ECONOMIC DECISION MAKING

part II

Part II In the next ten chapters, we will study the principles of economic decision making. Part IIA covers decisions by consumers concerning the goods they purchase. Part IIB focuses on firms' decisions about the outputs they produce and the production methods they use. Part IIC examines a number of additional topics including decisions that involve time, uncertainty, and strategic interaction, as well as behavioral theories of economic decision making.

part

IIA

Consumption Decisions

In the next three chapters, we'll investigate the determinants of decisions involving consumption. We'll develop a theory of consumer behavior that helps us to understand and predict choices in a wide range of contexts and provides a solid foundation for evaluating the costs and benefits of public policies. In Chapter 4, we'll introduce some basic principles of decision making and explore the concept of consumer preferences. In Chapter 5, we'll investigate the role of prices and income in constraining consumers' available alternatives, and we'll explain how to identify a consumer's most preferred choice given these and other constraints. In Chapter 6, we'll use our theory of consumer behavior to explore the foundations of demand curve analysis and develop methods of measuring the costs and benefits of public policies.

chapters

4

PRINCIPLES AND PREFERENCES

LEARNING OBJECTIVES

After reading this chapter, students should be able to:

- Explain the Ranking Principle and the Choice Principle.
- Illustrate consumers' preferences for consumption-bundles graphically through indifference curves.
- Understand the properties and functions of indifference curves.
- Determine a consumer's willingness to trade one good for another by examining indifference curves.
- Explain the concept of utility and compare consumption bundles by calculating the numerical values of a given utility function.

If we know the price of a good, we can use its demand curve to determine the amount purchased. But the price isn't always obvious. Take the case of mobile (wireless) telephones. What's the price of service per minute of conversation? If you own a mobile phone, you know this simple question has no simple answer.

In 2006, one wireless company, Cingular, offered more than a dozen different calling plans, each with different prices for different circumstances. In one plan, customers paid a monthly fee of $59.99, received 900 "free" minutes for calls made on weekdays, and paid 40 cents per minute for additional time. In another plan, a monthly fee of $99.99 bought 2,000 free minutes, with additional time charged at 25 cents per minute.

Which price is the relevant one? Free minutes cost nothing—or do they? If a customer incurs a monthly fee of $59.99 and uses exactly 900 "free" minutes, isn't he paying just under 7 cents per minute? And what about additional minutes? Is the price 40 cents, 25 cents, or something else entirely? Even if we knew the demand curve for mobile telephone services, which price would we use to determine the amount purchased? The answers to these questions are far from obvious.

Predicting consumers' choices accurately in such situations is important both to businesses and to policymakers. It requires an understanding of consumer behavior that goes beyond simple demand curves. A general theory of consumer behavior is valuable for at least two other reasons. First, economists are often called on to evaluate the costs and benefits of public policies. For example, the government taxes many goods and services and uses the revenues to finance public activities such as police protection, education, and national defense. Weighing costs and benefits, do the expenditures on any given program benefit taxpayers? A general theory of consumer behavior allows us to determine whether these programs make consumers better or worse off, and by how much.

Second, in analyzing markets, we often make assumptions about the properties of demand. For example, we usually assume that demand curves slope downward. Is that reasonable? Why or why not? Do demand curves typically have any other properties that might be useful in business or policy applications? A general theory of consumer behavior can provide answers to these questions.

This is the first of three chapters on consumer behavior. By the end of Chapter 6, you'll be able to answer each of the questions posed above. In this chapter, we lay the foundations for a theory of consumer behavior by addressing four topics:

1. *Principles of decision making*. We'll introduce and discuss two basic principles of consumer decision making which hold that consumers' choices reflect meaningful preferences.
2. *Consumer preferences*. We'll develop useful ways to describe consumers' preferences graphically and identify some tastes that most consumers share.
3. *Substitution between goods*. All economic decisions involve trade-offs between different objectives. We'll show how to determine a consumer's willingness to trade one good for another by examining his preferences.
4. *Utility*. We'll introduce a concept called *utility*, which economists use to summarize everything we know about a consumer's preferences, including her willingness to substitute one good for another.

4.1 PRINCIPLES OF DECISION MAKING

Three friends order dinner at a restaurant. One picks a salad, another chooses a steak, and the third selects pasta. Why do the three make different choices? They don't pick their meals at random; their decisions reflect their likes and dislikes. Economists refer to likes and dislikes as **preferences**.

Preferences tell us about a consumer's likes and dislikes.

What do we know about consumer preferences? Clearly, different people like (and dislike) different things. Their reasons for preferring one alternative to another may or may not be practical or tangible. Sometimes, those reasons are personal, emotional, and intangible. For example, many people strongly prefer designer jeans to equally functional jeans with unfashionable labels. Even so, each person's preferences, whatever they are, should provide a coherent basis for comparing possible alternatives. This requirement leads to our first main assumption concerning consumer behavior.

The Ranking Principle A consumer can rank, in order of preference (though possibly with ties), all potentially available alternatives.

