

market, that is, are not competing for the same patients. However, the results suggest that merging hospital systems has an effect on prices even when the hospitals do not compete for the same patients.

Specifically, the results, which correspond to acute-care hospital mergers over the period 1996-2012, suggest that mergers "cause" a 10 to 15% price increase. The intuition is that larger hospital systems have greater bargaining power with respect to insurers (which act as intermediaries between hospitals and patients). In other words, what the research suggests is that the effective market may be more than the local market where hospitals compete to attract a certain pool of patients: the effective market may be at the level of hospitals and insurance companies negotiating reimbursement fees.

Hospitals are not the only source of market power in healthcare. Many other segments of the healthcare industry are highly concentrated. A partial list includes:

- Pacemakers: 3 firms control 89% of the market
- PET Scanners: 3 firms control 82% of the market
- Medical devices: 4 firms control 77% of the market
- Orthopedic Products: 3 firms control 88% of the market
- Syringes and Needles: 2 firms control 69% of the market

Another important component of the health system is pharmaceutical drugs. Here, too, we observe significant concentration of market

power. Moreover, we observe several instances of dominant firms wielding their power with respect to potential entry threats in ways similar to Dupont in the titanium dioxide industry. Specifically, recent research suggest that large pharma companies acquire innovative targets solely to discontinue the target's innovation projects and preempt future competition, a practice referred to as **killer acquisitions**.

To recap, it is well known that US patients spend considerably more in healthcare than their European counterparts, even though the differences in quality of service are not very significant. There are surely many reasons for these differences. Market power is likely one of the more important ones.

8.2. ANTITRUST AND COMPETITION POLICY

Housing construction and healthcare, two industries considered in the previous section, are by no means the only sectors where seller concentration is high. Other industries with market power include online retail, where Amazon dominates; ride sharing, where Uber and Lyft dominate; the proprietary seed industry, where Monsanto and Dupont dominate; and online advertising, where Google and Facebook dominate.

Nor is the problem of market power a new one. The first legislative effort to address the issue of firm dominance, Canada's Competition Act, was passed in 1889. The US' Sherman Act followed in 1890. Today, there exist many government agencies in North America, Europe and throughout world with the single or main purpose of limiting the negative effects of market power. In this section, we summarize some of the dimensions of antitrust policy (sometimes referred to as **competition policy**).

PRICE FIXING

Explicit collusion, that is, an agreement between competitors to reduce competition (e.g., increase prices), is illegal. In fact, explicit collusion is a criminal offense in the US as well as in several other countries.

By way of example, consider the class-action suit brought in Canada in 2008 against several major chocolate makers. Lawyers representing chocolate consumers successfully argued that manufacturers conspired to increase prices. From court proceedings, it was revealed that discussions were held at trade shows and association events with the goal of restricting competition and push up consumer prices.

The total settlements from the case amounted to C$23.2 million (Canadian dollars), from C$3.2m paid by Mars to C$9m paid by Nestlé. Mars and Nestlé still face criminal charges from a separate case initiated by Canada's Competition Bureau (as in the US, price-fixing is a crime in Canada). (On a personal note, and as a matter of full disclosure, I should mention that I indirectly benefited from this settlement: Since it was difficult to find the consumers who were harmed by high chocolate prices, the Canadian Competition Bureau destined the fines to help the development of competition policy scholarship, including your servant's travel expenses to attend a conference in Canada.)

Unlike Mars and Nestlé, Hershey was left off the hook, courtesy of the Canadian leniency program. The **leniency program** has the goal of incentivizing cartel participants to provide antitrust authorities information pertaining to secret cartel agreements. Since these agreements are secret, it would be difficult to find out about them without the help of insiders.

Implicit collusion, the situation when firms effectively set higher prices as part of an unspoken agreement, is not per se illegal, that is, it does not explicitly violate the law. In other words, there may be an implicit "agreement" between firms where there is no direct communication. That said, we should add that exactly what constitutes communication is still an open question.

MERGER POLICY

In North America, Europe, China, Japan, and pretty much all over the world, if two firms want to merge, especially if they are large and operate in the same industry, they require authorization from the relevant government agency. The idea is that a reduction in the number of competitors may reduce competition and thus harm con-

sumers. **Merger policy** thus constitutes an important tool to address the sources and negative effects of market power.

For example, in 2007 Ryanair attempted to acquire Irish rival Aer Lingus. The European Commission (EC) blocked the acquisition on the grounds that it would imply a high risk of price increases (i.e., high airfares): the airlines overlapped on more than 30 routes from/to Ireland, thus the merger would imply reduced choice for many consumers. This decision was one of the Commission's first blocked mergers to be supported by extensive survey and quantitative data analysis to underpin the basic economic argument. Ryanair filed an application for annulment of the decision with the General Court of the European Union. However, in 2010 the Court ruled in the Commission's favor. Undeterred by this and other defeats, in 2013 Ryanair reformulated its proposal, including a "remedies package" that, it claimed, clearly addressed all of the Commission's objections. However, the EC again blocked the bid.

Both the US and the EU have specific guidelines regarding mergers. The idea is to balance the possible efficiency gains from a merger (e.g., **merger synergies**) against the threat of greater market power by the merged firms. One important step in this evaluation is the definition of the relevant market (a tricky business) as well as the measurement of the degree of concentration of market shares before and after the proposed merger takes place.

ABUSE OF DOMINANT POSITION

The DuPont example presented in the previous section shows how a firm with market power may cement its dominance by means of a preemptive strategy (capacity expansion in DuPont's case). Other preemptive strategies include DuaneReade or Starbuck's strategy of building a high density of stores such that there is little room for an entrant to compete.

Still in the realm of preemptive strategies, the artificial sweetener Nutrasweet provides an interesting example. On the eve of the expiry of Nutrasweet's patent, Monsanto (the owner) signed long-term contracts with PepsiCo and Coca-Cola, its two main customers. Since diet soda is the main use of artificial sweeteners, the long-term contracts effectively made it very difficult for potential competitors to enter.

In addition to Mosanto's Nutrasweet, another example of contracts as a preemption strategy is given by Intel's exclusive deals. Specifically, Intel offered its customers (computer manufacturers) a 15% discount with one condition, namely that they only purchase microprocessors from Intel. Understandably, this put AMD, Intel's main competitor, in a difficult position.

If preemption does not work (i.e., if you cannot keep your rivals away) you can always try to push them out of the market. For example, when Spirit Airlines challenged Northwest Airlines in the Chicago-Detroit market, the incumbent dropped its fares from about $150 to about $50, in the process also increasing the number of flights. After a few weeks of such aggressive competition, Spirit Airlines decided to leave the market, upon which Northwest's fares returned to $150+ values.

Similar to price-fixing and mergers, the above examples show how a dominant firm may use its muscle to maintain or increase its market power. In this context, the role of public policy is to limit the degree, and possible abuse, of this dominant position, which ultimately hurts consumers.

8.3. THE RISE OF THE TECH GIANTS

Unless you have been living under a rock for several decades, you will have noticed the emergence of several very large firms in the digital space, sometimes referred to as **tech giants**, or **superstar firms**, or some similar term. The acronym **GAFA** has come to be used as a reference to the largest of these giants: Google, Amazon, Facebook, Apple (and possibly Microsoft, in which case we talk about GAFAM). There are many reasons why politicians and common citizens are concerned with the increasing size of the tech giants. One relates to issues of security, privacy and political power. We will return to these in Section 10.2. A second concern relates to market power. The concern is similar to what was discussed in previous sections of this chapter. However, the GAFA case is sufficiently important to warrant separate treatment.

Our story begins in the early 1990s. Before the Windows operating system became widely adopted, most personal computers (PCs) ran some version of the Disk Operating System (DOS), namely MS-

DOS, DR DOS and IBM PC DOS. As the market share of DR DOS grew to levels that threatened Microsoft's dominance, the software giant essentially imposed on computer manufacturers a per-processor-fee contract: instead of paying for each copy of MS-DOS, manufacturers were asked to pay Microsoft a fee for each computer sold (or each processor sold), regardless of whether it was equipped with MS-DOS or with any other operating system (such as DR DOS or IBM PC DOS). A per-processor fee placed computer manufacturers in a difficult spot. Suppose that initially both MS-DOS and DR DOS were priced at $50. Then a computer manufacturer with a mild preference for DR DOS would go with this version of DOS; and it appears there were a good number of such computer buyers. However, under the per-processor deal, the effective price of MS-DOS was zero. Even if the buyer had a preference for DR DOS, the $50 difference was much too high to justify not buying the MS version. Thus it came as no surprise that the market share of DR DOS gradually dwindled until the company went out of business.

In 1993, the US Department of Justice (DoJ) opened an investigation and considered Microsoft's per-processor-fee deal to be anticompetitive. In 1995, Microsoft was forced to settle by signing a consent decree in which it agreed to stop the practice. Moreover, the software giant agreed not to tie other Microsoft products to the sale of Windows. By the time Microsoft signed the consent degree, its DOS rivals had left, so the agreement had no bearing on Microsoft's dominance over the operating systems market.

In the meantime, technology was changing rapidly. Microsoft's plain MS-DOS gradually gave way to the Windows operating system. Moreover, as the Internet expanded, the demand for web browsers increased. Netscape, one of the early entrants, dominated the browser market. Trailing Netscape by a few years, Microsoft introduced its own browser, the Internet Explorer (IE), which was bundled with Windows and thus offered at no extra charge.

In 1998, a major legal case against Microsoft was brought about by various US states as well as the Department of Justice. The plaintiffs claimed that Microsoft had violated the 1995 consent decree. The decree's imprecise definition of tie-in become apparent: is IE an *added feature* of the Windows operating system, or is it a different product that Microsoft (illegally) bundled with Windows? Microsoft argued the former, the DOJ argued the latter. Essentially, Microsoft

Pikrepo

Although the basics of competition remain the same, the antitrust tools we've used for decades are proving difficult to apply to the high-tech giants.

lost the case. However, the final outcome, highly influenced by then recently-elected President George Bush, was little more than a slap in the wrist. Several cases followed in the European Union and large fines were paid. However, by and large we might say that Microsoft successfully survived antitrust scrutiny over the past three decades.

The Microsoft case (Microsoft the company and the 1998 antitrust case) provides a good introduction to the high-tech giants for several reasons. First, in some ways it precedes the other giants chronologically. (This is not strictly true regarding Apple, but it is true regarding the "reborn" Apple, that is, the Apple of Steve Jobs' second coming.) Second, it exemplifies the power of network effects: People buy and use the Windows operating system largely because other people use the same system. Third, the 1998 case exemplifies the type of dominant behavior these giants are capable of and prone to: leveraging market power in one segment (e.g., operating systems) to cement dominance in other segments (e.g., internet browsers).

As the Internet expanded and media (music, movies, etc) became decidedly digital (think mp3), other digital giants emerged: Amazon and Google in the 1990s, Facebook in the 2000s. Apple, the oldest of all companies, experienced a "rebirth" of sorts with its launch of the iPod and then the iPhone, so much so that the company became better known for its i-stuff then for the Mac line of products. As the "five knights of the digital apocalypse" grew in size, we observed a series of parallels: They command a near-monopoly position in their own base segment. They leverage this power to largely dominate neighboring business segments. And they improve their technology largely by means of acquisitions.

At some level, there isn't much new about this type of behavior. Antitrust started in the late 19th century to curb the power of giants such as Standard Oil, whose market power leverage strategies had much in common with what we observe in the 21st century. There are, however, some important differences. First, over the years antitrust has had the goal of getting consumers a good deal, and monopolies were seen as dangerous to the extent that they were able to charge exorbitant prices. But Google and Facebook, for example, don't charge any user fees, which makes it difficult to find fault with their pricing. Second, while dominant firms of days past were wont to acquire their present and potential rivals, the vast majority of acquisitions by the tech giants correspond to companies you probably never heard about and probably would not have heard about had they not been acquired (Instagram and WhatsApp being two notable exceptions). Third, the way tech giants leverage their power is sometimes very difficult to observe or measure. For example, in order to understand the extent to which Google or Amazon favor their own offerings in their search results one would need to know and understand the way their search algorithms and designed and trained, which would require the knowledge of highly private information. Fourth, and perhaps most important, the key asset that many of these firms own is data, namely user-related data. How much data they have, how such data is used, how value is created from that data — much of this is unknown to regulators and the public alike.

To put it differently, although the basics of competition (or lack thereof) remain the same, the antitrust tools we've used for decades are proving difficult to apply to the high-tech giants. Consider the three parts of the previous section. First, collusion (price fixing or related). Clearly, this is not much of a problem with any of the GAFA (or GAFAM). In fact, prices are frequently zero, which makes it difficult to argue that prices are too high. In fact, they *are* likely high: The argument can be made that users should be compensated for the value that their data provides the platforms. However, it's difficult to argue there is any violation of the Sherman Act's prohibition of price fixing or related collusive practices.

Second, consider the application of merger policy. As mentioned earlier, the vast majority of acquisitions by the tech giants correspond to companies you probably never heard about and probably would not have heard about had they not been acquired. By traditional

merger policy criteria, these mergers do not create market power. In fact, it might be argued that many of these acquisitions provide a significant spur for innovative efforts by startups, eager to be acquired by one of the giants.

We are left with the third component of antitrust: regulating possible abuses of dominant position. The evidence points to reasonably clear and repeated abuses of dominant position by the tech giants. However, it is difficult to make the legal case that there is illegal behavior. It is also difficult to come up with an appropriate remedy. One thing seems clear: business as usual is not a sustainable outcome. As of writing this chapter, important efforts are under way both in the US and the EU to re-evaluate the way in which the tech giants can and should be regulated. Stay tuned.

KEY CONCEPTS

monopoly | oligopoly | dominant firm | patent

copyright | trade secret | network effects | game

players | rules | strategies | payoffs

dominant strategy | best response | Nash equilibrium

repeated game | tree game | forward reasoning

commitment | deadweight loss | killer acquisitions

competition policy | collusion | leniency program

implicit collusion | merger policy | merger synergies

tech giants | superstar firms | GAFA

REVIEW AND PRACTICE PROBLEMS

■ **8.1. Monopoly.** Why are there monopolies?

■ **8.2. Market power.** What are the main effects of market power?

■ **8.3. Patents and copyrights.** Ideas have a zero (or near zero) cost of being used by an additional agent. As such, the surplus-maximizing price of an idea should be zero.

(a) Why do governments assign monopoly rights over ideas and creative works, effectively allowing their owners to set a price greater than zero?

(b) Is there any empirical evidence for the argument presented in the previous answer?

■ **8.4. Firm and market elasticity.** Explain the difference between market elasticity and firm elasticity. (Hint: refer to the end of Section 5.3.) What relevance does it have for the discussion of market power?

■ **8.5. Air travel in Kabralstan.** There used to be two airlines serving Kabralstan's only route, which connects the capital to the country's largest city. Airfares were set at \$50 (single cabin). Each year, 5.2 million passengers flew on either of the two airlines. The variable cost of carrying one passenger was constant and equal to \$10 (same for both airlines). Recently, one of the airlines was acquired by its competitor. Since then, fares increased to \$80, the number of passengers dropped to 4.3 million passengers a year, and the cost of carrying one passenger increased to \$20 per passenger.

(a) Making (and justifying) the assumptions and approximations you deem necessary and reasonable, estimate the variation in consumer surplus (in \$ and in percent terms).

(b) Making (and justifying) the assumptions and approximations you deem necessary and reasonable, estimate separately the variation in productive efficiency and in allocative efficiency as a fraction of the initial total surplus.

(c) In addition to the change in economic efficiency, what are other relevant effects of the merger of the two Kabralstan airlines (open question)?

■ **8.6. kOS.** kOS is a new mobile operating system. It is associated with the kStore, an online store for apps running on kOS. The kStore charges app developers for placing their apps in the store. It is estimated that the number of apps placed for sale at the kStore is zero if the fee is $100 per app and 50 if the fee is zero. For intermediate values, the demand for placing apps in the store is linear. Suppose that the cost of including an additional app in the app store is zero.

(a) Using a spreadsheet, consider all possible fees (in even dollars) from 0 to 100. Determine the store's revenue for each price and the profit-maximizing fee.

(b) Determine the price elasticity of demand at the profit-maximizing fee. Show that the "elasticity rule" holds at this value.

(c) What is the fee that maximizes total surplus?

(d) How much buyer surplus is lost when the fee increases from the surplus-maximizing to the profit-maximizing level?

(e) The government is considering the possibility of regulating the fee paid by app developers to be listed in the kOS app store. What factors would you consider in determining the regulated fee? (Note: this is an open question.)

■ **8.7. California electricity.** Download the data file electricity.xls. The file includes information on California's main electricity generation plants as of 2000 (with thanks to Professor Severin Borenstein of

TABLE 8.2
California electricity supply

Variable name	Variable description	Variable units
name	Plant name	
capacity	Plant capacity	MW (megawatt)
fuel_cost	Fuel Cost	$ per MWH (MW hour)
var_OM	Variable operation and maintenance costs	$ per MWH
var_cost	Total variable costs	$ per MWH
fixed_OM	Fixed operations and management costs	$000 per day
start	Start up costs	$000

UC Berkeley). The variables listed are described in Table 8.2.

(a) Suppose that (1) each plant acts as an independent, price-taking firm, and (2) the marginal production cost is constant up to capacity. For example, DIABLO CANION 1 has production capacity of 1000MW and a marginal cost of $11.50 per MWH. Plot the supply curve. Specifically, suppose that each firm produces up to capacity if and only if the ongoing price is above their cost. (Hint: this is very similar Exercise 6.12, only with a larger number of firms.)

Suppose that demand is fixed (that is, insensitive to price changes) at 18,000MW.

(b) Determine the market equilibrium price.

(c) Suppose that demand increases to 22,000MW. What effect does this have on price?

(d) Return to the assumption that demand is given by 18,000MW. Suppose now that the SOUTH BAY plant is out of commission. What effect does this have on equilibrium price? (Hint: redo the calculations in (a) by excluding SOUTH BAY.)

(e) Determine SOUTH BAY's loss from shutting down.

(f) Determine ALAMITOS 3-6 profit gain from SOUTH BAY's shut down decision.

(g) Suppose that ALAMITOS 3-6 and SOUTH BAY merge into one single firm. Does the merged firm have an incentive to shut down its SOUTH BAY plant?

(h) How do the above results relate to the material presented in the present chapter?

■ **8.8. Southwest Airlines and the pandemic.** In what has arguably been the worst year in commercial aviation history, the September 2020 announcement by Southwest Airlines caught many be surprise:

> Despite the pandemic raging for more than six months, Southwest just announced plans to bring customers two new destinations later this year.

Discuss the parallel between Southwest's strategy in 2020 and DuPont's strategy in the Titanium Dioxide industry during the 1970s. (Note: Additional information may be found in the Wall Street Journal podcast, *While Airlines Shrink, Southwest Goes Big*.)

■ **8.9. Best response.** What is the relation between the concepts of best response and Nash equilibrium?

■ **8.10. Repeated games.** What is the relation between the equilibrium of a one-shot game and the equilibrium of the game that corresponds to the repetition of the above-mentioned one-shot game?

■ **8.11. Joke theft.** Listen to the podcast *Joke Theft* (or read the transcript). How does it relate to the discussion on repeated games presented in the present chapter?

■ **8.12. Commitment.** Explain and exemplify the concept that limiting one's options may have a strategic value.

■ **8.13. K and Giant Corporation.** You are the CEO of K, a small firm in a market which is dominated by Giant Corp., which commands 95% of the market. Your current challenge is to decide whether K should expand its capacity. If you don't, you expect to earn \$2 m, as you did last year, whereas Giant will earn \$30 m. If you do expand,

DI \ FA	M	H
M	80, 120	20, 135
H	50, 80	40, 100

FIGURE 8.8
Flibinite and Dayrdevl

your profits depend on whether Giant responds aggressively by cutting its price or passively by maintaining price at its current level. The estimated possible payoffs if you expand are:

- If Giant responds aggressively, you will lose \$2 m and Giant earns \$10 m.
- If Giant responds passively, your profits increase to \$4 m and Giant earns \$20 m.

Use a game tree to study the strategic interactions between K and Giant. Should K expand capacity?

■ **8.14. Flibinite.** Two airlines, Flibinite Airways (FA) and Dayrdevl Inc. (DI), offer competing services on the Cleveland/Newark route. No other airlines fly this route. The companies are now considering possible advertising/promotion campaigns for next year, for which they will make commitments in December. Each is considering both a "modest" (M) and a "heavy" (H) campaign. Since they compete with each other, the campaign of each would have consequences for the other's sales and profits. Also, since FA has a somewhat better safety record and a stronger brand name, its profits are higher. The estimated annual profits (in \$ million) that each company could expect are known to each other (they have been reported in the trade press) and are given by Figure 8.8.

(a) If each airline chooses its campaign without knowledge of the other's choice, what campaigns are they likely to choose? Explain.

(b) A consultant to FA has suggested that FA could commit to a choice of campaign in November and publicly announce its choice. Do you think that this is a good idea? Explain.

■ **8.15. Store clustering.** "Tourists traipsing along a half-mile stretch of 23rd Street in New York pass five Starbucks outlets. In Tokyo, 7-Eleven boasts 15 stores within a similar distance of Shinjuku station" (source). Does it make any sense for stores to be clustered in this way?

■ **8.16. Common ownership.** Common ownership has led to an increase in market power. Summarize the theoretical analysis and empirical evidence in favor and against this statement.

■ **8.17. Competition policy.** What are the main areas of competition policy?

■ **8.18. GAFAM.** What are some of the ways in which the giant tech firms may abuse their dominant position?

■ **8.19. Regulating Facebook and Google.** Listen to the Capitalisn't podcast, *Regulating Facebook and Google* (or read the transcript).

(a) Provide arguments in favor of big business, in particular in favor of avoiding excessive regulation of giants such as Facebook and Google.

(b) Provide arguments in favor of regulating big business, in particular giants such as Facebook and Google.

CHAPTER 9

EXTERNALITIES

In Chapter 1, we referred to private property as one of the pillars of the market economy. Witness, for example, the effects of rural reform in China in the late 1970s and early 1980s, the so-called "green revolution". In Chapter 2, we stressed the social nature of economics: A lot of what we discuss in economics involves transactions between individuals and/or firms, transactions which in turn may have repercussions for multiple third parties.

This chapter continues our survey of reasons why markets may not work as efficiently as discussed in Chapter 7. Specifically, we consider situations when an agent's decisions imply costs or benefits to third parties — an "externality" — to such an extent that the incentives for individual agents are not aligned with the incentives for the collective of agents.

This may sound a little confusing, but hopefully by the end of the chapter it will make more sense. At this point, suffice it to say that Section 9.3 deals with the most important source of market failure of this type in the current economy: climate change. We all jointly own, or take care of, our planet. Everything I do that harms the planet harms me but also harms billions of other people. In this sense, property rights over the planet are not well defined, or not well enforced, or both. There is a certain parallel between Chinese farms before the 1970s (the fruit of my effort is shared by all) and the world economy in the 21st century (the damage caused by my CO_2 emissions is shared by all). So, we might refer to this chapter's market failure

as "poorly defined property rights" (to which we add market power, from the previous chapter, and information, from the next chapter, as the main sources of market failure).

9.1. INTERNALIZING EXTERNALITIES

This section corresponds to the core of the chapter. In it, we introduce the central concept of externalities. The section begins with an example that motivates the analysis: fisheries in the North Atlantic ocean.

THE TRAGEDY OF THE COMMONS

The Atlantic cod, a highly sought-after fish species, has roamed the coast of Newfoundland for centuries. In the 18th and 19th centuries, the Portuguese were known for line-fishing during long campaigns (up to three months), after which large quantities of dried cod were brought to Europe to feed a large population of poor and protein-needy peasants.

Fishing technologies improved remarkably during the 20th century. Particularly important was the introduction of dragnets, which can catch enormous quantities of cod. A significant number of large ships from Canada, Japan, Russia, etc, flocked to the northwest Atlantic in search of a profitable catch.

Figure 9.1 plots data on catch levels, quota levels, stock levels and the catch rate. Specifically, the vertical bars show the (estimated) stock level of cod. As can be seen, the relatively high levels in the late 1980s (between 800 and 900 thousand tons) dropped to essentially zero in the mid 1990s!

What happened in the early 1990s is a tale of the dangers of poorly regulated fisheries. The quota levels were set at a generous level. The figure shows catch quotas in green and catch levels in blue. The values of quota and catch should be read on the right scale. In the late 1980s and early 1990s, we observe values in the vicinity of 200 thousand tons.

When the stocks began to decline in the early 1990s, catch levels declined as well, but not quickly enough. As a result, a downward spiral took place, whereby lower and lower stocks were quickly deci-

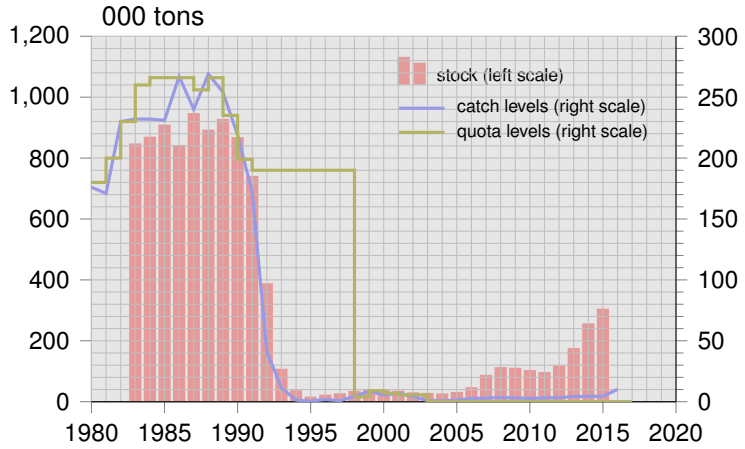


FIGURE 9.1
Newfoundland cod. Source: fishsource.org

mated. Only when stocks were very low compared to the early 1990s did catch levels drop to close to zero, but by then it was too late.

In the ensuing years, fishing authorities set more rigorous limits on cod fishing, in fact cod fishing was outlawed in Newfoundland for a number of years. Unfortunately, this did not stop several boats from fishing, leading to a failure to rebuild the stocks of cod. Finally, after 2005, with capture levels effectively at zero, we begin to observe a resurgence of the Atlantic cod.

The Newfoundland cod fishing episode is an instance of a more general problem: the so-called **tragedy of the commons**, a term coined by scientist Garrett Hardin. The term "commons", and the concept it refers to, dates back to an 1883 essay by British economist William Lloyd. He claimed that common land used for grazing (known as a "common") would inevitably be over-grazed. More generally, the idea is that individual choices, good as they may be from each individual's point of view, may result in an inferior collective outcome whenever there is a **common resource**.

More generally, the term **externality** refers to the effect that an economic action or transaction might have on a third party that is not part of the action or transaction. So, for example, if I fly across the Atlantic I incur in a certain private cost (e.g., the airfare I need to pay) and I enjoy certain benefits (e.g., visit relatives). However, to the extent that the plane I travel on burns a lot of fuel, my economic

decision implies an increase in CO_2 emissions, which in turn implies costs to a lot of other people, namely the above-mentioned third parties to the economic transaction between me and the airline.

So far, we only considered the tragedy of the commons as an instance of an externality. However, there are many other types of externalities, as we will see later in the section. Moreover, we normally think of an externality as a harm to a third party. However, in addition to **negative externalities** there may also be **positive externalities**. That said, we will continue the analysis by focusing on the negative externality resulting from common resource use: It's easier to understand it and it's quite important (note in particular the problem of climate change, the focus of Section 9.3).

MARGINAL SOCIAL COST

By now, you are probably aware that the economics modus operandi is to put a number on everything. Suppose there is a negative externality, that is, an action by a specific agent which implies a harm to third parties. For the sake of concreteness, consider the air travel industry, as characterized by Figure 9.2. Let q be the number of passengers flown and p the level of airfares. The demand curve is given by D and the supply curve by S. For simplicity, assume that the air travel industry is competitive (Section 8.1 suggests that it is not, at least not in the US, but for now we'll make that assumption to simplify things).

We may dispute the precise numbers, but we all agree that burning fossil fuels contributes to climate change and related harmful effects. What does this mean in economics terms? Suppose that an additional passenger implies an increase in carbon emissions given by e and let c be the economic harm produced by emissions e. The product $e \times c$ then measures the carbon cost of an additional passenger. In Section 9.3, we will discuss the issue of measuring this cost in practice. In Figure 9.2, this cost is given by MEC, where MEC stands for marginal external cost.

As we saw in Section 6.1, the market supply curve corresponds to the sellers' marginal cost. We thus have two sources of cost from flying an additional passenger: the (private) marginal cost, which we denote by MPC (or simply by MC, if there is no confusion); and the **marginal external cost**, which is simply the cost imposed on third

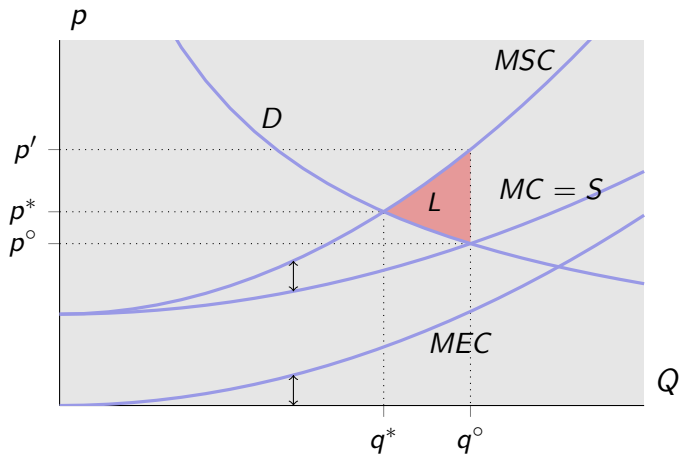


FIGURE 9.2
Negative externality and social loss

parties (in the present case, everyone else on planet Earth). Finally, by adding the private marginal cost and the marginal external cost we obtain the **marginal social cost**, which we denote by MSC.

As usual, the market equilibrium is given by the equality of supply and demand. This corresponds to point (q°, p°) on the graph. If there were no externality, this equilibrium would also be an optimal outcome in terms of market efficiency: absent externalities, (q°, p°) maximizes gains from trade, in other words, any value $q < q^\circ$ would be missing positive trades, and any value $q > q^\circ$ would include negative trades (that is, trades such that cost is greater than willingness to pay).

Once we factor in the externality, we notice that, at $q = q^\circ$, marginal social cost is greater than willingness to pay, that is, the MSC curve lies above the demand curve (specifically, the value of MSC is p', which is greater than p°). This implies that, from a social point of view, the q°th trade should not have taken place. In fact, the social optimal output is given by the point where the demand curve (willingness to pay) equals the MSC curve, that is, point q^*. Every trade corresponding to $q > q^*$ is inefficient, as the social cost is greater than the social value. We thus conclude that,

> *If there is a negative externality, then the equilibrium output level is greater than the socially optimal output level.*

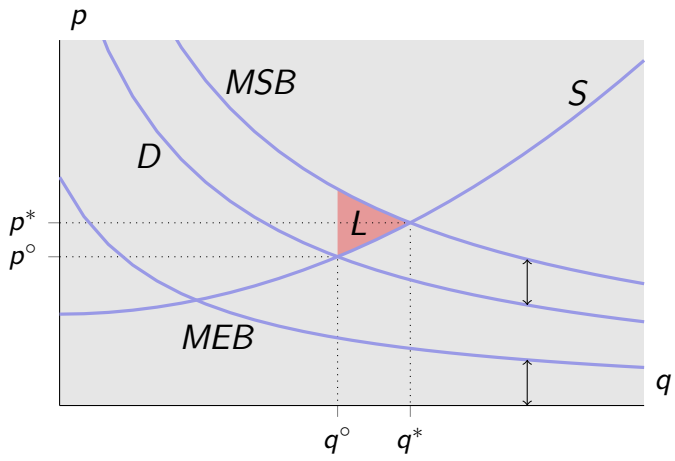


FIGURE 9.3
Positive externality and social loss

Finally, since all of the trades from q^* to q° have a social cost greater than willingness to pay, it follows that L measures the efficiency loss due to the over-production of the good subject to negative externalities.

As I mentioned earlier, externalities may be positive. For example, if I get a flu shot then I derive a (private) benefit, namely a lower probability of getting the flu. However, to the extent that the flu is contagious, my vaccine also accrues benefits to third parties.

The possibility of a positive externality is illustrated in Figure 9.3. This time, instead of a marginal external cost, an increase in q (e.g., number of people taking a flu shot) leads to a benefit to third parties, namely the **marginal external benefit**, denoted by *MEB* in Figure 9.3. Since the (inverse) demand curve measures the willingness to pay (private value), the total social value is given by the buyer's willingness to pay plus the marginal external benefit. This sum corresponds to the **marginal social benefit** and is denoted by *MSB* in Figure 9.3.

As before, the market equilibrium is given by point (q°, p°). The social optimum, in turn, is given by the equality of marginal cost (supply curve, S) and marginal social benefit (*MSB*). This corresponds to point (q^*, p^*). Unlike the case of a negative externality, where $q^* < q^\circ$, we now see that,

Box 9.1: External benefits from flu vaccination

Vaccination represents a typical example of a positive externality. However, it is not easy to estimate the magnitude of such externality, and such estimation is seldom done. One possible identification strategy is to compare different parts of the US with different rates of vaccination. However, this approach suffers from the common correlation-is-not-causality problem (that is, the issues of omitted variable bias, reverse causality and spurious correlation). For example, it could be that people in some states are very healthy and health conscious. This implies a cross-state correlation between the fraction of people who take a flu shot and how healthy people are, but such correlation would not necessarily correspond to a causal relation, the relation which would correspond to an externality.

A more promising identification strategy is to take into account the fact that there are many (hundreds?) of flu strains. As much as we try to predict the pesky virus, each winter brings a new slate and a few surprises. For the statistician, this provides the opportunity of an exogenous shock to the *actual* and *effective* degree to which people are vaccinated. For example, if many people took a flu shot but it turned out that the relevant strains were strains not included in this year's vaccine, then for all practical purposes it's as if people had not been vaccinated.

Recent research based on this approach shows that the effects of flu vaccination on others are significant. In a given year, a 1% increase in the US flu vaccination rate saves about 795 lives, especially among individuals aged 75 and older. If we try to put a monetary value on this, it comes to a benefit of about $63 per vaccination. The 1% increase in the vaccination rate also saves 14.5 million work hours, which has the economic value of about $87 per vaccination.

For reference, a flu shot costs between $20 and $40.

If there is a positive externality, then the equilibrium output level is lower than the socially optimal output level.

Finally, similar to the case of a negative externality, all of the trades from q° to q^* have a willingness to pay greater than social cost. It fol-

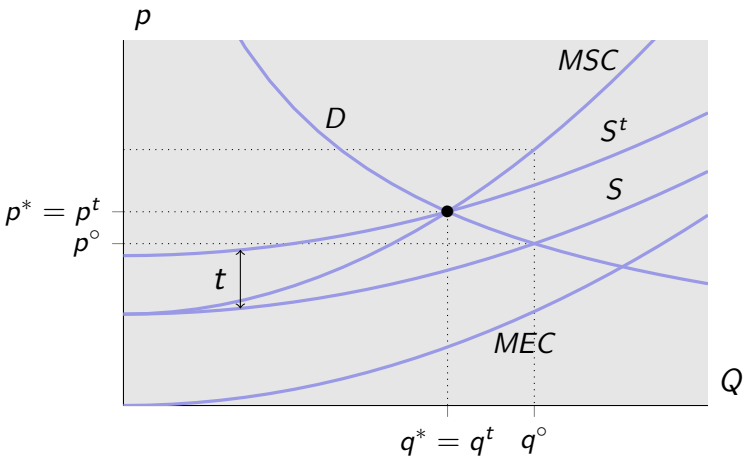


FIGURE 9.4
Pigou taxation

lows that L measures the efficiency loss due to the under-production of the good subject to positive externalities.

PIGOU TAX

In markets with externalities, the First Welfare Theorem fails to hold: The market price is no longer the right guide for consumers and producers. In particular, if the externality is negative then the equilibrium output level is too high from an efficiency point of view. The "invisible hand" of the marketplace no longer has the "magic" power that it has absent externalities.

Is there any hope for the market? Enter economist Arthur C. Pigou, whose answer is yes, there is hope for the market system even when there are externalities, so long as we impose an output tax (if the externality is negative) or an output subsidy (if the externality is positive). Figure 9.4 shows how this is done. Basically, we choose a value of t such that the new supply curve, given by S^t, crosses the demand curve at q^*. In other words, if we choose the right value of t, then the regulated market equilibrium (regulated by the Pigou tax t) is the same as in the socially optimal solution!

In other words, with Pigouvian taxation the "magic" of the price system is re-established, though with one caveat: Under the First Welfare Theorem, there is no information requirement for policy

makers: All they need to do is to let the market work its ways and expect an optimal q and p to emerge (as usual, by "optimal" we mean "efficiency maximizing"). By contrast, a Pigou-regulated market requires that we determine the value of t. As we will see in Section 9.3, this task is far from trivial.

A relative success story in applying Pigou's ideas is taxation of gasoline consumption in Europe, where a Pigou tax has moved consumption levels closer to the social optimum. The numbers in Box 9.2 suggest that a tax on gasoline price may be an effective one.

OTHER EXAMPLES AND SOLUTIONS

Once you start thinking about the concept of externality, you realize that the world is full of them. You also realize that there are different ways of dealing with it, some related to Pigou taxation, some different. This section surveys various instances of market failure due to externalities. I also recommend you look at the problems at the end of the chapter, where additional real-world examples are considered.

■ **Congestion.** One externality that may not be obvious at first, but turns out to be quite important, is congestion. Actually, it's an externality many of us have to deal with on a daily basis. If you fly a lot out of a busy airport like New York's LaGuardia or London's Heathrow, you know the drill: "Good morning folks, this is your captain speaking, we are now number 17 for takeoff." Which means an extra half hour taxiing on the tarmac. Excessive congestion results from an externality: when an airline decides to schedule a flight during rush hour, it does not take into account the extra delay it imposes on all flights departing right after.

Car congestion in city centers can also be very annoying. Some cities have come up with the creative solution of charging cars to drive in the city center (London, Hong-Kong, Singapore). New York tried it, but the proposal was killed. Road pricing, as the policy is known, is effectively a form of Pigou taxation.

■ **Free riding.** Where can you find beer for 5 cents a bottle? My best answer: try a class reunion with 100 diners. Let me explain: When you and your 99 colleagues go out for a meal, chances are you will split the total bill: it would be far too complicated to keep 100 indi-

Box 9.2: Approaches to reducing gasoline consumption: US and EU

In 2013, 1 liter of gasoline cost €1.53 at an average European Union (EU) pump, of which 58% corresponded to taxes and duties. In the United States, average price at the pump was $3.49 per gallon. Considering that one gallon equals 3.785 liters and that the yearly average exchange rate was 0.783 euros per dollar, this comes to about €.72 per liter, about one half of the price in Europe. For US readers, the European price was about $7.40 per gallon, about twice the US price.

Not surprisingly, gasoline consumption (both per person and per car) is much lower in the EU than in the US. Arguably, the value of q is much closer to q^* in the EU than in the US (see Figure 9.4). This is partly because the price elasticity of the demand for gasoline is different from zero, but also because the demand for cars is very different in the EU than in the US.

Reacting to high gasoline prices and the demand for low-consumption cars, European cars are smaller and consume less gasoline than their American counterparts. In 2013, average fuel efficiency in the US was 32 miles per gallon, whereas the EU showed a whopping 45. For European readers, this corresponds to 5.2 liters per 100 kilometers (EU) against 7.6 liters per 100 kilometers (US).

Various US governments have made efforts to increase automobile fuel efficiency, for example enacting Corporate Average Fuel Efficiency (CAFE) standards, regulations that impose on automakers a minimum average fuel efficiency. However, the regulated firms have managed to keep the minimum standards at "reasonable" levels. Moreover, various loopholes make CAFE standards less effective than one might think: for example, gas-guzling SUVs are treated as light trucks and thus excluded from the average, which effectively provides an "escape" for consumers and manufacturers who want to avoid regulation.

vidual tabs. When it comes to decide whether to order that second or third beer, if you are an economist, then the way you'll reason is as follows: one more beer, 5 more dollars added to the total tab; that's 5 cents for me — not a bad deal! Lest you think this is a purely theoretical consideration, economists have actually estimated this effect:

even for a party as small as 4, splitting the bill may lead to an increase in the total tab by as much as 40%.

In economics, this problem is referred to as the **free-rider problem**. The point is that an agent's decisions (for example, ordering an extra beer at a split-the-bill dinner) does not take into account the costs imposed on other agents (99% of that extra beer is effectively paid by them). As a result, the total quantity consumed at the dinner is likely to be higher than socially efficient: even if the marginal cost of a beer is, say, 30 cents, there will be a lot of beer consumed for which willingness to pay is lower than social cost.

If you think about it, the tragedy of the commons is really a free-riding problem. In fact, the tragedy of commons may be characterized by a concentration of benefits and a dilution of costs. What I mean is that if I fish in a fishery that is close to maximum extraction rate, then the benefit from the catch is concentrated (I get the fish), whereas the cost (increased risk of a total collapse of the fish stocks) is shared by everyone.

Let's go back to the class reunion example. In addition to being a fun example, it also suggests that Pigou taxes may not be feasible, or indeed necessary, to solve the market failure caused by externalities. Suppose that one of your classmates comes to the reunion and insists in always ordering the most expensive items on the menu: Beluga caviar, Dom Perignon champagne, etc. He or she may get a lot for little money on this occasion, but chances are they will not be invited to the next reunion. In other words, our society includes a series of mechanisms and institutions that prevent people from constantly free riding. It's not a market solution, but it works.

■ **Community organization.** The above point regarding social mechanisms and institutions warrants further discussion. In much of economics there is a tendency to contrast two extremes: the government (i.e., the case of centralized decision-making); and the market, where it's each one for him or herself. This is clearly an exaggeration: There are multiple cases when local or regional organizations do a very good job at effectively preventing the free-riding problems of unregulated market competition.

More formally, the idea (attributed to economist Ronald Coase) is that, if negotiations costs are not very high, then we should observe an agreement between the relevant parties which effectively induces

an efficient outcome. To put it differently, if direct negotiations between the relevant parties is relatively costless, then the externalities problem is really not a problem!

In fact, research by economist Elinor Ostrom on the actual workings of commonly held resources (water, fisheries, pastures, etc) suggests that it's much less of a tragedy than the "tragedy of the commons" would suggest. If communities are sufficiently small, then experience shows that they will find rules for a fairly efficient use of resources. In other words, there's a lot going on between the extremes of a centralized government and the unregulated, decentralized market.

PUBLIC GOODS

Similar to other professions, economists like to have their jargon. When it comes to characterizing goods and services, we make two important distinctions. First, goods can be **rival goods** or **non-rival goods**. An apple is a rival good: if I eat one, then you cannot eat it (that is, you cannot eat the *same* apple). Beethoven's string quartets are a non-rival good: the fact that I listen to them on my earphones does not detract from your ability to do so on your own mp3 player.

A second relevant characteristic is whether consumers can or cannot be excluded from consumption. For example, if I issue a music EP with special copy-protection provisions, I can effectively exclude people from listening to my song (for example, I can choose to only allow paying fans to download my song). By contrast, if I go to Central Park's Strawberry Fields on a Sunday afternoon and start playing my song, then I cannot exclude passersby from listening to it. In the former case, I say the good is **excludable**, whereas in the latter case the good is **non-excludable**.

With these two dimensions in mind, I can now create a 2x2 matrix, Table 9.1, listing four types of goods. Earlier, I mentioned that this chapter is about poorly defined property rights as a cause for market failure. In terms of Table 9.1, this corresponds to non-excludable goods, that is, goods for which I cannot prevent free riding. We've seen how, in this setting, an unregulated market may lead to an inefficient outcome. So far, most of the examples we considered correspond to the top right cell, common-pool resources. We now consider the case on the bottom-right cell, **public goods**, that is, goods which

	Excludable	Non-excludable
Rivalrous	**Private goods** food, clothing, cars, parking spaces	**Common-pool resources** fish stocks, timber, coal
Non-rivalrous	**Club goods** cinemas, private parks, satellite television	**Public goods** free-to-air television, air, national defense

TABLE 9.1
Types of goods (source: Wikipedia)

are non-rivalrous and non-excludable. In addition to the list in Table 9.1, examples of public goods include neighborhood security, public health, public parks, art.

Public goods provide a particular challenge to the market economy. For the reasons considered earlier, the market equilibrium leads to under-provision of public goods. There are several possible solutions. One is direct provision by the government. For example, the US federal budget includes funds for the National Endowment for the Arts as well as the Public Broadcasting System (covering about 50% of the system's budget). Another solution is private provision. Going back to our early discussion, there's a lot going on between the extremes of a centralized government and the unregulated, decentralized market. For example, New York's Central Park Conservancy is a private, non-profit organization which takes care of the maintenance of the city's most cherished (and used) park. The Conservancy receives no federal, state or city funds. It does receive multiple small and large donations, as well as many hours of volunteer work. Finally, another source of private provision of public goods is given by philanthropy. For example, the Gates Foundation has been instrumental in the development of a malaria vaccine, a clear case of a public good that has been under-provided for decades. We'll return to the important issue of philanthropy in Section 12.3.

To conclude this section, we discuss a few cases of public goods in the corporate world. One interesting (and controversial) case is that of advertising commodities. This is a clear case of a public good where the free-riding problems can be significant. As one of several thousand peanut producers in the US, I'm quite happy if an adver-

Box 9.3: Advertising commodities

It has been estimated that each dollar spent on advertising agricultural products like eggs, milk, beef, prunes or almonds yields $3 to $6 of additional revenue to producers. Not a bad return on investment. For example, the 1980s "California Raisins" campaign was credited with increasing sales by 10 percent. Before the ad campaign, raisins were "at best dull and boring," states the California Raisin Board. After the campaign, people were no longer "ashamed to eat raisins."

Profitable as they are, Commodity Promotion Programs, as these campaigns are called, are difficult to implement. Given that some producers are paying for such a campaign, other producers may have a strong incentive not to pay for it: there is nothing better than reaping the benefits without paying the costs.

In order to solve this free-riding problem, some of the programs are mandatory, that is, growers vote whether to start a marketing program; and, if the vote succeeds, then all growers are required to participate.

But mandatory programs create their own problems. Since the early 1990s, a series of U.S. producers have sued their respective boards, claiming that they cannot be forced to participate in such deals. Initially, the Courts ruled largely in the plaintiffs' favor. But, in 2005, the US Supreme Court ruled 6-to-3 that beef marketing programs did not violate the First Amendment (rights of free speech and association).

tising campaign on the New York subway encourages consumers to eat more peanuts. I am particularly happy if the campaign is paid by someone else. As Box 9.3 shows, the potential gains from these campaigns are enormous, but you can see how the free-riding incentives are equally enormous. Trade associations may play an important role here, but this may imply difficult legal problems.

Another public-goods problem in the corporate world is given by corporate reputation. Take a franchise like McDonald's. More than 80% of the restaurants are owned by franchisees, not by McDonald's itself. This can be a source of great tension: If a customer has a bad experience in my store on Broadway, they may decide never to return to McDonald's, not just to my McDonald's on Broadway. In this

case, the solution to the free-riding problem is to have a very strict set of franchisee rules that all restaurants must follow (e.g., clean restrooms). Once again, there are many institutions between the extremes of a centralized government and a decentralized market.

Collective reputations go beyond corporations such as McDonald's. Particularly important is the problem of country reputation. Each time a Chinese firm exports electronics to Europe, or a Chilean winery exports a carménère to Australia, or a Mexican farmer sells avocados in the US, the consumer experience affects their perception of Chinese electronics or Chilean wine or Mexican avocados, respectively. And this affects all of the exporters from that country, not just the firm that exported a particular product. The list of externalities is seemingly endless!

9.2. THE COVID-19 PANDEMIC

The year 2020, and possibly human history for a long time to come, has been dominated by the COVID-19 pandemic. Many things changed during 2020, but, as someone jokingly remarked, the indicator that increased the fastest was the number of "experts" in epidemiology. It is good that we all have an opinion on the most important event of the year, especially if that opinion is coherent and well founded. This section summarizes some of the central issues from an economics perspective.

The question may be asked, What does economics have to add to epidemiology? Two possible answers: First, public policy during a pandemic is largely a matter of trade-offs, and economics is, to a great extent, the formal analysis of trade-offs. Second, unlike the modeling of natural processes (earthquakes or cell reproduction, for example) the dynamics of a pandemic depend largely on human behavior, and economics is, to a great extent, the formal analysis of how rational agents behave, in particular how they react to incentives.

A different preliminary question is, Why include the pandemic in the present chapter? The answer is that the present chapter is about externalities, and the economics of a pandemic is largely about externalities, about the fact that each individual's actions have an effect that goes well beyond that individual.

FLATTENING THE CURVE

Before addressing specifically the economics of a pandemic, one interesting empirical question is the extent to which public health measures are effective in reducing the spread of a virus like COVID. As we saw in Section 2.1, using historical data for this purpose can be tricky business. Take for example the top panel of Figure 9.5, which includes a cross-country scatter plot of strictness of health measures (horizontal axis) and excess mortality rate (vertical axis) in August 2020. (Excess mortality is basically the difference between the mortality rate and the "expected" mortality rate for the same time of the year based on the experience of previous years.)

The data is all over. If we believe stricter policy measures are effective in reducing the spread of the virus and thus reduce deaths, then we would expect a negative correlation between the two variables. However, we find that New Zealand had a very loose policy *and* very low excess mortality, whereas the US had a much stricter policy *and* a much higher mortality rate. Clearly, there are more factors not considered here. Clearly, the US was hit harder than New Zealand, which implied both a higher mortality rate and stricter public health measures. In other words, the New Zealand vs US comparison is a case of correlation, not causality. Moreover, causality is likely to work both ways: If it is true that stricter measures protect lives, it is also true that stricter measures, which are always unpopular, are likely to emerge in response to an increase in the number of deaths.

The problem with cross-country comparisons is that typically there is a lot of "noise" (what economists refer to as "unobserved heterogeneity") which makes it difficult to tease out causal relations from simple correlations. In this sense, a better approach is to compare the different states of the US, the idea being that there is less heterogeneity than across countries. The bottom panel of Figure 9.5 does that. The data sources are different and the specific indicators are also different, but, similar to the top panel, we measure public policy on the horizontal axis and outcomes on the vertical axis. This time we see more of a correlation along the lines one would expect from a causal relation, namely that public policy to limit the spread of the virus does save lives. At the extremes, we have South Dakota, with the least measures and the highest death rate, and Hawaii, with the most measures and the lowest death rate. Nevertheless, there is still a

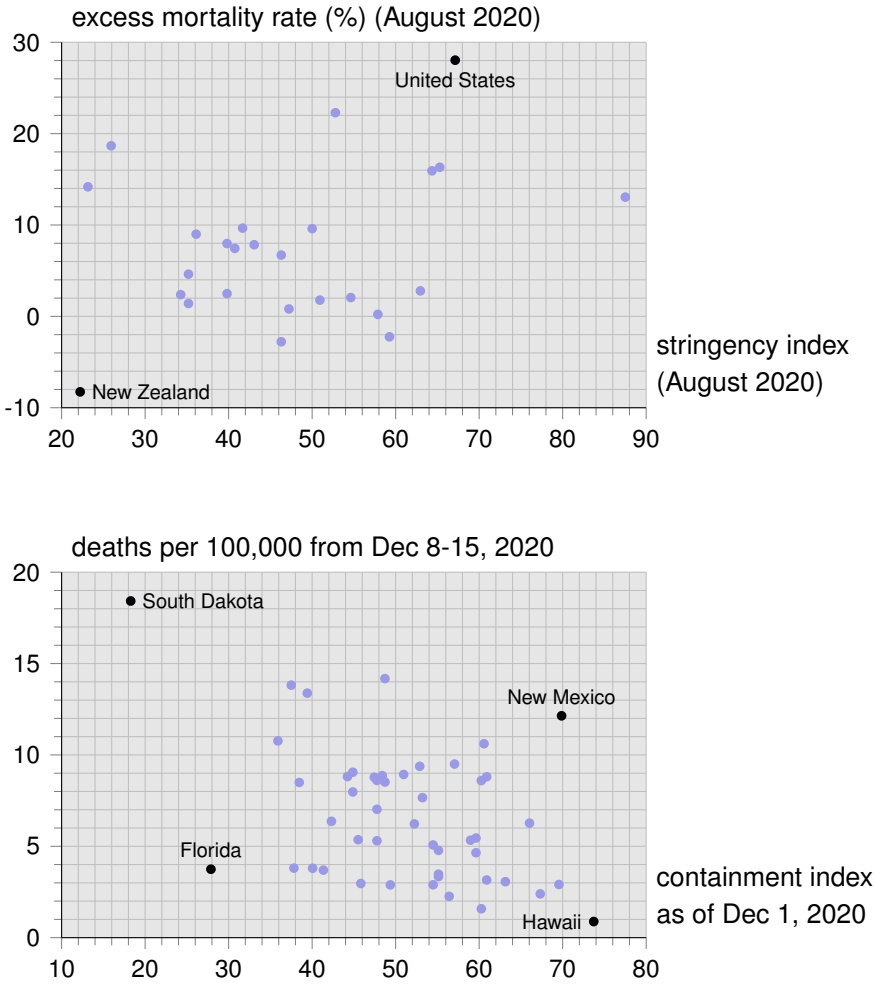


FIGURE 9.5
COVID-19: Public policy and outcomes (sources: Our World in Data for top panel, Oxford University, CDC, and Census Bureau for bottom panel)

lot of noise. For example, Florida did not implement that many measures but was having a low death rate in December, whereas New Mexico was experiencing a high death rate despite many restrictive measures.

As we saw in Section 2.1, one way to identify and measure a causal relation is to run a counterfactual. Consider the case of Sweden, a country that stood out among European countries for not having imposed stringent restrictions during the first months of the pandemic. What impact did this have on mortality? One possible counterfactual is to compare the actual number of deaths to the average

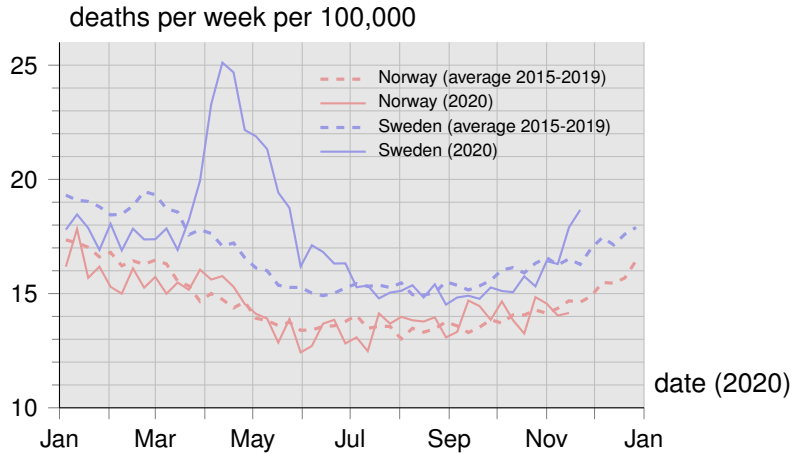


FIGURE 9.6
Mortality rate in Norway and Sweden: 2020 and average during 2015-2019 (source: Our World in Data and author's calculations)

number of deaths during the same time of the year in previous years. Another possibility is to compare Sweden to neighboring Norway, a country where more stringent and early regulations were imposed.

Figure 9.6 shows the results from these calculations. We observe that the mortality rate in Sweden during 2020 (solid blue line) is considerably higher than the mortality rate in Norway during 2020 (solid red line). However, part of this difference is due to the fact that, probably for demographic reasons, the mortality rate is "normally" higher in Sweden. This is the advantage of a counterfactual approach: Sweden shows a higher mortality rate than Norway, but the difference in this gap is greater in 2020 than in previous years. This positive difference in differences suggests that Sweden's looser approach to the pandemic resulted in a higher death rate. A more rigorous counterfactual study suggests that, had Sweden implemented an early lockdown, excess mortality would have been 38% lower. A separate study estimates a 25% drop in excess mortality. (Interestingly, Figure 9.6 also shows that the mortality rate in Norway during 2020 was not very different from that of previous years.)

PUBLIC POLICY TRADEOFFS

The basic model of an epidemic is the so-called SIR model. If you have not contracted the virus, you are part of the group of susceptible individuals (S). If you are infected with the virus, then you are part of group I. Finally, if you had the virus and recovered from it then you are part of group R. A new infection takes place when a member of group S interacts with a member of group I, so that the S individual becomes an I individual. An individual in group I, in turn, either dies or moves to group R.

Suppose that there are very few individuals in group I and that most individuals belong to S. Consider a random encounter between two individuals. Most likely, this will be an encounter between two individuals of the S population. Such interaction produces no virus transmission. At the opposite extreme, suppose that a large fraction of the population is in group I. Now a random encounter will likely match two individuals belonging to group I. Such interaction produces no virus transmission (though for a different reason than before).

Together, these features of virus transmission lead to a dynamic path of new infections that is bell shaped: the number of new infections is first very low, then increases "exponentially", then declines to very low numbers again. (I am writing "exponentially" in quotation marks since it may not follow the exponential function literally.) For similar reasons, the number of individuals in the Infected group will follow a bell-shaped curve.

The actual time paths of number of infected individuals depends on nature (how the virus actually gets transmitted), on individual behavior (the frequency and nature of the encounters between individuals), and on public policy (to the extent that it conditions and influences individual behavior). The expression *flattening the curve* has become a common expression when referring to public policy in a pandemic context. The idea is to minimize the S-I encounters that are likely to produce a new case (by means of lockdowns, for example), or alternatively minimize the likelihood that such encounters result in actual transmission (by means of mask wearing mandates, for example).

Figure 9.7 shows the time path (during 2020) of the number of new cases in a selected set of countries. (Specifically, for each day

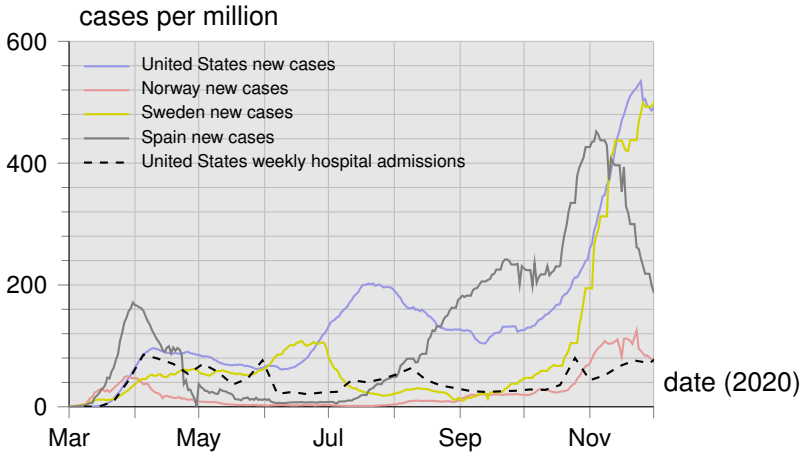


FIGURE 9.7
New cases per million inhabitants, smoothed (source: Our World in Data)

the value corresponds to the average of the previous 7 days.) The actual paths differ from the bell-shaped path predicted by simple models for various reasons. First, public policy and individual behavior change over time, which in turn affects both the rate of encounters and the likelihood that an I-S encounter leads to actual transmission. Second, there is also a measurement issue: to the extent that testing is limited, there may be many actual cases of infection that are not counted. In this sense, a statistic such as hospital admissions may be a more reliable indicator of the actual number of symptomatic cases. As can be seen in Figure 9.7, at least for the US the number of hospital admissions shows a much less dramatic scenario than the number of new cases.

TRADE OFFS

Public-policy measures to flatten the curve include stay at home orders, mandatory quarantines for travelers, closures of non-essential businesses, closures and restrictions imposed on restaurants and bars, limits on gatherings, mandatory face coverings, and so forth. This is where economic trade-offs come in, as these restrictions have an economic cost. It's not easy to measure this cost: public policy measures seem to change by the week or by the day, whereas academic economic activity (e.g., GDP) is typically measured on a quar-

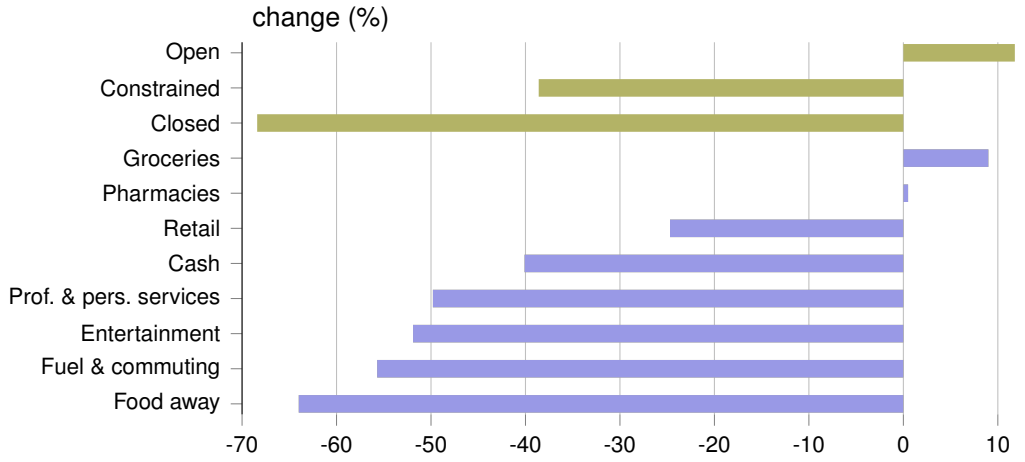


FIGURE 9.8
Shutdown effects on credit-card spending in Denmark (source: Andersen et al)

terly basis. One solution is to measure consumer spending based on credit card use, for which daily data is available. Figure 9.8 shows results for Denmark, an economy where credit-card payments play an important role. The chart shows the estimated effect of restrictive measures on consumer spending. The green bars show the effect by type of sector. Those that were not subject to any restriction ("open") actually showed an increase with respect to the counterfactual of no pandemic restrictions, whereas the sectors subject to partial constraints ("constrained") or heavy constraints ("closed") saw a drop in spending of almost 40 and almost 70 percent, respectively. The blue lines show the effect by specific sector.

This brings us to the issue of trade-offs. From the very beginning of the pandemic, many analysts talked about the conflict (or absence thereof) between the economy and the efforts to contain the pandemic: *health vs wealth* was the common mantra. Is there really a trade-off between the two? Yes and no. Figure 9.9 shows the feasible set in the heath vs wealth map. Obviously, this is a bit simplistic: it is very difficult (in fact, it is impossible) to summarize the health or economic status of a country in one single indicator. However, for the purposes of illustration, such simplified model may be of help.

The first point is that, by virtue of the law of diminishing marginal returns, there should be no trade-off at the extremes. Suppose that we were to set health provisions at a minimum: simply ignore the pandemic. This would have deeply negative effects in terms

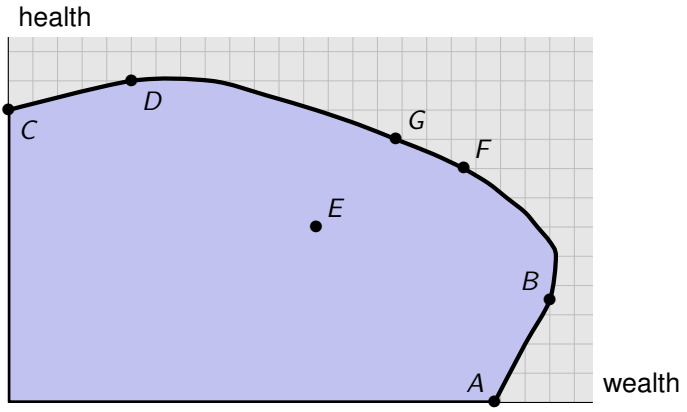


FIGURE 9.9
Health-wealth feasible set

of health: there would be an enormous number of infections and deaths. Moreover, these health costs would have a significant negative effect on the economy. For example, many workers in critical sectors would be unavailable, either due to sickness or death. Starting from an extreme point like this (say, point A in the graph), increasing the level of health efforts would improve the state of health *and* would improve the state of the economy, that is, it would move us to a point like B. At this point, there is no health-wealth trade-off.

Now consider the opposite extreme: We completely and entirely shutdown the economy. This would imply the lowest level of wealth, point C in Figure 9.9. The problem with this draconian policy is that the economy is so affected that some essential products and services required by the health sector (e.g., personal protecting equipment) would not be available. Starting from an extreme point like this, increasing the level of economic activity would improve wealth *and* would improve the level of health as well, that is, move us to a point like D. At this point, there is no health-wealth trade-off.

Aside from these extreme cases (all the way for wealth or all the way for health) we can also find intermediate situations when there is no trade-off. These are the cases when the health measures are clearly suboptimal, so that we are in a point like E. For example, suppose the government shuts down factories that produce personal protective equipment but allows bars and large entertainment-related events to continue to take place. An appropriate change in policy would allow

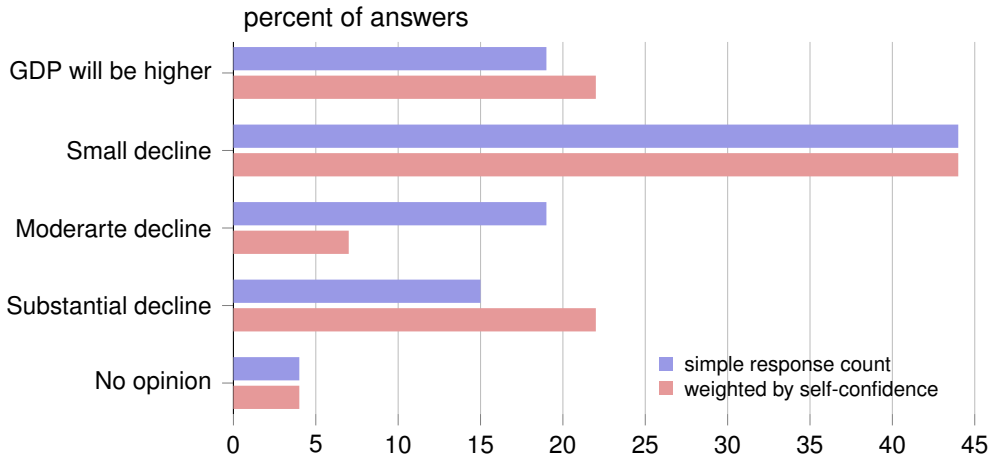


FIGURE 9.10
Economic effects of lockdown. Replies to the question, How much will the new lockdown measures introduced on Thursday, November 5 hurt UK economic activity this year relative to a counterfactual with the milder measures adopted over the summer? (source: Center for Macroeconomics)

us to move to a point like F, with a better health outcome *and* a better economy.

Once all of the low-hanging fruit has been caught (that is, once the obviously sub-optimal policies have been fixed), we end up in a point along the frontier of the feasible set, a point like F. At this point, we are faced with a trade-off: if we want to achieve a better health outcome (a point like G), then we must sacrifice some economic value. It is common to hear that there is no trade-off, that we don't need to sacrifice any economic gain as we increase the strictness of health measures. This may be true in come cases, maybe in most cases (e.g., going from A to B or from E to F), but is certainly not the case in general. Considering the specific policies enacted by different countries during the 2020 pandemic, the case can be made that stricter measures did not come at a large cost. For example, a recent paper shows that the drop in consumer spending in Denmark was not much greater than in Sweden, even as Denmark implemented more restrictive measures than Sweden. Not much greater, true, but greater nevertheless. There seems to be a trade-off.

More recently, a November 2020 survey of UK based economists included the question, How much will the new lockdown measures

introduced on Thursday November 5 hurt UK economic activity this year relative to a counterfactual with the milder measures adopted over the summer? The responses are shown in Figure 9.10. Although there are differences of opinion, the majority of experts believes that there is a tradeoff, though probably a small one (which seems consistent with the Denmark-Sweden comparison). In one answer that is somewhat representative, Ricardo Reis of the LSE writes that "by the time the UK government imposed a lockdown, people had already been voluntarily withdrawing from contact with each other. The people led, the government followed. There would have been a large tumble in GDP even without the lockdown, as the experience in Sweden suggests."

Understanding and measuring trade-offs is one of the important contributions of economics in the context of a pandemic. A case in point is the policy debate surrounding the **rate of reproduction** $R_\circ$, that is, the average number of people that an infected person goes on to infect. A critical threshold of $R_\circ$ is given by $R_\circ = 1$. To understand why, suppose that $R_\circ = 2$. This means that an infected individual leads to 2 infected individuals who in turn lead to 8, 16, 32, ... infected individuals. Before long you have a very large number.

"All we need is to keep $R_\circ < 1$," we heard repeatedly. But it's not so simple. Cambridge economist Flavio Toxvaerd writes:

> Consider a disease like the common cold, which for most people has very mild symptoms and no significant health effects but is very highly infectious. It has a rate of reproduction of 2-3, significantly higher than 1. Should we impose a complete lockdown of the economy to combat the common cold? Of course not. Since symptoms are mild, it is not reasonable to incur large economic costs to combat this disease.
>
> Now consider a disease like MERS. This disease has a rate of reproduction of 0.3-0.8, i.e. well below 1, but has serious health effects for those infected. The case fatality ratio of MERS is estimated at 43%. Should we take decisive measures to combat this disease? Almost certainly.

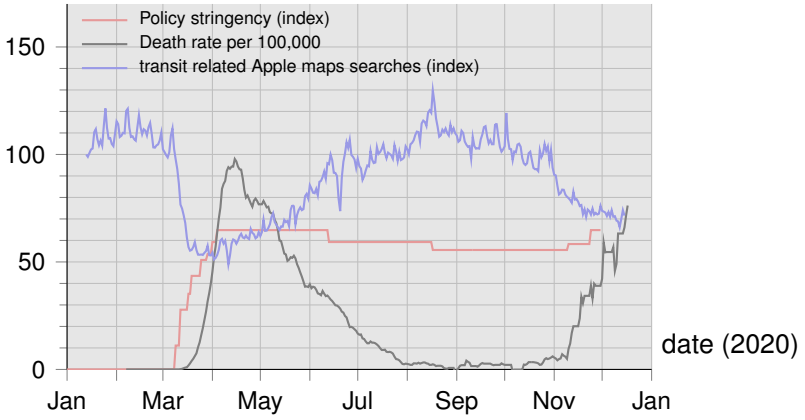


FIGURE 9.11
Sweden: Stringency of containment measures, individual behavior, and health outcomes (source: Our World in Data)

INCENTIVES, BEHAVIOR, AND OUTCOMES

Economics is largely about incentives. We saw this in Section 2.3 and will discuss it again in the next chapter. For now, let us focus on Sweden as an example of the interaction between policy, behavior and outcomes. Figure 9.11 shows the evolution of three variables. First, a policy indicator, namely an index of stringency of COVID-19-related regulations. Second, a behavior indicator, namely the frequency of traffic-related searches on Apple maps. Third, an outcome indicator, namely the weekly death rate per 100,000 inhabitants.

The story this data suggests is that until early March not much happened. Then, as people started getting infected and dying, the government imposed a number of restrictions, which by early April had reached their highest value. In tandem with the enactment of public restrictions, we "observed" a decline in the use of public transportation, as proxied by the drop in public-transportation-related Apple maps searches. From April to August, as the number of deaths declined, the number of transit related searches increased, even though the level of government restrictions did not change that much. This suggests that individuals are more guided by their own risk analysis, which in turn is based on actual outcomes, than by government restrictions per se: If the death rate is high, then people are more afraid and behave in a more careful manner. If the death rate is low, then people are willing to take greater risks. And all of this

regardless of what actual regulations state.

Are individuals the best judges of the costs and benefits of their own actions? Much of economic analysis is based on the concept of **revealed preference**, a concept introduced in Section 2.3 and developed in Section 6.2. Most economists believe that, in a market context, the answer to the above question is positive: If I spend $5 at Starbucks it must be that that coffee is worth at least $5 to me (if you can believe that). An extreme libertarian might also extend the revealed preference argument to all or almost all situations, including social distancing and mask wearing. If people are willing to take the risk, who am I to deny their rights?

A related issue is the measurement of outcomes. There is a bias — surprise, surprise — in the direction of measuring the measurable, for example, the number of cases or the number of deaths. But what about the psychological benefit of meeting a relative or friend (or the psychological cost of not being able to do so)? Economist Tyler Cowan, for example, remarked in November 2020:

> Take all of the pending Thanksgiving travel — the biggest risk is to parents and grandparents, but mostly they are receiving their children voluntarily.

In other words, if I receive my family for Thanksgiving, it's because I value the reunion more than the cost of the increased risk. Why not let me decide what is best for me? Unfortunately, things are more complicated that this, as we will see next.

EXTERNALITIES

There is one important difference between buying a cup of coffee at Starbucks and inviting my family for Thanksgiving during a pandemic: The difference is that the latter decision has significant externalities. It's not just my risk, it's also the risk I'm subjecting others to.

There are many instances of externalities in the context of a pandemic. The most natural one is the so-called infection externality: An infected person can spread the disease to others, who can in turn spread it further and so on. When I protect myself from becoming infected, I typically take into account the costs and benefits that in-

fection would imply for me, but not the effects that my behavior, and the possibility of becoming infected, would have on others.

The gap between private and social incentives (the marginal social effect) may be particularly high, for example, in the case of children. The evidence suggests that healthy children are unlikely to suffer adverse health effects from becoming infected themselves. But since children may interact with elderly relatives or with people with underlying health conditions, they may in fact have a strong negative infection externality on others.

As we saw in Section 9.1, externalities provide a natural rationale for government intervention. When it comes to market control, there are essentially two types of policy instruments to fix externalities: q based and p based. In Section 9.1 we saw that economists are very fond of Pigou taxes (for example, a carbon tax). A Pigou tax is a p-based instrument: it changes the price effectively paid by the economic agent, thus affecting their incentives. In the context of public health, by contrast, q-based instruments, by which I mean direct constraints on the agents' level of economic activity, tend to be more prevalent. Examples include limiting a restaurant's opening hours or the number of patrons it can accommodate. However, there is no *fundamental* reason why q should be used instead of p. Instead of forcing all businesses to close, one could imagine asking specific businesses to pay a tax in order to remain open (with a tax level proportional to the externality imposed by the business' activity). If the business thought it sufficiently important (economically speaking) to remain open, then the business would pay the tax rather than close down. That said, you can see how this might raise a series of issues, namely equity issues: For example, should wealthier individuals be allowed to pay their way out of mobility restrictions?

VACCINES

As of the writing of this section, COVID-19 vaccines are being distributed in various countries. For many, this is not the end but at least the beginning of the end of a painful period in our collective history. Just like the pandemic itself, the vaccine raises a number of interesting economics questions. Given their limited supply, how should this limited resource be best used: Should we prioritize the individuals who have the greatest risk of dying from the virus (e.g., the

elderly)? Should we prioritize the individuals who have the greatest risk of contracting the virus (e.g., health care workers)? Should we prioritize the individuals whose current contribution to the economy is greatest (e.g., teachers)? Perhaps more controversially, should we prioritize the individuals who, given their frequent contact with others, are the most likely to transmit the virus (e.g., party goers)? These are important questions for which I do not have a good answer.

In addition to prioritizing recipients, there is also the issue of who should be allowed to produce and distribute the vaccine. A given dosage of a given vaccine is a rival good, to use the terminology introduced earlier: if I get that particular dosage, no one else can get it. However, the ideas required in order to produce a vaccine are non-rival goods: the fact that I apply these ideas to produce a series of dosages does not preclude others from doing so. In practice, what currently stops an Indian or a South African pharmaceutical company from producing COVID-19 vaccine dosages is that they have no access to the information required (some of this information is a trade secret) or, having access to the information, they are legally barred from using it (due to patents).

The current situation is highly inefficient: The marginal cost of producing a dosage is relatively small, much smaller than the price the pharmaceutical firm is receiving for it. Moreover, pharmaceutical firms have limited capacity, which implies that it will take months before the vaccines reach all 7 billion inhabitants of planet Earth. For this reason, some have called for the suspension of patent rights on COVID-19 vaccines (cf Exercise 9.21).

Pharmaceutical firms, in turn, have a point, too: Intellectual property over ideas (for example, a patent on how to make a vaccine) is an important innovation incentive. If there is no prize at the end of the tunnel, why would a pharmaceutical firm invest millions in developing new drugs?

Patent rights certainly create an incentive, but is this the only way of providing such incentive? One solution proposed by a number of economists is to create a prize for the first firm (or the first firms) to find the solution to a given problem (e.g., a vaccine against COVID-19). In this way, the inventors have their financial incentive and the research becomes available to all. In the present case, this would greatly alleviate capacity constraints and probably also allow for lower costs. However, if we were to create a prize we would need

to finance the prize. Would it be covered by taxes? If not, how? Ultimately, it's the public goods problem: Efficiency dictates that public goods should be free, since there is no additional cost of giving it to an additional individual. However, public goods need to be financed, and absent patent rights or some similar incentive scheme they will likely be under-provided.

9.3. CLIMATE CHANGE

Climate change is the ultimate public good problem faced by the modern economy. We all jointly own, or take care of, our planet. Everything we do to it will be, in one way or another, shared by all, not only all across the planet but also all across generations.

As mentioned in Section 1.3, there is a general consensus that human intervention (economic activity) is a central cause of climate change. Since about 1850, human activities have been releasing extra greenhouse gases (especially CO_2) into the air. The higher concentration of greenhouse gases in the atmosphere has slowly propelled a rise in average temperatures across the globe. Overall, the 2017 global average was 0.9 degree C (1.6 degrees F) higher than it had been between 1951 and 1980. There is also a general consensus that this change has implied, and will likely continue to to imply, significant changes in climate patterns.

The economist's perspective on the problem of climate change is not very different than that of other public goods or public bads: The equilibrium of an unregulated market economy leads to the under-provision of public goods and the over-provision of public bads. Left to its own devices, the unregulated world economy will produce too much CO_2.

EFFICIENCY AND EQUITY

Much of economics is about balancing equity and efficiency considerations, and climate change is no exception to the rule. One important consideration regarding efficiency is that the relation between economic activity and CO_2 emissions is not uniform across the world. Figure 9.12 shows the relation between level of economic activity and level of CO_2 emissions for a sample of large countries (GDP greater

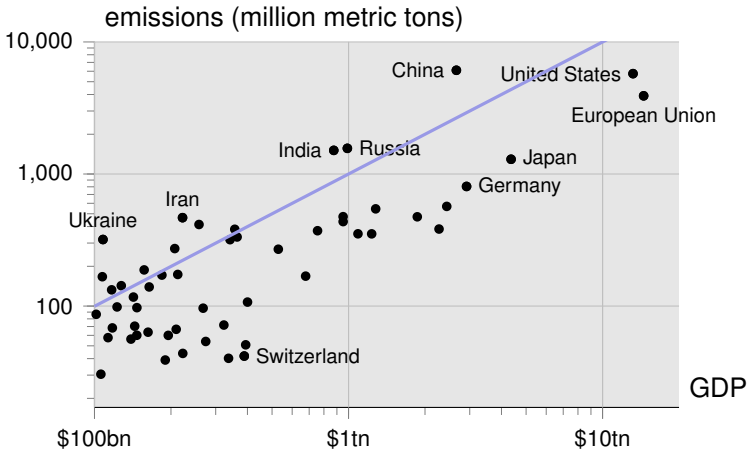


FIGURE 9.12
GDP and CO_2 emissions (source: Wikipedia)

than 100 billion dollars). Given the large disparities in size across countries, the GDP (horizontal axis) is plotted on a logarithmic scale.

The blue line in Figure 9.12 depicts the estimated average relation between economic activity and CO_2 emissions. Specifically, let γ be the coefficient indicating the level of CO_2 emissions per dollar of economic activity. On average and in 2019 this coefficient comes to about .3753 metric tons per $1,000 (or .3753 kilograms per dollar). However, this average hides a big disparity across countries. For example, the value of γ in the European Union is .2694, whereas the value of γ in China is a whopping 2.2964. We should also add that these are *average* values for each country. As we saw in Section 6.1, marginal costs are typically increasing, which implies that the marginal cost (in terms of CO_2 emissions) is likely higher than the average cost measured by γ.

The large cross-country disparities imply an important point: If we want to reduce the level of emissions at the lowest economic cost possible, then it might be better to do so by reducing the level of economic activity in China rather than in Germany. To understand why this is what economic efficiency dictates, consider Figure 9.13, which depicts the cost, in terms of CO_2 emissions, of a given level of (carbon emitting) economic activity. Notice that the cost curve is convex. This reflects the fact that, at lower levels of economic activity, we can choose the ones that are the "cleanest". If we insist on reaching yet

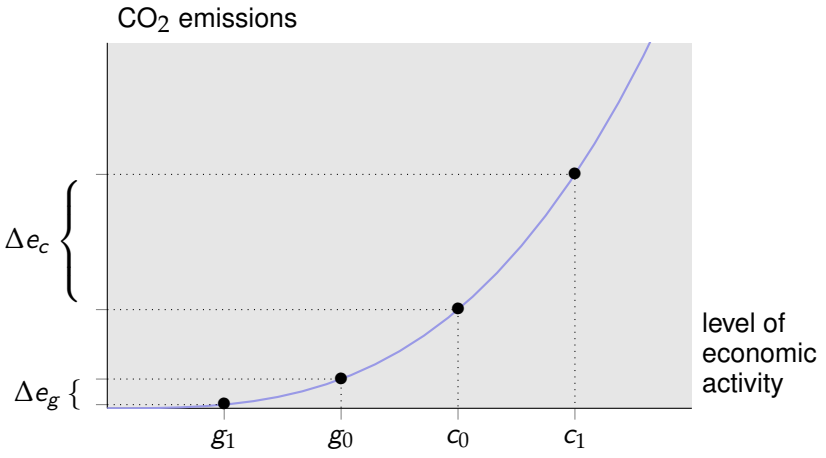


FIGURE 9.13
Marginal benefit and marginal cost

higher levels, then we gradually need to have recourse to "dirtier" technologies. This is similar to the idea of decreasing marginal product introduced in Section 5.1.

Suppose that Germany is initially at point g_0 and China at c_0, that is, China has a higher level of carbon-emitting activities. Now consider an increase in China's activity level from c_0 to c_1 and a decrease in Germany's activity level from g_0 to g_1. In terms of economic value created, China's increase is equivalent to Germany's decrease. However, the increase in emissions created by China with the shift from c_0 to c_1 (the difference Δ_c) is considerably greater than the decrease in emissions achieved by Germany with the shift from g_0 to g_1 (the difference Δ_g). If the goal is to reduce the level of CO_2 emissions on a per-dollar of economic activity basis, then we are going in the wrong direction: It's China that should be reducing its emissions, not Germany. However, recently the German government announced plans to spend €40 billion (about $44 billion) over four years to help the country cut its CO_2 emissions. The move is expected to reduce the global rise in temperature by 0.00018°C in a hundred years, a considerably small gain for such a large cost. In the meantime, China continues to build about one coal-fired power plant a week!

This leads to the equity issue. Although it is more efficient to reduce emissions in China, the argument can be made that, for decades, Germany has experienced considerable economic growth

largely based on CO_2-emitting activities. Why cannot China now enjoy the same type of economic growth? The argument is even more cogent when we consider CO_2-creating activities in developing countries that have still not reached China's level of economic development. We must also recall that Figure 9.12 measures the distribution of *production* across the world, not the distribution of *consumption*. Much of the CO_2-emitting production in China corresponds to consumption elsewhere, including the US. Were we to draw a similar graph with consumption instead of production, US consumers would likely come out as prominent contributors to CO_2 emissions. Finally, to further compound the cross-country equity dilemma, we must recall the simple fact that the countries that stand to lose the most from climate change (in terms of rising sea levels, forced migration, etc) are typically developing countries.

As important as cross-country differences may be, the big elephant in the room, when it comes to major asymmetries, is the differential impact on current and future generations. Future generations have the most to gain or lose from today's climate policy. However, future generations do not have a voice or a vote (except possibly for the very next generation). Repeatedly, we hear individuals, governments, and other organizations pledge to be good stewards and hand on a well-kept planet to the next generations. But do we really give future generations the same weight as ours? We will return to this issue below.

THE MARGINAL SOCIAL COST OF CO_2

Climate change poses a particularly difficult public bads problem because of the sheer severity of the problem as well as its truly global nature. That said, the solution proposed by most economists is not that different from the solution proposed to solve most other externality problems: Most economists argue for a Pigou tax, or, to use the common term in the present context, a carbon tax. Implementing such a tax requires an estimate of the externality in question in dollar terms. We now turn to this critical problem in the context of climate change.

In climate change lingo, the marginal external cost of CO_2 emissions is normally referred to as the **social cost of carbon** (SCC). Typically, it is expressed as the dollar value of the total damages from

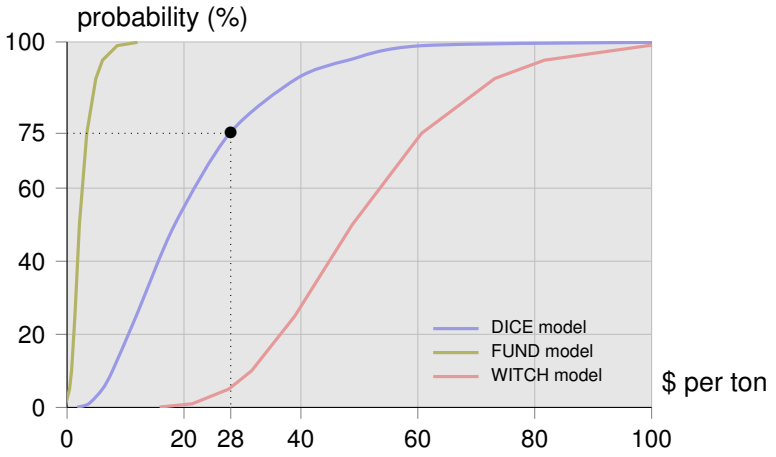


FIGURE 9.14
Estimates of the social cost of carbon (SCC)

emitting one ton of carbon dioxide into the atmosphere. Over the past decades, economists and scientists have developed models to estimate of SCC. These are typically dynamic models of the world economy based on equations which relate the level of economic activity to the rate of CO_2 emissions, as well as equations which describe the cost of coping with varying climate conditions. The models then estimate how a change in the level of CO_2 emissions in year t reflects on the overall evolution of the world economy. Adding up all of the costs across time and space finally leads to an estimate of SCC, which basically corresponds to the marginal social cost introduced in Section 9.1.

The reports issued by the Intergovernmental Panel on Climate Change (IPCC), the world's authority on climate change issues, typically include a variety of scenarios: there is no certainty in climate change science. Similarly, there is no certainty in economic modeling of the future impacts of climate change. The best that current economic research can do is to consider different values for key parameter values and estimate the sensitivity of results to changes in these parameters. In addition to parameter values, we must also account for differences in how to model climate and the economy.

Overall, this process leads to a significant degree of variation in the estimate of SCC. Figure 9.14 provides estimates based on three different studies, codenamed DICE, FUND, and WITCH. The process

underlying this figure consists of running a given model with multiple combinations of parameter values and deriving the distribution of resulting values of SCC (a process known as Monte Carlo simulation). In other words, each model does not produce one value of SCC, rather a distribution of possible values. One way of representing these results is to plot the **cumulative distribution function**. This is a function stating, for each value x of SCC, the probability that the true value of SCC is lower than x. For example, the bullet point at (28,75) signifies that, according to the DICE model, there is a 75% probability that the value of SCC is lower than \$28. (As an example, suppose that the Kabral model stated that SCC is \$10 with probability 30%, \$50 with probability 50%, and \$80 with probability 20%. Then the cumulative distribution function is zero up to 10, .3 from 10 to 50, .8 from 50 to 80, and 1 for values of SCC greater than 80.)