The Ranking Principle is a simple but important assumption. It tells us that the consumer has a clear idea of what's good (something with a high rank) and what's bad (something with a low rank). It implies that the consumer is never uncertain or befuddled in making comparisons—at least not after some reflection.[1] While the Ranking Principle may not hold in all circumstances, it's a reasonable starting point for thinking about most economic decisions.

Notice that the Ranking Principle allows for ties. This doesn't mean that the consumer is uncertain or befuddled; it simply means that he likes two (or more) alternatives equally. Economists say that the consumer is **indifferent** between such alternatives.

A consumer is **indifferent** between two alternatives if he likes (or dislikes) them equally.

Our second main assumption concerning consumer behavior states that consumers follow their preferences in making decisions:

The Choice Principle Among the available alternatives, the consumer selects the one that he ranks the highest.

Another way to say this is that consumers always try to achieve the highest possible level of well-being.

These two principles are, in a nutshell, the basic building blocks of consumer theory. The rational consumers of economic theory—also known as *homo economicus*—will always follow the Ranking Principle and the Choice Principle. We'll spend the rest of this chapter, as well as Chapters 5 and 6 and portions of several subsequent chapters, exploring the many implications of these principles.

Example 4.1

Dinner Selections and the Ranking Principle

Every Tuesday evening, Ethan has dinner at his favorite restaurant. The chef knows how to cook five dishes: hamburgers, tacos, chili, pasta, and pizza. Because he cannot prepare more than three dishes at once, he always limits the menu to three choices, which he varies from day to day. Ethan is familiar with all five dishes, but he has no way of knowing which three will be available on any given day.

On one particular Tuesday, on the way to the restaurant, Ethan's thoughts turn to his potential dinner selection. After sampling each dish in his imagination, he realizes that he is definitely in the mood for tacos. He would be happy with either pasta or a hamburger (both of which seem equally appealing), and could stomach pizza, but he finds the thought of chili unbearable. With this realization, Ethan has ranked all the alternatives that might be available, thereby satisfying the Ranking Principle. Table 4.1 summarizes Ethan's preference ranking on this Tuesday night.

"The little sad faces next to some items mean they don't taste very good."

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[1] The Ranking Principle is equivalent to two assumptions about comparisons between *pairs* of alternatives. The first, *completeness*, holds that, in comparing any two alternatives *X* and *Y*, the consumer either prefers *X* to *Y*, prefers *Y* to *X*, or is indifferent between them. The second, *transitivity*, holds that, if an individual prefers one alternative, *X*, to a second alternative, *Y*, which he prefers to a third alternative, *Z*, then he must also prefer *X* to *Z*. If preferences are complete and transitive, then the consumer can rank the alternatives from best to worst, as required by the Ranking Principle. Likewise, if he can rank all the alternatives from best to worst, he can make complete, transitive comparisons between pairs of alternatives.

Table 4.1

Ethan's Preference Ranking

Choice	Rank
Hamburger	2 (tie)
Tacos	1
Chili	5
Pasta	2 (tie)
Pizza	4

Ethan eventually arrives at the restaurant and inspects the menu. On this particular Tuesday, the menu lists chili, pasta, and pizza. Noticing with disappointment that tacos are unavailable, Ethan orders pasta. Based on his preference ranking, this is the best choice he can make given the available alternatives.

Equipped with a knowledge of Ethan's preference ranking, we can accurately predict the choices he would make, no matter what's on the menu. For example, if the menu lists hamburgers, tacos, and pizza, he will select tacos. If it lists hamburgers, chili, and pizza, he will order a hamburger. If it lists hamburgers, pasta, and pizza, he will choose either pasta or a hamburger. (Since he is indifferent between those two options, we cannot be more specific.)

Application 4.1

Preference Rankings, Home Video Rentals, and Netflix

On the way home from dinner, Ethan decides to spend his evening watching a movie. He drives to the nearest Blockbuster and wanders the aisles, scanning row after row of unfamiliar titles. He scratches his head in bewilderment, confounded by the prospect of choosing among so many unknowns. By reading the video jackets, he gleans some superficial information—actors, director, genre, rating, perhaps a brief plot summary, and some carefully selected snippets from reviews. Based on this information, he tries to pick the movie he would enjoy the most. However, he knows from experience that it's very hard to judge a movie by its jacket. Because he lacks most of the information required to evaluate a movie before he sees it, he is often surprised and disappointed. Ideally, Ethan would like to know how he would rank all the movies in the store *had he already seen them*. Then he would be able to make consistently satisfying choices.

Ethan's familiar dilemma creates an opportunity for profit-seeking firms and entrepreneurs to make money by providing him with useful advice. The most common approach employs reviews and ratings. For example, a variety of published movie guides provide summary information and a simple quantitative evaluation—"three stars" or "two thumbs up"—for each title. However, since different people have different tastes, no single rating system can accurately predict everyone's reactions. As all movie lovers know, reviews reflect the tastes, preferences, and moods of the *reviewer* rather than those of the consumer.