The DICE model is the oldest and, arguably, the best known economic model of climate change. As the figure shows, the model's prediction of the value of SCC is far from precise. The average is given by \$21.6 and the standard deviation by \$13.8. Although the graph only shows values of SCC from 0 to \$100, the model admits the possibility of SCC being greater than \$100, though with small probability.

In addition to variation of estimates by a given model, we also notice considerable variation from model to model. This results from different modeling assumptions, in particular assumptions regarding the evolution of technology (i.e., CO_2 emissions per dollar of economic activity).

Finally, as mentioned earlier, one big issue regarding the impact of climate change is the relative weight given to current and to future generations. In terms of estimating SCC, this is reflected in the **discount rate** used in calculations. Suppose that I give you the option of receiving a dollar today or $1 + r$ dollars a year from today. Different people might ask for different values of r. For example, if I say "I will give up a dollar today if you give me a dollar and 10 cents a year from now," then you would say my discount rate is 10%.

Now, suppose that a certain climate policy leads to an estimated cost of 1 billion dollars today and an estimated benefit of 2 billion dollars fifty years from now. Is it worthwhile? Well, that depends on the relative weight we give to our descendants half a century from now. If a dollar now is the same as a dollar in fifty years, then the net

benefit is positive and we should go ahead with the policy. However, if the weight given to people fifty years from now is less than 50% of the weight given to today's costs and benefits, then the answer is negative, that is, it is not worth incurring a cost of 1 billion dollars now.

Unlike other model parameters, which reflect matters of science or economics, the discount rate is largely an ethical choice: how much weight should we give to future generations? This matters a lot because the value of SCC is highly sensitive to changes in the discount rate. For example, the value of SCC in the US ranges from \$10 at a 5% discount rate to \$50 at 2.5% discount rate. For reference purposes, in a major survey of 197 economists, the average long-term discount rate was 2.25%. This would put us closer to the \$50 figure than to the \$10 figure. However, there are those who think that a 3% rate into the distant future in unethical. For example, it implies that the weight given to costs and benefits 100 years from now is 1/20th of the weight given to current costs and benefits. This does not seem entirely fair, some might say. If we choose a lower and declining discount rate, then the estimate of the current cost of CO_2 can be as high as \$400. The Stern Review, considered by many as one of the more credible economic analysis of climate change, uses a discount rate of 1.8% and estimates a SCC of \$85 per metric ton. By contrast, the Heritage Foundation, a conservative think tank, calls for a 7% rate, which would bring the SCC to a one-digit dollar value.

UNKNOWN UNKNOWNS

The economics approach to measuring the cost of climate change, and in particular the cost of CO_2 emissions, is subject to a number of criticisms. In addition to the problem of discounting, one of the greatest limitations of models such as DICE is that they do not account for so-called **unknown unknowns**. At a famous February 12, 2002 news briefing, US Secretary of Defense Donald Rumsfeld mentioned that

> As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we

> do not know. But there are also unknown unknowns—the ones we don't know we don't know.

Rumsfeld was referring to the US involvement in Iraq, but the idea applies to climate change as well. The idea is that the economic/climate science models, as accurate as they may be with respect to what is known, may miss out relevant implications of climate change.

A related criticism, coming from climatologists and economists alike, is that there are tipping elements in the earth system. For example, some scientists have argued that global warming beyond 2C might lead to an irreversible melting of the Greenland ice sheet. This and other tipping-like possibilities imply that climate change may lead to very large effects — indeed, catastrophic effects — even if these occur with small probability. The argument is then that, given the nature of the climate change "lottery", one cannot safely conduct the cost-benefit analysis that economists are used to.

One possible response to this criticism is that risk and uncertainty are an integral part of life, and we must make decisions based on the possibility (better still, the probability) of a catastrophic outcome. As a brief but relevant digression, consider another risk which we are constantly subject to: being hit by an asteroid. This is not a theoretical possibility: A meteor exploded over the Bering Sea between Russia and Alaska at the end of 2018. It happened with no warning whatsoever. Had it hit a populated area, the effects would have been catastrophic: This particular asteroid was relatively small, but it had the energy of about 10 Hiroshima-like atomic bombs.

In any given year, the chance of a decent-sized asteroid hitting the earth is somewhere around 1 in 500. The probability that humans are hit by an asteroid is even smaller. The effect, however, is as high as the probability is low. It turns out that a catastrophe of this nature is largely avoidable: We have the technology to detect and deflect these asteroids.

It would cost us about $500 million to create the appropriate asteroid monitoring system. The B612 Foundation, led by former astronaut Ed Lu, has not been able to raise more than a small fraction of the necessary funds. This suggests that we are able to live with the risk of being hit by an asteroid. Clearly, to have an asteroid wipe out the entire Northeast of the United States is not the same as large parts of planet Earth becoming unlivable (the essence of the climate change

threat). However, the point is that balancing costs and benefits in a world of risk and uncertainty is part of life. And in this context models such as DICE play an important role. (On this matter, recently deceased economist Martin Weitzman represented an important dissenting opinion.)

CLIMATE STRATEGY

There is a consensus on the need to reduce the density of greenhouse gases in the atmosphere. What is not as clear is how to best achieve this goal. The following equation, depicting the dynamics of greenhouse gases, helps address the issue of climate strategy:

$$C_1 = C_0 + E \times \gamma - R \tag{9.1}$$

where C_0 and C_1 denotes the level of carbon emissions (tons) currently and in the future (respectively), E the level of economic activity (dollars), and R the level of direct carbon reduction efforts. Finally, γ is the coefficient introduced earlier, that is, the coefficient indicating the level of CO_2 emissions per dollar of economic activity.

The above equation is helpful because it indicates three types of policies aimed at achieving a lower value of C_1, starting from a given C_0: reducing the value of E, reducing the value of γ, or increasing the value of R. We next consider each of these.

The argument for the first strategy is that economic activity has been responsible for the increase in atmospheric greenhouse gases. Therefore, we should reduce the level of economic activity so as to counteract the negative effects of the past two centuries. For example, many climate activists argue that we should urgently reduce transportation services based on fossil fuels (air travel, car travel, ocean shipping, etc).

A very different approach is to reduce the value of γ, that is, to find forms of economic activity that are more efficient in terms of CO_2 emissions. In the field of transportation, significant progress has been achieved in the past decades (transportation represents an important slice of total CO_2 emissions). We already mentioned the case of fuel efficiency in the auto industry. Impressive as the gains have been, especially among European car manufacturers, the improvements in air travel have been even more impressive. In 2019, for the first time

US Department of Agriculture

Tolotama Reforestation (Burkina Faso). Reforestation remains one of the most efficient CO_2 reduction strategies.

ever, the fuel cost of air travel, on a per-mile basis, is lower than that of car travel. As to ocean shipping, Mersk, one of the world's largest shipping companies, has been working on switching to hydrogen-fueled ships, a switch that would imply a considerable lower value of γ.

Another area of great promise in terms of lowering the overall value of γ is renewable energy, including solar and wind. Many skeptics of the promise of renewable energy have been surprised by the very rapid drop in production costs. For example, China is currently producing solar panels at a small fraction of the cost of one or two decades ago. Notwithstanding these great achievements, renewable energy production is still subject to the so-called **intermittency problem**, the unfortunate fact that one cannot control weather at will: it's windy when it's windy and the sun shines when it does. Since electrical power cannot be stored in a cost efficient way (at least not yet), renewable energy sources suffer from the limitation that the moment of production may not coincide with the moment of demand.

Finally, going back to Equation 9.1, we have the term R, efforts to reduce the level of CO_2 on the atmosphere. It may be said that technology had a lot to do with the increase in carbon emissions since about 1850. To a great extent, technology is also one of our best bets to reduce the level of carbon emissions going forward. In other words, technology is both part of the problem and part of the solution. Among others, atmospheric CO_2 reduction may be achieved by:

- reforestation
- capturing and sequestering CO_2 from point sources

- direct capture of CO_2 from air

The feasibility and efficiency of each alternative is still open to debate (see one view and a different view). As of 2019, the most efficient path, on a carbon per dollar basis, is reforestation. However, this may well change in the future. In fact, this is one of the points that economists repeatedly make: The advantage of the price system is precisely to provide the incentives and the information to guide investors in the right path. If we are able to put the right price on carbon, then (a) investors will have incentives to find ways to reduce the level of carbon from the atmosphere; and (b) the price level will lead investors to choose each alternative to the extent that it is efficient.

UNINTENDED CONSEQUENCES

The economy is a large "network" of interconnected markets. What may seem a good idea in isolation (e.g., in a given market) may lead to negative effects in other parts of the economy (e.g., other markets) which more than outweigh the positive effects. Climate change and climate-related policies provide many instances of such unintended consequences.

One example of this is the growing movement known as "flight shame", which has been popularized by well-meaning climate activists and is gaining momentum around the world. Its premise is that flying is bad for the climate (it contributes 2.5% to global carbon emissions). Therefore, if you care about the planet you should simply avoid air travel and encourage others not to fly and perhaps simply ban flights.

But would stalling air travel really save the planet? The problem is that the tourism industry, in particular eco-tourism, depends heavily on air travel. In some destination countries, nature-based tourism is a top foreign exchange earner, and tourist inflow is one of the greatest incentives for reforestation. Finally, by most estimates, the positive CO_2 impact of reforestation dwarfs the negative CO_2 impact of air travel. In sum, fly shaming may actually lead to the opposite effect of what's intended.

Another example is given by what economists call leakage, when partial regulation of a product results in increased consumption of unregulated goods. In 2015, Portugal banned plastic bags from su-

permarkets. This was very effective in reducing one type of plastic consumption. But households need plastic in order to dispose of some types of garbage. Since supermarket plastic bags were recycled as garbage bags, the ban implied that households started to purchase garbage bags (which moreover were imported). The trade-offs are complicated: Supermarket bags are thin and run the risk of getting out of the waste system and into the oceans. Garbage bags, on the other hand, are heavier and require more energy and CO_2 emissions to produce. The bottom line is that a positive effect (lower consumption of one type of bags) was counteracted, and possibly outweighed, by a negative effect. (For another instance of possible unintended consequences, this time in the context of health policy, see Exercise 9.16.)

THE POLITICS OF CLIMATE CHANGE

So far, we have focused on the role of scientists and economists in the climate debate. However, these are by no means the only players in the game. Scientists and economists do not make decisions; politicians and voters do. The problem with politicians is that they are subject to all sorts of influences, in a way that is not necessarily representative of the general consensus. For example, the Trump administration rolled back a number of climate policy measures of the Obama administration. One important piece of this reversal is the Trump administration's estimate that the current value of SSC is around $1 to $7. This is a considerable drop from the value of about $50 that had been set by the Obama administration, which in turn was closer to the mean estimate from economic models.

The problem with voters is manifold. First, voters are not always given the right explanation regarding carbon taxes. The very word "tax" is a loaded term: it suggests that voters are poorer by the amount of the tax, which is not true, considering all of the effects ensuing from correcting an externality. In this regard, one success story is given by British Columbia's (BC) pioneering carbon tax, first enacted in 2008, where the tax hike was clearly linked to a cut in income tax rates. Analysts argue that the system has been effective in reducing fuel use, with no apparent adverse impact on the province's economy. Since 2008, BC's fuel consumption has fallen by 17.4% per capita (while in the rest of Canada it slightly increased). BC's GDP, in

Box 9.4: The carbon tax puzzle

Economists wax lyrical about carbon taxes as a solution, or an important step toward the solution, to climate change. Why are carbon taxes then not commonly implemented?

One reason is that there are a lot of unknowns surrounding the evolution of climate and the economy. In principle, the optimal carbon tax is equal to the social cost of carbon, that is, the marginal external cost of carbon emissions. But, if we over-estimate this value (and the tax), then we may cause more harm than good.

Second, unless it is offset by some form of income distribution, a carbon tax can be regressive: poorer consumers spend a greater percentage of their income on things such as fuel and electricity.

Third, opinions regarding climate and carbon taxation vary quite a bit. Higher taxes typically lead to bigger government. In the US only, a carbon tax of $50 per ton would likely raise about $300 billion in revenues. Left-leaning voters are happy with it, not so right-leaning voters. And as France president Emmanuel Macron stated, "no tax deserves to endanger the unity of the nation."

Fourth, climate change is a type of tragedy of the commons:

> The planet is divided into 195 countries that share a single atmosphere, and the atmosphere doesn't much care where emissions come from, as the impact on climate is the same. Meanwhile, no country or state wants to hurt its economic competitiveness.

Most of the above objections would be obviated if the tax were implemented by all or most of the countries and if there were a clear system of offsets to compensate poorer consumers. However, as the experience of recent years shows, it is very difficult to come to a global agreement, namely one that includes China and the US (the two "elephants in the room"). Moreover, few people trust the government's promise that the revenue raised by a carbon tax will be redistributed so as to make it tax-revenue neutral.

turn, kept pace with the rest of Canada's over the same time period. Moreover, carbon tax revenues enabled BC to set Canada's lowest in-

come tax rates. Overall, taxpayers may even have benefitted in net terms.

In the US state of Washington, however, Initiative 732 (I-732), largely modeled after the BC tax, was rejected 59.3% to 40.7% when it appeared on the November 2016 ballot. One reason for this defeat might be the free-riding problem alluded to earlier in the chapter: why should Washington state residents pay a carbon tax if all other 49 US states do not pay a carbon tax?

Finally, we have climate activists, who, by any reasonable impact measure, play a crucial role in the process. Differently from scientists and economists, activists tend to view the problems and the solutions more radically. For example, US Representative Ocasio-Cortez went on record stating that "the world is gonna end in 12 years if we don't address climate change." Greta Thunberg, arguably the leading activist of our time, addressed the World Economic Forum with an emphatic statement:

> Adults keep saying: "We owe it to the young people to give them hope." But I don't want your hope. I don't want you to be hopeful. I want you to panic. I want you to feel the fear I feel every day. And then I want you to act. I want you to act as you would in a crisis. I want you to act as if our house is on fire. Because it is.

Economists' typical reaction to this stance (here illustrated by Thomas Schelling) is that

> Exaggerating the threat won't help. When people find out that you are doing that — and they will at some point — you lose credibility and end up further behind than when you started.

This is by no means the first time we face "apocalyptical" views regarding the future of the economy and the world. In 1968, Paul Erlich declared that "the battle to feed all of humanity is over" and predicted that "sometime in the next 15 years, the end will come," by which he meant "an utter breakdown of the capacity of the planet to support humanity." Also in 1968, a report by MIT's Jay Forester, commissioned by the so-called Club of Rome, projected imminent

collapse for the world economy unless economic growth was halted immediately!

All of the above said, one must also admit, as economist Daron Acemoglou does, that

> The young activists leading school strikes and mass protests around the world have been highly effective in sounding the alarm about climate change. ... The world — particularly the United States — needs a wake-up call.

KEY CONCEPTS

tragedy of the commons | common resource | externality

negative externalities | positive externalities

marginal external cost | marginal social cost

marginal external benefit | marginal social benefit

free-rider problem | rival goods | non-rival goods

excludable | non-excludable | public goods

rate of reproduction $R_\circ$ | revealed preference

social cost of carbon | cumulative distribution function

discount rate | unknown unknowns | intermittency problem

REVIEW AND PRACTICE PROBLEMS

■ **9.1. Property rights.** Why are property rights important in the market economy?

■ **9.2. Externalities.** What is an externality? Why does it matter?

■ **9.3. Tragedy of the commons.** What do we mean by the tragedy of the commons? Provide an example.

■ **9.4. Marginal social cost.** What do we mean by marginal social cost? Provide examples.

■ **9.5. Types of goods.** Find examples corresponding to the four types of goods listed in Table 9.1 (other than the examples already listed in the table).

■ **9.6. Pigou.** What is a Pigou tax?

■ **9.7. Congestion pricing.** Read the article, *It's Time to Try Congestion Pricing in L.A.*. What are the basic features of the proposed plan? The article's author claims that "congestion pricing can improve life for most people who own a car and for all people who do not." If this is so, why don't we then see more congestion pricing in practice?

■ **9.8. Private firefighting.** Listen to podcast *The Private Firefighter Industry* (or read the transcript).

(a) How are private firefighters similar to and different from publicly-funded firefighters?

(b) Does private firefighting create an externality? Is this a positive or a negative externality?

(c) What are the efficiency and equity issues involved in private firefighting?

■ **9.9. Externality and welfare loss.** Consider Figure 9.15, denoting the demand curve in a given market as well as a series of cost curves: (private) average total cost (*ATC*), marginal private cost (*MPC*), and

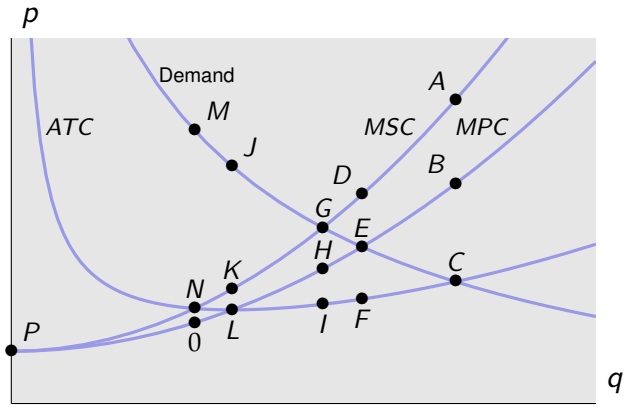


FIGURE 9.15
Externality and welfare loss

marginal social cost (*MSC*). Indicate (in words and using the points from *A* to *P* that you deem appropriate) the area corresponding to the deadweight loss resulting from the externality.

■ **9.10. COVID externalities.** Reflecting on Thanksgiving celebrations during the pandemic, economist Tyler Cowan argues that

> Many of the American people are voting with their feet when it comes to externalities, and we may not always like the answers we are seeing. Take all of the pending Thanksgiving travel — the biggest risk is to parents and grandparents, but mostly they are receiving their children voluntarily.

Do you agree? Why or why not?

■ **9.11. The Pigou Club.** Listen to the podcast *The Pigou Club* (or read the transcript).

(a) Why are economists so favorable to a carbon tax?

(b) Why is the average citizen so reluctant to accept the idea of a carbon tax?

(c) What creative solution did the Canadian government propose to circumvent the public's resistance?

■ **9.12. Carbon tax.** Suppose it is estimated that the social cost of carbon is $50 per ton.

(a) What is the optimal carbon tax?

(b) Suppose the tax on carbon corresponds to 50 cents per gallon of gasoline. Would you expect gasoline prices to increase by more, less, or exactly 50 cents per gallon?

(c) More generally, what information would you need in order to estimate the impact on gasoline prices?

■ **9.13. Compensating consumers for a carbon tax.** The government is considering creating a carbon tax of t per unit of carbon. Suppose we have an idea of the "typical" consumer's preferences for carbon-intensive and carbon-free goods (that is, we know the typical consumer's indifference curves for these two aggregate goods). Suppose the government wants the tax to be welfare neutral, that is, it wants to make sure consumers are not worse off with the tax.

(a) Show graphically how you would estimate the income transfer required for the typical consumer to be equally off as in the initial situation?

(b) How does the consumption of carbon-intensive goods compare with the initial level if no income is provided by the government?

(c) How does the consumption of carbon-intensive goods compare with the initial level if the government hands out enough income so as to maintain the initial utility level?

■ **9.14. Empty storefronts.** According to the *San Francisco Chronicle*,

> Vacant storefronts mar nearly every shopping district in San Francisco — from North Beach to Union Street. More than just eyesores in the city's beloved shopping districts, empty retail spaces are lost opportunities for tax revenue, jobs and foot traffic that help support neighboring businesses. ... Now the Board of Supervisors has a plan to help: a tax on landlords who leave their storefronts empty

for more than six months. The point? Encourage building owners to quickly rent out spaces, by either settling for a lower rent or finding a pop-up or short-term tenant.

How does this episode relate to the material presented in this chapter? What are the pros and cons of the SF policy?

■ **9.15. Dollar stores.** Listen to the podcast *Dollar Stores Vs Lettuce* (or read the transcipt).

(a) Using the concepts developed during the course, present one or more arguments for the case that the market equilibrium in the retail industry is efficient.

(b) Using the concepts developed during the course, present one or more arguments for the case that the market equilibrium in the retail industry is inefficient, specifically, that there are too many dollar stores with respect to the efficient outcome.

■ **9.16. COVID handouts.** Hong Kong Health Secretary Sophia Chan announced that HK's government will begin giving a one-off HK$5,000 handout to everyone who tests positive for the coronavirus (source). The goal of this measure is to ease the concerns of people who are avoiding tests for fear of losing income. Discuss the unintended consequences that the policy might have.

■ **9.17. Wilma Theater.** Philadelphia's Wilma Theater (capacity 300 seats) normally runs three to five plays a year. In March it was preparing to start the play, *Is God Is*, but the plans were cancelled due to the COVID-19-induced shutdown. Instead, the company decided to "stage" the play on radio. The recording was available from July 23-24 to the listeners willing to pay a minimum $10 donation. Considering Table 9.1 in the book, how would you classify the play as an economic good both in the theater version and in the radio version? What implications does this have, both for efficiency and for the company's pricing strategy?

■ **9.18. Covid testing.** Listen to the podcast *A Billionaire's Plan for Mass Covid Testing*. What is the benefit of systematic testing? What is

the market failure in systematic testing? What is the nature of innovation reported in the podcast? What incentive does Graham Weston have to spend his own funds on systematic Covid testing? What does this case say about the role of government and other institutions in remedying market failures?

■ **9.19. Climate change.** Watch Dan Miller's TED talk, *A Simple and Smart Way to Fix Climate Change*, and address the following questions.

(a) What is the economic root of the climate change problem, that is, why do people (firms, consumers, etc) engage in activities which imply a cost to the environment that exceeds the economic benefit?

(b) How does Miller's proposal relate to the concept, presented in class, of Pigouvian taxation?

(c) How does Miller's proposal relate to the concept of repeated interaction (i.e., repeated games)?

(d) What are the main constraints stopping proposals like Miller's from being implemented?

■ **9.20. COVID-19 externalities.** Comment the following tweet regarding COVID-19 in the US in light of the ideas discussed in this chapter.

> One of the most striking things to me about the pandemic in the US is how crucial it is for states to cooperate effectively. Nash mitigation (each state equates marginal cost to marginal own-state benefit) is WAY TOO LOW because a lot of the harms fall outside the state.

■ **9.21. COVID vaccines.** For many people, the three coronavirus vaccines recently developed mark the beginning of the end. However, outside of the developed world it will take a while for the population to have access to these vaccines. A proposal put forward by India and South Africa (in October 2020) calls for a suspension of patents and trade secrets related to the vaccines so as to allow for their wider availability. The argument is that intellectual property (IP) laws are

currently "hindering or potentially hindering timely provisioning of affordable medical products" (source).

Several developed countries have rejected the proposal, characterizing it as "an extreme measure to address an unproven problem." The editorial board of *The Wall Street Journal* went as far as denouncing the proposal as a "patent heist," adding that "their effort would harm everyone, including the poor." By contrast, those favorable to the proposal argue that

> The vaccines developed by these companies were developed thanks wholly or partly to taxpayer money. Those vaccines essentially belong to the people.

One of the companies that benefited from public funds, AstraZeneca, "struck deals with manufacturers in India and Latin America ... to help poor countries get access to its vaccine."

Summarize the main arguments in favor and against the proposal, relating them to the material presented in the course.

■ **9.22. Water.** Listen to the podcast *The Bottom Of The Well* (or read the transcript). How does it relate to the ideas presented in this chapter?

■ **9.23. Solar.** Listen to the podcast *Why Cheap Solar Could Save the World* (or read the transcript).

(a) How has the cost of solar evolved over the recent past?

(b) What percentage of US energy is accounted by solar in 2020? Are there any signs that this value will change?

CHAPTER 10

INFORMATION

Competitive markets presume that (a) there are many players both on the supply side and on the demand side; (b) property rights are well defined; and (c) all agents are well informed about the relevant information required to transact. In Chapter 8, we discussed what happens when the first assumption fails to hold, that is, when there is market power. In Chapter 9, we discussed what happens when property rights are not well defined. In this chapter, we conclude Part IV of the book by looking at the third important source of market failure, namely imperfect information. The chapter is divided into two parts. In Section 10.1, we look at markets when one side (either the seller or the buyer) is better informed than the other, a case economists refer to as asymmetric information. We deal with two typical situations, adverse selection and moral hazard. The second part of the chapter, Section 10.2, deals with the role that public policy might have in protecting consumer interests when the consumers are poorly informed.

10.1. ASYMMETRIC INFORMATION

Health insurance is a very unusual market. Buyers are very different from each other. Some people are very healthy and hardly need any health care beside preventive care. Other people are very sick, perhaps chronically so, and require constant (and expensive) health

care. Relatively healthy individuals don't perceive the need to buy health insurance, especially if it is costly. The chronically ill, by contrast, badly need health insurance, not only because of the greater uncertainty regarding future expenses, but also because of the high level of health care they require at all time.

Because of this heterogeneity among insurance buyers, health insurance companies are faced with a pricing dilemma: a low price attracts many patients, healthy and unhealthy, but a low price leads to small margins. A high price, in turn, runs the risk of attracting only high-risk buyers, the ones who require large health expenditures, and a high cost leads to small margins too.

What should an insurance company do? Specifically, suppose that there are two types of insurance buyers: low-health-risk and high-health-risk buyers. Low-health-risk buyers are individuals in good health, unlikely to require medical services. High-health-risk buyers, by contrast, are individuals with a medical condition who are very likely to require expensive medical treatment. High-risk buyers constitute 10% of the population.

Suppose that health insurance is worth \$20,000 a year to a high-risk buyer and \$3,000 to a low-risk buyer. In other words, a high-risk buyer is willing to pay up to \$20,000 for insurance, whereas a low-risk buyer is only willing to pay up to \$3,000. This reflects the assumption that a low-risk buyer is less likely to be sick and less likely to require serious treatment. The differences between patient types are also reflected in insurer average (or expected) costs, which we assume are \$30k for a high-risk buyer and \$1k for a low-risk buyer. The idea is that a high-risk buyer most likely will use health services repeatedly, whereas a low-risk buyer will hardly show up at the doctor's office.

Suppose we were to take a random sample from the population and ask their willingness to pay for insurance. In 90% of the cases we would be asking a healthy person, in which case willingness to pay is \$3,000. In 10% of the cases we would be asking a sick person, in which case willingness to pay is \$20,000. It follows that, on average, that is, considering a random individual taken from the population, willingness to pay is given by $10\%\times\$20{,}000+90\%\times\$3{,}000 = \$4{,}700$. Moreover, on average, the cost of providing insurance is given by $10\%\times\$30{,}000+90\%\times\ \$1{,}000 = \$3{,}900$. Since average willingness to pay is greater than average cost, one might argue that there are gains

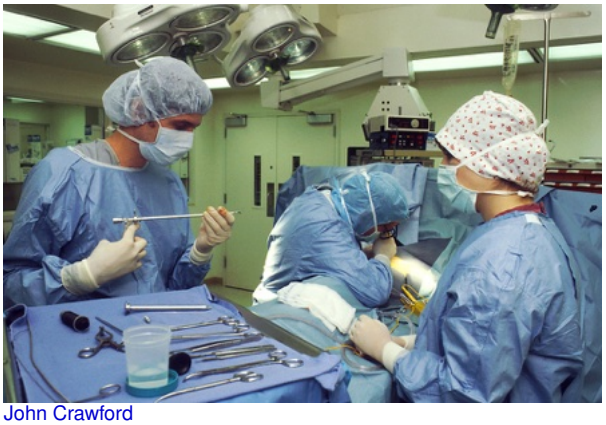
from trade, that is, society as a whole is better off if the insurance company offers insurance services to all individuals.

Specifically, suppose that buyers do not know their risk type. (I'm aware that this is not very realistic assumption, I'm only making it for expositional purposes.) Suppose moreover that a buyer's willingness to pay is the (weighted) average of the high-risk and the low-risk buyer's willingness to pay, the \$4,700 value derived in the previous paragraph. Then, by setting an insurance premium of, say, \$4,650, the insurance company makes an expected profit of \$150 per buyer, since average cost is \$4,500. The average buyer, in turn, receives an expected consumer surplus of \$4,700−\$4,650 = \$50. In other words, everyone is better off with insurance than without.

In reality, however, buyers have knowledge of their risk level. Maybe not perfect knowledge, but at least some knowledge. For simplicity, suppose that the insurance buyer knows exactly her risk level whereas, as before, the insurance company only knows that 10% individuals are high-health-cost buyers (that is, does not know whether a *particular* individual is a high- or a low-cost type). In reality, this is not an entirely realistic assumption: the insurance company is likely to know *something* about the buyer's health status, and the buyer does not know her health status with certainty. What's important for our purpose is that the buyer has a better idea of her health condition than the insurance company, which seems realistic.

Suppose that the insurance company sets the insurance premium \$4,650 as before. The problem is that, since insurance buyers know their risk level, only high-risk individuals accept the offer of buying insurance for \$4,650. By contrast, low-risk individuals have a willingness to pay of \$3,000, which is well below the price of \$4,650. It follows that, conditional on an insurance offer being accepted, the cost of providing health services is given by \$30,000, which is considerably higher than the price of \$4,650. To understand this, notice that, while the insurance company does not know the health condition of each person in the population, the insurance company knows that, if its offer is accepted, then the buyer is a high-risk patient for sure and the cost of offering her health services amounts to \$30,000. We conclude that, by selling at \$4,650, an insurance company risks losing money: the cost per customer, \$30,000, is considerably greater than the revenue per customer, \$4,650.

In order to avoid losing money, the insurance company would



John Crawford

Surgeons during an operation. Healthcare markets are arguably the most important instance of adverse selection.

need to set a price at least equal to $30,000. However, such a high price would drive away even high health-risk, high willingness-to-pay buyers. Bottom line: there is no equilibrium where health services are bought and sold in the market! This example illustrates the problem of **adverse selection**.

> *If an uninformed party makes an offer which is then accepted or rejected by an informed party, then there may be situations when the market shrinks or completely collapses even though there are gains from trade. In other words, information asymmetry may lead to market failure.*

In the above example, the uninformed party is the seller of health insurance, whereas the informed party is the patient. Unfortunately, there are many other real-world situations featuring this sort of information asymmetry and this sort of negative implications, as we will see later in this chapter. Fortunately, one of them led to a famous funny quote by comedian Groucho Marx. While there is some dispute about the exact quote and its circumstances, it appears that New York's famous Friar's club admitted Groucho Marx as a member. Since Groucho did not participate in the club's activities, he sent in his resignation letter. The president inquired why Groucho was resigning, to which he replied, "Because I don't want to belong to any club that would have me as a member!" Can you see how this is a case of adverse selection?

SOLVING THE ADVERSE SELECTION PROBLEM

In Chapter 8, we saw how public policy (antitrust) plays an important role in addressing market failures resulting from market power. In Chapter 9, we saw how Pigouvian taxes (and other mechanisms) play an important role in addressing market failures resulting from externalities. What about adverse selection — are there policy instruments to address this type of market failure?

Let us go back to the problem of health insurance. One first solution is to impose a **health mandate**. As the simple high-risk-low-risk example in the previous section suggests, the market would exist and create gains from trade if *all* patients purchased health insurance. This implies that one possible solution to the adverse selection problem is to *enforce purchase*. This induces a **pooling equilibrium**, that is, an equilibrium where low and high risks are pooled.

The Massachusetts health reform, which was signed into law in April 2006, included a health insurance mandate as one of its key components (non-poor residents either purchase a health insurance plan that meets minimum coverage criteria or pay a penalty). The Massachusetts experiment would later became a model for the national reform popularly known as **Obamacare**.

Did these policies make a difference in terms of alleviating the adverse selection problem? The example presented earlier is just that — an example. Is adverse selection really important in real-world health markets? One possible test for the presence of adverse selection is the following: as the number of insured individuals increases, we should observe a decrease in the average cost of the insured. This would be consistent with the observation that the added insured individual was a lower-risk individual than the previously insured individuals.

The evidence from Massachusetts is consistent with this interpretation: The 2006 reform increased coverage by 26.5 additional percentage points, and the growth in coverage was associated with a reduction in the average cost of the insured by 8.7 percent. Overall, the reform is estimated to have increased total surplus by about 5 percent, of which about 4% corresponds to alleviating the adverse selection problem.

A more radical way to solve the adverse selection problem in health markets is to enact a **universal healthcare** system, as many

countries in Europe and throughout the world have done. Although there is a lot of variation across countries, it is not uncommon for the state to offer directly health care services through state owned health care facilities and affiliated doctors. This solution essentially solves the adverse selection problem because by design all patients are included in the same pool.

A related policy, in terms of its pooling effects, is that of a **single payer system**, in which the government pays for health care for every citizen, even as health care services are provided by private hospitals and doctors. In the US, the Medicare program offers health insurance to residents over age 65 and people with disabilities. One proposal often discussed, "Medicare for All", would extend these benefits to all of the population. In sum,

> *Solutions to the adverse selection problem in healthcare include insurance mandates, government-offered insurance, and government-offered health services.*

Although the discussion in this section is couched in terms of health markets, the basic ideas are more widely applicable. For example, one of the reasons why car insurance is mandatory is that it pools all types together, thus mitigating the adverse selection problem. In reality, we do not have complete pooling, in the sense that different drivers are subject to different rates, depending on observable characteristics (e.g., age), but the pooling effect described above plays a role.

OTHER EXAMPLES OF ADVERSE SELECTION

There is a reason why people focus on healthcare when discussing the adverse selection problem: healthcare represents a huge chunk of GDP (about 17% in the US, about 10% in Europe). However, there are many other instances when adverse selection plays a role, resulting in some form of market failure.

The original economics research on adverse selection took used car sales as a motivating example. Suppose I'm in the market for a 2014 Toyota Camry. I know that there are good used cars and bad used cars. I have a hard time finding out whether a particular 2014 Toyota Camry is in good shape. Equally important, I know that the

Quintin Soloviev

American Airlines AAirpass program is a classical example of the perils of adverse selection and moral hazard.

seller knows whether that particular 2014 Toyota Camry is in good shape (maybe not perfectly, but certainly better than I do). Consulting the blue book, I see the average price is about $15,000. However, depending on the car's condition its value can be as high as $20,000 and as low as $10,000. Now, here's the essence of the adverse selection problem in this context: If I offer to pay $14,000 (a little less than average value), then the owners of the best 2014 Toyota Camry's (those worth about $20,000) are unlikely to accept the offer. This implies that, *conditionally on my offer being accepted*, the average value is lower than $15,000, maybe even lower than my $14,000 bid.

In 1981, American Airlines launched a membership-based discount program called AAirpass. At one point, the program offered *lifetime unlimited* travel on American Airlines and unlimited access to Admirals Club locations. Some of these passes remain valid today. The lifetime passes cost $250,000. Not surprisingly, they attracted very frequent flyers. In 2007, an AA internal report concluded that two specific passengers were costing the airline more than $1 million annually (for example, one of them made 500 trips to London in 10 years). Their passes were eventually cancelled due to fraudulent behavior (attempting to sell a companion ticket). Although these were rather extreme cases, overall the pass was a major flop on account of the adverse selection problem.

A more recent example of the "adverse selection tragedy" is provided by the MoviePass program, a subscription-based movie ticketing service created in 2011. Subscribers were issued a branded prepaid debit card. Using the MoviePass mobile app, users checked-in at a supported theater and selected a film and showtime occurring

within the next 30 minutes. The card was then automatically loaded with the amount of money needed to purchase a single ticket. Although Movie Pass's business model was never completely clear, one important element was to use or sell the user information collected in each transaction. The program was reported having 2 million subscribers by February 2018 and to be supported at 91% of US theaters.

The adverse-selection nature of MoviePass is that it is disproportionately likely to attract heavy movie goers, so that the cost per subscriber is greater than what it would be if MoviePass attracted a representative sample from the population.

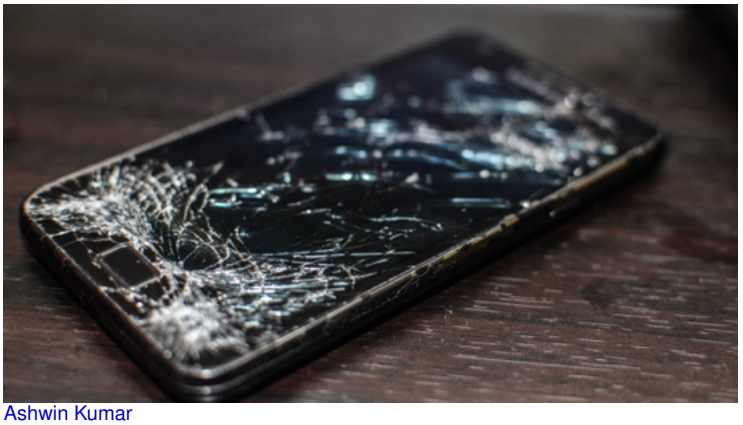
Over the years there were many changes in rules, including reducing the "unlimited" plan to only offer three no-cost tickets per month. Despite all of these adjustments, the program remained essentially unviable, largely due to the adverse selection problem. On September 13, 2019, MoviePass announced the service would shut down the following day.

MORAL HAZARD

I read the other day that "there are two types of people in this world — people who have suffered from a cracked iPhone screen and those who live in fear of the inevitable." If this is so, why don't we all buy insurance against a cracked screen? As it happens, there are insurance products in the market. However, they are typically very expensive. For example, protectyourbubble.com sells insurance for £8 a month, which comes to £96 a year, or about $125 a year. That's a lot of money! In fact, $125 is not very different from the annual amortization of a phone. Oh, and did I mention there is also a $125 deductible?

Why is insurance so expensive? Partly, because of adverse selection: If I have a history of smartphone screen cracking, then I am more likely to buy insurance. Insurance companies are aware of the relation between buyer types and likelihood to purchase, and so price their plans accordingly.

However, important as the adverse selection problem is, insurance contracts such as screen cracking are subject to another huge problem, one which frequently leads to market failure: **moral hazard**. The issue is that the likelihood of a cracked screen depends a lot on how careful the owner is. And the **incentives** for the owner



Ashwin Kumar

Moral hazard is the main reason why it is so difficult to find affordable insurance against a shattered screen.

to be careful are considerably lower if her phone is insured against a cracked screen.

How can moral hazard lead to market failure? Suppose that the probability of a cracked screen is (a) small if the owner takes good care of it (e.g., places a protective cover on the phone) and (b) large if the owner does not take good care of the phone. Suppose that there are gains from trade in case (a) but not in case (b). In other words, if the owner takes good care of the phone then her willingness to pay for insurance is greater than the cost of offering insurance. However, to the extent that the insured phone owner is likely to be careless, there exists no price such that both seller and buyer are willing to trade.

> *The inability of one party in a transaction to observe the other party's actions (moral hazard) may reduce the realized gains from trade.*

If the insurer could easily monitor its customer's actions, then it could offer a policy such that you would only be paid if you had been careful not to crack the screen. In other words, we are faced with another case of market failure due to information asymmetry: The user knows whether she is taking good care of her phone, but the insurance company does not.

INCENTIVES

In Section 2.3, we mentioned incentives as one of the central themes of microeconomics. The problem of moral hazard brings the issue of incentives to the fore. The operative expression is, "it's not my

money." If people talk or think or act in this manner, then there is a moral hazard problem. One example that touches many of my readers is that of course textbooks. The choice of a textbook is made by the instructor but the purchase is made by the student. Suppose there are two candidate textbooks, one selling for $30 and the other for $300. Even if the latter is just a little better than the former (e.g., it comes with better teaching materials), an unscrupulous instructor is likely to assign the expensive book. It's not my money.

In Chapter 8, we mentioned the fact that healthcare is considerably more expensive in the US than in comparable European countries. One possible explanation, one that I proposed in Chapter 8, is market power. Another explanation is incentives: Frequently, healthcare providers are reimbursed based on the fee-for-service model, that is, they are paid for every appointment, test, procedure, etc. This creates an incentive to multiply the quantity of healthcare even when the increment in terms of quality is not that significant (do we really need that MRI at this moment?). Since the cost is passed on to the insurance company, the healthcare provider has little to worry about. It's not my money.

One can argue that the adverse selection examples considered in the previous section are also examples of moral hazard (frequently, adverse selection and moral hazard go hand-in-hand). For example, if I purchased the AAirPass, then my decision to fly will be determined by many factors but not by the cost of flying (since the price I need to pay is zero). This is similar to the phone user who is not careful about cracking the screen. It's not my money.

At a deeper and more fundamental level, the issue of moral hazard came to the fore in the aftermath of the 2008 financial crisis. In the fall of 2008, Congress authorized then-Treasury Secretary Henry Paulson to spend $700 billion to rescue the rapidly-failing financial system. The Troubled Asset Relief Program (TARP) was set in place. Paulson used the money to invest in banks, auto companies and insurance giant AIG. By many measures, the program was a success. However, at a Congressional hearing, Neil Barofsky, the special inspector general for TARP, argued that

> The good financial news should not distract from the careful and necessary assessment of TARP's considerable, non-financial costs, [in particular] the increased moral

> hazard and potentially disastrous consequences associated with the continued existence of financial institutions that are 'too big to fail.'

The idea is that being "too big to fail" diminishes your incentives to avoid risks, in the expectation that losses will be "socialized" through TARP-like government bailouts. However, considering how rare these events have been (in US history), one can argue that the benefits of TARP (avoiding the failure of key corporations, with all of the "domino" effects that this might imply) exceeded its costs, including its moral hazard costs.

THE PRINCIPAL-AGENT PROBLEM

American Express has a problem: its AmEx card is not accepted at all stores. In the past, this was partly due to AmEx charging higher rates from merchants than other cards. Since then, rates have lowered, but the reluctance of retailers to accept AmEx remains. Faced with this difficulty, American Express hires consultants whose job is to persuade stores to install the AmEx equipment and accept the AmEx card. The job is done when finally that magic decal is placed on the store's window ("We accept AmEx cards").

How should American Express reward its consultants for this task: Pay consultants by the hour? Pay consultants by the number of stores they "convert" to AmEx? One thing is clear: American Express does not have the ability to carefully monitor its consultants' actions: The stores are dispersed throughout the country, and so the job of following the consultants would be as difficult as American Express itself doing the consultant's job.

The above example illustrates one of the most canonical cases of moral hazard, a case known as the **principal-agent problem**. A **principal** (American Express in the above example) hires an **agent** (the consultant in the above example) to perform a certain task. What makes this a challenging problem is that the outcome depends on the agent's effort as well as on other factors, and moreover the agent's actions are not directly observable by the principal. Specifically, the challenge is how to best design a reward system so as to get as close as possible to the perfect-information outcome, that is, the outcome when the principal can easily observe the agent's actions. Before, we

considered two options: pay the consultant by the hour or pay the consultant by the number of stores "converted". The advantage of paying by the hour is that it provides the consultant with secure compensation (you know what you can count on), which in turn makes it easier to find consultants willing to take the job. The advantage of paying strictly based on success is that it provides the agent with strong incentives: it is no longer someone else's money, it is now *my* money.

More generally, economists say that paying based on success is an example of a **high-powered incentive scheme**, whereas paying a fixed wage is an example of a **low-powered incentive scheme**. Since a high-powered incentive scheme involves both costs and benefits, there is no general optimal scheme: as often is the case in economics, it depends. Specifically, it depends on how closely the outcome tracks the effort put in by the agent. If the outcome is very closely related to effort, then the risk associated with pay for performance is low, and thus the benefits from a high-powered incentive scheme dominate. By contrast, if there is a lot of noise in the outcome measure, then pay for performance leads to a very volatile compensation level, and the relative benefits of a fixed wage dominate.

10.2. CONSUMER PROTECTION

In the previous sections, we examined two cases of asymmetric information: the cases when a seller does not know a buyer's *type* (e.g., is the patient a high health risk?) and the case when the seller is unable to observe a buyer's *action* (e.g., will the insured owner take care of the product?). In this section, we consider the all-too-common situation when a buyer is poorly informed about the seller or the conditions offered by the seller.

Have you ever read the entirety of a user agreement before entering a website? I didn't think so. I don't know anyone who has: we all click on the "agree" button without giving it much thought. Similarly, many sales contracts (e.g., a credit card contract) include pages and pages of small print which we could read but do not actually read. This may be a problem (in fact, may lead to market failure) because it allows sellers to impose terms that are legal (strictly speaking) but harmful to the buyer. In this case, the market failure is that

a transaction takes place (*perceived* willingness to pay is greater than price) even though it should not have taken place (*actual* willingness to pay is lower than cost).

In the United States, many health insurance plans require that the patient use hospitals and services from their insurance network. However, with some frequency patient treatment includes out-of-network services. As a result, when the patient is asked to pay the bill, in addition to the normal co-pay, the patient may be asked to pay the balance of the bill that is not covered by the insurance plan. This is often referred to as balance billing or **surprise billing**, a reference to the fact that many patients, especially in emergency situations, are unaware that some services are out-of-network services. In recent years, several states in the US have enacted legislation which limits the extent of this type of surprise billing. In other countries (e.g., Germany, Japan) balance billing is simply prohibited.

A similar phenomenon occurs in the wireless industry, where consumers may fall victim to so-called **bill shock**. One common reason (in the US) used to be exceeding the monthly allotment of voice minutes, text, or data consumption. To remedy this problem, in 2013 the US Federal Communication Commission successfully persuaded cell phone companies to inform users when they approach and exceed their voice, text, or data allowances.

In many instances, consumers purchase a bundle of products and/or services. For example, if I buy a Keurig coffee machine I will likely also buy Keurig coffee capsules as well. As of January 2020, I could buy a machine (from the Keurig website) for as little as $64.99. Coffee pods go for about 50 cents each. If I drink one per day, after a year I already spent north of $180 on coffee pods. In other words, expenditure with add-ons is considerably greater than with the initial purchase. If consumers are perfectly informed about all prices, including **add-on prices**, then this is not a problem: each consumer will compare his or her willingness to pay to the price they are asked to pay, and then make the right decision. However, many consumers are not aware of the total cost they will need to incur when they buy a coffee machine or a printer or when they open a bank account. This can lead consumers to underestimate the actual effective price they have to pay and, as such, lead to a market failure: a transaction takes place (willingness to pay is greater than *perceived* price) when it should not take place (willingness to pay is lower than *actual*

price).

To conclude this section, a related area of public policy is the enforcement of **truth in advertising**. To quote from the FTC site

> When consumers see or hear an advertisement, whether it's on the Internet, radio or television, or anywhere else, federal law says that ad must be truthful, not misleading, and, when appropriate, backed by scientific evidence.

In this context, much of the agency's role is to warn companies when there is suspicion that they may be violating the FTC Act and that they can face serious legal consequences if they do not immediately stop.

SEARCH GOODS AND EXPERIENCE GOODS

In some cases, the quality of a product can be found out before purchase. For example, if you are shopping for a coat, you try it on to see if it fits, you look at it to see if you like it. You may be in for a surprise later on, but by and large what you see is what you get. Economists refer to these goods as **search goods**. In other cases, however, you are only able to judge the quality of what you bought after you bought it and experienced it. For example if a new falafel food truck parks in your neighborhood, you won't be able to know how good it is until you try it. Economists refer to these goods as **experience goods**. There is an even more extreme case, what economists call **credence goods**. This is the case when, even after experiencing a service, the buyer has difficulty ascertaining its quality. Suppose your doctor says you need a double-bypass surgery and suppose you actually go through it. Even if you survive the operation, how can you be sure everything was well done? How do you know the decision to operate was the right one in the first place? (Suggestion: ask for a second opinion.)

Experience goods (and credence goods) lead to a potential market failure. If the consumer can only discover the quality of her purchase after she paid for it, then the incentives for sellers to provide a quality product are lower than in a search good. In the latter case, if the seller offers a low-quality product, then consumers, who are able to determine quality before purchase, avoid purchasing the low-quality

Box 10.1: Restaurant Hygiene Cards.

Restaurant hygiene cards are now a common feature in the US. As you walk into an establishment, you will likely find its grade (A, B, C) displayed by the entrance. (If it's a C, consider going elsewhere).

Mandatory hygiene cards, which were first introduced in California in 1998, provide a way to test the relation between consumer information and market outcomes. First, research shows that making restaurant grades available to consumers led to a 20% decrease in foodborne hospitalizations. This suggests that better information puts pressure on sellers to provide better service.

It is also interesting to note that the impact of hygiene cards was not uniform across restaurants: Restaurants located in tourist areas typically had worse grades before the introduction of scorecards and showed a greater improvement in hygiene following the introduction of score cards.

The figure below shows the best and the worst restaurants in Santa Monica according to hygiene card grades. Note, for example, that the Venice boardwalk (a typical tourist area) includes few of the best restaurants but many of the worst ones.

best restaurants

worst restaurants

This pattern is consistent with the idea that restaurants in tourist areas have less market incentives to provide good service, since most customers are not repeat customers. In this case, market self-regulation provides a good substitute for seller reputation.

product. In a world of experience goods, however, sellers may be tempted to offer low-quality products in the hope that consumers will purchase them before they find out they made a mistake.

Fortunately, there are market mechanisms to prevent this opportunistic behavior by sellers. In particular, if consumers purchase a

product or service repeatedly, then they can "punish" bad sellers by not buying from them again. As the saying goes, "Fool me once, shame on you, fool me twice, shame on me." Box 10.1 provides an interesting application of this idea to the issue of restaurant quality. Because of the role played by repeat purchases, you'd expect quality to be greater in restaurants frequented by repeat customers than in restaurants frequented mostly by tourists (ever heard the expression "tourist trap"?).

In addition to repeat purchases, there may be other reputational mechanisms that give sellers the right incentives. Think, for instance, of professional or crowd-sourced reviews. Would you go to a restaurant with a 1-star rating on Yelp? With the increase in online sales and online product reviews, this mechanism of seller reputation has become increasingly important. It also has its issues (e.g., fake reviews), but it's certainly better than no information at all.

> *Many market transactions involve considerable uncertainty for consumers. Seller reputation partly helps keeping seller opportunism in check, but public policy also plays an important role in consumer protection.*

NUDGES

(Reader advisory: the ideas discussed in this section are highly controversial.) In the previous two chapters, we encountered two reasons why governments should regulate markets: market power (normally on the seller side) and poorly defined property rights (a.k.a. externalities). In Section 10.1, we added one more reason: information asymmetry (one side of the market is better informed than the other, as in the adverse selection or moral hazard problems). Section 10.2 considers a related possibility: consumers are poorly informed about the seller's conditions (product quality, add-on prices, etc).

In some cases, public policy goes beyond that: It addresses not the individuals' lack of information but the individuals' poor judgement or inertia or inability to do what they want to do. Right away, you can see how controversial this is. Libertarians, about whom we write more in Chapter 12, are firmly set against most of the policies included in this section: The individual, they argue, is the supreme

judge of their own preferences and, absent any significant side-effects on third parties (externalities), there should be no public policy with the goal of directly or indirectly influencing their behavior.

Reality is more complicated than this. Is it right for the government to mandate the use of safety belts or bike helmets? "It's my life," you might say. But in case an accident happens there is a good chance you will impose a significant burden on the health system (which is paid by all), a burden that would be smaller (on average) if you'd buckled up when driving or wore a helmet when riding. In this sense, we might think of safety regulation not so much as a form of "paternalism" but rather as a way to correct for an externality.

A recent doctrine in favor of government intervention comes under the name of **nudge theory**. Its main premise is to encourage people to make decisions that are in their broad self-interest. Economists Richard Thaler and Cass Sunstein write that

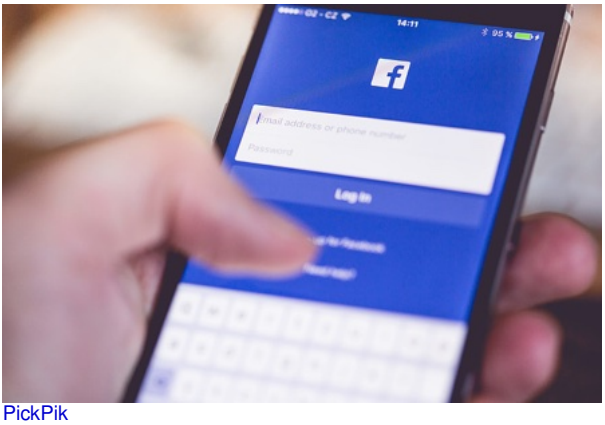
> By knowing how people think, we can make it easier for them to choose what is best for them, their families and society.

For example, in 2012 the UK government changed the way private pension fund contributions work. Workers became automatically placed into a firm's scheme, with contributions deducted from their pay packet, unless they formally requested to be exempted. However, the new regulation did not change the set of options available to each worker, it simply changed the default choice. The policy change had an enormous effect: Active membership in private sector pension schemes jumped from 2.7 million in 2012 to 7.7 million in 2016.

A similar example is given by organ donation regulations. Spain operates an opt-out system: All citizens are automatically registered for organ donation in case of death by accident unless they choose to state otherwise. By contrast, in the UK donors have to opt in in order to become organ donors. The Spanish system is one of the reasons why Spain is a world leader in organ donation.

Nudge theory is not free from criticism. Some claim that

> Government-by-nudging amounts to a kind of technocracy, which assumes that experts will know which choices are in the interests of ordinary people better than those people know themselves. This may be true under some



PickPik

Studies estimate that Facebook creates a consumer surplus of about $10 billion per month in the US only. However, these estimates, based on compensation required to de-activate Facebook, may denote the level of addiction to Facebook more than the value it creates.

> circumstances, but it will not be true all of the time, or even most of the time, if there are no good opportunities for those ordinary people to voice their preferences.

What about addiction? Is it right to enact policies that discourage people from products and services that are addictive? Government policy regarding substance abuse (for example, the US recent fight against the opioid crisis) suggests a positive answer. But what about Facebook? In Chapter 7, we presented estimates of the demand for Facebook and the value created by the social network. These estimates are based on asking people how much they would require to de-activate their account. By these calculations, Facebook creates billions and billions of dollars of value each month. But what if the reluctance to break from social networking is a reflection of addiction rather than value creation? For example, it has been estimated that approximately 50% of 18–24 year-olds visit Facebook as soon as they wake up. This suggests that the idea of social networking in general, and Facebook in particular, may share some of the addictive features present in other activities (such as substance abuse).

Continuing in the direction of greater controversy, what about public policy regarding access to information? When and how should public policy regulate the information individuals have access to? Is it right to block consumers from accessing fake news? If so, who defines what constitutes fake news and how is that classification made? You can see how these types of policies are ripe for criticism, and not just from die-hard libertarians. We will return to these issues in Section 12.2, when we discuss the government provision of goods and services as a form of "interpreting" and pursuing

the interests of ordinary people.

KEY CONCEPTS

adverse selection | health mandate | pooling equilibrium | Obamacare | universal healthcare | single payer system | moral hazard | incentives | principal-agent problem | principal | agent | high-powered incentive scheme | low-powered incentive scheme | surprise billing | bill shock | add-on pricing | truth in advertising | search goods | experience goods | credence goods | nudge

REVIEW AND PRACTICE PROBLEMS

■ **10.1. SafetyNet™.** SafetyNet™ was a simple insurance plan designed to help people if they lost their job due to a layoff, a job elimination or business closing, or if they got hurt or sick and couldn't work at their job for a month or longer. The insured party paid $5-$30 a month and then, if one of the above events took place, SafetyNet paid a lump sum benefit (up to $9,000) depending on the amount insured. According to the company's website,

> As of August 28, 2019 SafetyNet income and disability insurance is no longer available for sale. . . . SafetyNet has helped many people through difficult times and we are grateful to those who chose us as part of their financial planning. Our decision to stop issuing new policies as of August 28, 2019 is unrelated to interested individuals' personal details or COVID-19.

Discuss.

■ **10.2. Missing insurance markets.** There are many missing insurance markets. Consider the following examples and discuss whether absence of insurance is due to moral hazard or to adverse selection (H/T Ray Fisman). Focus on three of the examples below.

(a) Divorce.

(b) Giving birth to twins.

(c) Catastrophic long-term medical care.

(d) Missing a flight.

(e) Mountain climbing accident.

(f) Handgun liability.

(g) Failing to become the CEO at a Fortune 500 company by the age of 50.

■ **10.3. Pet health care.** As documented in a recent paper, the markets for pet health care and human health care are similar in many respects. Specifically, in both markets we observe (i) rapid

growth in spending over the last two decades; (ii) a strong income-spending gradient; (iii) rapid growth in the employment of health-care providers; and (iv) a similar propensity for high spending at the end of life in pets and humans. However, insurance is much less common in pet care, and regulation — or government involvement more broadly — is not as prevalent in pet health care. What does this tell us about the reasons behind the "health care puzzle," namely the fact that the US spends about twice as much in human health care as comparable developed nations?

■ **10.4. Doctor's office visits.** Suppose that a consumer's annual demand for office visits is described by the equation $q = 8 - 0.1\,p$. If office visits cost \$30, and the consumer has no health insurance (i.e., the consumer pays full price), how many office visits will she make? What is the price elasticity of demand for office visits at this point? Suppose a health insurance plan is instituted that pays for one-third of each office visit. How would this affect the quantity and the demand elasticity at the new equilibrium?

■ **10.5. Amazon and consumer protection.** Listen to the podcast *How Amazon's Counterfeit Products Threaten Safety* (or read the transcript). Amazon controls about 38% of U.S. online sales. In 2019, 58% of all of its sales came from these third-party sellers. Many of the products sold on Amazon are counterfeit goods. Who are the relevant parties in the issue of counterfeit goods? What solution would you propose to the problem? Justify your answer.

■ **10.6. J. Screwed.** Listen to the podcast, *J. Screwed* (or read the transcript). How does it relate to the issues presented in Chapters 8 and 10?

■ **10.7. Auditing.** Listen to the podcast *A String of Scandals, the Same Auditor*. How does it relate to the issues presented in Chapter 10?

■ **10.8. Terms of service.** Listen to the podcast *Terms of service* (or read the transcript). Discuss the relative importance of market forces, information and legislation in consumer protection.

■ **10.9. Fitbit.** Listen to the podcast *Should Google be allowed to ac-*

quire Fitbit?. What is the case for opposing the Google/Fitbit merger? What is the case in favor of the Google/Fitbit merger?

Alicia Nijdam

PART V

SOCIAL JUSTICE

CHAPTER 11

EQUITY

As mentioned in Chapter 7, competitive markets perform quite well in terms of efficiency, that is, in terms of generating value from trade. However, as we then mentioned, and as many have repeated in recent years, "market forces and capitalism by themselves aren't sufficient to ensure the common good." This chapter is based on the observation that the unregulated market economy may result in outcomes that are not equitable, no matter how efficient they are. In Section 11.1, we deal with inequality, in particular inequality in the distribution of income, whereas Section 11.2 focuses on discrimination and exclusion.

11.1. MEASURING AND EXPLAINING INEQUALITY

In Section 1.3, we put forward the idea that the capitalist revolution, by having taken place selectively in a few countries, led to an increase in inequality *across nations*. As we will see next, this is only one of many dimensions of the inequality phenomenon.

TYPES AND MEASURES OF INEQUALITY

There are marked differences in income levels across the world. One way of measuring these differences is to derive the worldwide income distribution. The blue lines on the top panel of Figure 11.1 do

this for the years 1988 (dashed blue line) and 2008 (solid blue line). Specifically, these lines correspond to the income probability density function in each of the years. The term probability density function may sound a bit intimidating for the reader less familiar with statistics jargon, but the idea is simple: Suppose that you create a histogram by dividing income levels into a series of bins: from 0 to 100, from 100 to 200, from 200 to 300, etc. For each bin, you measure the percentage of people whose income falls into that bin and draw a column the height of which measures the percentage value. Now suppose you make the bins thinner and thinner. Eventually, instead of a series of columns you have something like a continuous line that connects the tops of the bins. That's essentially the probability density function.

The world income probability density function ranges from about \$100 to about \$100,000, meaning that most people's income levels fall within that range. Of course there are people who earn more than \$100,000, and unfortunately there are also people who earn less than \$100 a year. But most fall within the 100-100k range. This range is so wide that we measure income on a logarithmic scale: each extra tick corresponds to multiplying income by 10, not adding 10 (as we would on a normal scale).

Notice the dashed blue line is bimodal, which means it has two humps: one at about \$1,000 (or a little less than that) and another one at about \$10,000. Bimodal distributions like this one reflect a high degree of inequality, with two relatively "separate" groups. Naturally, this separation is not perfect, but one might say that, by 1988, the world was broadly divided into those earning less than \$5,000 a year and those earning more than that.

By contrast, the 2008 world distribution looks rather more unimodal, that is, closer to the typical bell-shaped distribution we find in many other settings. In this sense, we might say that, worldwide, the two-decade evolution from 1988 to 2008 has been in the direction of lower inequality. The main reason for this evolution is given by the other pair of densities plotted in the top panel of Figure 11.1 (in red), both representing China. As can be seen, the twenty years from 1988 to 2008 saw a remarkable shift in the density to the right, that is, in the direction of higher income leves. The peak of the China 1988 density (the mode, in statistical jargon) was well below \$1,000 in 1988, whereas by 2008 it was already above \$1,000. In plain En-

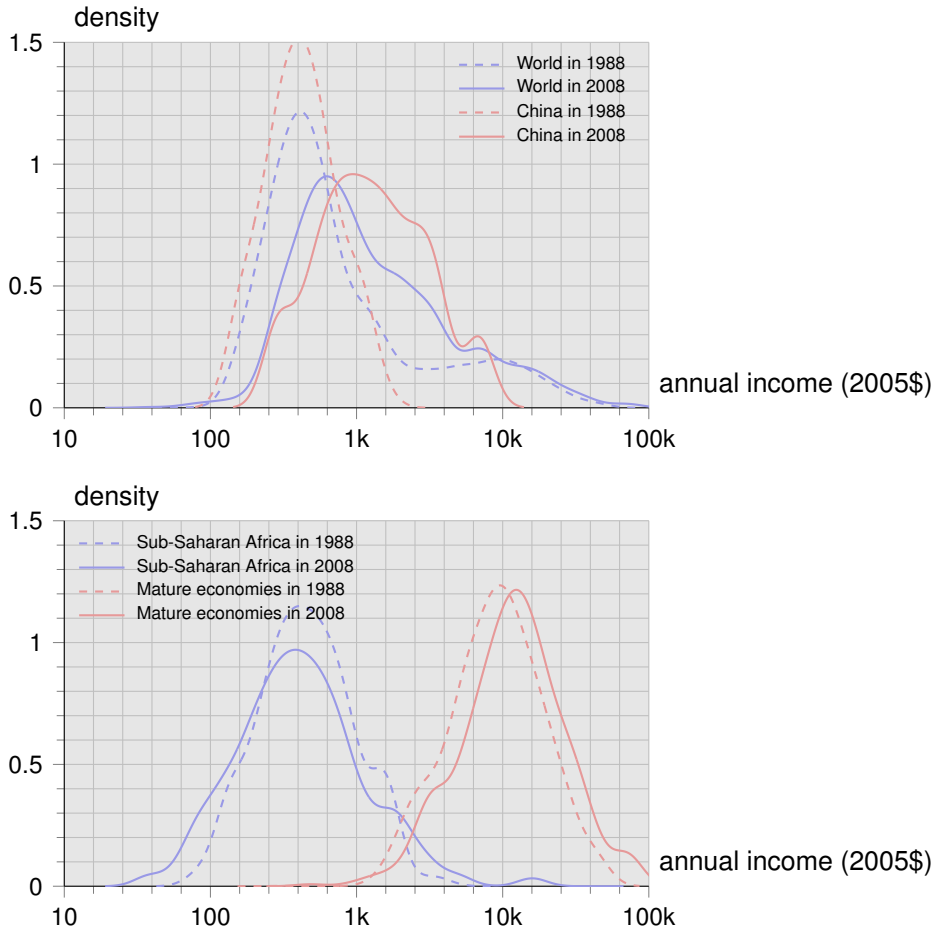


FIGURE 11.1
Income density distribution in the world, China, mature economies, and Sub-Saharan economies (1988 and 2008). Source: LM-WPID database and author's computation

glish, we might say that, in the past few decades, economic growth in China has expanded the world's middle class to an extent that the world income distribution now looks more like one group rather than two different groups of people (that is, the income distribution went from bimodal to unimodal).

This is all very well, but there are also reasons to believe world inequality is still considerable and, in some sense, greater than it was a few decades ago. The bottom panel of Figure 11.1 plots the income density functions for two groups of countries: Sub-Saharan African countries and mature economies (essentially Europe, North America

and a few other countries). The two distributions hardly overlap, denoting a high level of cross-country-group inequality. Moreover, the movements from 1988 to 2008 have been in the direction of *increasing* inequality, the opposite of what the top panel suggests. The difference between the two perspectives corresponds, essentially, to the "China effect": If we take China into consideration, then we are inclined to say the world is more equal than it was a few decades ago. If we exclude China and compare the wealthier and poorer countries, then we are inclined to say the world is more unequal than it was a few decades ago.

As important as cross-country inequality levels are, most of the time the problem of income inequality is cast in terms of *within-country inequality*. The social protests of recent years (for example, Occupy Wall Street in 2011 or the Yellow Vest Paris movement of 2018) were more concerned about social conflicts in the US and France than about inequality with respect to other countries.

Within-country inequality is frequently represented by a **Lorenz curve** and measured by the associated Gini coefficient. Figure 11.2 plots the Lorenz curves of a variety of countries. Take Brazil, the curve in green. First we compute the percentage of total income that is accounted for by the bottom 10% of the income distribution. In Brazil, this corresponds to a very low value, about 1.2%. We therefore plot the point (.1,.012), denoting that the bottom 10% population receive 1.2% of the total income of Brazil. Next, we compute the percentage of total income that is accounted for by the bottom 20% of the income distribution. In Brazil, this is given by 3.6 percent, thus leading to the point (.2,.036). We continue this process until we finally get to (1,1): by definition, the bottom 100% of the population (everyone) must account for 100% of income (all of it). Connecting all of these points, we get Brazil's Lorenz curve.

In the limit when every citizen receives the same income level, the Lorenz curve coincides to the main diagonal, that is, the line going from (0,0) to (1,1). This is the only Lorenz curve such that the bottom x% of the population receives exactly x% of total income. All of the Lorenz curves in Figure 11.2 fall below the main diagonal, meaning income distribution is to some extent unequal. For example, notice that Brazil's Lorenz curve includes the point (.9,.6). This implies that the bottom 90 % account for 60% of total income, which in turn implies that the top 10% account for 40% of total income. This is a high

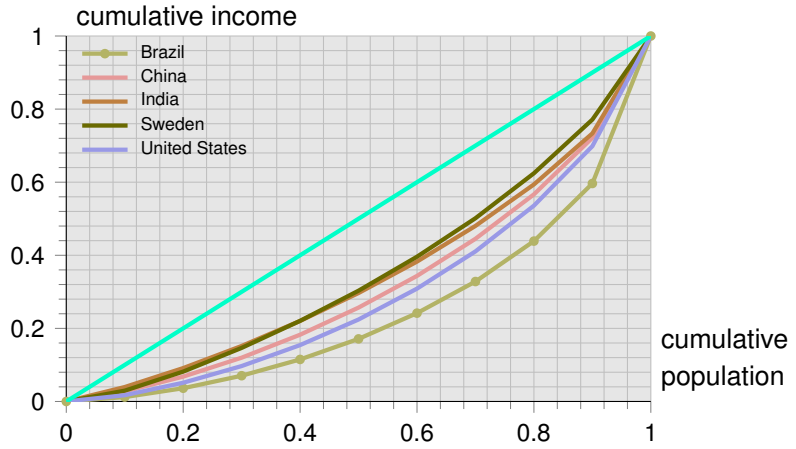


FIGURE 11.2
Lorenz curves (source: World Bank)

number! In fact, income distribution in Brazil is rather unequal. This we can see by the fact that Brazil's Lorenz curve is very low, that is, very far from the main diagonal.

From the Lorenz curve we derive the **Gini coefficient**, a summary measure of inequality in a given economy. The Gini coefficient corresponds to the area between the Lorenz curve and the main diagonal (multiplied by 2). In the limit of complete equality, the Lorenz curve corresponds to the main diagonal, and thus the Gini coefficient is equal to zero. In the opposite limit, when one person only out of millions gets all of the income, the Lorenz curve would coincide with the horizontal axis and then jump to 1 at 1. The area between the Lorenz curve and the main diagonal would be $\frac{1}{2}$ (the area of a triangle with sides equal to 1). Multiplying by 2, we get a Gini coefficient of 1. We thus conclude that the Gini coefficient varies between 0 (no inequality) and 1 (maximum inequality).

One disadvantage of the Gini coefficient is that it loses some information with respect to the Lorenz curve. For example, as can be seen from Figure 11.2, the Lorenz curves for Sweden and India cross: the bottom 10% of incomes in India correspond to a higher percentage of total Indian income than the bottom 10% of incomes in Sweden represent of Sweden's total income. However, the top 10% of incomes in India correspond to more of India's income than the top 10% of Sweden. In those cases, we cannot make unambiguous comparisons

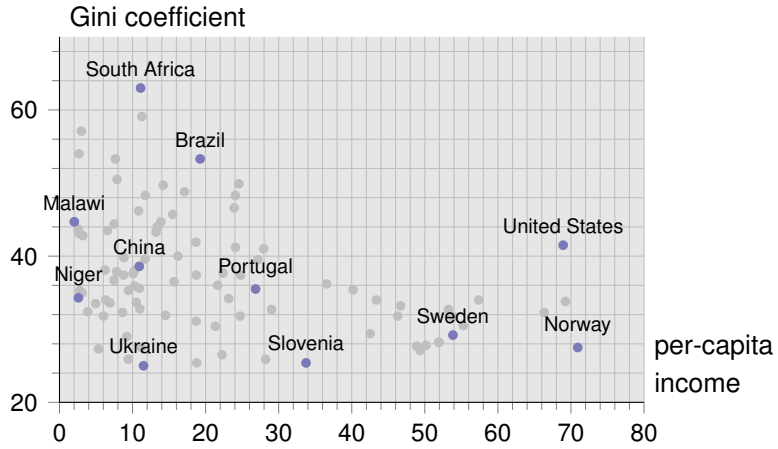


FIGURE 11.3
Income and income inequality (source: World Bank)

unless we introduce additional inequality measurement criteria.

One advantage of the Gini coefficient is that it's just one number. This allows us better to compare a large number of countries. For example, Figure 11.3 plots, for each country, the value of per-capita GDP and the country's Gini coefficient. Is there a relation between a country's per-capita GDP and the country's level of inequality? Figure 11.3 suggests that there may be a weak negative relation (wealthier countries have lower Gini coefficients) but the relation is weak. Moreover, there are outliers such as the US, with a considerably higher Gini coefficient than other countries with similar levels of per-capita GDP.

One feature of the Gini coefficient is that it gives the same weight to all parts of the Lorenz curve. However, judging by the social protests and, more generally, by the media coverage, people tend to be more concerned with income and wealth concentration at the very top. The Occupy Wall Street movement, for example, was very much focused on the top 1% of the income distribution. In fact, one of its main slogans was precisely "we are the 99%."

Figure 11.4 shows the evolution of the top 1% share in some selected countries. It illustrates a much-talked-about stylized fact: that the level of inequality, which had declined in many countries since the middle of the 20th century, has been increasing since about 1980. This happens to coincide with the shift to a more free-market eco-

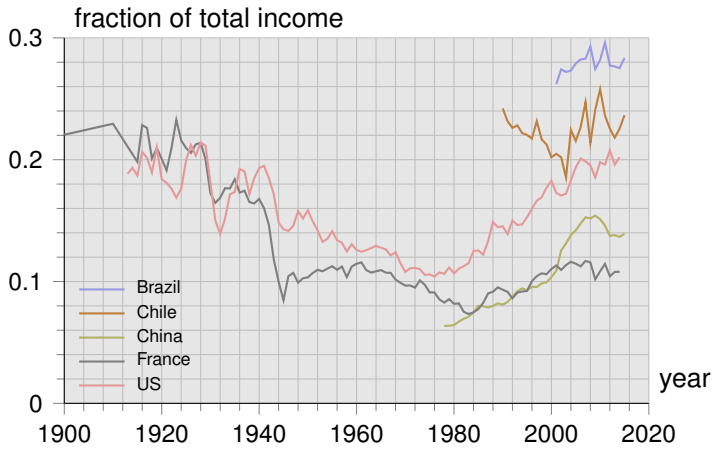


FIGURE 11.4
Income percentage earned by the top 1% percent earners (source: World Inequality Database)

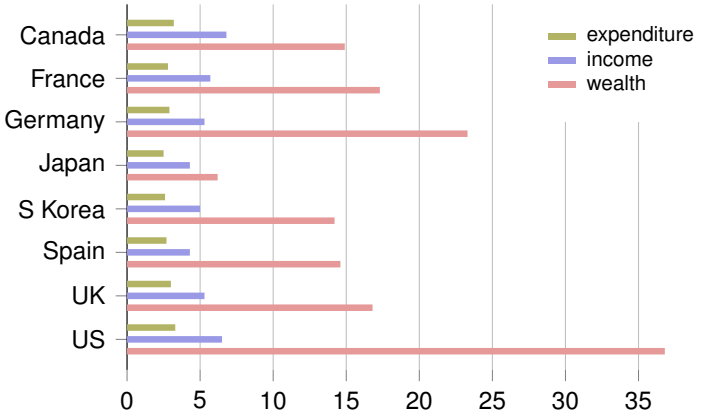


FIGURE 11.5
Relative weight (%) of top 1% in 2013 (source: OECD)

nomic policy approach in the US, the UK, and several other countries (cf Section 2.4). This correlation suggests one possible cause for the increase in inequality, but the question is more complex than that.

Although much of the debate on inequality centers on income inequality, there are many other dimensions of disparity to consider. Figure 11.5 shows the concentration on the top 1% of three economic measures: expenditure, income, and wealth. Two remarkable facts stand out: First, there is considerable variation across countries, with

the US standing out as a clear outlier in terms of wealth concentration: the top 1% concentrate more than 35% of the country's wealth! Second, the concentration of wealth is greater than the concentration of income, which in turn is greater than the concentration of expenditure. One possible explanation for the difference between concentration of wealth and concentration of income is that the latter results from income variability over time rather than real inequality. Suppose for simplicity that everyone lives for three periods and that income is very high during period 2 but very low during periods 1 and 3. If I measure the income distribution in a given year, I will observe a lot of variation, but much of it results from life-cycle variation rather than genuine inequality. Continuing with the example, each individual is aware of the variation in their income throughout their lifetime. Accordingly, they save and draw on savings so as to keep a more constant expenditure stream. In other words, each individual's expenditure pattern represents a smoothing of the uncertain and variable lifetime income stream. This implies that any measure of the expenditure distribution in a given year will show greater uniformity than the income distribution in a given period. Research shows that part of the increase in income inequality may be explained by increased income volatility, a trend that is shown in measures of income inequality but less so in measures of expenditures inequality.

We conclude this subsection with a note on data. Part of the controversy over the level and evolution of inequality can be traced to measurement issues. For example, notice the enormous difference in the estimate of the top 1% earners in the US based on Figures 11.4 and 11.5. This is largely explained by the fact that Figures 11.4 is based on tax returns whereas Figure 11.5 is based on consumer expenditure surveys.

SOURCES OF INEQUALITY

The relation between income and wealth in Figure 11.5 suggests a neo-Marxist explanation for the widening gap we've observed in the past few decades: Very wealthy individuals consume a small fraction of their income. What they don't consume accrues to their wealth. Moreover, their wealth does not simply increase as a result of non-spent income, it also grows as a return on investment. Mean-

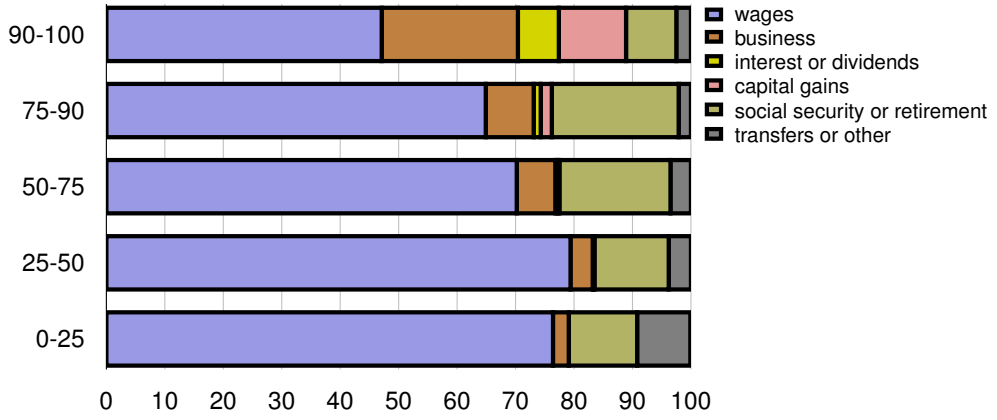


FIGURE 11.6
Income distribution by US income bracket (source: Federal Reserve Board)

while, for the poor, who essentially consume what they earn, the only hope for improvement is that the expansion of output will lead to an expansion in their wage income. As Piketty puts it in *Capital in the Twenty-First century*, "once constituted, capital reproduces itself faster than output increases. The past devours the future." (A not-too-subtle reference to *Das Kapital* and the *Communist Manifesto*'s "the past dominates the present".) Numerically speaking, the economic condition of the wealthy grows at the rate of interest r, whereas the economic condition of the poor grows at the economy's growth rate, g. And, historically, r has been considerably higher than g. A beautiful theory of an ugly reality.

One criticism of this theory is that the concentration of capital income among the very wealthy is not that high. Figure 11.6 shows the split of income sources for various US income brackets. The figure shows that labor income represents almost 80% of the income of the bottom 25%, but less than 50% of the income of the top 10%. More than half of the income earned by the top 10% results from business income, dividends, capital gains and other non-labor sources. At first, this seems to provide credence to the capital vs labor theory of widening gaps. However, it's important to understand what underlies the "business" component of income. As a recent study shows (pithily titled *Capitalists in the Twenty-first Century*), much of the business income of the top 10% corresponds to S corporations (as opposed to the more commonly-known C corporations). These S

corporations essentially work as tax shelters for highly skilled professionals: doctors, lawyers, engineers, accountants, consultants, etc. The idea is that a large fraction of what is classified as business income in the statistics (and in Figure 11.6) is actually labor income (even if it is not wage income). Once this correction is taken into account, we conclude that the labor income fraction among the wealthy is not that different from the poor. In fact, the fraction of income accounted for by labor (about two thirds) is fairly constant across income levels.

An alternative source of increased income inequality is therefore the widening gap between the labor income of the rich and the labor income of the poor. Specifically, economists refer to the phenomenon of **skilled-biased technical change**. The idea is that developments in robotics and artificial intelligence (AI) have disproportionately increased the demand for high-skilled workers, thus increasing the wage gap between high-skill workers and low-skill workers.

In order to understand the concept of skill-biased technical progress, it helps to go back to Section 5.2's analysis of the firm's input mix. Figure 11.7 largely reproduces Figure 5.8 but casts the problem in terms closer to the problem at hand. The top panel depicts the effect of technical progress on the cost of robots, assuming that robots are close substitutes for low-skilled labor. In fact, in the graph we assume they are perfect substitutes, so that the isoquants q_1 and q_2 are straight lines. While the perfect substitutes assumption does not hold strictly, this extreme case serves the purpose of illustrating the main effects. Initially, robots are expensive (price r_1), so that the optimal input mix (point m_1) is to offer L_1 jobs and employ no robots. Then the cost of a robot falls to $r_2 < r_1$. Assuming, for simplicity, that the firm continues to operate on the same input budget, the budget line pivots upward around m_1. The new optimal input mix is m_2, that is, the firm employs K_2 robots and no labor. In practice, however, we would expect the isoquants to be curved somewhat. Moreover, we would expect w to adjust. All in all, we would expect a drop in both w and L.

Consider now the bottom panel, which depicts the effect of technical progress on the cost of AI systems, which we assume are close complements to high-skilled labor. In fact, in the graph we assume they are perfect complements, so that the isoquants q_1 and q_2 are perfectly L-shaped lines. While the perfect complements assumption

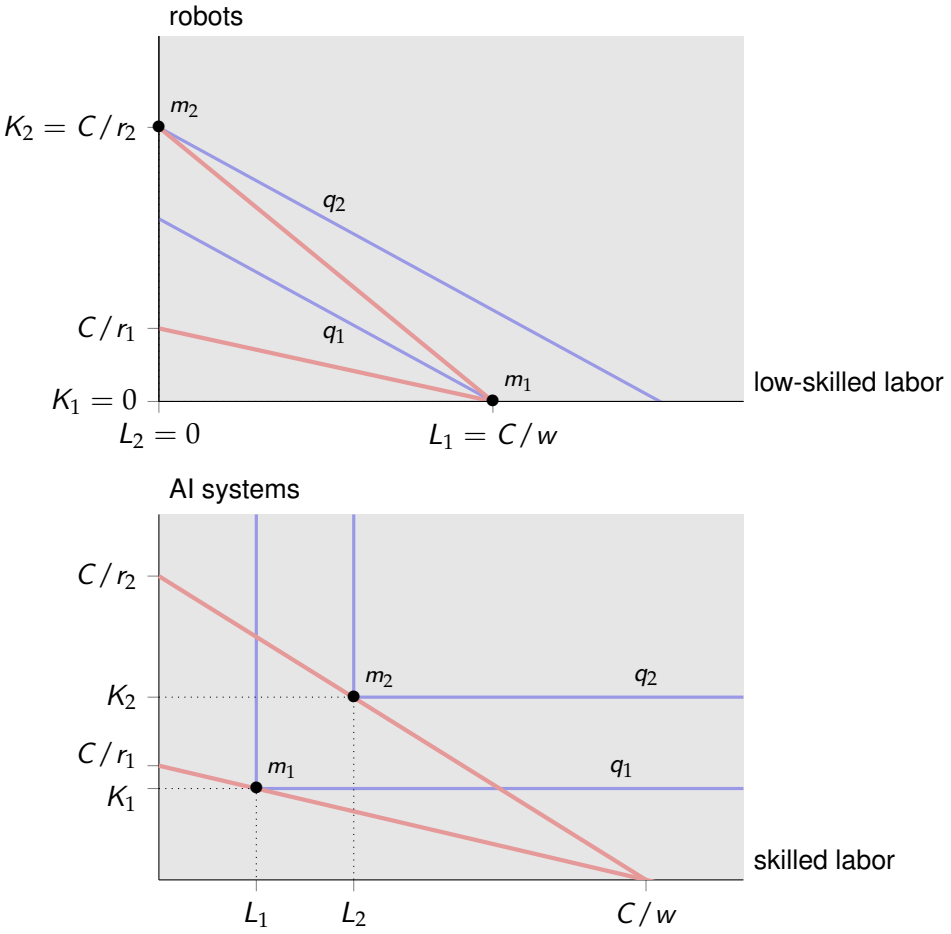


FIGURE 11.7
K and L: perfect substitutes (top) and perfect complements (bottom)

does not hold strictly, this extreme case serves the purpose of illustrating the main effects. Initially, AI systems are expensive (price r_1), so that the optimal input mix (point m_1) is to employ L_1 units of labor and K_1 AI systems. Then the cost of an AI system falls to $r_2 < r_1$. Assuming, for simplicity, that the firm continues to operate on the same input budget, the budget line pivots upward around m_1. The new optimal input mix is m_2, that is, the firm employs K_2 AI systems and L_2 units of labor, where $L_2 > L_1$. In practice, however, we would expect the isoquants to be somewhat curved. Moreover, we would expect w to adjust. All in all, we would expect an increase in both w and L.

In sum, taking into account the heterogeneity of capital (robots

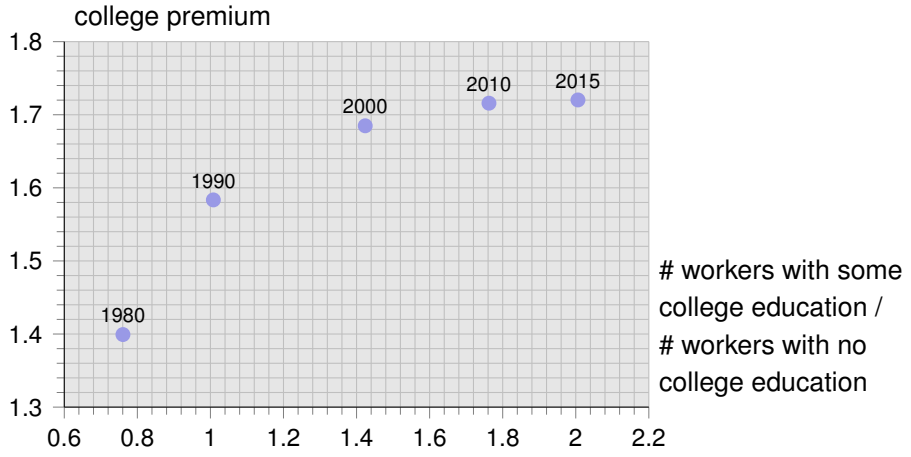


FIGURE 11.8
Skill demand, skill supply, and equilibrium. College premium measured by ratio of college graduates wage and high-school graduates wage. Source: Table 1 and author's calculations.

are not the same thing as AI systems) and the heterogeneity of labor skills, we observe that the drop in the cost of capital has depressed the demand for low-skilled jobs and increased the demand for high-skilled jobs.

Figure 11.8 shows the evolution of the *relative* quantity and *relative* price of skilled vs unskilled labor in the US. Specifically, on the vertical axis we measure the ratio of the wage paid to a college graduate and the wage paid to a high-school graduate. Sometimes the same information is also presented as the percent difference rather than the ratio and referred to as the **college premium**. (We will return to this in Chapter 13, when talking about college as an engine of economic mobility.) On the horizontal axis, we measure the ratio of the number of jobs held by people who attended college (including those who did not graduate, as well as those who attained post-graduate degrees) and the number of jobs held by people with no college experience. For example, in 1980 for each job held by a person with no college education there were 0.76 jobs held by people with some college education; and those with a college degree earned 39.9% more than those with a high-school diploma (i.e., the earnings ratio was 1.399). By 2015, the ratio of the number of jobs increased to 2.00, whereas the college premium increased to 72%. Overall, we observe

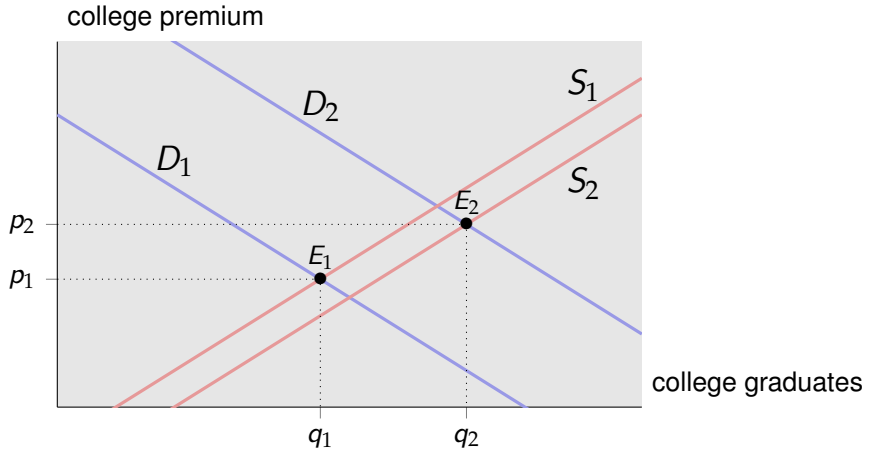


FIGURE 11.9
Comparative statics in the market for college graduates.

a significant increase in skill levels as well as an increase in the college premium. However, the latter has slowed down somewhat in recent years.

Figure 11.9 helps understand the evolution of the labor market according to the comparative statics framework introduced in Section 7.1. Equilibrium E_1 represents the US economy at the turn of the century. Since then, we've observed a shift in demand for skilled workers (e.g., workers with a bachelor's degree). There has also been an increase in the supply of such workers (as one can check from college enrollment statistics). However the increase in demand dominates in terms of effects on price, here defined as the relative wage of college graduates with respect to non-college graduates (high school degree or less). In other words, the college premium results from a "race" between technology, which pushes the demand for skilled labor to the right, and schooling, which pushes the supply of skilled labor to the right. In the past few decades, the demand-shift effect has dominated the supply-shift effect.

To summarize the discussion so far, we have seen that rising income inequalities may be partly attributed to ownership of physical and financial capital, but likely more important are differences in **human capital**, namely in qualification levels. This makes access to advanced education all the more important as a means for moving up the income ladder. We will return to this in Section 13.3. It also

raises the question of how much of the skill-bias of technical progress is a matter of "fate" or rather the result of economic incentives. We will return to this in Section 12.3.

Going back to Figure 11.6: Even though, as we argued before, most of the business income of the top 10% corresponds to labor income (highly qualified labor), it still remains the case that it is earned through corporations. Moreover, Figure 11.6 shows quite clearly that the top percentile receives a considerable part of their income in the form of dividends and capital gains. In fact, dividends and capital gains are almost exclusively concentrated in the top 10% of the income distribution. To be precise, I must add that this is not exactly true: a good chunk of retirement funds include stock holdings, and these presumably extend to some of the lower income brackets. That said, it seems fair to say that an increase in firm profits benefits higher income brackets disproportionately. In this sense, the increasing **market power** trend reported in Section 8.1 is likely to have contributed to increased inequality.

But there's more: The market power wielded by corporations is manifested not only in higher prices charged to the consumer, as reported in Section 8.1, but also in the form of lower wages paid to workers. A significant trend in the US has been the weakening power of labor and the parallel increase in **monopsony power** wielded by corporations. Figure 11.10 shows the employment-weighted average of the Herfindahl-Hirschman Index (HHI) of employment by firms, computed at the county-three-digit industry-year level. The HHI is defined as the sum of the squares of all market shares. It measures the level of concentration and its value ranges from zero to one. A value of zero corresponds to infinite fragmentation, whereas a value of one corresponds to maximum concentration (e.g., all employment corresponds to one employer only). As the figure shows, it has steadily increased since the 1970s.

In addition to greater concentration on the employer side, there is also evidence of collusive behavior by employers. For example, in 2010 the US Department of Justice initiated an investigation into "no poach" agreements among high-tech companies (Adobe, Apple, Google, Intel, eBay) and animation companies (Pixar, Lucasfilm). The allegation was that these firms would agree not to "cold call" other companies' highly skilled employees. The DOJ investigation resulted in various civil settlements on behalf of employees whose

Box 11.1: Robots, jobs and wages

Since the Industrial Revolution, we have repeatedly observed the pattern of increased automation, whereby capital substitutes for labor. What is the evidence regarding the recent wave of industrial robots? One pattern that seems common across all adopters is that production workers get laid off, tech workers get hired, productivity increases, and output expands.

Data from France suggests that only a small fraction of manufacturing firms adopt automation, typically the larger firms. The share of production workers in these firms declines, but output increases by so much that employment in these firms actually increases. So far, so good, but this increase in employment is largely at the expense of competitors who do not adopt automation and experience a sharp decline in output and employment. Overall, robot adoption in a given sector is associated with lower sector employment.

In terms of wages, data from Denmark suggests that average real wage increases by .8% but wages in manufacturing drop by 6%. Welfare losses are particularly concentrated among older workers, who have fewer options to switch into the tech sector. Overall, industrial robots can account for a quarter of the fall in the employment share of production workers and 8% of the rise in the employment share of tech workers since 1990.

wages were likely lower as a result of the agreement among employers.

On the other side of the labor market, we observe that, due to legal and political changes over the past 40 years, only about one in 10 American workers now belongs to a union. For example, when the city of Seattle tried to facilitate collective bargaining for Uber drivers, the US Chamber of Commerce, with the cooperation of the Department of Justice and the Federal Trade Commission, sued the city based on the Sherman Antitrust Act (cf Section 8.2) and compelled the city to back down. The decline in union power is relevant not just for union members but also for non-union members due to the so-called threat of unionization: When unions are powerful, non-union corporations tend to treat workers better so as to avoid inducing the work force to unionize. A related labor market trend is that,

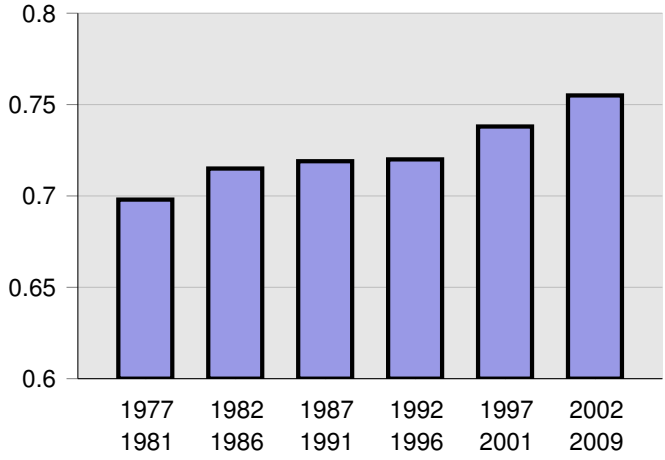


FIGURE 11.10
US Employer Herfindhal-Hirshman index (source)

at the US national level, more than a third of US workers now have part-time or full-time arrangements related to the gig economy. Finally, at the bottom of the wage distribution, one important factor has been the drop in minimum wage in real terms (that is, in most states minimum wage has increased less than inflation). All in all, in terms of income inequality, this is a double-whammy: not only are wages lower, which harms the lower-income brackets, but firm profits increase, which benefits the higher-income brackets.

To conclude this section, we should mention the role played by so-called **superstar effects**. These effects are quite pervasive, as I will argue in the next paragraphs, but they are particularly evident in the entertainment industries. Soccer fans of a certain age (football fans, if you live outside of the US) will appreciate the following comparison. Up until the 1980s the reach of cable and satellite television was very limited (and there was no Internet). For this reason, national football leagues (in England, Spain, Italy, etc) essentially catered to a local market. The main revenue source was gate receipts, with merchandizing and TV rights representing a very small fraction. In this context, the revenue ratio between, say, the English and the Portuguese leagues was about a factor of two or three, reflecting the higher purchasing power of English fans and the larger average size of their stadia. The advent of cable TV and globalization had a dramatic effect: Now everyone in the world can be a fan of Liverpool or Manchester

FIGURE 11.11
Superstars then and now. Can you tell the differences?

United and follow their games live. Put yourself in the shoes of a soccer fan in Shanghai. Once you have access to TV and the Internet, you can access any league you like. If you are to follow a non-local league, you might as well follow the best. Granted, not everyone agrees on what the best is (England? Spain?), but most would agree that a handful of leagues are significantly more competitive than the rest. Finally, this implies that the gap between the top leagues and the rest widens considerably with respect to the era of national leagues with national reach. Currently, the earnings of the English league are approximately 15 times bigger than those of the Portuguese league (up from a factor of 2 or 3).

This is not to say that the Portuguese league is not good or competitive. In fact, it is one of Europe's top 10 leagues. However, in the global digital era, the difference between the top spots and the near-the-top spots is much greater than it used to be. In other words, globalization and digitization together have created strong superstar effects, which in turn result in increasing inequality among earners.

Another way of measuring these superstar effects is by estimating the ratio between top earners today and top earners in the past. Even correcting for overall growth of the sector, top talent earns disproportionately more. This can be found in various segments of the sports and entertainment world, as illustrated in Figure 11.11. For example, in 1953 Humphrey Bogart was paid $300,000 for his role in *Sabrina*. It was the most he was ever paid for a role. Based on simple

calculations, I would expect that, in today's money and considering the growth of the movie industry, this would correspond to about $7 million today. This is considerably less than an actor like Tom Cruise charges for a movie role. John Grisham, the leading writer in the late 20th century, sold about 60 million copies in one decade. Fast forward to the 21st century and J K Rowling sold more than 600 million copies in one decade. Similar comparisons could be made between The Beatles and Madonna (rock music), Pele and Ronaldo (soccer). In fact, the same superstar phenomena is also found in professions such as management (contrast GM's Alfred Sloan and GE's Jack Welch) or architecture (contrast Le Corbusier and Frank Ghery).

A recent study brings these ideas to the data. First, it classifies industries along two dimensions: how skill-intensive they are, as measured by the percentage of workers with higher education; and how tradable the industry's output is, as measured by the ratio (exports + imports)/output. Examples of sectors that are skill intensive but not tradable include education and health. Examples of sectors that are tradable but not skill-intensive include transportation, warehousing, wholesale trade. Examples of sectors that are neither skill intensive nor tradable include accommodation and food services, retail, administrative support, waste services. Finally, the important quadrant is that of **skilled tradable services** (STS), corresponding to sectors that are skill intensive and tradable. Examples include information, finance, insurance, management of companies, professional services. These are the sectors where superstar phenomena are more likely to take place. In fact, the evidence shows that, from 1980 to 2015, wages in STS increased by a factor close to 5, whereas in other sectors the factor was between 3 and 4.

Let us zoom in onto one of the above examples of STS: management of companies. Figure 11.12 plots three different indexes, all normalized to equal 1 in 1980. In red, the compensation index for CEOs at the top 350 US firms ranked by sales. The index includes all forms of compensation, including stock options realized. In green, the compensation index for full time salary workers 16 years and over. Finally, in green the S&P 500 index.

The contrast between the red and green indexes is astounding. It's not that workers' wages did not increase; they did: In 2019, average full time wages were about 13% higher than in 1980. Given the scale required to plot all indexes, this variation is barely perceptible.

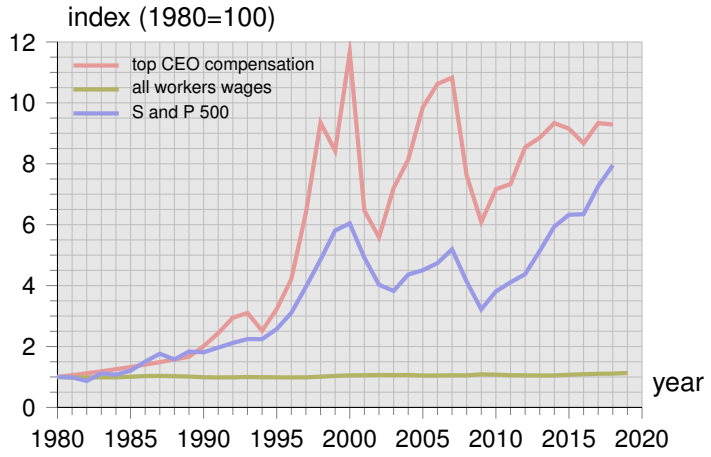


FIGURE 11.12
CEO compensation, worker compensation, and the S&P stock market index. See text for details. Sources: Economic Policy Institute for CEO pay and S&P index, FRED for wage rate.

By contrast, the shocking variation is that top CEO compensation is about 9 times higher: an increase of 800 per cent (in real terms) with respect to 1980.

The indexes only show how compensation varied over time. If we were compare top CEO compensation to average wages, we would get a ratio of about 20-to-1 in 1965, 30-to-1 in 1978, 58-to-1 in 1989, and 344-to-1 in 2000! During the 21st century the ratio has not changed that much, though 344 is admittedly a very large number.

One explanation of why top CEOs earn so much more than the rest of the world is the superstar phenomenon: they are at the helm of larger and larger superstar firms. Recall that we are restricting to the top 350 corporations. In fact, the increase in compensation is, to some extent, consistent with the rise of the market value of the largest firms (cf blue line in Figure 11.12, which corresponds to the S&P 500). Moreover, as the variance in the red line in Figure 11.12 shows, top CEO compensation is subject to substantial risk. Together, this leads some to argue that the rise in CEO pay can be largely attributed to the increase in market capitalization of large companies. It's the market at work: CEOs are paid what they are worth, high compensation is required in order to attract the best and the brightest to the job. However, other economists disagree with this view ("Do we really

Box 11.2: Superstar firm protests

We have seen a lot of anti-inequality social protests in recent years, from Occupy Wall Street to Paris' Yellow Vests to Santiago's Metro protests. In California, some of this animus is targeted at specific "superstar" firms such as Apple or Google. In December 2013, for example, as Google employees boarded the bus that would take them on their daily commute, a group of protesters showed their anger against the tech giant's privileged employees. The pamphlet they were distributed read

> In case you're wondering why this happened, we'll be extremely clear. The people outside your Google bus serve you coffee, watch your kids, have sex with you for money, make you food, and are being driven out of their neighborhoods. While you guys live fat as hogs with your free 24/7 buffets, everyone else is scraping the bottom of their wallets, barely existing in this expensive world that you and your chums have helped create.

One of the protesters summarized the crowd's mood when they unfurled a banner bearing the words, "F—Off, Google." One protester even smashed the whole of the bus' rear window.

thing CEOs have gotten hugely better since the 1960s, while workers haven't?"). It's complicated.

Income inequality is caused by the concentration of capital, including in particular human capital. Other important factors include skill-biased technological change, market power, and superstar effects.

The superstar effect on income inequality is also felt at the level of firms. A recent study suggests that as much as two-thirds of the rise in wage inequality occurred due to a rise in the dispersion of average earnings *between* firms, as opposed to *within* firms. In other words, it's not that the top and bottom salaries within firms are increasing, rather that some firms are paying much higher salaries than other firms. Why? Largely because **superstar firms** disproportionately attract higher-skilled and higher-paid workers. This concentration of

talent further fuels the companies' momentum, turning them into large giants with rapidly rising productivity. Meanwhile, employees in less-successful companies continue to be poorly paid and their companies fall further behind.

Another study suggests that industry sales are increasingly concentrated among a small number of firms. These superstar firms are so much more productive than the average firm that, while they pay better, the share of labor is lower than average. In other words, Facebook pays higher-than-average wages, but the share of Facebook's sales that corresponds to labor is lower than the national average, so much so that Facebook's generous wages don't contribute much to the aggregate labor share. But this then implies that a concentration of economic activity in this small set of superstar firms has the effect of *lowering* the overall labor share. In sum, superstar firms, though they treat their own workers better than average, may be part of the trend whereby the average worker gets a smaller cut of the overall pie. Box 11.2 suggests that this phenomenon has not gone unnoticed.

Understanding the sources of increased inequality is an important step toward finding the best remedies. For example, a wealth tax, which we will discuss in Section 12.3, has been proposed as a means to counteract the increasing concentration of wealth and income. The perception that technological innovation has been biased against low-skilled labor has led to calls for a "robot tax", something we also discuss in Section 12.3. To the extent that market power is a central force toward inequality, the discussion on antitrust presented in Section 8.2 is particularly relevant.

11.2. DISCRIMINATION

Discrimination is the act of making distinctions between human beings based on the groups, classes, or other categories to which they belong or are perceived to belong. Examples include age, disability, national origin, race/color, religion, sex. Discrimination is a wide-ranging phenomenon, and we do not have the space or the ability to cover all of its forms. Instead, in this section we restrict primarily to the economic roots and effects of discrimination. Discrimination is one of the causes of economic inequality, including, but not restricted to, income inequality. For example, on average, women in the US

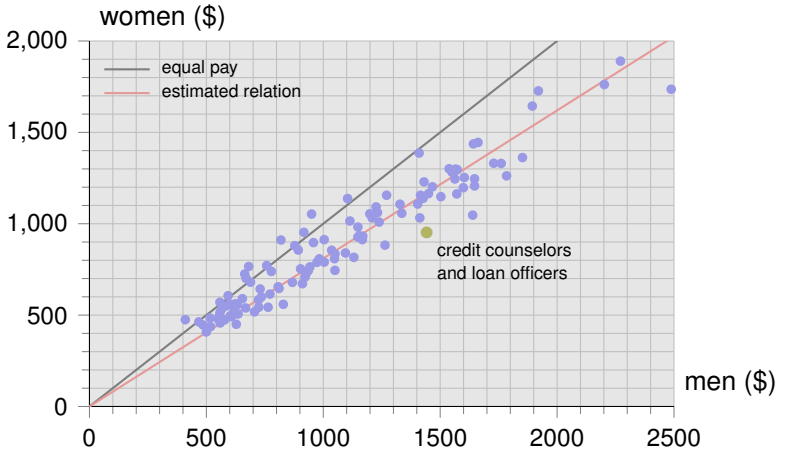


FIGURE 11.13
US median weekly earnings of full-time wage and salary workers by detailed occupation and sex, 2018 annual averages (source: Bureau of Labor Statistics)

earn 12% less than men, and the percentage of African-Americans not working is twice as large as that of white Americans.

As mentioned in Section 1.3, economists distinguish between statistical discrimination and taste discrimination. An example of statistical discrimination is provided by car insurance rates. A 16-year-old woman pays an average 6-month premium of $3,378, whereas a 16-year-old man pays a higher $3,897. The fact that women are charged less does not reflect any animus against men, simply the fact that, statistically speaking, 16-year-old men are more prone to accidents than 16-year-old women. Similarly, the fact that a 24-year-old man pays on average $1,381, substantially less than his younger counterpart, does not necessarily reflect age discrimination in the sense that the expression normally has. By contrast, the differential way that racial minorities are treated in the labor market frequently goes beyond statistical outcome expectations, rather reflecting a distaste for hiring minorities. For the remainder of this section, we will be primarily concerned with the non-statistical part of discrimination (gender, age, race, or otherwise based).

THE GENDER PAY GAP

The gender pay gap is one of the manifestations of gender discrimination: women earn less than men. A simple way of measuring the gender pay gap is to compute the ratio between the average wage earned by women and the average wage earned by men. Figure 11.13 plots, for each detailed occupation, median earnings of men (horizontal axis) and women (vertical axis). Each dot in the figure corresponds to a particular occupation. For example, in the "credit counselors and loan officers" sector, men earn on average $1,443 per week whereas women earn on average $948 per week. As can be seen, almost all points are located below the main diagonal, the line such that $y = x$, that is, the equal-pay line. On average, the relation between men's and women's salary is given by the red line, the slope of which is .811. This means that, in the US and on average, for every dollar that a man earns a woman earns $100 - 81.1 = 18.9$ cents less. This is the easy part of the analysis: the more difficult part is to decompose those 18.9 cents into its various components.

Claudia Goldin, one of the world's leading experts on the matter, argues that this number "answers a particular question but it doesn't say that men and women are doing the same thing. It doesn't say that they're working the same amount of time, the same hours during the day, or the same days of the week." In other words, one part of the wage gap is due to the fact that women self-select into different types of jobs (including in particular lower-pay jobs); and that, even within the same job, they work different hours or choose a different career path.

Specifically, the US evidence shows that recent graduates start at about the same salary level, with salary gaps arising later during one's career. Moreover, only about 15% of the emerging pay gap is due to self-selection into types of jobs (e.g., more women choose to be grammar school teachers, and these jobs pay less than average). In other words, most of the gender pay gap (85 percent) occurs *within professions* and as a career proceeds. One reason for this age-increasing pay gap seems to be that the pay-worktime relation is not linear: employees are paid more than proportionately for their willingness to work long hours (and be flexible about it), and men are more likely than women to choose such deals. One may be tempted to say that this is just another instance of self-selection ("women earn

less because they choose to do so"). However, as we will see below, even this self-selection effect may correspond to a form of discrimination.

IDENTIFYING DISCRIMINATION

Similarly to climate change and other "hot" topics, there are those who deny that taste discrimination plays an important role, claiming that the differences we observe are either due to statistical discrimination or selection and aggregation biases. For this reason, the work of various economists has been instrumental in identifying actual bias in the way women and minorities are treated. One particularly interesting example refers to American symphony orchestras. By as late as 1970, about 10% of musicians in each of the US "big five" orchestras were women. (The "big five" are the Boston Symphony Orchestra, the Chicago Symphony Orchestra, the Cleveland Symphony Orchestra, the New York Philharmonic, and the Philadelphia Orchestra.) Economists Claudia Goldin and Cecilia Rouse state that the extent of bias against female musicians was considerable and likely responsible for such small percentages.

> Many of the most renowned conductors have, at one time or another, asserted that female musicians are not the equal of male musicians, claiming that "women have smaller techniques than men," "are more temperamental and more likely to demand special attention or treatment," and that "the more women [in an orchestra], the poorer the sound."

In July 1969, at the height of the civil rights movement, two black musicians (a double bassist and a cellist) accused the New York Philharmonic of racial discrimination. Although the musicians lost their case, various symphony orchestras gradually introduced blind auditions as a means to avoid bias in hiring. Since the introduction of blind auditions was gradual (that is, different orchestras did it at different times), the historical data provides a strategy for estimating gender bias in hiring new musicians: Did the percentage of female musicians increase when blind auditions were introduced? By 1970, about 10% of orchestra members were female. By the mid-1990s, that

Steven Pisano

The New York Philarmonic in February 2020. By as late as 1980, fewer than 12% of musicians in each of the US "big five" orchestras were women.

percentage was up to 35%. Goldin and Rouse estimate that about 30% of this gain was due to blind auditions. This vindicates the claim that discrimination against women was present when the candidate could be identified by the jury. Many other similar studies provide compelling evidence that some form of discrimination has been present, and continues to be present, in various industries.

IMPLICIT DISCRIMINATION

Many social psychologists believe that an individual's attitudes occur in both implicit and explicit modes. In other words, people can think, feel, and behave in ways that oppose their explicitly expressed views. One application of this dichotomy between explicit and implicit attitudes regards discrimination, namely racial discrimination. Specifically, we may refer to **implicit discrimination** as the unconscious mental association between a target (such as an African-American) and a given attribute. The evidence suggests that these associations exist and moreover are correlated with actual behavior patterns. In one much-discussed experiment, economists Marianne Bertrand and Sendhil Mullainathan sent a bunch resumes to potential employers. The experiment's main feature was that a given list of qualifications was present both in a resume with a white-sounding name (e.g., Emily or Greg) and in a resume with an African-American-sounding name (e.g., Lakisha or Jamal). Having sent a large number of randomly selected resumes to potential employers, the experiment tests the possible association between a name, a perception of race, and the weight given to objective qualifications listed on the resume.

The results are remarkable: White names receive 50% more callbacks for interviews. Moreover, this difference is relatively uniform across occupation, industry, and employer size. The one dimension on which the difference is not constant is qualification level: a higher-quality resume widens even more the gap between whites and African-Americans. What makes these results particularly remarkable is that the experiment was carried out in Boston and Chicago, two cities where the population and employers frequently consider themselves free from racial prejudice. In fact, the racial gap is the same if we restrict to employers who explicitly state that they are "Equal Opportunity Employers." (In Chicago, the racial gap is slightly smaller when employers are located in more African-American neighborhoods.)

As we saw in Section 2.2, the basic economics model assumes rational, logical agents who take actions in the pursuit of individual welfare maximization. There are several reasons why this is a simplifying and limited set of assumptions. One is given by implicit attitudes, attitudes that we are not conscious of.

DIVERSITY TRAPS

In the previous section, we saw how economics has much to learn from social psychology when it comes to the issue of discrimination. Sociology, another related field of social research, can also be quite relevant. Unlike economics, which focuses on the preferences and choices of individual agents (households, firms, etc), sociology places a greater weight on structural and institutional factors. Consider again the gender pay gap. As we saw earlier, much of the gap can be accounted for by different career paths followed by men and women. In this sense, creating an egalitarian workplace might require reducing the cost of offering workers flexibility in their schedules. In other words, it's not just that there is or might be an animus against women in the workplace but rather that the "system" is set up in a way that primarily addresses the needs and preferences of men.

More generally, the idea is that, even if no individual person pursues discriminatory actions, the system is such that women and/or minorities are at a considerable disadvantage. Consider the following story which, as they say in Hollywood, is inspired by true events.

A recent male economics PhD graduated from a good but not top school. His work was of high quality, but not having graduated from the very top schools makes it more difficult to get the attention of potential employers, especially leading economics departments. So our recent graduate decided to attend an economics conference where a number of leading economists were presenting. One day, after the formal sessions had taken place, our recent graduate heads for the bar and finds that Professor X, a famous faculty member at University Y, is sitting by himself drinking a beer and watching a baseball game on TV. Our recent graduate decides to risk it: he introduces himself to Professor X and asks if they can watch the game together. Professor X is happy for the company. Now, if you have watched baseball before, then you know that it's not a highly intense watching experience: There are plenty of dull moments, which our recent graduate took advantage of to present his research. The rest is history: Professor X recommends that University Y look into our recent graduate's work, who eventually was hired by Y.

What's the moral of the story? The moral is that a woman would have found it more difficult to follow the same path as our recent graduate: walking into a sports bar and introducing yourself to a man sitting by himself drinking beer is a far less common and socially accepted course of action for women than for men. It is possible that, were Professor X presented with equally good work by a recent female graduate, he would recommend that she too be hired. However, one must admit that certain institutions, customs, etc, lead to a "system" that effectively discriminates against women.

More generally, **diversity traps** may imply that women and minorities have difficult access to a given profession because of a bad chicken-and-egg equilibrium. For example, the number of female faculty in economics is remarkably small, considering the number of women who study economics at the undergraduate and graduate level. One explanation for this gap is the scarcity of mentoring and role models. Female faculty find it difficult to be the only one or one of the very few faculty members in a given department, and end up moving away from this career path. In the end, there are very few women in academic economics because there are very few women in academic economics — the essence of the chicken-and-egg equilibrium. A similar argument (in some ways, a stronger argument) might be made with respect to racial minorities, for whom mentor-

Tim Webb

Incoming freshmen students during orientation day at Berea College in Kentucky.

ing and the sense of belonging may be particularly important.

AFFIRMATIVE ACTION

The policy of **affirmative action** can be seen as a strategy to move away from "diversity traps". The idea is that, by bringing in a critical mass of minority students, it becomes considerably easier to successfully attract additional ones, for there will be enough mentors and role models to make a minority member feel accepted and belonging. In this sense, affirmative action would be a temporary measure designed to break an undesirable chicken-and-egg equilibrium.

However, this is not the only, or even the main, argument in favor of affirmative action. A more common argument is that diversity is a value by itself. For example, going back to symphony orchestras, the argument has recently been made that blind auditions should be scrapped and replaced by a recruitment system that takes into account race, gender and other factors, so that eventually ensembles reflect the communities they serve. In other words, the system (blind auditions) that has played such an important role in fighting gender discrimination (see previous section) may be an obstacle to racial diversity.

Ultimately, the issue for symphony orchestras, colleges, and other organizations is determining the objective function. If the goal is a single performance measure (e.g., average SAT score of the college entering class), then affirmative action is clearly detrimental to the college's objective. But there is no reason to believe indicators such as the average SAT score should be the sole or even the main objective in selecting an entering class.

Tribes of the World

Saudi women in Riyadh. Fewer than 5% of Saudi women work outside their home.

Even if the above considerations are understood, affirmative action remains a controversial system, as the recent Harvard admissions case shows. In 2014, a class-action suit against Harvard University claimed that the college discriminates against Asian-American applicants in its undergraduate admissions process. The claim was rejected by the court in 2019, but you can see the arguments on each side: On one hand, minority students have a harder time adapting to an environment where mentors and role models are rare. On the other hand, favoring such applicants must come at the expense of some other group or groups.

BELIEFS ABOUT BELIEFS

Earlier on, we discussed the gender pay gap. In countries like Saudi Arabia, more than the gender *pay* gap, the main issue is the gender gap in *access* to the labor market: Less than 15% of the Saudi female population aged fifteen and above were employed in 2017. Moreover, only a small fraction of these 15% worked outside of the home (around 4% of the female population). Is this a case of discrimination? If so, what are its roots?

Through the custom of guardianship, husbands typically have the final word on their wives' labor supply decisions in Saudi Arabia. A recent study finds that the vast majority of young married men in Saudi Arabia *privately* support women working outside the home (WWOH). However, they substantially *underestimate* the level of support for WWOH by other similar men, even men from the same social setting (for example, neighbors). In some way, this is similar to the chicken-and-egg equilibrium mentioned before, with the difference

that in the present case it's all about beliefs: We're stuck in the no-WWOH equilibrium because men believe that other men disapprove of WWOH, even though they don't actually disapprove of WWOH. The situation where most people privately hold an opinion but incorrectly believe that most other people hold the contrary opinion is known as **pluralistic ignorance**.

Consider the following (actual) experiment. A group of 500 Saudi men from Riyadh are asked for their opinion about WWOH. 87% are in favor, but most underestimate the percentage of other men in favor. Now split the 500 sample in two and disclose the results to one half only. It turns out that even this simple correction of Saudi men's beliefs has an important real effect: A few months after the initial survey, the subjects are asked to sign their wives up for a job matching mobile application specializing in the Saudi female labor market. (They are incentivized with a gift card.) The percentage of men who accept the deal is substantially higher if they were previously disclosed the survey results (36 vs 23 percent). In fact, the difference is particularly significant among those who had underestimated support for WWOH by a greater margin. In sum, the results provide significant support for the pluralistic ignorance narrative.

Women working outside the home is by no means the only instance of pluralistic ignorance. In 1968, most white Americans substantially overestimated the support for racial segregation among other whites. In other words, white Americans thought white Americans were more racist than they actually were. More generally, these examples show the importance of **social norms** as a form of institutionalized discrimination. Finally, this all begs the question: How can inferior social norms and pluralistic ignorance be an equilibrium, and so persist over time? One reason is that individuals are reluctant to reveal their private views for fear of social sanction. This is one of the reasons why freedom of speech and the ability to openly debate these social issues is so important. It is my hope that this section contributes to this ongoing debate.

KEY CONCEPTS

Lorenz curve | Gini coefficient

skilled-biased technical change | college premium

human capital | market power | monopsony

superstar effect | skilled tradable services

superstar firms | implicit discrimination | diversity traps

affirmative action | pluralistic ignorance | social norms

REVIEW AND PRACTICE PROBLEMS

■ **11.1. Andrew Yang.** Comment the following 2020 statement by Andrew Yang, then US Presidential candidate:

> Our current emphasis on corporate profits isn't working for the vast majority of Americans. This will only be made worse by the development of automation technology and AI.

■ **11.2. Executive compensation.** According to a recent report,

> While chief executive officers (CEOs) have always been well paid, the ratio of CEO pay to typical worker pay went from 20- or 30-to-1 in the 1960s and 1970s to 200- or 300-to-1 in recent years. The average CEO at a Fortune 500 firm now makes close to $20 million per year. It is not uncommon for a CEO to make $30 or $40 million if their company has an especially good year or if they have a favorable contract.

Discuss the arguments in favor and against curbing the rising gap between executive pay and average pay.

■ **11.3. Income inequality at the University of California.** A group of economics researchers performed the following experiment: They randomly selected a subset of employees of the University of California and informed them how their pay compared to average pay in their job category. They found an asymmetric response to the information about peer salaries:

> Workers with salaries below the median for their pay unit and occupation report lower pay and lower job satisfaction, while those earning above the median report no higher satisfaction. Likewise, below-median earners report a significant increase in the likelihood of looking for a new job, while above-median earners are unaffected.

How does this relate to the discussion on income inequality in Chapter 11?

		employee: high w	employee: low w
employer	high w	200 70	30 50
	low w	30 50	60 210

FIGURE 11.14
Wage setting game

■ **11.4. Assortative mating.** Listen to the podcast For Richer Or... Richer (or listen to the transcript). What is the meaning of "assortative mating"? How is it related to inequality?

■ **11.5. Monopsony power.** In Section 11.1, we argued that monopsony power (market power in the labor market) has been a factor contributing to increasing inequality. To illustrate this idea, consider a simple model where employer and employee propose a high wage or a low wage. The payoff for employer and employee as a function of the offer made by employer and employee is given by the matrix in Figure 11.14. (Notice that payoffs are particularly low when the employer and employee's proposals differ.)

(a) Determine the equilibrium where players move simultaneously

(b) Determine the equilibrium where one of the players moves first.

■ **11.6. The power of workers.** Listen to the podcast *The Power Of Workers* (or read the transcript). What are the alleged three main reasons why the "power of workers has been in decline for decades"? Do you agree? Why or why not?

■ **11.7. Skill-biased technical progress.** Explain skilled-based technical progress by using the isoquant framework introduced in Chapter 5. Specifically consider a firm with three inputs: capital, skilled labor (S) and unskilled labor (U). Draw the isoquant map in the (S,U) map. Show how technical progress changes the shape of the isoquants and, as a result, the firm's demand for skilled and unskilled

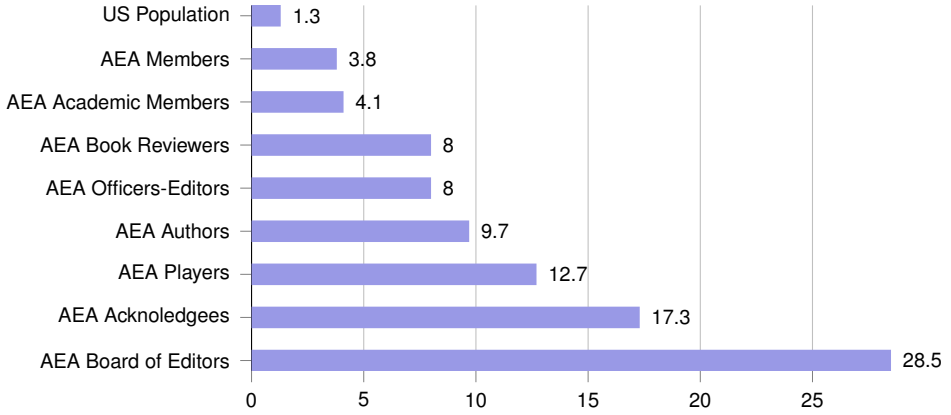


FIGURE 11.15
Number of registered Democrats divided by number of registered Republicans by group (source). AEA denotes American Economic Association.

labor.

■ **11.8. Housing market.** Listen to the podcast All The Single Ladies...Are Losing In The Housing Market (or read the transcript). What are the main patterns reported? How do you explain these patterns?

■ **11.9. Objective and subjective poverty.** "What's really damaging about being poor, at least in a country like the United States — where, as he notes, even most people living below the poverty line possess TVs, microwaves, and cell phones — is the subjective experience of feeling poor. ... Inequality so mimics poverty in our minds that the United States of America ... has a lot of features that better resemble a developing nation than a superpower" (source). Discuss.

■ **11.10. Political diversity.** In an article titled Republicans Need Not Apply, an economist documents the preponderance of Democrat registered voters among members and officers of the American Economic Association. Figure 11.15 summarizes some of the main results. How would you interpret the data?

CHAPTER 12

SOLIDARITY

In much of this book, we follow the economics approach of assuming that economic agents are primarily concerned with their own interests. As mentioned in Section 2.1, this is not a normative statement, rather a positive statement: the world would be a much better place if we cared more for each other! Fortunately, even as a positive statement the selfish behavior paradigm is more a point of reference than a reality. In this chapter, we consider individual (Section 12.1) and social (Section 12.2) attitudes towards others: fairness, income distribution, provision of goods, etc. The chapter concludes with Section 12.3, devoted to the economics of taxation, one of the main tools of economic solidarity.

12.1. FAIRNESS

As we saw in Section 2.1, the basic model of economics, the *homo economicus* model, assumes that agents are rational, individual maximizers of their own interests. As 19th century economist Francis Edgeworth put it,

> The first principle of economics is that every agent is actuated only by self-interest.

But a few decades earlier, Adam Smith, arguably the founder of economics as a discipline, thought of human behavior as a complex mix

of rational, selfish motivation, on the one hand, and social virtue on the other hand. He wrote that

> How selfish soever man may be supposed, there are evidently some principles in his nature which interest him in the fortunes of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it.

Who was right, Smith or Edgeworth? In this section, we attempt to answer this question, or at least come closer to answering this question.

THE ULTIMATUM GAME

One approach to understanding human behavior is to organize a **laboratory experiment**. One of the most popular experiments is the so-called **ultimatum game**. Here's how it works: Player 1 is given \$100 with a condition: she must offer to share it with Player 2. Specifically, Player 1 offers Player 2 a deal, s for Player 2 and $100 - s$ for Player 1. Player 2 then decides whether to accept or reject Player 1's offer. If he accepts, then Player 1 gets $100 - s$ dollars and Player 2 s dollars. If however he rejects Player 1's offer, then both players get zero.

Figure 12.9 illustrates this game. (Since players clearly move sequentially, it is better to represent the game in tree form.) As usual, we look forward and reason backward in order to "solve" the model, that is, in order to predict the players' choices. First, put yourself in the shoes of Player 2. Any s value that Player 1 offers is better than nothing. Therefore, Player 2's optimal strategy as a rational agent is to accept any positive offer. (If $s = 0$, then Player 2 is indifferent between accepting and rejecting.)

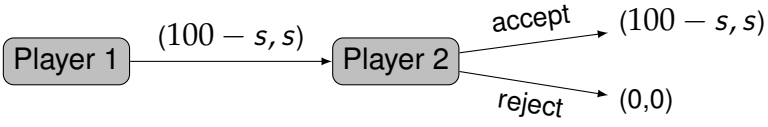


FIGURE 12.1
The ultimatum game

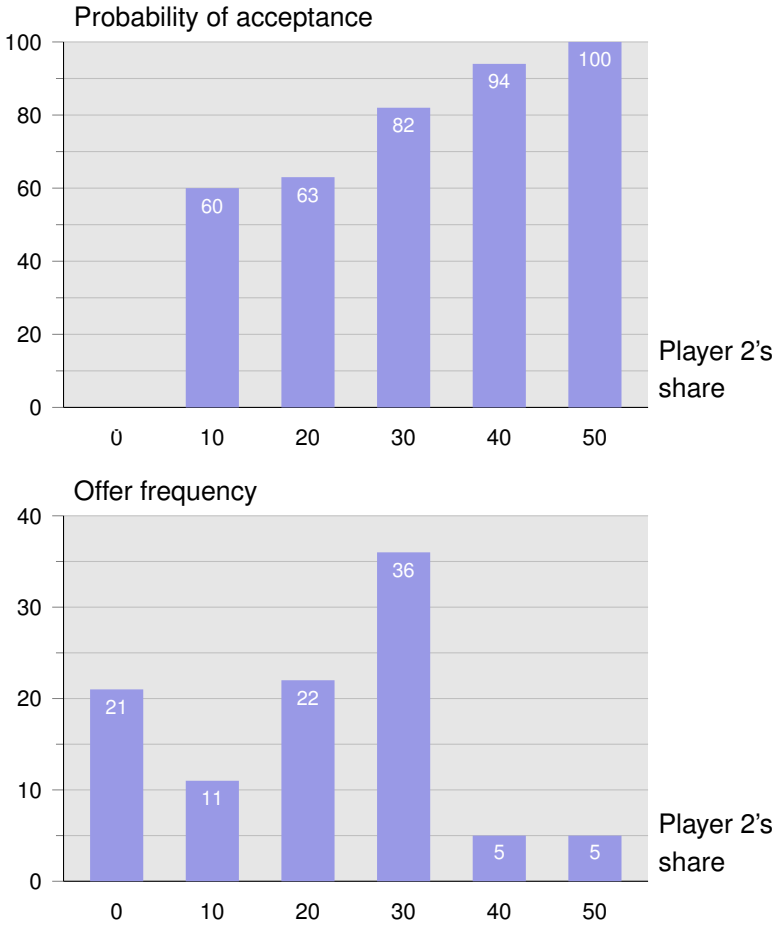


FIGURE 12.2
The ultimatum game: experimental results (source)

Given the above prediction of Player 2's behavior, consider now Player 1's strategy. Believing Player 2 to be rational, Player 1 expects that any positive offer will be accepted by Player 2. Therefore, Player 1's optimal strategy is to offer the smallest value s possible. (If there is a strictly positive probability that $s = 0$ will be rejected by Player 2, then Player 1 does not want to offer $s = 0$, rather a very small s.) In sum, the Nash Equilibrium of the game corresponds to the prediction that Player 1 offers $s \approx 0$ and Player 2 accepts such offer.

Evidence from laboratory experiments is at odds with the predictions from game theory and the conventional rational behavior assumption. While the many studies vary in terms of their precise predictions, the values in Figure 12.2 provide a representative sam-

ple of the experimental data. It corresponds to a laboratory experiment with Emory University undergraduate students. The top panel shows the frequency with which a proposal is accepted by Player 2. The simple theory of own-payoff maximization would predict a 100% probability of acceptance (except for an offer of zero). However, the observed probability of acceptance is well below 100%, especially for offers close to zero.

These data suggests that Player 2 derives satisfaction (utility) from financial gain but also from "punishing" Player 1 for what Player 2 perceives as an unfair proposal. Experiment after experiment, this is one of the more common departures from the simple model of own monetary payoff maximization: economic agents derive utility from what they perceive is a fair outcome and are willing to sacrifice monetary payoff for the sake of imposing a lower payoff on players perceived not to act in a fair manner.

The bottom panel of Figure 12.2 shows the frequency with which Player 1 makes different offer levels. The Nash Equilibrium derived above would predict that Player 1 offers a value of s as small as possible, so we might say that the *homo economicus* model would essentially predict an offer of 0 with probability 100 percent. The observed frequency of offers differs from this: an offer of zero is only observed with 21% probability. However, considering that Player 2 does not behave according to his own payoff maximization, we must consider that even a rational, own-payoff maximizing Player 1 should play differently than prescribed by the game's Nash Equilibrium. Exercise 12.5 is highly recommended as a complement to this section. The exercise suggests that, given Player 2's behavior pattern, Player 1 is better off by offering 30 to Player 2. In other words, $s = 30$ maximizes Player 1's expected payoff if Player 1 expects Player 2 to behave according to the probabilities shown in the top panel of Figure 12.2. In this sense, the surprising pattern in the bottom panel of Figure 12.2 is that Player 1 is more "greedy" than a rational player should be (and sometimes, though less frequently, more generous than a selfish, own-monetary-payoff maximizer should do).

THE FAVOR-EXCHANGE GAME

The experimental literature is filled with studies addressing nonstandard behavior by economic agents, that is, behavior that departs

from own monetary payoff maximization. Concepts such as altruism, kindness, fairness, reciprocity, etc, are brought to bear on the results. One limitation of this literature is that, frequently, only one of the above narratives is presented. A better way to test theories is to run a "horse race" that allows multiple narratives to explain the data.

Consider the following **intertemporal favor-exchange** game. Each period, a pair of numbers is randomly generated. These numbers correspond to a potential payoff for Players 1 and 2. The sum of the two payoffs is always positive, but one of the values may be negative. For example, one player stands to gain \$8 while the other stands to lose \$3. The two players then simultaneously decide whether or not to accept the proposal. If any of the players vetoes the proposal, then both get zero during the current period. Otherwise, they receive the indicated payoff.

If the game were played only once, then the standard economic model would predict that a payoff pair such as $(8, -3)$ would not pass the veto test. However, if the game is repeated, then there may be Nash Equilibrium such that a player accepts losing 3 during the current period with a view at earning a higher payoff in the future. Independently of the game being repeated or not, a player may also accept losing 3 simply because he or she cares for the other player's payoff and understands that a loss of 3 is less important than a gain of 8.

The data shows that, in the indefinite repetition of the above game, players exchange "favors" frequently (i.e., accept to lose money apparently for the other player's sake). Figure 12.3 plots the various observations split into acceptances and rejections. Whenever both players receive a positive payoff, typically both players accept the proposal. This can be seen on the positive quadrant of the left panel of Figure 12.3 compared to the positive quadrant of the right panel of Figure 12.3.

Comparing the second and fourth quadrants in the left and right panels of Figure 12.3, we see that, whenever one of the players gets a negative payoff, the proposal is typically rejected (higher density on the right panel). However, we observe a significant numbers of proposals yielding a negative payoff to one of the players which are nevertheless accepted.

Another interesting feature of the data is that there are cases when

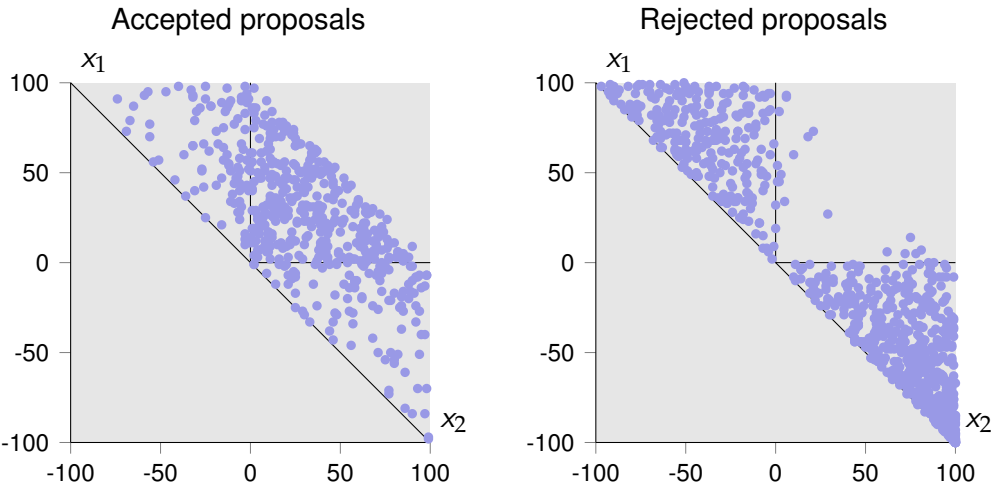


FIGURE 12.3
Accepted and rejected offers in the favor-exchange game

one of the players rejects a proposal even though both players stand to receive a positive payoff. In other words, the first quadrant in the right panel (rejections) includes some observations.

There are various theories compatible with these observations. One is **altruism**: Player 1 accepts a negative payoff for the good of Player 2's positive (and higher) payoff. A second narrative is what we might refer to as **intrinsic reciprocity** (related to the concept of fairness mentioned in the context of the ultimatum game). The idea is that if Player 2 was good to Player 1 in the past (in the sense that Player 2 accepted proposals that yielded Player 2 a negative payoff), then Player 1 derives satisfaction from being kind to Player 2. Finally, a third possible explanation is that players, selfish as they are, offer to help other players as part of a Nash Equilibrium of the repeated game they play. In other words, the favor exchange is a case of **instrumental reciprocity** (ultimately a form of self-interested behavior).

Careful analysis of the data suggests that instrumental reciprocity (a.k.a. forward-looking reciprocity) explains the lion's share of variation in the data. From a testing point of view, an important source of differentiation between the three explanations is a treatment where subjects are told, at the beginning of the last period, that this is indeed the last period. What we then observe is a significant decline in the acceptance of negative payoffs, an observation which is consis-

tent with the instrumental-reciprocity explanation but not with the intrinsic reciprocity or the altruism explanations.

In sum, the ultimatum and the favor-exchange games suggest that

> *Real-world economic agents value fairness, to the point that they are willing to sacrifice monetary value for the sake of fairness.*

The experiments also show that the model of rational behavior has much to say about real-world economic agents: agents largely choose actions with the goal of increasing their own payoff; and agents behave strategically when considering the other agents' preferences for fairness.

To put it differently, human behavior is a complex combination of selfish and unselfish behavior, very much along the lines of Adam Smith's quote. We are a social species, we do not live as isolated individuals. We care for each other, from local neighbors to fellow human beings who live far apart. In the next section, we consider how societies are organized so as to address these feelings of solidarity, in particular in the economic sphere.

12.2. POLITICAL ECONOMY

Whenever we talk about caring about each other at a societal level, we talk about politics. This section is about politics, namely how economists think about politics and political doctrines.

THE PARETO FRONTIER

In Sections 2.3 and 3.1, we introduced the concept of feasible set. In the context of agent choice, a feasible set corresponds to the set of possible individual outcomes (for example, Alexei's set of possible combinations of leisure and course grade). The concept of feasible set is very broad. We can also think of a society's feasible set as the set of possible levels of individual welfare. Consider a society with two individuals, A and B. Suppose we can measure A and B's welfare by means of some index, for example, the total surplus each receives in equilibrium. Figure 12.4 illustrates this idea. In it, we plot A's welfare on the horizontal axis and B's welfare on the vertical axis. The

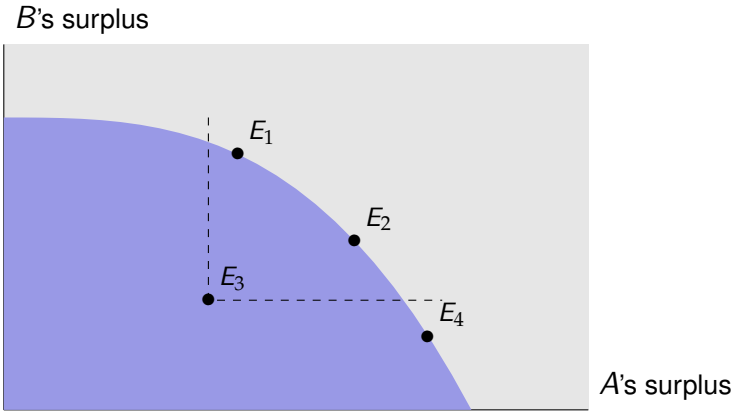


FIGURE 12.4
Society's feasible set

shaded area shows the set of attainable combinations of A's welfare and B's welfare: society's feasible set.

The frontier of this feasible set is called society's **Pareto frontier**. The idea is that points like E_1 and E_2 are **Pareto optimal** outcomes, or simply Pareto optima. This means that it would be impossible to improve A's welfare without reducing B's welfare, and vice-versa. A point like E_3, by contrast, is not Pareto optimal: by moving to E_1 or E_2, for example, we can make both A and B strictly better off.

> *A Pareto optimal allocation is an allocation such that we cannot increase one agent's welfare without reducing another agent's welfare.*

In Section 7.2, we introduced the First Welfare Theorem. It states that, in a competitive market, the equilibrium levels of output and price correspond to the maximum total surplus. Figure 12.4 allows us to restate the theorem as follows:

> *In an economy where markets are competitive, the equilibrium distribution of welfare levels corresponds to a point along the frontier of the welfare feasible set, that is, a Pareto optimal point.*

So, in terms of Figure 12.4, points E_1, E_2 and E_4 would correspond to equilibrium points of the (competitive) economy. Does this mean that there exists more than one equilibrium? Yes: In Section 7.1, we

implicitly assumed an initial set of endowments. In particular, we assumed that A and B were endowed with certain levels of capital, labor ability, cash, etc. These endowments lead to a series of supply and demand curves, which in turn lead to a series of equilibrium values of p and q, which in turn lead to surplus levels for A and B.

Suppose that we are initially at competitive equilibrium E_1. Suppose that we take some of B's initial endowment and give it to A, and then let the equilibrium be "replayed". Such reallocation of initial endowments would imply a different equilibrium from the initial one. To the extent that we transferred endowments from B to A, we should observe a movement along the Pareto frontier in the SE direction — point E_2, for example. The new equilibrium is as efficient as the first one, that is, both E_1 and E_2 maximize the gains from trade (First Welfare Theorem), which can also be interpreted as stating that, at either E_1 or E_2, one cannot make A better off without making B worse off (Pareto optimality).

Since we introduced the First Welfare Theorem in Section 7.2, we've made multiple references to this important result. You may have wondered — is there a second one? Yes! If, in terms of the feasible set, the First Welfare Theorem states that a competitive economy equilibrium corresponds to a point on the frontier, the **Second Welfare Theorem** states that

> *Any competitive economy equilibrium, that is, any point along the Pareto frontier, may be attained by an appropriate shift in initial endowments.*

Similar to the First Welfare Theorem, a few notes are in order. First, the issue is not whether these theorems are right or not. They are formal statements that follow logically from a set of assumptions. In this sense they are right. The important question is whether they are *relevant*. As discussed in Part III, the argument can be made that competitive markets are the exception, not the norm. In this sense, it would appear that the First Welfare Theorem should be considered as a reference point, not an actual description of economic reality. Is the Second Welfare Theorem relevant? To this question we turn next.

POTENTIAL AND ACTUAL PARETO MOVES

One of the first examples, perhaps the first example, of gains from trade is Adam Smith's analysis of wine and wool exchange. Smith observed a fairly obvious fact: Scotland produces excellent wool but horrible wine, and France, by contrast, produces lousy wool and excellent wine. Consider an initial situation where no exports between France and Scotland are allowed. Assuming Figure 12.4 depicts Europe's feasible set (with France and Scotland welfare levels on each axis), this initial state corresponds to point E_3. (I'm assuming Europe comprises France and Scotland only. This is a simplifying assumption, not a political statement.) Note that point E_3 is not Pareto optimal, that is, it lies strictly below the Pareto frontier. Why? As Smith pointed out, it's a pity that the French use French wool and the Scots drink Scottish wine. By an appropriate exchange, we might reach a new outcome so that everyone drinks French wine and wears Scottish wool. And everyone will be happier!

Everyone? Not necessarily so. There is this fellow in Scotland who used to produce wine — or what he called wine — and is now out of work (it's hard to compete with French wine). In terms of Figure 12.4, we might say that opening the country to trade implied a movement from E_3 to E_4. This movement implies a huge gain for A but a loss (smaller, but still a loss) for B. If markets are competitive, you might argue that we could and should make the move from E_3 to E_4 and, at the same time, distribute resources from A to B so that we end up, as per the Second Welfare Theorem, in a point like E_2, where both A *and* B are strictly better off.

The above example helps illustrate an important difference. A movement from E_3 to E_2 is called a **strict Pareto move**: it's a move such that everyone is better off. By contrast, a movement from E_3 to E_4 is a **potential Pareto move**: conditional on a subsequent transfer from A to B, the final outcome is also E_2, in which case both A and B are strictly better off. However, the latter move is based on a big "if", namely the assumption that a movement from E_4 to E_2 will take place.

The distinction between a potential and an actual Pareto move is quite important from a political economy point of view. For example, it is, one might say, the critical point in the globalization debate. Pro-trade economists argue that Adam Smith's principles apply as well

Pete Souza

President Barack Obama signs the "United States-Korea Free Trade Agreement Implementation Act," in the Oval Office (October 21, 2011). Economists believe free trade leads to a *potential* Pareto move: Total gains from free trade are typically positive, most gain from it, though typically not all.

to France-Scotland trade in the 18th century as they do to US-China trade in the 21st century. Admittedly, there are Americans who stand to lose from lowering import tariffs to Chinese imports. Admittedly, opening up US-China trade leads us from E_3 to E_4, but surely we will be able to compensate B such that all Americans are better off. The counter-argument, however, is that compensation rarely if ever takes place, partly because it requires public funds which are hard to come by. We will return to this later.

ECONOMIC AND POLITICAL THOUGHT

In Section 7.2, I noted that the First Welfare Theorem has played a very important role in political thought for the past two centuries or so. I should now add that the same applies, though to a lesser extent, to the Second Theorem of Welfare Economics. Together, these two results form the basis for the following general principle of political economy: To the extent that markets are close to competitive, market equilibrium leads to efficiency. Efficiency per se does not mean that the equilibrium is fair. For example, in terms of Figure 12.4, one might argue that E_1 is not a fair outcome, for B's welfare is considerably greater than A's. This is where the Second Theorem kicks in. The idea is to redistribute initial endowments (i.e., cash, which is usually the easiest endowment to distribute) and let markets do the rest. Specifically, let markets lead us to a point on the Pareto frontier, this time one closer to a balanced outcome. In other words, the political thought based on the the above two theorems corresponds to the idea that we should create **equality of opportunities**, as measured by

initial endowments, rather than **equality of outcomes**, which may be very different if A and B have different tastes.

This is by no means a point of general agreement. At the risk of slightly simplifying the various schools of thought in terms of political economy, I think there are four different camps one might consider:

1. **Libertarians**. Respect private property, respect markets, respect individual freedom (so long it does not harm the freedom of others). Concern for others is an individual attribute, not a social one.

2. **Market-based, socially concerned**. Use the welfare theorems as a guide. Government policy should be focused on redistributing endowments, letting markets do the rest.

3. **Regulated markets, socially concerned**. Most markets are not competitive (think Facebook, Apple, etc). As such, the first theorem fails frequently. This calls for public policy focused on regulating markets, also as a form of distribution.

4. **Socialists**. Both of the theorems of welfare economics fail frequently. This calls for public policy focused on market regulation and distribution policies largely based on public provision of goods.

If I had to characterize the economics profession, I would say the vast majority fall under 2) and 3), with a recent slight shift from 2) to 3). In other words, one might divide the spectrum of political and economic thought along two dimensions. The first one is the extent to which the state should push for redistribution. This ranges from zero, for an extreme libertarian, to maximally (equality), for an extreme socialist. The second dimension refers to the instrument for distribution. At one end (extreme market based), the state enforces monetary transfers (initial endowments) between its citizens, letting markets do the rest. At the opposite end (extreme socialism), the state directly offers goods and services to its citizens, thus largely replacing the market in that role.

Many (most?) of the hot-button economic issues in the current political climate may be characterized as positions within the above

spectrum. They are frequently correlated, in the sense that, if you favor little distribution, the you are likely also to favor reliance on markets; and, if you favor massive distribution, then you are likely also to favor social provision of goods. However, the two dimensions are not perfectly correlated. In fact, one may argue that, compared to an average citizen, a typical economist tends to favor more distribution *and* more reliance on markets and market mechanisms. (If you're wondering, in this sense I am a typical economist.)

Economics research (cf Section 12.1) suggests that there is "demand" for reducing inequality levels (that is, there is a desire for fairness even if at the cost of one's own share). However, the debate about the precise desirable level of distribution is largely a matter of political debate. By contrast, the debate about the extent of state provision of goods and services is largely, though not entirely, an economics question. It is, to a great extent, a question of alternative means of achieving a given end (a fair distribution of well-being). This we discuss in the next section.

INCOME VS IN-KIND TRANSFERS

Should distribution take place primarily by means of money transfers or primarily be means of in-kind transfers, that is, by direct provision of goods and services? Market-oriented economists insist on the contrast between opportunities and outcomes. We are all different. For example, some people prefer a large house, whereas other people put more weight on their house's location. Therefore, even if A and B's surplus levels (an economic measure of well-being) are identical, these surplus levels may correspond to very different bundles (for example, A lives in a large house in New Jersey, whereas B lives in a tiny apartment in Manhattan). One size does not fit all. This view, which emphasizes differences in tastes, tends to favor income distribution rather than in-kind transfers. "It's not the state's business to get into business" would be an apt motto.

The opposite view also has its merits. First, as mentioned above, many markets are not competitive, and the market equilibrium may lead to undesirable outcomes. One specific but very important example is given by health markets, as we saw in Section 10.1. This can be fixed by market regulation (e.g., legislation such as the US Affordable Care Act) or simply by making the state the main supplier (e.g.,

health services offered by state-owned facilities with state-employed personnel, as is the case in several European countries).

Second, as mentioned earlier, not all consumers are fully rational at all times. In this context, direct supply of products and services may be an effective way of **nudging** consumers in the direction society considers desirable. However, you can see how controversial this line of argument can be, with more libertarian-leaning individuals warning against the dangers of "paternalism", that is, a society that turns into a "big brother" or a "nanny state".

The above list of points in favor of in-kind transfers is longer than the pro-market doctrine of "give them cash and let the market work." However, notwithstanding the many imperfections of many markets, the argument for separating resource distribution from resource allocation, that is, the argument that the two welfare theorems correspond to two different societal tasks, is a strong argument and one that has had a deep influence in economic thought.

> *The welfare theorems suggest that cash transfers are preferable to in-kind transfers. However, market imperfection and limited consumer rationality may favor in-kind transfers.*

Pro-market economist are frequently accused of being heartless. In some cases, the defendant is guilty as charged. In other cases, however, the accusation is based on a confusion (or conflation) of the roles of efficiency and fairness. When pro-market economists decry the effect that Hugo Chavez and Diego Maduro had on Venezuela since the beginning of the century, they are not critical of the leaders' concern for the poor, rather they are critical of their policy choices, which, pro-market economists would argue, are unsuccessful in helping the poor. There are ends and there are means. Most of the disagreement in matters of political economy stems from the latter, not the former.

EXAMPLES

Consider the case of **schooling**. Some people favor the system of public schooling whereby access to primary and secondary education is directly provided by the state (in the US, by each individual state). An alternative view is that education might be financed by the state

but supplied by private entities which follow the public-school principle of accepting students without charging tuition. In this US context, this corresponds to the system of charter schools. Still another alternative view is that education might be financed by the state in the form of school vouchers which can be redeemed at privately-run schools. Still another (less popular) alternative view is simply for the state to let the market provide education services. (This is the case in many instances of specialized and advanced education, less so in the case of primary and secondary education.) All in all, the above possibilities span a vast range of solutions with greater emphasis on income transfers, direct provision of services, or none of the above. Can you see the mapping from these alternatives to the political economic spectrum considered earlier?

Consider now the case of **pension systems**. Many economists argue that retirement age should be made as flexible as possible. Some people are very eager to retire and put their newly-acquired free time to good use. Other people, by contrast, enjoy their work (and the payment that comes with it!). Let each decide what's best for them: "Different strokes for different folks," as the saying goes. However, research suggests that about one third of US households headed by individuals older than 55 have no savings. In other words, a large (and growing) percentage of Americans are not prepared for retirement. For this reason, Oregon, Illinois and California have launched initiatives to create retirement savings accounts for residents whose employers do not offer company-sponsored programs. Basically, the government program takes money out of people's paychecks (5 percent) and places it into a retirement account with a few basic investing options. This type of policy seems to have voter support. For example, a poll conducted in Oregon for the AARP found that 82% of state residents like the idea of an automatic savings plan, i.e., "big brother" taking care of your retirement plan.

One final, somewhat unusual, example, comes from Baldwin, Florida. For a variety of reasons, in 2018 the only grocery store in town shut down. This is a common problem with very small towns that do not have enough scale to justify the opening of a store. However, the case can be made that the consumer surplus created by a store is sufficient to justify, from a social point of view, a store opening. The solution was for the city hall itself to open its own grocery store!

UNIVERSAL BASIC INCOME

A specific application of the principle described above, "give them cash and let markets do the rest," is supplied by the **Universal Basic Income** (UBI) policy. The idea is to provide every citizen with a certain amount of income (and to finance this transfer with taxes that are paid primarily by people with higher income or wealth or both). When defining UBI, it's important to state what it is not. In particular, UBI differs from means-tested support, a welfare policy whereby income transfers are targeted to those who need them the most. During the 2020 presidential campaign, candidate Andrew Yang made UBI part of his platform. His proposal was to provide each American adult $1,000 per month (what he called the "Freedom Dividend"). This would be financed with a value-added tax of 10% (half of the typical rate in European Union countries). A tax expert claimed that a more realistic plan would require reducing the Freedom Dividend to $750 per month and raising the VAT to 22 percent, but even then you can see how the idea may attract pro-market economists with social concerns, that is, economists who think cash transfers are the best way of moving along the Pareto frontier.

Opponents of the UBI system point to its very high cost: why raise distortionary taxes in order to send Bill Gates a $1,000 check? A very different but equally important criticism relates to the emotional effect of cash transfers such as the UBI. Economist Robert Shiller explains:

> We need to find a way to insure people against the risks of the global market without in any way demeaning them. ... When the government spends tax money on universal public education and health care, it does not strike many as redistribution, because the services are offered to everyone, and accepting them appears more patriotic than abject.

In this sense, UBI is clearly better than means-tested income support: having to pass a means test creates a social stigma that UBI does not (or does to a lesser degree). According to Shiller and others, direct service provision is an even better means. In conclusion, not all economists agree when it comes to the means to achieve a given end.

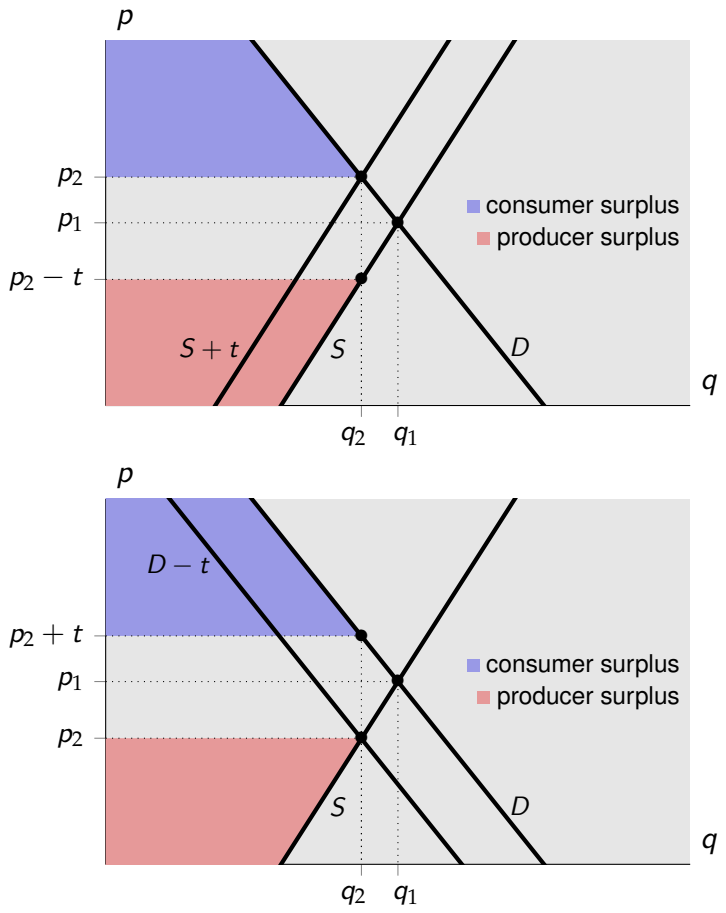


FIGURE 12.5
Principle 1: irrelevance of payer

12.3. TAXATION

Regardless of whether distribution takes the form of income transfers or direct provision of goods and services, the state needs resources to finance its activity. The main source of these funds is taxation. In this section, we cover some basic principles of the economics of taxation. For most of the section, we analyze, with the help of a supply-and-demand framework, the effects of a sales tax. However, the principles developed below apply to other forms of taxation as well.

TAX INCIDENCE

We begin with one of the most important principles in the economics of taxation: Ultimately, it makes no difference which party on a given transaction pays a tax.

> *Consumer surplus and producer surplus from a given tax are invariant with respect to the actual party responsible for paying the tax.*

In economics jargon, we say that the **incidence** of a given tax does not depend on who actually pays it. Figure 12.5 illustrates this idea. For the same set of supply and demand curves, the two panels consider two possibilities: in the top panel, a tax t paid by sellers (who therefore require a higher price for each unit sold); and in the bottom panel, a tax t paid by buyers (who therefore are willing to pay a lower price for each unit sold). As can be seen, the prices effectively paid by buyers and sellers are the same in both cases, and so is tax revenue.

This first principle reflects an important idea in economic analysis: When estimating the impact of any policy, we must take into account how economic agents (e.g., buyers and sellers) adapt to the policy in question. At some level, one might think that a buyer prefers that the tax be paid by the seller, not the buyer herself. However, once the seller is asked to pay the tax, he increases price accordingly. At the end of the day, the buyer spends the same amount, regardless of who is actually paying the tax. This is true beyond retail markets. For example, the US federal government collects payroll taxes from every job at the rate of 12.4%. Half of this amount is paid by the employer, half by the employee. Suppose the government were to decide that, from now on, all 12.4% are paid by the employer. Eventually this would be translated into a lower value paid to the employee and the net take-home would be the same.

There may be additional considerations that break the indifference between seller and buyer as the actual tax payer. Consider, for example, the case of a gasoline tax. It would be rather cumbersome to collect the tax from the millions and millions of buyers who fill up at the pump. For this reason, it makes a lot of sense for the government to collect the tax from sellers, not from buyers.

Finally, note that the above indifference result only applies to collecting from the buyer or from the seller of a given transaction. It *does* make a difference whether the government taxes a transaction in a market X or in a market Y. In fact, this is one of the main issues in the economics of taxation, namely to determine which transactions the government should tax.

EFFICIENCY LOSS

As we saw in Section 7.2, the equilibrium of competitive markets maximizes efficiency, that is, maximizes gains from trade. To the extent that a tax on a market transaction has an effect on equilibrium price and output level, we conclude that such a tax implies a loss of efficiency. For example, in Figure 7.16 we measured the **deadweight loss** implied by a competitive market distortion. Taxes make up one of the main sources of such distortion.

> *Taxes imply a loss in allocative efficiency (distortionary effect of taxes).*

The top panel of Figure 12.6 illustrates this point. Initially (no tax), equilibrium is given by price p_1 and output q_1. Suppose a tax t is imposed, to be paid by the seller. This implies a shift in the supply schedule and a new equilibrium where price paid by consumers is p_2 and the net price kept by the seller is $p_2 - t$. Given the price increase, output is now given by $q_2 < q_1$. This implies that all trades from q_2 to q_1 fail to take place as a result of the tax. These are trades such that willingness to pay, given by the (inverse) demand curve, is greater than marginal cost, given by the (inverse) supply curve. The sum total of the value of trades lost is given by the area of the shaded triangle. This is the deadweight loss due to the tax.

Deadweight loss, the sum of missing trades implied by a tax, is a dollar value. The revenues raised through taxes are also a dollar value. Therefore, we can measure the distortionary effect of a tax by computing the deadweight loss per dollar raised. This leads us a rather unfortunate principle:

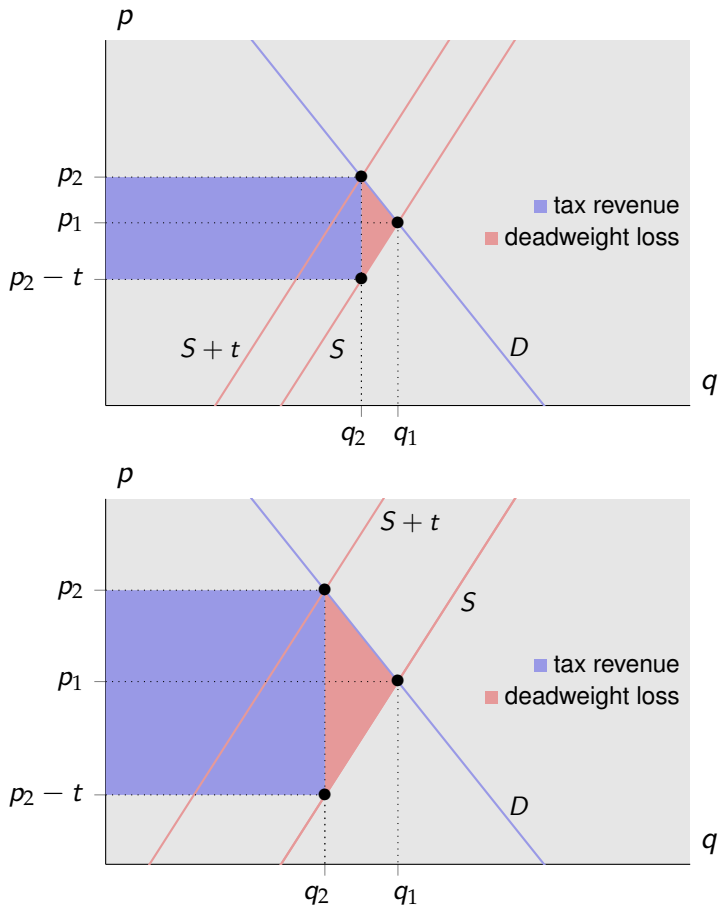


FIGURE 12.6
Principle 3: Increasing DWL

A tax's deadweight loss increases at an increasing rate. In other words, the deadweight loss per revenue dollar increases with the tax rate.

Let us rephrase this important principle in a more formal way. The value of a tax's deadweight loss is given by the area of the shaded triangle on the top panel of Figure 12.6. This area is given by

$$\frac{1}{2}\, t\, (q_2 - q_1)$$

The difference $q_2 - q_1$ is greater the greater t is. In fact, it varies approximately at the rate of t. This in turn implies that deadweight loss is given by

$$L \approx \alpha\, t^2$$

where α is a constant. In words, the deadweight loss varies approximately at the rate of t^2. That is, not only is deadweight loss greater the greater t is, but the rate at which L increases is itself increasing in t. This in turn implies that deadweight loss per unit of revenues raised is increasing in t. Figure 12.6 illustrates this by considering two different levels of t (top and bottom panels). Specifically, the bottom panel considers a higher tax rate than the top panel. In each panel, the deadweight loss is given by the area of the triangle from q_2 to q_1. Tax revenue, in turn, is given by the area of the rectangle $t\,q_2$. As can be seen, the ratio between the area of the triangle (deadweight loss) and the area of the rectangle (tax revenue) is greater in the bottom panel than in the top panel. In the limit, as t becomes very large, tax revenue goes to zero, and the ratio converges to infinity.

One important implication of this principle is that it may be better to spread taxation over many goods (e.g., a single VAT rate) rather than targeting only a few. That said, one should add that there may be reasons why some goods are targeted by taxation. This is the case, for example, with Pigou taxes (e.g., carbon tax), that is, goods which are taxed due to negative externalities (cf Section 9.1).

Trade policy (cf Sections 7.3 and 11.1) provides another application of the above principle. Opening up to trade largely corresponds to lowering import tariffs; and an import tariff is effectively a tax. As we move down to lower tariff levels, the additional welfare gain from a further cut in import tariffs becomes smaller and smaller. This is basically the counterpart of the principle that the deadweight loss per revenue dollar increases with the tax rate. By contrast, economist Dani Rodrik and others argue that the marginal cost of compensating losers becomes higher and higher as we converge to zero tariffs. This suggests that the optimal level of tariffs may be strictly greater than zero.

ELASTICITY AND THE EFFECT OF TAXES

There are many reasons why you would want to tax certain transactions and not others. For example, in Section 9.1 we look extensively at the role played by Pigou taxes in counteracting negative externalities. Carbon taxes, in particular, have been proposed by economists as a central tool to address the climate change crisis. Another important consideration is to minimize the distortionary cost of taxation.

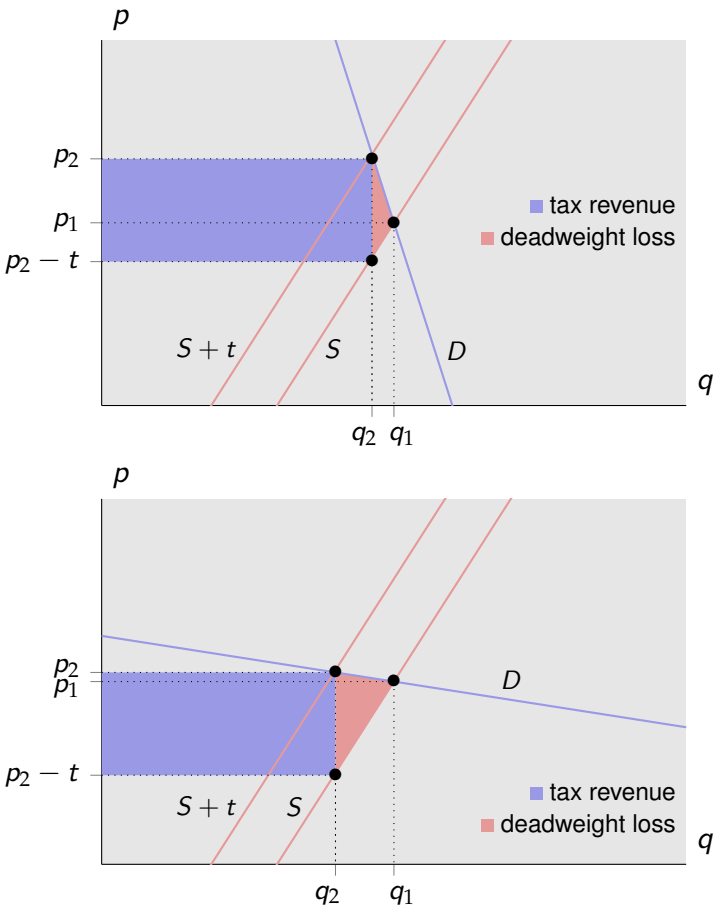


FIGURE 12.7
Principles 4 and 5: demand elasticity

In the previous subsection we saw that, everything else constant, we might want to "spread the wealth", that is, tax everything at the same rate. However, everything is not constant. In particular, different transactions correspond to different supply and demand curves. In this context, one important principle is that

> *The deadweight loss of a tax is greater the greater the price elasticity of demand.*

This is illustrated by the two panels in Figure 12.7. Both panels depict the same supply curve and the same tax (to be paid by the seller). The difference between the two panels is that the demand curve is steeper (more inelastic) in the top panel than in the bottom panel. As can be

seen, the area of the deadweight loss triangle is greater in the bottom panel, that is, the more elastic demand is, the greater the deadweight loss.

This principle suggests that, if the goal is to minimize deadweight loss per dollar of tax revenue, then it is better to tax goods with inelastic demand. Note, however, that there may be other reasons to tax goods with inelastic demand. For example, so-called **sin taxes** (e.g., taxes on cigarettes, alcohol, gambling) are targeted at goods with typically very low demand elasticities. However, the goal is to "nudge" consumers away from those products, products which happen to have inelastic demand.

Demand elasticity matters for the size of a tax's deadweight loss. It also matters in terms of incidence.

> *The incidence of a tax on consumers is greater the lower their demand elasticity.*

Again, the two panels in Figure 12.7 illustrate this contrast. When demand is more elastic (bottom panel), then most of the tax's impact is a lower net price received by the seller. In other words, consumers are relatively unaffected by the tax. This is intuitive: If demand is elastic, then consumers have options, alternative goods they can purchase instead of the good in question. As such, they are relatively immune to a tax. Obviously, the situation would be different if all goods, including the alternatives, were taxed.

One implication of the above principle is that, if the government wants to protect consumers, then it should primarily tax elastic demands. However, this may come at a high cost in terms of deadweight loss. In fact, as we saw earlier, the more elastic demand is, the greater the deadweight loss. (By now, you may have realized that there is always a "but" in economics.)

Finally, although Figure 12.7 refers to changes in demand elasticity, the principles also apply to supply elasticity. For example, if supply is very inelastic (i.e., the level of supply is not sensitive to price changes), then (a) the deadweight loss of a sales tax is relatively smaller and (b) the incidence of the tax falls primarily on the seller.

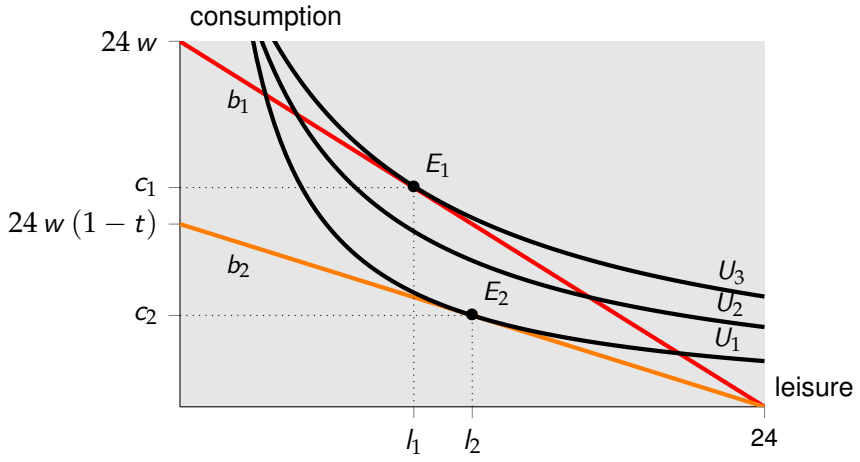


FIGURE 12.8
Income taxation and labor supply

INCOME TAXATION

So far, the discussion on the effects of taxation has been cushioned in terms of a sales tax. As mentioned earlier, the principles apply equally well to other types of taxes. For example, if the demand for labor is very elastic, then a tax on labor is likely to lower the net wage received by workers.

Notwithstanding the general nature of the principles on taxation, in this section we focus specifically on taxes on inputs, such as labor or capital. These are particularly important transactions in the economy and as such deserve a specific focus. In this context, one important principle is that

> *Taxing revenues from production inputs (capital, labor) may create a disincentive for input supply.*

Figure 12.8 illustrates this idea. It considers a worker's choice between income and leisure, similar to what we considered in Section 4.2. Initially, there is no tax. The worker's feasible set is limited by a straight line extending from $(24, 0)$ to $(0, 24\,w)$, that is, from 24 hours of leisure and no income to no leisure and an income of $24\,w$. Given the worker's preferences (indifference curves), the optimal choice is given by point E_1, corresponding to l_1 hours of leisure and, therefore,

TABLE 12.1
Taxes and economic growth

period	Fed. income tax / GDP (%)	GDP growth (%)
1868–1912	2.4	1.8
1913–1950	10.7	2.0
1951–2017	17.2	1.9

$24 - l_1$ hours of work. This corresponds to a consumption level c_1, which in turn is given by $(24 - l_1) \cdot w$.

Suppose now that a tax t is levied on labor income. This implies a rotation of the budget line around (24,0). Specifically, if the worker chooses zero hours of leisure (and 24 hours of work), then (net) income is $24\,w\,(1 - t)$. Given the worker's preferences, the new optimal point is E_2, corresponding to l_2 hours of leisure and, therefore, $24 - l_2$ hours of work. This corresponds to a consumption level c_2, which in turn is given by $(24 - l_2) \cdot w$.

Putting it all together, we conclude that an income tax implies a decrease in labor supply from $24 - l_1$ to $24 - l_2$. This is the essence of the problem of taxing income: the greater the tax rate, the lower the incentives for agents to engage in the economic activity underlying income generation, which in the present case corresponds to work.

Some notes are in order. First, as discussed in Section 4.2, the effect of a price change on quantity may be positive or negative, depending on the size of the income effect. Looking at the specific example of labor supply, the idea is that an increase in wage may imply an increase or a decrease in labor supply. In fact, empirical evidence suggests that, for low levels of w, an increase in w leads to greater supply, whereas, for high levels of w an increase in w leads to lower supply (because the income effect of a higher w dominates the substitution effect).

Second, the relation between income taxes and input supply is a contentious issue. At a now-famous 1974 dinner, economist Arthur Laffer, arguing against President Gerald Ford's tax increase, reportedly sketched a graph on a napkin illustrating that, starting from a high tax rate, a further increase in the tax rate leads to lower revenue. Although the idea had been known for a long time, the term **Laffer curve** caught up. The idea is that the effect illustrated in Figure 12.8 can be so strong that the decline in input supply (e.g., labor supply)

TABLE 12.2
Taxes and economic growth

Concept	1950–1980	1990–2020
Average top individual income tax rate	80	37
Average top estate tax rate	76	47
Average corporate tax rate	50	34
Average growth rate of GDP per adult	2.2	1.3

more than compensates for the increase in tax rate, to the point that tax revenues are lower.

The Laffer curve is certainly relevant for very high levels of the tax rate. In particular, if the tax rate is 100%, then the incentives for labor supply are limited, and it's likely that the value created is lower than it would be were tax rates lower than 100 percent. Consider, for example, a dentist who must decide how many days she wants to work each week. If the income tax rate is, say, 90%, then for each $100 she earns she only gets to keep $10. You can see how this would lead her to work less (for example, to work Monday to Wednesday instead of Monday to Friday).

What does the data suggest regarding the effect of income tax rates on input supply? Before answering this question, a very brief history of income taxation in the US is in order. Up to 1920, the (very small) federal government budget was paid primarily by import duties and liquor taxes. Prohibition eliminated liquor taxes, which in turn led Congress to create an income tax as an alternative revenue source. Later, during the years of Roosevelt's New Deal, income taxation was extended considerably and so was the government's role in distributing from those with greater income/wealth to those will lower means. Today, the federal government plays a bigger role in transfers than in providing goods, which explains the high income tax rates.

Regarding the relation between these rates and economic growth, the US historical evidence is not very clear. Table 12.1 shows that, historically, income tax rates have increased considerably: from 2.4% at the turn of the 20th century to 10.7% through mid-20th century to 17.2% during late 20th century and early 21st century. The GDP

growth rate, however, has remained steady at around 2%. Table 12.2 zooms in on the past 70 years. It shows that, compared the 1950–1980 period, several tax rates have been lowered in the past 30 years. The average top individual income tax rate, the average top estate tax rate, the average corporate tax rate — all declined from 50–80% to 34–47%. However, growth rates did not increase (as "predicted" by the Laffer curve), rather the opposite happened. That said, and as mentioned in Section 2.1, correlation is not causality, and absence of correlation is not absence of causality. In one case where we have evidence beyond pure correlation, a Congressional Research Service report found that the estate tax's net impact on private saving is unclear (it causes some people to save more and others to save less) and that its overall impact on national saving, a critical determinant of the amount of capital available for private investment, is likely negative.

CAPITAL VS LABOR TAXATION

For most people, their primary job is also their primary income source. Some, however, also earn income from their businesses, the shares they own, the capital assets they sell, and so on. Different income sources are taxed differently, and this variety of treatments has both efficiency and distribution implications. Particularly important is the distinction between capital and labor taxation, the focus of this section.

If the government needs to raise $1, what's the best way of doing so: taxing capital income or taxing labor income? From a distributional point of view, and to the extent that capital assets are more concentrated than labor income, there is an advantage in taxing capital rather than income. From an efficiency viewpoint, however, this is not necessarily the case. The economic theory on this fundamental problem is complex, long, and unfortunately largely unsettled. The results are very dependent on the particular assumptions regarding the structure of the economy and the behavior of agents (workers, consumers, firms, etc). Some argue that the substitution effect of capital taxation on savings is so large that capital should not be taxed at all. In other words, taxing capital would have such a negative effect on savings and investment that, in the long run, it would amount to "killing the goose that lays the golden eggs." However, others state

that the income effect of capital taxation may be so large that it is optimal to set capital taxes in a progressive pattern.

In case you need to refresh your memory, the substitution and income effects of a price change are discussed in Section 4.1, but here's how these concepts apply to the case at hand. (This paragraph is a little technical and may be skipped on a first reading.) An increase in capital taxation amounts to a decrease in the "price" of consumption today. In fact, what I give up (in terms of future consumption) is lower the greater the tax on capital. The change in the "price" of today's consumption has a substitution effect and an income effect. The substitution effect implies that I consume more today relative to future consumption. The income effect is the effect the price increase has on my real income. Since aggregate consumption is a normal good (more income implies more consumption), an increase in tax implies that I consume less today. If this income effect is sufficiently strong, then an increase in capital taxation leads me to save *more* (and consume less today). The idea is that I am so concerned about future consumption that I compensate for the increase in capital taxation by consuming less today. Sounds crazy but it's actually quite possible.

So, the bottom line of the economic theory on capital taxation vs labor taxation is that there is no bottom line. Much research still needs to be done. And it gets worse: most prior analysis measures capital and labor as aggregate factors, but, as we have seen multiple times, neither capital nor labor are homogeneous production factors: A sophisticated AI system is not the same thing as a building or a sewing machine (but all count as capital). Similarly, a rocket scientist or an experienced trial lawyer are not the same as a worker with only basic instruction (but all count as labor).

How are capital and labor taxed in practice? Regarding labor, the answer is relatively easy. If you reside in the US, are unmarried and hold a job paying $50,000 a year, then you pay 22% in federal income tax; 12.4% in payroll tax (social security), half of which is paid by your employer on your behalf; and 2.90% for Medicare, half of which is paid by your employer on your behalf. As we know from the discussion on incidence, it really does not matter whether it's you or your employer who pays: adding all up, a total of 37% is paid to the federal government (and this excludes state and city government). This may seem like a lot, but it's actually less than the average of OECD countries. Now suppose that instead of $50,000

you earn $150,000 a year. Then your income tax rate is a little higher, 24%, but your social security rate is actually lower: payments are capped at $8,537.40, which means that the rate you effectively pay is about 5.7%. So, all in all, a 150k job is taxed at approximately the same rate as a 50k job.

Regarding capital taxation, the question is much more difficult to answer. There are multiple rules and exceptions and exemptions. All in all, it's fair to say that capital income is taxed at a lower rate than labor income. Partly for this reason and partly due to the skill-biased nature of technical change, a number of people (including, for example, Bill Gates) have proposed the creation of a robot tax. At some level, there is merit to the proposal: labor is heavily taxed, which implies that the system incentivizes the development of labor-saving innovations: automatic checkout machines, ATM machines, assembly-line robots, and so forth. The critics of the robot tax also have a point: It's very difficult to define what a labor-substitution innovation is. In other words, most innovations fall somewhere in-between: they do substitute some workers but they also greatly enhance the productivity of other workers. It may simply not be a very practical tax, and ultimately may do more harm than good.

WEALTH TAXATION

Wealth taxation has become a hot topic in recent years, especially in the US, where former presidential candidates Sanders and Warren have made it as part of their political platforms. Sanders proposed to levy a 1% tax on wealth above $32 million (for married couples), and then slowly increase the tax for wealthier households all the way to 8% on wealth over $10 billion. Warren, who was advised by UC Berkeley economists Emmanuel Saez and Gabriel Zucman, proposed to levy a 2% tax on fortunes greater than $50 million and a 3% tax rate on fortunes greater than $1 billion.

The case for a wealth tax starts with the observation that, in the past few decades, we have observed a significant concentration of wealth among a small number of people. Moreover, at the current levels of wealth, interest rates, and estate tax rates we can easily fall into a trajectory where a new class emerges which lives off inherited wealth rather than acquired wealth.

To this, proponents of the wealth tax add that it's the only really viable option. True, many economists would advocate for a combination of a progressive income tax and an inheritance tax, rather than a tax on wealth. However, many of the super-rich actually have little income. For example, Warren Buffett and Mark Zuckerberg earn little more than they spend. For this reason, one may argue that

> Their wealth increases as a result of capital gains, not saved income. And because such gains are taxable only when the corresponding assets are sold, their annual increase in wealth essentially escapes taxation.

Alternatively, one might think that an inheritance tax would eventually take care of this issue, but some believe that such a tax is politically unfeasible ("opinion polls consistently show that while economists love the idea, most voters hate it"). (In the US, the inheritance tax rate is very small and applies to a small number of inheritances.)

The case against a wealth tax is multi-dimensional. Similar to an income tax, one may argue that wealth taxes create the wrong incentives.

> Imagine two very rich people. Joe is a spendthrift who buys yachts, fancy cars, diamonds, and other rapidly depreciating property. Because his spending habits keep his assets below the wealth tax threshold, he effectively is rewarded for his spending habits.
>
> Jane makes the same annual income as Joe. But she is a saver and investor, prudently putting money away for the future or using her wealth to help create or expand businesses and job opportunities. Because she accumulates sufficient assets to be subject to the wealth tax, she effectively is penalized for saving and investing.

To this, one might add the claim that wealth taxes are unfair.

> Most wealth has already been subjected to income and other taxes, perhaps multiple times. It doesn't seem fair to the holders of that wealth to suddenly pay additional taxes on assets that they thought were in the clear, and such taxes would signal that previous policy has failed.

There are also implementation issues. Perhaps the most important one is tax competition. If country A creates a wealth tax, then wealthy citizens have a big incentive to move to country B. In this respect, Switzerland provides a useful example. While the wealth tax base is defined at the federal level, tax rates vary considerably across locations and over time. It can be shown that, when two different cantons set different wealth tax rates, we observe a movement of taxpayers to the canton with lower rates.

Finally, in order to tax wealth you have to first measure wealth. At some level, this seems doable: bank accounts, stocks, bonds, and other financial assets are relatively easy to measure. However, this only corresponds to a fraction (less than half?) of the total wealth in the US. What about all of the assets for which there is no market price (e.g., the Vermeer painting hanging in my living room)?

ADDITIONAL NOTES

A few final notes on principles of taxation. First, a principle we might refer to as the "second-best principle". The above considerations and calculations typically assume that we start from an efficient market. But the world is more complicated: there are market distortions everywhere. In this context, taxes may actually create a "good distortion". Examples include Pigou taxes and sin taxes. (In a similar vein, allowing for market power by unions, or setting a minimum wage, may correct for an existing distortion. Note: this is a very controversial idea.) Another important consideration for tax design is the ease with which taxpayers can avoid or evade a tax. This is particularly important when it comes to income or wealth taxes, but not exclusively. Finally, we must also consider the issue of a tax's political feasibility. Nobody likes taxes, but there are taxes which people particularly dislike. (And, possibly, taxes which people love, especially if they apply to others.)

PHILANTHROPY

One additional argument against a wealth tax is that many (most?) wealthy people put their wealth to good use, in particular through philanthropy. A particular case in point is the Giving Pledge created by Bill Gates and Warren Buffett in 2010. In essence, this is a cam-

British Crown

Melinda Gates speaking at the UK's Department for International Development. The Bill and Melinda Games Foundation ("All Lives Have Equal Value: We are impatient optimists working to reduce inequity") has spearheaded a number of philanthropic causes, including the fight against malaria.

paign to encourage extremely wealthy people to contribute a majority of their wealth to philanthropic causes. As of May 2019, it counted 204 signatories (individuals or couples) from 22 countries. From the *Giving Pledge* website:

> The goal is to talk about giving in an open way and create an atmosphere that can draw more people into philanthropy. ... The pledge does not involve pooling money or supporting a particular set of causes or organizations. ... The pledge is a moral commitment to give, not a legal contract.

Specifically, the pledge taken by its signatories, which is not legally binding, corresponds to the "commitment to give the majority of their wealth to address some of society's most pressing problems." Table 12.3 suggests that, if fulfilled, the pledges would correspond to substantial contributions, probably at levels at or above what a wealth tax would levy.

That said, one must also beware of the perils of billionaire philanthropy. Philanthropy may result in little more than self-serving policy advocacy. A number of wealthy donors (e.g., the Koch brothers) use their philanthropy to advance specific causes, which may or may not correspond to the will of most. For example, an important share of charitable donations are directed at educational institutions. In this context, a danger posed by philanthropy is that highly exclusive schools in affluent school districts receive a disproportionate share of funding, thus compounding one important source of inequality and absence of social mobility.

TABLE 12.3
Giving Pledge Top 10 by net worth (source: Giving Pledge)

Name	Net worth ($b)
Bill and Melinda Gates	101.0
Warren Buffett	87.4
Larry Ellison	62.5
Mark Zuckerberg and Priscilla Chan	62.3
Michael R. Bloomberg	55.5
MacKenzie Bezos	36.6
Azim Premji	22.6
Elon Musk	22.3
Jim and Marilyn Simons	21.5
Paul G. Allen	20.3

But it gets worse (or may get worse): Recently, the US witnessed a major case of corruption in higher education, whereby wealthy parents bribed college coaches, test proctors, and others to rig college admissions, while funneling funds through tax deductible foundations. Also, some foundations pay family members to serve on boards, staff foundations, and subsidize family reunions in the form of board meetings. In other words, sometimes philanthropy is nothing more than a form of self-dealing.

Obviously, this is not the case of all, or even most, philanthropic foundations. For example, the Gates Foundation has committed more than $7 billion to programs related to infectious diseases control and malaria control, an investment that would likely not be taken by any individual government.

KEY CONCEPTS

laboratory experiment | ultimatum game | intertemporal favor-exchange | altruism | intrinsic reciprocity | instrumental reciprocity | Pareto frontier | Pareto optima | Second Welfare Theorem | strict Pareto move | potential Pareto move | equality of opportunities | equality of outcomes | libertarians | market-based, socially concerned | regulated markets, socially concerned | socialists | nudge | schooling | pension systems | Universal Basic Income | incidence (tax) | deadweight loss | sin tax | Laffer curve

REVIEW AND PRACTICE PROBLEMS

■ **12.1. Self interest.** True or false: The first principle of economics is that every agent is actuated only by self-interest.

■ **12.2. Ultimatum game.** What is the ultimatum game and what do we learn from its laboratory experimentation?

■ **12.3. Favor-exchange game.** What is the favor-exchange game and what do we learn from its laboratory experimentation?

■ **12.4. Reciprocity.** What do we understand by reciprocity? What types of reciprocity can one consider? How do these concepts help understand behavior in the favor-exchange game?

■ **12.5. Ultimatum game (reprise).** Consider the ultimatum game introduced in class. Player 1 is asked to share $100 with Player 2. Player 1 makes a proposal. Player 2 either accepts the proposal, in which case payoffs are distributed according to the proposal; or Player 2 turns down the proposal, in which case both players receive zero payoffs.

Based on a series of laboratory experiments, it has been observed that the probability of acceptance is given by the values on the top panel of Figure 12.9. For example, if Player 1 offers 30 to Player 2, then the latter accepts the offer with probability 80%. It is never observed that Player 1 offers more than 50% to Player 2, so only the values 0 to 50% are displayed.

(a) What do the values of probability of acceptance say about the economics' assumption of individual (selfish) utility maximization? Specifically, if Player 2 were to maximize Player 2's monetary payoff, how would their strategy differ from the observed behavior?

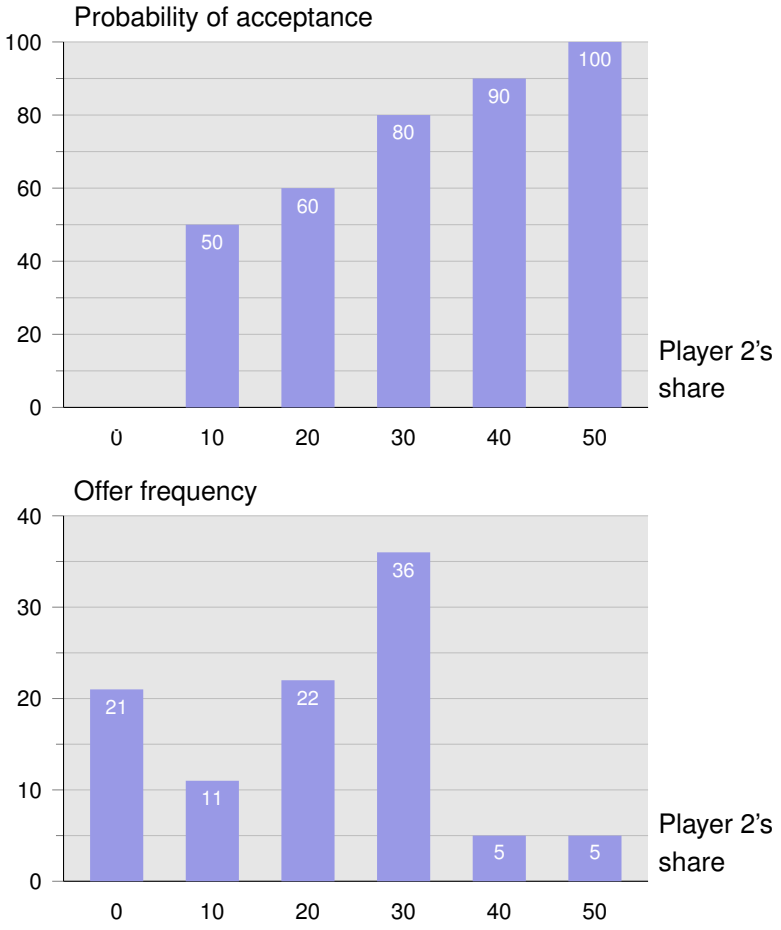


FIGURE 12.9
Ultimatum game

(b) Assuming that Player 1 is aware of the values on the top panel of Figure 12.9; and assuming that Player 1 is rational (that is, wants to maximize the expected value of their payoff), determine the optimal fraction that Player 1 should offer Player 2. (Hint: compute the product of Player 1's payoff times the probability that Player 2 accepts the offer for each possible offer value.)

(c) What is the outcome that maximizes joint payoffs? Explain the nature of the tension between individual optimality and social optimality.

(d) The bottom panel of Figure 12.9 shows the frequency with which each offer was made during the experiment. What do these values say regarding the economics' assumption of selfish maximizing behavior?

■ **12.6. Pareto.** What is a Pareto optimal allocation?

■ **12.7. Pareto frontier and welfare theorems.** How can the First and the Second Welfare Theorems be formulated with respect to the Pareto frontier?

■ **12.8. Strict and potential Pareto move.** Explain the difference between a strict and a potential Pareto move.

■ **12.9. Income vs in-kind transfers.** What is the case for solidarity through income transfers as opposed to in-kind transfers? Conversely, what is thee case for solidarity through in-kind transfers as opposed to income transfers?

■ **12.10. Wealth distribution.** Table 12.4 shows the results of a 2015 Gallup poll on Americans' attitudes towards wealth distribution. The first column indicates classifications of those surveyed by group. The second column ("fair") shows the percentage of those of believe the current wealth distribution is fair. The third column ("unfair") shows the percentage who believe wealth should be more evenly distributed. The final column shows the percentage of those who did not know the answer or refused to answer.

(a) What are the main correlations between a person's characteristics and a person's views on wealth distribution? Do any of these correspond to a causal relation?

TABLE 12.4
Results from 2015 Gallup poll with the question,
What are your views on the distribution of U.S. wealth?

Group	Fair	Unfair	No answer
Adults	31	63	6
Democrats	12	86	2
Independents	32	61	7
Republicans	56	34	9
18 to 34	30	66	4
35 to 54	30	64	6
55+	34	59	7
Under $30k	20	74	5
$30 to $75k	31	62	6
$75k+	41	54	5

(b) Overall, for each American who believes that the current distribution is fair, there are two Americans who believe that the current distribution is not fair and that re-distribution should take place. In a country where elections are decided by much small differences, this 63 to 31 is a large difference. How can we then explain that more distribution does not actually take place? (Note: this is an open question.)

■ **12.11. Liberty city.** Listen to the podcast *The Liberty City* (or read the transcript). How does it relate to the Chapter 12 discussion regarding income transfers vs in-kind transfers? How does it relate to the Chapter 9 discussion regarding public goods?

■ **12.12. Incidence.** What do we mean by the incidence of a tax? What does it depend on?

■ **12.13. Import tariffs.** In October 2020, President Trump asserted that "We are making tremendous progress with this horrible disease

that was sent over by China," adding that "China will pay a big price for what they did to the world and to us." Although the President did not specify the way this price would be paid, many believe that it consisted of higher import tariffs directed at Chinese exports. Are tariffs an effective way of making China "pay the price"? What does the recent research (here, here, here, here suggest — H/T Catherine Rampell)? How would you explain these results in light of the analysis in Section 12.3? (Hint: recall that an import tariff is essentially a sales tax, so the analysis of tax incidence applies equally well to import tariffs.)

■ **12.14. Deadweight loss.** Explain in words why the deadweight loss of a tax increases with tax level and increases at an increasing rate?

■ **12.15. Income taxation.** What do we mean by the incentive effects of income taxation? Provide an example.

■ **12.16. Income tax rate and income tax revenue.** Based on the consumption-leisure choice model, show that the relation between tax rate and tax revenue has the shape on an inverted U.

■ **12.17. Inheritance tax.** Read the article, *Tax the Rich and Their Heirs*. What are the arguments in favor and against increasing inheritance taxes, both in terms of efficiency and in terms of fairness?

■ **12.18. Wealth tax.** Watch this wealth tax debate.

(a) Summarize the main points in favor of wealth tax.

(b) Summarize the main objections by Summers and by Mankiw.

(c) Summarize the main points refuting these criticisms.

CHAPTER 13

OPPORTUNITY

Broadly speaking, we can think of two ways to solve the wide inequalities documented in Section 11.1. One is to redistribute income and wealth, as discussed in Section 12.3. An alternative approach is to create opportunities for upward economic mobility, the focus of this chapter. How important is a person's starting point in terms of their life opportunities? Relevant factors include wealth, race and ethnicity, genetic factors, family structure, and location (the country where they were born and the neighborhood where they grew up). The goal of economic opportunity is that a person's options at birth be as much as possible independent of the above factors.

13.1. MIGRATION

Based on the media coverage we are exposed to, the word "migration" evokes images of refugee migrants. For example, in recent years, millions of middle-eastern refugees fled war-stricken countries such as Syria seeking asylum in countries such as France or Germany. According to the UN, as of 2019, a total of 79.5 million of the world's inhabitants (about 1 in 100) were displaced for involuntary reasons. Table 13.1 displays the top source and the top host countries of refugees as of 2019. The source countries listed in Table 13.1 account for more than two thirds of the total. Three out of four refugees are hosted in neighboring countries, a fact that is reflected

TABLE 13.1
Forcibly displaced people worldwide at the end of 2019 (source)

Top source countries (million)		Top host countries (million)	
Syria	6.6	Turkey	3.6
Venezuela	3.7	Colombia	1.8
Afghanistan	2.7	Pakistan	1.4
Sough Sudan	2.2	Uganda	1.4
Myanmar	1.1	Germany	1.1

in a close parallel between the two rankings in Table 13.1. But as important and dramatic as these migratory movements are, the fact is that more than 90% of the world's movements of people occur for voluntary reasons, typically migrants who seek better economic opportunities. Accordingly, the focus of this section is on migration as an economic phenomenon, that is, as a source of economic opportunity.

MIGRATION AS ECONOMIC OPPORTUNITY

Figure 13.1 shows the income probability density of the world (blue) and the US (red). (See Section 11.1 for more details.) The first thing that stands out is the fact that US incomes are, by and large, higher than those of other countries. The second interesting observation is that the range of incomes in the world distribution is considerably higher than in the US. In the US, practically no one has an income lower than a few thousand dollars. Elsewhere in the world, your income may be as low as $100 a year or less. Income inequality is not just an issue within the US and within other high-income economies, in fact it's even more important worldwide. In other words, if we had to predict a newborn's economic prospects, we would say that the place where he or she is born would explain a lot of the variation in predicted outcome. In a way, this is just a way of repeating the idea that migration is an important source of opportunity: The country where you are born may put you at a significant economic disadvantage with respect to people born in other countries, and migration may be a way of leveling that difference. In sum,

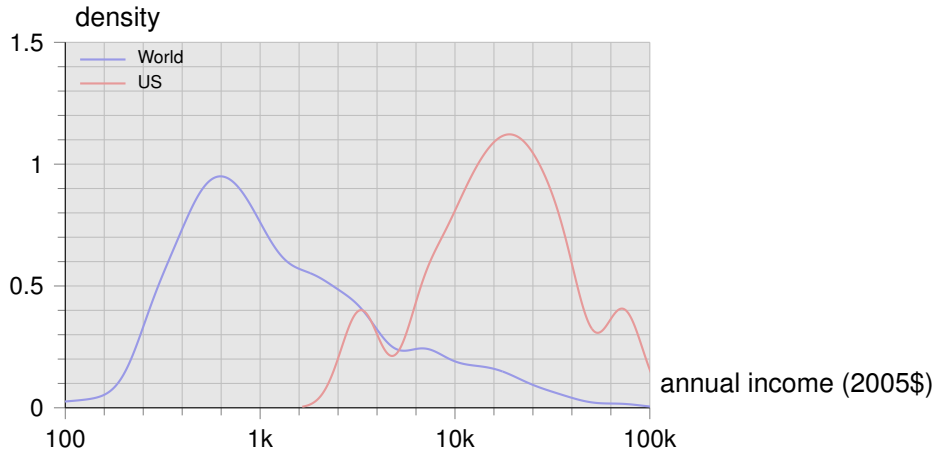


FIGURE 13.1
Income density distribution in the world and in the US (2008).
Source: LM-WPID database and author's computation

Migration is an important source of opportunity, namely economic opportunity.

As of 2014, 247 million people lived in a country not of their origin. Consistent with the idea of economic opportunity, broadly speaking, migrants originate in developing countries and move to more economically developed economies. Table 13.2 shows the top 10 source countries and top 10 host countries in 2014. The US is, by a long shot, the country with the largest number of foreign-born residents: 47 million.

Migration has continuously grown over time. In the past few decades, it has essentially grown at the same rate as population has grown. However, the data shows that, between 2000 and 2018, the increase in foreign-born population accounted for more than three-quarters of the total population increase in European OECD countries, and for almost 40% of the increase in the United States.

From the data in Table 13.2, it's easy to think of the US as the "land of opportunity": the number of individuals who have moved to the US looking for a better life is astounding. However, in relative terms (that is, controlling for country size), the data paint a different picture. Figure 13.2 shows the number of foreign-born population *as a percentage* of the host country's or host city's total population for

TABLE 13.2
Top 10 migrant origins and destinations by the end of 2014 (source)

Top migrant origins (million)		Top migrant destinations (million)	
India	16	United States	47
Mexico	12	Germany	12
Russia	11	Russia	12
China	10	Saudi Arabia	10
Bangladesh	7	United Kingdom	9
Syria	6	United Arab Emirates	8
Ukraine	6	Canada	8
Pakistan	6	France	8
Philippines	5	Australia	7
Afghanistan	5	Spain	6

various countries and cities of destination. The contrast between Figure 13.2 and Table 13.2 is remarkable. Australia, which is a the ninth destination in absolute numbers, is the most significant in terms of percentage of domestic population. Figure 13.2 also shows that the relative importance of foreign-born population varies considerably from city to city, with Sidney, Miami and London being some of the world's very large and very international cities.

Figure 13.2 is restricted to a selected number of (relatively large) countries. If we were to look at the whole sample we would find unusual cases such as Luxembourg. Luxembourg is a small European country with a mere 281 thousand foreign-born residents in 2018. However, this represents an enormous fraction of the domestic population, close to *one half*. In this sense, it would appear that Luxembourg is more of a "land of opportunity" than the US. Another interesting fact related to Luxembourg is that more than 80% of the foreign-born population was born in other European Union countries. The idea that migration is primarily a movement of individuals and families from developing to mature economies is not always accurate. That said, one must add that more than 30% of foreign-born Luxembourg residents were born in Portugal, which, while not being

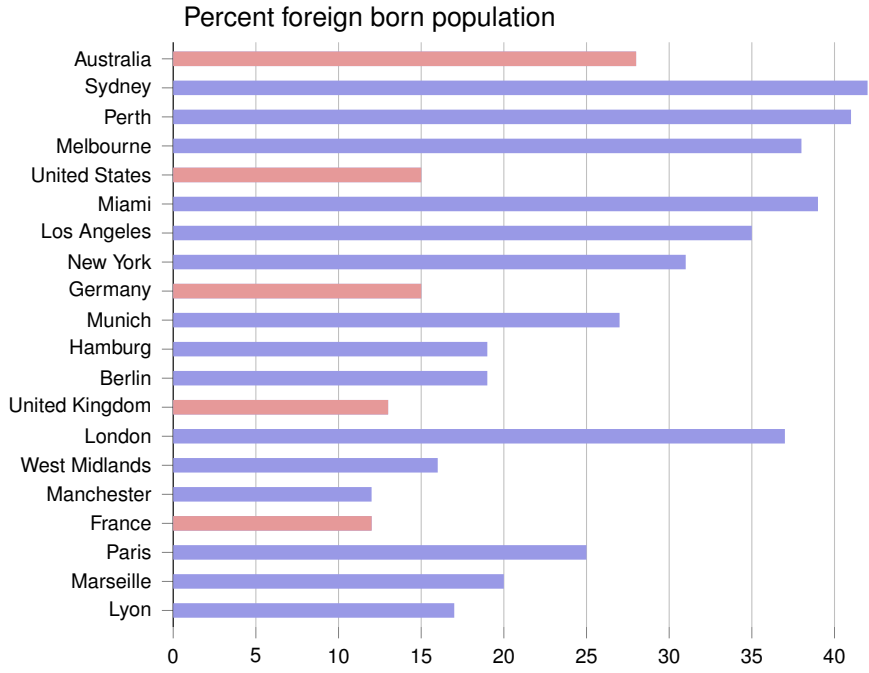


FIGURE 13.2
Migrants as a share of population in selected countries and cities (source)

a poor country, is certainly poorer than Luxembourg.

MIGRATION AS A MARKET OUTCOME

In various parts of the book, I stressed the point that trade generates value, and that markets, by facilitating trade, create value too. To repeat the example considered in Section 7.2, suppose that Jane would be willing to pay up to $10 for one pound of golden delicious apples. It costs Old McDonald 50 cents per pound to grow apples. When Old McDonald sells one pound of apples for $3 per pound, the seller is $2.5 better off and the buyer is $7 better off. Trade can be a win-win operation.

Similarly, migration can in principle be a win-win process. More generally, we can think about the world as a "market" where countries supply citizenship/residence and individuals demand citizenship/residence. To the extent that individuals have different preferences regarding location, political regime, economic opportunity, etc, there is the potential that movements of people across countries cre-

ate value both for themselves and for the countries they move to. In addition to this market-based idea, one can also think of migration as a manifestation of an individual's freedom. The pursuit of happiness frequently includes a choice of where to live, and we should strive to offer to all the ability to pursue their happiness.

Interestingly, this line of argument also suggests that differences across countries (for example, in terms of societal and political organization) may be a good thing. In Section 1.2, we talked about varieties of capitalism. More generally, we also observe varieties of democratic systems. Is the French presidential system better than the German parliamentary system? Is the more market-based US system better than the more socialist system of Denmark or France? In some sense, these may be the wrong questions, for they ignore the possibility that each system is more appropriate for the majority of each country's residents. In this sense, rather than making all countries identical in terms of economic and political system, the world may be better off by allowing for differences across countries and, at the same time, providing the world's citizens the freedom to choose between systems.

ECONOMIC EFFECTS OF MIGRATION

In Section 5.1, we introduced the concept of production function with two inputs. Table 13.3 provides a numerical example of such a production function when there are two production inputs, capital (K) and labor (L). For each value of K and L, Table 13.3 shows the value of output. In Section 5.1, we also introduced the concept of decreasing marginal returns of a given input. As a reminder, consider, for example, the production function of restaurant meals. It requires two inputs, kitchen space (in square feet) and workers. Fixing the input "kitchen space", you can see how the contribution of an additional worker would decline as more workers are added. In terms of Table 13.3, we can measure diminishing marginal returns by fixing $K = 1$ (for example). The output added by the first worker, second worker, etc, is then given by 100, 41, 32, 27, 23, 21. Decreasing marginal returns.

Another feature of most production functions (including the one in Table 13.3) is that the marginal return from adding a worker (say, a second worker) is greater the greater the amount of capital. For

TABLE 13.3
Production with two variable inputs

$K \downarrow L \rightarrow$	1	2	3	4	5	6
1	100	141	173	200	223	244
2	141	200	244	282	316	346
3	173	244	300	346	387	423
4	200	282	346	400	447	489
5	223	316	387	447	500	547
6	244	346	423	489	547	600

example, as K changes from 1 all the way to 6, the added output obtained from a second worker is given by $141 - 100 = 41$ if $K = 1$, $200 - 141 = 59$ if $K = 2$, ... all the way to $346 - 244 = 102$ if $K = 6$. In a way, this property is similar to diminishing marginal returns. Generally speaking, we might say that the output added by one worker is greater the greater the ratio of capital over labor, that is, the K/L ratio.

What does this all have to do with migration? A lot: One of the main differences between developing and developed economies is precisely that developed economies are more capital intensive, that is, have a higher K/L ratio. Going back to Table 13.3, it's as if a migrant were to leave from a firm with $(K = 2, L = 4)$, so $K/L = \frac{1}{2}$, where that worker's contribution was $282 - 244 = 38$, and move to a firm with $(K = 5, L = 2)$, so $K/L = 2.5$, where the worker's contribution is $387 - 316 = 71$. Following this line of argument, a McKinsey report estimates that, considering differences in worker productivity across countries, migrants contributed roughly \$6.7 trillion, or 9.4%, to global GDP in 2015 — some \$3 trillion more than they would have produced in their origin countries. North America captured up to \$2.5 trillion of this output, while up to \$2.3 trillion went to Western Europe.

The simple economics of production functions and input mix suggests that the overall economic gain from migration can be significant. But: are all parties better off? It seems reasonable to assume that migrants are better off. This is a classic example of what economists refer to as revealed preference: If migrants move of their own voli-

tion, and assuming that they are well informed about the conditions in the host country, then the move signals that they are better off by migrating.

Regarding the country of origin, the question is not so simple. Going back to the previous example, the marginal contribution $282 - 244 = 38$ is lost. However, the data shows that a substantial amount of the $387 - 316 = 71$ created by the worker in the host country is sent to the country of origin in the form of cash remittances. In 2014 only, remittances totaled $580 billion (roughly 8.7% of the output generated by migrants). The largest inflows went to India ($70 billion), China ($62 billion), and the Philippines ($28 billion). In many cases, however, the losses may be greater than the gain. In fact, it is estimated that remittances correspond to about one half of the value migrants would have generated in their country of origin if they had not moved. This is especially true for high-skilled workers, the so-called **brain drain** problem, that is, the loss in human capital due to emigration. One study found that dozens of poor countries, mostly small countries in sub-Saharan Africa, developing Asia, and the tropics, were losing one third to one half of their college graduates.

Finally, the effects on the host country are generally estimated to be positive. Much of the economic contribution of immigrants is captured by their employers and by tax authorities. Moreover, the immigrants' entrepreneurial and innovative effort contributes significantly to the economic growth of their host economies. That said, when discussing the effects of immigration, one cannot avoid the controversy regarding the impact on wages and unemployment: Aren't immigrants simply replacing domestic workers and sending the latter to the ranks of the unemployed, or at least putting additional downward pressure on wages, especially lower-skill wages? A simple supply-and-demand analysis suggests that immigration, by pushing the supply curve to the right, leads to a new equilibrium with lower wage rates. In fact, one study estimates that a 10% increase in immigration leads to a 3 to 4% decline in wages.

However, two important remarks are in order. First, the standard supply-and-demand diagram assumes that labor is a homogeneous production factor. In reality, there are many different qualification levels, many different skills, etc. Earlier, we saw that capital and labor may be complementary inputs, in the sense that a higher level of

capital benefits labor (specifically, increases the marginal product of labor). Something similar can happen between different types of labor. For example, it may be that native labor is better at tasks that require command of the local language, whereas immigrants are relatively better at tasks that do not require such language skills. To the extent that we have complementarity between types of labor, the effect of immigration could well be to increase the average wage of native workers. To give a simple example: Even Google, which hires a lot of high-skilled workers, needs janitors to clean up its buildings. If immigrants take those jobs, they replace, and thus displace, native workers. However, many of these displaced workers might find a job as, say, checkout clerks, a job at which they might have greater relative advantage. Inevitably, there are adjustment costs to be paid, but it's not impossible that all be made better off. In fact, one study that controls for type of work (as well as the particular commuting zone where immigrants are located) suggests that immigration has a zero or *positive* effect on the wages earned by native workers.

Naturally, the effects of immigration go well beyond the short-run effect on wages. As we saw in Section 2.3, immigration quotas, especially when applied to skilled immigrants, produce significant harm to the domestic economy. That's a clear lesson from US economic history: Between 1921 and 1924, the US first adopted immigration quotas for "undesirable" nationalities, so as to stem the inflow of Eastern and Southern Europeans (ESE). It is estimated that, due to these quotas, 1,170 ESE-born scientists were missing from US science by the 1950s. This in turn led to a 68% decline in patenting in the fields where ESE immigrants researched. Moreover, these effects were still felt well into the 1960s. More generally,

> *The evidence broadly suggests that migrants of all skill levels make a positive economic contribution to their host country, whether through innovation, entrepreneurship, or freeing up natives for higher-skill jobs.*

Given this evidence, why is there so much resistance to immigration? First, as mentioned earlier, the benefits to the host country are not uniform across time or across the population. In particular, the case can be made that *some* domestic workers experience lower

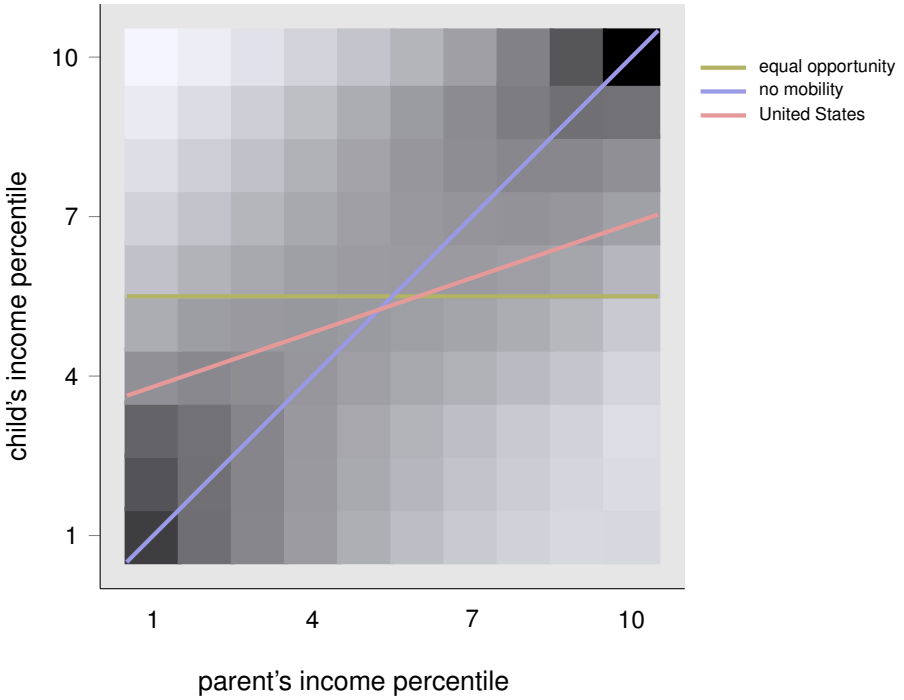


FIGURE 13.3
US income transition matrix by percentile (source: Opportunity Insights and author's calculations). A darker square corresponds to a higher conditional probability of child's percentile given parent's percentile.

wages following an influx of immigrants. Second, the public perception regarding immigrants is frequently misinformed. For example, a survey shows that as many as 38% Americans agree that "immigrants today are a burden to our economy because they take our jobs and social benefits." However, it can be shown that the per-capita cost of providing welfare to immigrants is substantially less than the per-'capita cost of providing welfare to native-born Americans. Ultimately, attitudes toward immigration are largely influenced by non-economic arguments.

13.2. INTER-GENERATIONAL MOBILITY

In the previous section we, looked at the opportunity to improve one's economic condition by moving to a different country. Within a given country, a person's opportunities also depend on his or her

parents: We inherit genes, possibly some wealth, and grow up where our biological or adoptive parents live. How important are these factors in determining an individual's economic opportunities? A way of addressing these questions is to construct a **mobility matrix**. Figure 13.3 does so for the United States based on the 1980-82 birth cohorts. The way this matrix is constructed is as follows. First we divide the parents' income into ten deciles: decile 1 corresponds to the bottom 10%, decile 2 to the second bottom 10%, and so forth, all the way to decile 10, which corresponds to the top 10% of the parents' income distribution. Next, within decile 1 (bottom 10% of the parents' income) we tabulate the children's income level when adults. Specifically, we assign the child's income to each of the 10 deciles of the overall distribution of children's income. Instead of writing the fraction of children's income corresponding to each decile, in Figure 13.3 we color each square in the first column according to the value of each cell. The fact that the (1,1) cell is very dark signifies that, conditional on the parent's income falling into the first decile, it is very likely that the child's income also falls into the first decile. By contrast, the fact that the (1,10) cell is shaded white signifies that the probability that the child's income falls into decile 10 (the richest), given that the parent's income falls into the lowest decile, is very close to zero.

More generally, Figure 13.3 suggests that inter-generational mobility in the US is rather limited. If the parent's income is at or close to the bottom decile, then it's very likely that the child's income falls at or close to the bottom decile. Conversely, if the parent's income is at or close to the top decile, then it's very likely that the child's income falls at or close to the top decile. In the limit when the child's income ranking is *exactly* the same as the parent's income ranking, we would observe the cells along the main diagonal in black and the off-diagonal cells in white. The pattern in Figure 13.3 differs from that extreme, but we do observe the general pattern that off-diagonal cells are shaded lighter than cells close to the main diagonal.

Another way of expressing the degree of inter-generational mobility, or lack thereof, is to correlate the child's ranking (vertical axis) with the parent's ranking (horizontal axis). Zero mobility would yield a relation like the blue line in Figure 13.3: the child's rank is equal to the parent's rank. At the opposite extreme, if your parent's rank says nothing about your own rank, then the child's expected

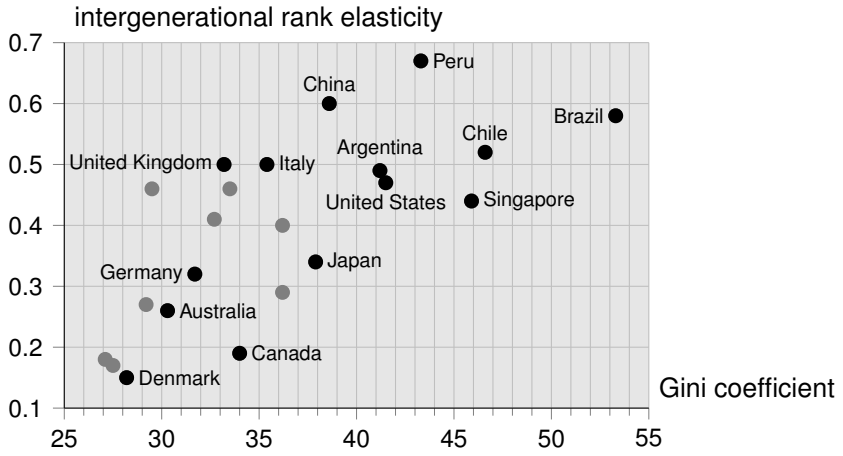


FIGURE 13.4
The so-called Great Gatsby curve: Income inequality and intergenerational elasticity (*x* source and *y* source)

rank is 50% regardless of the parent's rank. This corresponds to the green line in Figure 13.3. The actual regression based on US data corresponds to the red line. The slope of this line is given by .341. For comparison purposes, the slope of the same line estimated is .180 in and .174 in Canada. Both of these values are considerably closer to zero, that is, closer to the green line in Figure 13.3 (the line corresponding to equal opportunity). This suggests that inter-generational mobility is considerably lower in the US than in Denmark or Canada.

A similar statistic of inter-generational mobility is given by the **rank elasticity**: if we increase the parent's rank by 1%, how much does the child's rank increase. An elasticity of zero denotes equal opportunity: the parent's rank has no effect on the child's rank. At the opposite end, an elasticity of 1 corresponds to no mobility. One meta study combined several estimates for several countries and reached a series of meta-estimates for twenty-one countries. These are plotted in Figure 13.4, together with each country's Gini coefficient, which, as seen in Section 11.1, measures the degree of income inequality.

Figure 13.4 suggests three observations. First, there is a positive correlation between inequality (Gini coefficient, on the *x* axis) and lack of mobility (rank elasticity, one the *y* axis). Norway, Finland and Denmark are countries with relatively little inequality *and*

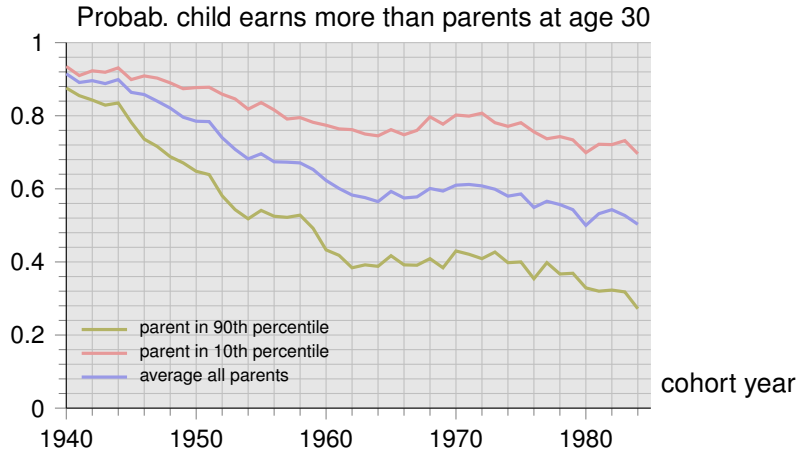


FIGURE 13.5
The fading American dream (source)

where your parents' position on the income distributions says relatively little about where on the income distribution you will end up. Second, the US stands out as a clear outlier among this set of developed economies, with both a high degree of inequality and a low degree of inter-generational mobility. Third, while there is a positive correlation, there is also considerable variation and a few outliers. For example, the UK and Canada, while having similar levels of inequality, are quite different in terms of inter-generational mobility (fairly high in Canada, fairly low in the UK). (The cross-country relation between inequality and inter-generational mobility is sometimes known as the Great Gatsby curve. There is no clear justification for the positive relation, but it's nevertheless an interesting relation.) Overall, we conclude that

> *Across countries, there is a positive correlation between measures of inequality and measures of inter-generational inertia. Within developed economics, the US shows one of the highest levels of both inequality and lack of mobility.*

In other words, the US is much less the "land of opportunity" that is often pictured. The difficulty of Americans rising above their parents' economic conditions is, in some way, a new phenomenon. Figure 13.5, aptly titled "The fading American dream," plots the probability that, at age 30, an American's income is greater than his or her

parents'. Three curves are plotted: The red curve restricts to parents on the 10th decile. The green curve, to parents on the 90th percentile. Finally, the blue curve corresponds to the overall average. Figure 13.5 suggests that, for an American born in 1940, the likelihood that, by 1970, he or she earned a higher income than his or her parents was a very high 94%. Even if the parent's income fell on the 90th percentile, that probability was 87.6%. For the cohort of American's born in 1984 (the last cohort year for which there is data), the probability of having an income higher than one's parents is 50.3%. Essentially, it's a coin toss!

Figure 13.5 also shows that all three curves decline over the years. This suggests that the fading American dream is as much about a decrease in intergenerational mobility as it is about the slowdown of economic growth in the US. Still, it is remarkable that, in 1940, if your parent's income was in the 10th percentile, the probability you would earn less than your parent was a mere 5.4%. By 1984, it's up to 21.7%!

13.3. HOUSING, SCHOOLING AND FAMILY

In Section 13.1, we documented the significant variation in income levels across the world. A significant variation can also be found within each country. A series of studies by a group of scholars in collaboration with the US Census Bureau has led to a rich data set that allows us to visualize economic measures at the level of each of 70,000 neighborhoods across America: the so-called Opportunity Atlas. The top panel in Figure 13.6 presents a **heat map** of household income levels in the US. In some parts of the country, colored in red, average household income is lower than $35,000. In other parts of the country, colored in blue, it is higher than $55,000. The data on the top panel is presented at the commuter zone level. However, as we zoom in on a particular area, we find that average household income varies at a very granular level. The bottom panel in Figure 13.6 zooms in on New York City (and its environments), with data plotted at the Census track level, a much more granular division than commuting zone. In the top panel of Figure 13.6 New York City is colored green, as it is part of a commuting zone with above-average income. However, as the bottom panel shows, there are many neighborhoods

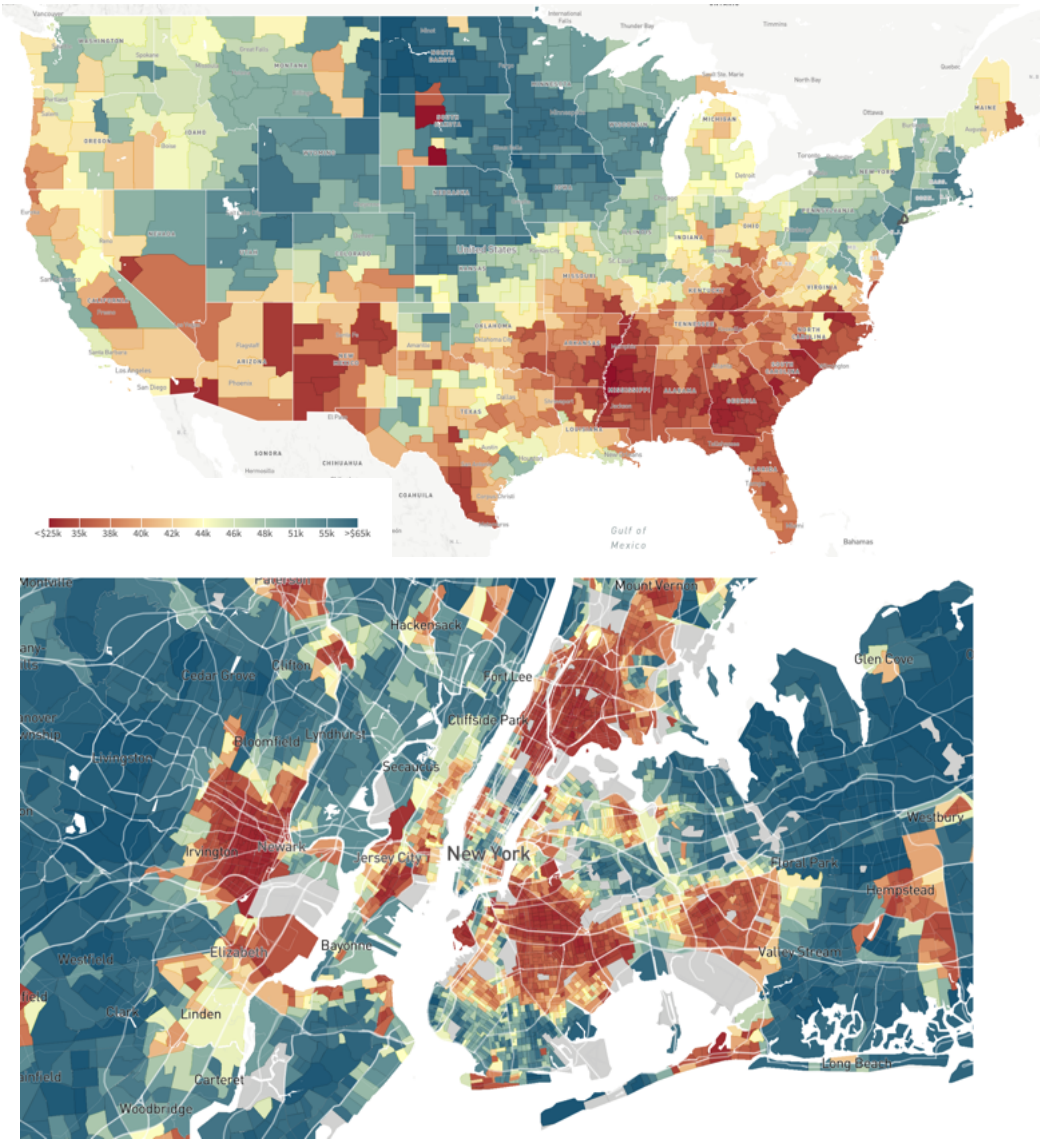


FIGURE 13.6
Average household income by US commuting zone (top panel) and by New York City census track (bottom panel). Source: Opportunity Atlas

in New York city with income levels below $35,000.

A second important pattern we learn from the Opportunity Atlas is that the degree of mobility also varies greatly across the US. Figure 13.7 shows the probability of staying in the same commuter zone as an adult. In some commuting zones, such probability is greater than two thirds, whereas in many others it is less than one third — a

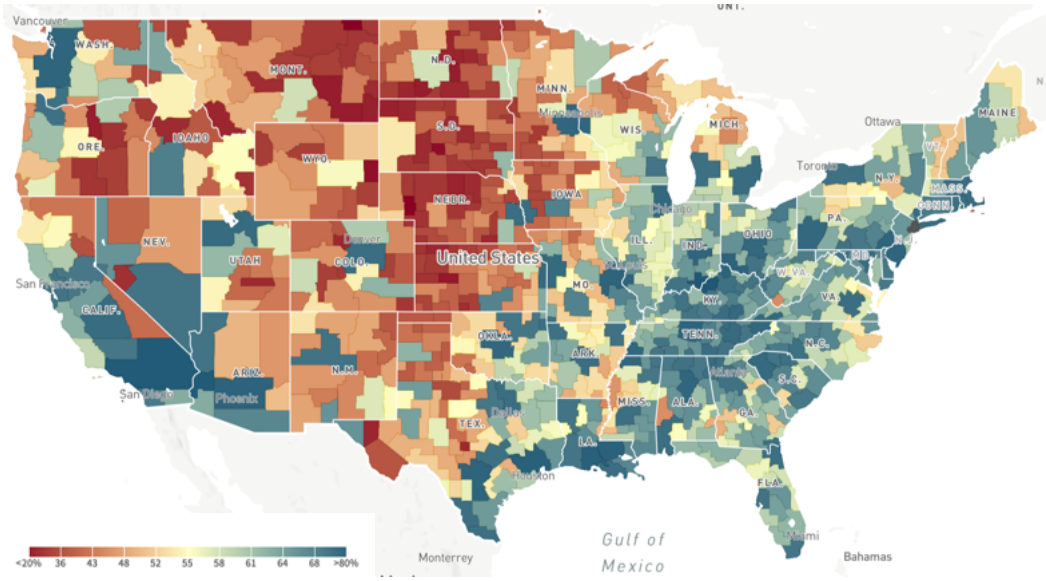


FIGURE 13.7
Probability of staying in the same commuter zone as an adult (by commuter zone). Source: Opportunity Atlas

considerable variation. The striking feature about the spatial distribution of these probabilities is the high correlation with average income, as per the top panel in Figure 13.6: US commuting zones with lower household income (red in Figure 13.6) are also US commuting zones with higher inertia (blue in Figure 13.7).

> *There is considerable variation in income levels across US commuting zones. Moreover, within each commuting zone there is significant variation across Census tracks. Finally, there is a positive correlation across locations between income levels and the probability of moving away from the location where one grows up.*

What explains these striking spatial variations? At first, one might think that location is simply a proxy for other variables, such as education level or race. However, Figure 13.8 replicates the heat map of the top panel of Figure 13.6 for black households only. Several commuting zones are colored gray, denoting that there is not enough data to make the probabilities statistically significant. With that qualifica-

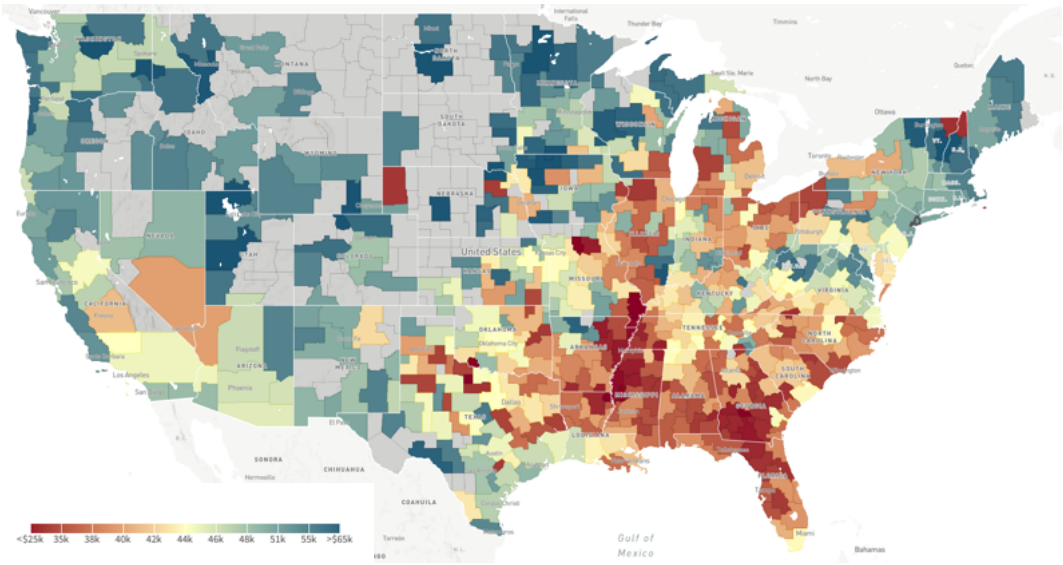


FIGURE 13.8
Average black household income by US commuting zone. Source: Opportunity Atlas

tion in mind, it is remarkable how highly correlated the color patterns in Figure 13.7 and the top of Figure 13.6 are.

Overall, Figures 13.6 and 13.7 suggest that the area where you grow up has much to say about your economic condition. Why is there such a variation across neighborhoods? Is it the schools? Is it the social fabric? And what causes what: Is it that certain neighborhoods nurture success (or failure), or rather is it that some neighborhoods just attract those who would succeed (or fail) anyway? As frequently is the case, the empirical challenge is to distinguish correlation from causality. We next turn to the challenging but crucial question of the role played by address (housing, schooling, etc) in determining one's economic opportunity.

MOVING TO OPPORTUNITY

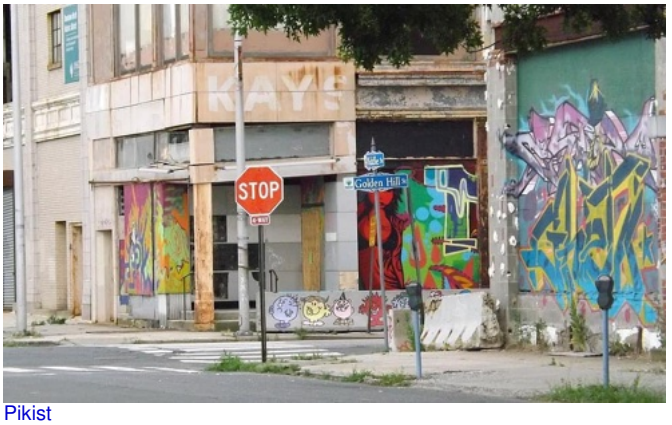
The United States Department of Housing and Urban Development (HUD) is a Cabinet department in the executive branch of the US federal government. Over the decades, HUD has developed a number of programs related to mortgage and loan insurance, community development, rental assistance, subsidized housing, etc. A particu-

larly important program for economics researchers was the Moving to Opportunity for Fair Housing (MTO), a 10-year program created in the 1990s (1994-1998). The reason why researchers were so interested in the program is that the program consisted of a **randomized controlled trial** (RCT). The idea is to apply the program to a randomly chosen set of families and then compare results with a control group (namely, families that were not offered the same conditions). From a research point of view, this is a plus because it avoids the usual problem of confounding correlation and causality. In some ways, these RCT are the "gold standard" of empirical research, for they manage to "distill" causal effects in a "clean" way.

The MTO program was offered to low-income families with children living in high-poverty public housing projects in Baltimore, Boston, Chicago, Los Angeles, and New York City. About 4,600 families volunteered for the program, mostly families headed by African-American or Hispanic single mothers. These families were then randomly assigned to three different groups. One group received housing vouchers that could be used only in low-poverty areas for the first year as well as counseling to help them find units there. After a year, they could use their vouchers anywhere. One group received vouchers that could be used anywhere but no counseling. A third (control) group did not receive vouchers but remained eligible for any other government assistance to which they otherwise would have been entitled.

Having started a quarter of a century ago, by 2020 the MTO program provides a rich set of longitudinal data regarding the eventual fate of the children involved in each of the three treatments. (By linking each family to tax records, it is possible to obtain longitudinal information of close to 100% of all subjects.) The results are astounding. Compared to the control group, which received no extra benefits, those who received housing vouchers with no strings attached (and no counseling) experienced small or no significant long-term effects. Most of them remained in the same neighborhood where they lived before the program went into effect. (The compliance rate in this group was 66%.)

By contrast, the long term effects of offering housing vouchers that required families to move to low-poverty areas were quite significant. (The compliance rate in this group was 48%.) Specifically, if the children in the family were younger than 13 at the time of the



Pikist

The evidence suggests that a child's economic prospects are largely determined by the neighborhood where they grow up.

move, then we observe that, once they become adults, annual income is $3,477 higher than the control group. This represents a 31% increase with respect to the $11,270 average of the control group. Although there is variation in income levels, the statistical probability that the neighborhood move had no effect on the income of the children once they become adults is as low as 1.4%. Other indicators also show significant signs of improvement. For example, the probability of college attendance increases by 21.7% with respect to the control group (and the probability that an increase is simply the result of noise is as low as 2.8%).

Another important result is that the effect depends drastically on the age of the children at the time of the move. For example, if the child in question is female and younger than 13, then the probability of becoming a single mother (specifically, to give birth with no father present) decreases from 30 to 23%. However, if the mover is between 13 and 18 years old at the time of the move, then the probability of becoming a single mother increases from 4.14 to 51.8%.

These results prompt two questions. First, what are the "mechanisms" that make a move to a different neighborhood so effective in terms of long term effects such as college attendance and earnings. Second, if the benefits are so significant, then why do we not observe more moves apart from these controlled programs? Let us start with the second question. One possible explanation for inertia is that low-income families prefer low-income neighborhoods for reasons such as affordability or proximity to family and jobs (in other words, social mobility is not their primary concern). A more recent study/program, similar to the MTO program, provided services to

reduce barriers to moving to high-upward-mobility neighborhoods. These services included customized search assistance, landlord engagement, and short-term financial assistance. This intervention increased the fraction of families who moved to high-upward-mobility areas from 14% in the control group to 54% in the treatment group. The evidence suggests that families induced to move to higher opportunity areas by the treatment do not make sacrifices on other dimensions of neighborhood quality and report much higher levels of neighborhood satisfaction. In other words, most low-income families do not have a strong preference to stay in low-opportunity areas. Rather, locational inertia results from barriers in the housing search process. This shows the importance of providing customized assistance in housing search as a means to help low-income families move to high-mobility areas.

We now turn to the first question: What are the mechanisms whereby moving families achieve such long-term results? First, the results suggest that neighborhoods (schools, community, neighbors, local amenities, economic opportunities and social norms) play an important role in shaping a child's outcomes. Beyond that, it's difficult to pinpoint the exact mechanism, for the simple reason that many of these neighborhood characteristics are highly correlated with each other.

A recent study relates the gains from a family's move to the characteristics of the neighborhood the family moves to. The study compensates for the absence of a clean randomized experiment by analyzing a very large number of children, close to 25 million. The problem of not having a randomized experiment is that moves are endogenously determined by families and are potentially dependent on events that are not observed by the analyst. Based on the results from the MTO project, the authors are particularly interested in measuring the effect of the time children are exposed to "better" neighborhoods. For this reason, the important assumption required for correct identification of the relevant effects is that the probability of a move is not determined by the age of children. This is a strong assumption, but one that the authors check by looking at families with multiple children. The results reiterate the prior results from the MTO program: moving to a better neighborhood seems to have a significant long-term effect on children, especially when the children move at an early age. Specifically, each year of childhood exposure

Box 13.1: Moving out of Chicago Poverty Areas

In the 1970s, a group of African-American tenants sued the Chicago Housing Authority (CHA) for assigning tenants to public housing on the basis of race. Although the District Court dismissed the plaintiffs' complaint, the Court of Appeals reversed the decision and ordered the District Court to enter summary judgment for the plaintiffs, holding that there had been a violation both of the Fifth Amendment and of the Civil Rights Act of 1964. This led to another case, namely regarding the remedy. The original plaintiffs wanted to consider a move within the Chicago metropolitan area, whereas the CHA wanted them to remain within the city limits. Eventually, the US Supreme Court, in *Hills v Gautreaux*, ruled in favor of the tenants, many of whom used their Section 8 vouchers to move to the Chicago suburbs.

Subsequent research showed that the families who moved aways from high-poverty neighborhoods in Chicago fared considerably better than the ones that remained behind. However, it was not clear whether there was any causal effect. After all, it could simply be that the families that decided to move had better abilities to begin with and decided to move precisely because of those better abilities.

More recent research suggests there was a causal effect from the move. In fact, it is estimated that DuPage County (the western suburbs of Chicago) "produces the best outcomes for children from below-median income families among the 100 largest counties. Growing up from birth in DuPage County would increase a child's income by 16.0% relative to the average county ... Moving from Chicago proper to the western suburbs of Chicago at birth would increase a child's household income by $7,510 a year on average, a 28.8% increase."

to a one-standard-deviation better county increases income in adulthood by 0.5%. Moreover, the authors estimate that there is substantial variation in the size of the effects across counties: it matters a lot where you move to. What are then the characteristics of neighborhood that contribute to positive long-term effects? Quoting from the paper,

Counties with less concentrated poverty, less income in-

> equality, better schools, a larger share of two-parent families, and lower crime rates tend to produce better outcomes for children in poor families. Boys' outcomes vary more across areas than girls' outcomes, and boys have especially negative outcomes in highly segregated areas.

The authors also show that — not entirely surprising — house prices are on average higher in better neighborhoods (where better corresponds to the above characteristics). However, there are many "opportunity bargains", that is, places that generate good outcomes but are not very expensive.

By way of conclusion, we might say that the study of US neighborhoods results in both good news and bad news. The bad news is that not only economic conditions vary enormously across neighborhoods but also the neighborhoods with worse economic conditions are also neighborhoods of lower mobility. The good news is that moving to a better neighborhood seems to have significant and long-lasting effects on the children of low-income families. The good news is also that the benefits of such move largely compensate the costs. Finally, the bad news is that many beneficial moves simply do not take place, but the good news is that proper counseling has a significant effect on the families' decision to move.

EDUCATION AND OPPORTUNITY

Economists, policymakers, parents — all seem to agree that education can be an important source of opportunity. However, underneath such general statement lurk a number of difficult questions. What should we do to improve the opportunities offered by education? If the government had $1 to spend on education, where would that dollar go? The problem for an analyst is that there are many levels of education, and at each level there are many variables one has to consider. To make things worse, these variables tend to be highly correlated: across communities, when education works well it seems that everything works well: students attainment, teacher quality, parental education and involvement, household income, and so on. When all measurable variables vary in the same direction, it's difficult to determine what causes what; we must therefore find strategies to tease out correlation from causality. We have seen may

instances of this throughout the book, but there is a sense in which education poses particularly difficult problems, namely the fact that there are so many correlations.

COLLEGE EDUCATION

To what extent is college education a source of opportunity, an engine of mobility? A recent study looks at the over 30 million college students who enrolled in US colleges from 1999-2013. Four main results come out of this study. First, access to colleges varies greatly by parent income. For example, children whose parents are in the top one% of the income distribution are 77 times more likely to attend an Ivy League college than those whose parents are in the bottom 20%. Second, children from low and high-income families have similar earnings outcomes conditional on the college they attend. Third, rates of upward mobility (the fraction of students who come from families in the bottom income quintile and reach the top quintile) differ substantially across colleges, largely because low-income access varies significantly across colleges with similar earnings outcomes. Fourth, between 2000-2011 the fraction of students from low-income families enrolled at elite private colleges did not change substantially, but the same fraction at colleges with the highest rates of bottom-to-top-quintile mobility declined sharply. In other words, college is less of an engine of mobility that it has been in the past.

As mentioned earlier, there is considerable variation across colleges regarding their role in promoting mobility in the income distribution. Table 13.4 plots two top 10 mobility lists. The top panel refers to the top 10 colleges in terms of bottom quintile to top quintile mobility. The bottom-to-top-quintile mobility rate is the fraction of students whose parents were in the bottom quintile of the parent household income distribution (when the children were aged 15-19) and whose own earnings (at ages 32-34) placed them in the top quintile of the children's income distribution. The mobility rate equals the product of the fraction of children at a college with parents in the bottom quintile of the income distribution (column "Access") and the fraction of children with parents in the bottom quintile of the income distribution who reach the top quintile (top panel) or the top percentile (bottom panel) of the income distribution ("Success Rate"). By means of example, consider the numbers for New York Univer-

TABLE 13.4
Colleges with the Highest Mobility Rates (source)

Top 10 Colleges by Bottom-to-Top-Quintile Mobility Rate				
Rk	Name	Mobility	Access	Success
1	Cal State, LA	9.9	33.1	29.9
2	Pace University — New York	8.4	15.2	55.6
3	SUNY — Stony Brook	8.4	16.4	51.2
4	Technical Career Institutes	8.0	40.3	19.8
5	University of Texas — Pan American	7.6	38.7	19.8
6	CUNY System	7.2	28.7	25.2
7	Glendale Community College	7.1	32.4	21.9
8	South Texas College	6.9	52.4	13.2
9	Cal State Polytechnic — Pomona	6.8	14.9	45.8
10	University of Texas — El Paso	6.8	28.0	24.4
Top 10 Colleges by Bottom-Quintile-to-Top-Percentile Mobility Rate				
Rk	Name	Mobility	Access	Success
1	University of California — Berkeley	0.76	8.8	8.6
2	Columbia University	0.75	5.0	14.9
3	MIT	0.68	5.1	13.4
4	Stanford University	0.66	3.6	18.5
5	Swarthmore College	0.61	4.7	13.0
6	Johns Hopkins University	0.54	3.7	14.7
7	New York University	0.52	6.9	7.5
8	University of Pennsylvania	0.51	3.5	14.5
9	Cornell University	0.51	4.9	10.4
10	University of Chicago	0.50	4.3	11.5

sity (NYU). 6.9% of the accepted students come from households in the bottom quintile (i.e., bottom 20%) of the income distribution. Of these students, 7.5% end up in the top 1% of the income distribution. Multiplying 6.9 by 7.5 we conclude that 0.52% of the students admitted at NYU (approximately 1 in 200) move from the bottom quantile to the top percentile of the income distribution.

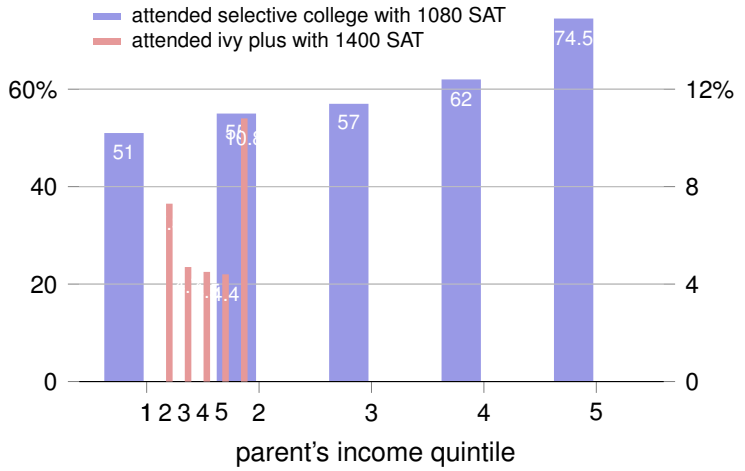


FIGURE 13.9
Distribution of students by parent's income quintile (1 to 5). Blue bars: students who attended a selective college and had an SAT score of exactly 1080. Red bars: students who attended an ivy plus college and had an SAT score of exactly 1400. Source: Opportunity Insights.

The two panels in Table 13.4 suggest a number of observations. First, when it comes to moving to the very top of the income distribution, elite universities seem to be the most relevant vehicles. For example, if your parents are in the bottom quintile of the income distribution and you are enrolled at Stanford, there is a 18.5% change you will get to the top 1% of the income distribution. Second, the most successful colleges in moving students from the bottom quintile to the top quintile are a mixture that includes research universities and community colleges, private and public institutions, well-known names and not-so-well-known names. The table also suggests that the elite schools accept a fairly low number of lower-income students. Specifically, the access rates in the bottom panel are considerably lower than those in the top panel.

The values in Table 13.4 suggest that lower-income students may be under-represented at top colleges. For example, the access rates at the schools listed in the bottom panel are uniformly lower than 10%. However, we must be careful before jumping to conclusions. First, the list of schools in the Table 13.4 forms a very selective sample. Second, to the extent that higher-ability students have on average higher

income, we might observe a low percentage of low-income students even if there were equal opportunity based on abilities. Figure 13.9 addresses the issue of selection and opportunity head on. We fix a student's ability as measured by their SAT score and then compute the distribution by income quantile *conditional on a given level of ability*.

The blue bars in Figure 13.9 show the fraction of students by parental income quintile who attend selective (i.e., non-open-enrollment) colleges, among students who have an SAT score of exactly 1080 (the median score among students who attend selective colleges). The chart shows that children from lower-income families are under-represented relative to children from high-income families despite having the same test scores: If students were selected solely based on SAT scores, then we would expect the distribution by percentiles to be approximately constant, which is not the case. The red bars, in turn, show how the fraction of students who attend elite private colleges (the Ivy-League plus Chicago, Duke, MIT, and Stanford) varies with parental income, among students who scored exactly 1400 on the SAT (the median score among Ivy-Plus students). (Since the frequencies are uniformly lower than those of 1080 SAT students, the values are scaled up and should be read on the right-hand scale.) As can be seen, middle-class students are especially underrepresented at Ivy-plus colleges. Somewhat surprisingly, students from the lowest income (bottom quintile) families are only slightly under-represented at elite private colleges.

The above analysis is essentially descriptive. In particular, it does not identify a college's causal effects on students' outcomes. The difficulty, as mentioned before, is to distinguish correlation from causality. When we compare the income stream of a student who went to college with that of a student who did not go to college, we get an uncorrected **college premium** (see, for example, Figure 11.8). However, it is likely that the innate unobservable skills of the student who went to college are higher than those of the student who did not. Therefore, a part of the uncorrected college premium is not a premium in the causal sense of the word, that is, is not a measure of the income return from going to college. Similar to the problem of estimating a demand curve (cf Section 6.2), causal estimates can be obtained if we observe a variable that shifts the supply of skills but not the demand for skills (for example, a change in the ability to apply for col-

lege loans). Research based on such empirical strategies estimates a return on college education of about 9%. Two notes are in order, however. First, as suggested by Figure 11.8, the return on college education has somewhat decelerated. Second, and related, there is a significant difference between the average return and the marginal return to the lower-skilled college enrollees (the latter can be as low as 1%). This distinction, which is yet another instance of decreasing marginal return, is important as we try to reconcile the effects of the wage distribution on increasing inequality with the deceleration of the college premium.

PRIMARY AND SECONDARY EDUCATION

When it comes to primary and secondary education, one of the most important questions asked by economists is whether teachers have an impact on students, both in terms of their success in school and in terms of long-term outcomes. The empirical challenge is that a teacher with low-achievement students may nevertheless be a very good teacher: had the students had a different teacher, their academic scores would have been even worse. One possible solution to this identification problem is to measure a student change in grades when studying under a certain teacher, what is usually referred to as the **teacher's value added** (VA). However, even then there are two problems. First, a high VA may simply result from sorting: For example, a certain teacher becomes popular for some reason unrelated to his or her abilities, many students try to study under this teacher, and the teacher in turn is able to select students with better abilities, which in turn is reflected in higher gains in terms of grades. In other words, differences in VA may result from sorting rather than a causal effect of teacher quality. The second problem with VA measures is that higher-VA teachers may simply teach to the test, in which case higher grades may not reflect actual long-term gains.

A series of studies addresses both of these criticisms of the use of VA as a means of valuing teachers. Based on more than one million of student and teacher observations, the data indicate that VA does measure teacher qualities rather than sorting. Moreover, it can be shown that high-VA teachers are not simply teaching to the test, rather they have a long-term effect on their students' outcomes: Students assigned to high-VA teachers are more likely to attend college,

earn higher salaries, and are less likely to have children as teenagers. Replacing a teacher whose VA is in the bottom 5% with an average teacher would increase the present value of students' lifetime income by approximately $250,000 per classroom.

Given all of this variation in teacher VA, it follows that studying under the right teacher, or attending the right school, may have a signifiant impact on a student's long-term opportunities. This leads to a natural follow-up question: Similar to moving to a different neighborhood, the ability to choose a different school may be a significant engine of mobility. In the US, there are two types of programs that have attempted to increase the ability of parents, especially low-income parents, to choose their children's school: voucher programs and charter schools.

A **school voucher** is a government-supplied coupon that is used to offset tuition at an eligible private school. The main argument in favor of choice in general, and voucher programs in particular, is that they provide disadvantaged students the opportunity to attend a better school, similar to what programs such as MTO attempt to achieve with family relocation. Moreover, by increasing competition between schools, better outcomes are achieved (more motivated teachers, etc). Last but not least, to the extent that both parents and schools differ in their education philosophies, allowing families to choose leads to a better match between supply and demand. The main argument against voucher programs is that they lead to sorting, an outcome sometimes referred to as **stratification**. The idea is that the students with better abilities are more likely to leave public schools, leaving the latter with a low-ability pool. So, while student migration may improve the outcomes of the outgoing students, the ones who stay behind are likely to suffer from the program (both because of so-called peer effects and because of the stigma associated with studying at a lower-achievement school). Also, to the extent that private schools may be able to charge tuition add-ons, vouchers may also contribute to income stratification.

Even if we restrict to the US, the programs that distribute school vouchers vary in several dimensions: who is eligible to receive them, the source of funding for the program, the criteria for private-school participation, and so forth. For this reason, it is difficult to make a general assessment of the effects of voucher programs. That said, with regard to the effect on the students enrolled in the program, the

TABLE 13.5
Characteristics of traditional public schools and of charter schools, 2015-2016 (source)

Characteristic	public	charter
White students	49.9	33.1
Black students	14.7	26.8
Hispanic students	25.6	31.7
75%+ students eligible for lunch program	23.9	32.6
Urban location	24.9	56.5

empirical evidence is mixed. For example, research of the Milwaukee voucher program (one of the earliest in the US) reports that voucher recipients had faster math score gains than the comparison groups but similar reading score gains. However, research on a Louisiana voucher program shows that participants saw their math scores decline, a pattern the authors attribute to poor school selection on the part of the parents. There are also many studies reporting very low effects on participating students.

Several studies suggest that there is some sorting effect, not so much on income (after all, the programs are typically targeted at lower-income families) but in terms of ability. In other words, better students are disproportionately more likely to take advantage of voucher programs. There is also evidence that the threat of losing students to voucher programs leads public schools to improve their performance.

I should also add that voucher programs have become a bit of a political hot button, especially in the US. In addition to the points raised above, many feel uncomfortable with the idea of government funds being used for non-public schooling. In this sense, charter schools, an alternative school choice policy, provides a more consensus approach. The idea behind the **charter school** movement is to maintain universal access, as in the traditional public system, but giving each school the freedom to organize, a freedom that is provided in exchange for greater accountability.

The first US charter school opened in Minnesota in 1992. Since then, the scale of the charter movement has grown, as of the 2016-17 school year, to nearly 7,000 schools and three million students in 43

states plus the District of Columbia. Charter enrollments constitute about 6% of annual public school enrollments in the United States, with enrollment shares as high as 43% in the District of Columbia. Table 13.5 provides some descriptive statistics of US charter schools, in particular as they compare to traditional public schools. As can be seen, charter schools focus primarily on urban neighborhoods with mostly black and hispanic populations.

How effective are charter schools? One advantage of the data available from various schools is that, when oversubscribed, which happens often, their admissions are based on a lottery system. This effectively provides researchers with a randomized control trial with which to estimate causal effects. The results from these studies tend to show positive and significant effects. A study based on Harlem data finds that attending an HCZ (charter) middle school effectively closes the black-white achievement gap in mathematics. A study based on Charlotte-Mecklenburg data finds a significant overall increase in college attainment among lottery winners who attend their first-choice school, and that gains in attainment are concentrated among girls. A study based on Boston data shows significant score gains for charter students in middle and high school. Interestingly, it also compares charter schools with pilot schools. Like charter schools, pilot schools are answerable to independent governing boards and determine their own budgets, staffing, curricula, and scheduling. Unlike charter schools, however, pilot schools remain part of the Boston school district and their teachers are part of the teachers' union. Lottery estimates for pilot school students are mostly small and insignificant, with some significant negative effects.

The internal validity of these studies is unassailable: In a sense, randomized control trials are the gold standard of social science. However, the sample of schools used for these RCT is necessarily biased: oversubscribed schools are likely to be better than average. There is also ample evidence of poorly performing or even failing charter schools. In this regard, a particularly important study, based on data from Texas, finds that average school quality in the charter sector is not significantly different from that in regular public schools after an initial start-up period but that there is considerable heterogeneity. Moreover, parental decision to exit a charter school is significantly related to school quality and more so than in the regular public school sector. This is consistent with the notion that the in-

troduction of charter schools substantially reduces the transactions costs of switching schools.

The heterogeneity in the effect of charter schools also seems related to their location. A consistent pattern seems to be that in urban areas, where students are overwhelmingly low-achieving, poor and nonwhite, charter schools tend to do better than other public schools. By contrast, outside of urban areas, where students tend to be white and middle class, charters do no better and sometimes do worse than public schools. In this regard, an important feature of the charter school system is that their independence comes at the cost of regular review: failing charter schools are closed much more easily than traditional public schools are. This is a very important feature. Earlier, I mentioned that, by replacing a teacher whose VA falls in the bottom 5% with an average teacher would increase the present value of students' lifetime income by approximately $250,000 per classroom. These large gains result from the large heterogeneity in VA across teachers. Something similar happens with charter schools: The data show considerable variation in their performance. At some level, this is a bad thing (nobody likes poor performing schools). But together with the flexibility the system has, namely in terms of closing failing schools, the end result may be quite good.

EARLY YEARS

In the late 20th century, two psychology experts in early development decided to follow a number of families from different socioeconomic backgrounds. They were interested in understanding why, by age four, there were already such marked differences in the children's ability to absorb new vocabulary learned in pre-school and kindergarten. They assembled a sample of 42 Kansas families from different socioeconomic status (SES). There were African-American families in each SES category, in numbers roughly reflecting local job allocations. Each month, for 2.5 years, the researchers spent one hour with each family simply observing their habits, in particular the interaction between parents and children.

The results were remarkable. First, perhaps not surprisingly, children at an early age are very much a reflection of their parents.

> Before children can take charge of their own experience

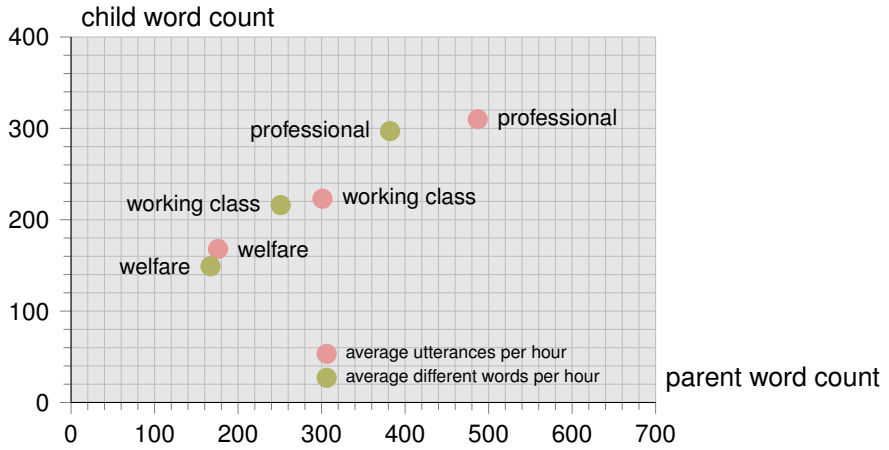


FIGURE 13.10
Relation between parents and children's vocabulary (source)

> and begin to spend time with peers in social groups outside the home, almost everything they learn comes from their families.

In quantitative terms, 86 to 98% of the words recorded in each child's vocabulary consisted of words also recorded in their parents' vocabularies. Figure 13.10 provides a graphic description of this correlation. On the horizontal axis we measure word counts for parents, on the vertical axis word counts for their children. Two different concepts are plotted: the average number of words per hour and the average number of *different* words per hour. (Naturally, the latter is smaller than the former.) A first striking feature of Figure 13.10 is the high correlation between parents and children. Drawing a line through the red dots (number of words) or the green dots (number of different words) shows a close-to-proportional relation between parents and children.

A second remarkable feature of Figure 13.10 is the significant difference in number of words across socio-economic groups. On average, a professional parent speaks 2.77 more words (2.29 more different words) than a parent on welfare. In other words, it's not just the fact that higher SES parents have a better vocabulary, it's also the fact that they talk more to their children.

As frequently is the case with studies of this sort, the question arises as to whether there is a causal relation or simply a correlation

Hunter Brady

Education, especially during a child's early age, can be an important path of social and economic mobility.

implied by genetic factors. In other words, since the parents' and the children's genetic features are correlated, what we observe in Figure 13.10 may result solely from spurious correlation. This view, while popular in certain circles, has been largely discredited by recent studies on cognitive abilities. For example, a recent study finds very minor differences in test outcomes between black and white infants. In other words, the data leads one to believe that correlations like that in Figure 13.10 correspond to causal relations dictated by a child's growing environment.

Moreover, the evidence from the Kansas study suggests that the differences across SES are more than purely cognitive.

> We can extrapolate similarly the relative differences the data showed in children's hourly experience with parent affirmatives (encouraging words) and prohibitions. The average child in a professional family was accumulating 32 affirmatives and five prohibitions per hour, a ratio of 6 encouragements to 1 discouragement. The average child in a working-class family was accumulating 12 affirmatives and seven prohibitions per hour, a ratio of 2 encouragements to 1 discouragement. The average child in a welfare family, though, was accumulating five affirmatives and 11 prohibitions per hour, a ratio of 1 encouragement to 2 discouragements.

In sum, the evidence suggest that there is much to be gained from policies that help children and their parents. Since the above-mentioned Kansas research took place, several other studies have

identified parenting practices that play an important role, including doing enriching activities with children, getting involved in their schoolwork, providing educational materials, and exhibiting warmth and patience. In fact, a recent study claims that

> Parental behavior interpreted in this way probably accounts for around half of the variance in adult economic outcomes, and therefore contributes significantly to a country's intergenerational mobility.

In this regard, one important program (and research study) is the Perry Preschool program, a program that served disadvantaged African American kids in Ypsilanti, Mich. Essentially, the program consisted of regular home visits during the kids' preschool years, involving both the kids and their parents. Similarly to the MTO program mentioned earlier, families were randomly assigned to the program (among the families that initially volunteered). Because the Perry Preschool Program was conducted in the 1960s, researchers have been able to follow the children who went through the program through adulthood. The results suggest the effects of the program were enormous: Adults from the treatment group were "much more likely to graduate high school, much more likely to make earnings, much more likely to go on to college, much less likely to commit crime." More: the benefits of the program extended beyond the first generation: children of participants in the program appear to have benefitted as well.

> The children of the participants are healthier. The children of the participants are also earning more. They have better social and emotional skills, are more likely to graduate high school and go on to college, less likely to engage in the criminal justice system, so they're less likely to be incarcerated or even have ever been arrested.

The studies surveyed above represent a small subset of the research on the effects, including the economic effects, of education, and of education as an engine of economic and social mobility. Three common themes what seem to summarize the evidence: First, it pays to invest in education. It pays both for individuals and for public policy. Moreover, the return on investment seems to be greater the earlier these investments are made. Second, school quality varies from

school to school, and within a given school teacher quality varies too. For this reason, mechanisms that allow for selection (e.g., replacing poorly performing teachers with average performance teachers) can have significant positive effects. Third, families matter a great deal, both in terms of household structure and in terms of parental involvement in the kids' education.

> *Education, especially during a child's early age, can be an important path of social and economic mobility.*

Finally, as should be clear from the previous analysis, education is not limited to educational establishments. In particular, the family has a critical role during a child's early years. As economist James Heckman argues, "it's just a fact that family life plays a fundamental role in shaping our children [to] either succeed or fail." In this regard, it is worth mentioning a recent study of Denmark. Despite the important role played by "transfers, and free tuition, and childcare, and preschool," the authors find that there are considerable differences across people and that success frequently occurs when "children are growing up in stable, two-parent homes with a lot of support."

As frequently is the case, one can see the glass half full or half empty. The current scope for economic and social mobility in the US is rather low, especially when compared with other developing countries. However, there is ample room for improvement, and we seem to know a number of ways in which improvement can be attained.

KEY CONCEPTS

brain drain | mobility matrix | rank elasticity | heat map | randomized controlled trial | college premium | teacher's value added | school voucher | stratification | charter school

REVIEW AND PRACTICE PROBLEMS

■ **13.1. Refugees.** True or false: War refugees represent the main source of migration.

■ **13.2. Migration.** What are the main economic effects of migration?

■ **13.3. An Immigration Backfire.** Listen to the podcast *An Immigration Backfire?* (or read the transcript). Summarize its main argument.

■ **13.4. Income transition matrix.** How does an income transition matrix illustrate the extent of economic mobility? Specifically, what are the transition matrices corresponding to minimum and maximum mobility?

■ **13.5. Race and income rank at birth.** Visit the *Opportunity Insights Data Library* website. Choose "Race" from the topic pull-down menu. Focus on the first data set, "National Statistics by Parent Income Percentile, Gender, and Race". Download the EXCEL spreadsheet. Download the README file as well, so as to understand the variable names.

(a) Confirm that, for each race, the probability values of each income percentile add up to 100 per cent (approximately).

(b) Produce the following graph: On the horizontal axis, plot income percentile (from 1 to 100). On the vertical axis, the percentage of children born to parents with a given income level by race. This corresponds to a total of five plots.

(c) Describe, in words, the main qualitative features of the plots.

(d) Determine the odds (relative probability) of being born in a percentile #1 family vs being born in a percentile #100 family for each race.

■ **13.6. Race, household structure, and opportunity.** Visit the *Opportunity Insights Data Library* website. Choose "Census Tract" from

the geographic level pull-down menu. Focus on the first data set, "All Outcomes by Census Tract, Race, Gender and Parental Income Percentile".

Download the spreadsheet, as well as the respective README file. (Note: this is a very large file. It will take minutes to download and it may take minutes to open on Excel. If you or a colleague of yours is familiar with Pandas/Python, writing a few lines of code may greatly simplify the process.)

Restrict the data set to the New York commuting zone (i.e., keep the rows with czname="New York"). Select the variables (that is, keep the columns)

two_par_pooled_pooled_mean
working_pooled_pooled_mean
kfr_top20_black_pooled_mean
kfr_top20_white_pooled_mean

Consult the Readme file to understand the meaning of these variables.

(a) Create a scatter plot with the fraction of children with two parents on the horizontal axis and the probability that a child is employed when an adult on the vertical axis. Comment the results.

(b) Create a scatter plot with the probability of reaching the top quintile of the national household income distribution for whites (horizontal axis) and blacks (vertical axis). Comment the results.

■ **13.7. College and social mobility.** Visit the *Opportunity Insights Data Library* website. Choose "College/University" from the geographic level pull-down menu. Focus on the first data set, "Preferred Estimates of Access and Mobility Rates by College". Download the spreadsheet, as well as the respective README file. Select the variables par_median (parents' median income) and k_median (child's earnings). For each college (i.e., for each row) compute the ratio between the values of these columns and the column mean.

Plot the relation between parents' ratio (horizontal axis) and child's ratio (vertical axis). Also, plot the 45 degree line. What does

the scatter plot say about social mobility for those attending college? What assumptions do you make to justify your answer?

■ **13.8. Wealth and college access.** True or false: Controlling for academic achievement (SAT scores), elite colleges are disproportionately likely to enroll students from wealthier families.

■ **13.9. College premium.** What do we mean by college premium? How do we measure it?

■ **13.10. Free college.** 2020 Presidential candidate Pete Buttigieg's economic plan included free college for Americans earning under $100,000. Do you agree with the proposal? Why or why not?

■ **13.11. Teacher's value added.** What are the pitfalls of measuring teacher's value added? (Hint: refer back to the discussion on correlation and causality in Section 2.1.)

■ **13.12. Charter schools.** What are the arguments in favor and against charter schools?

INDEX