Netflix.com, a pioneer in online DVD rental services, solves this problem by offering personalized recommendations. Whenever a subscriber logs into a Netflix account, he or she is invited to rate previously viewed movies, especially recent rentals. Netflix stores this information in an enormous database. A computer program identifies like-minded subscribers based on the similarity of their ratings. For any title that a subscriber has not yet viewed, it consults information supplied by like-minded viewers and predicts the subscriber's rating. Netflix then ranks unwatched movies by these predicted ratings and recommends the most highly ranked selections. In effect, Netflix predicts the subscriber's preference ranking and applies the Choice Principle!

Providing reliable online recommendations is an essential component of the Netflix business model. It is an important aspect of customer service, and it reduces the fees that Netflix pays to movie studios by steering customers toward lesser-known films. Does the approach work? In 2002, Netflix provided more than 18 million personalized recommendations daily. Roughly 70 percent of its rentals were computerized suggestions. Moreover, Netflix viewers enjoyed a much wider range of films than customers of conventional video rental stores.[2] At the typical store, 80 percent of rental activity involved just 200 titles. At Netflix, 80 percent of rental activity involved 2,000 titles. Web site recommendations steered Netflix users to niche films such as *Memento*, which became the seventh-most-rented movie on Netflix (outpacing marquee offerings such as *Harry Potter* and *Moulin Rouge),* despite grossing only $25 million at the box office.

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[2] The extent to which Netflix's recommendations account for this pattern is unclear. Netflix may also attract customers with stronger preferences for variety by virtue of its greater selection.

4.2 CONSUMER PREFERENCES

Each of the applications we've considered so far has focused on a single decision in isolation—which meal to order, which movie to rent. In practice, however, our decisions tend to be interrelated in two ways. First, the enjoyment of one activity often depends on other activities. For example, many people enjoy jogging and drinking beer, but usually not at the same time. A decision to jog should not be made independently of a decision to drink beer. Second, when an individual spends money to purchase one good, less money is available for other goods. A decision to consume more of one good is therefore also a decision to consume less of another.

To make sound decisions, consumers need to consider these interrelationships. They must keep an eye on the big picture—a master plan for allocating their limited funds to competing needs and desires over some fixed period, such as an hour, a day, a month, a year, or even a lifetime. By following such a plan, the consumer ends up with a collection of goods, known as a **consumption bundle**, for the period in question.[3]

A **consumption bundle** is the collection of goods that an individual consumes over a given period, such as an hour, a day, a month, a year, or a lifetime.

To illustrate this concept, suppose Ethan cares only for restaurant meals and movie rentals. For a given week, the combination of three restaurant meals and two movie rentals is one possible consumption bundle; the combination of one restaurant meal and eight movie rentals is another. In practice, the consumption bundle for any particular individual includes a very large number of goods.

A consumer's choices should reflect how he feels about various consumption bundles, rather than how he feels about any one good in isolation. Otherwise, he might ignore important interrelationships between decisions. In the rest of this chapter, we'll develop useful ways to describe preferences for alternative bundles, and we'll identify some characteristics of preferences that most consumers share.

How Do People Rank Consumption Bundles?

The Ranking Principle tells us only that consumers can rank consumption bundles. It does not by itself tell us how someone will rank any particular bundle relative to another. Since different consumers have very different tastes, consumer theory allows for a wide variety of rankings.

Despite their differences, consumers do have some things in common. For example, in most contexts, the typical person prefers more to less. Even if people disagree about the relative importance of meals and movies, virtually everyone will agree that three meals and three movies is better than two meals and two movies. We'll state this observation as a third general principle of consumer decision making:[4]

The More-Is-Better Principle When one consumption bundle contains more of every good than a second bundle, a consumer prefers the first bundle to the second.

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[3] Consumption bundles are sometimes called *consumption baskets*, but in this book we'll use the word *bundle*.

[4] This is also known as the Non-Satiation Principle.

No doubt you can think of situations in which someone might have too much of a good thing. Consumer theory can accommodate this relatively rare possibility. But for the typical decision, we can reasonably assume that consumers prefer more to less.

The following example illustrates preferences for consumption bundles.

Example 4.2

Preferences for Meals

Madeline eats all of her meals at a restaurant that serves only soup and bread. The restaurant sells soup by the bowl and bread by the loaf. We'll describe her potential consumption bundles by listing the amounts of soup and bread she eats on a given day.

Table 4.2 shows some of her potential choices. The rows indicate the number of loaves of bread and the columns indicate the number of bowls of soup. Obviously, Madeline's options may include eating more than three loaves of bread or more than three bowls of soup on a given day, but we omit these possibilities to keep the table relatively simple. Each cell in the table corresponds to a single consumption bundle. For example, the arrow identifies the cell corresponding to one bowl of soup and two loaves of bread. Altogether, Table 4.2 has 16 different cells, each associated with a different bundle.

Table 4.2

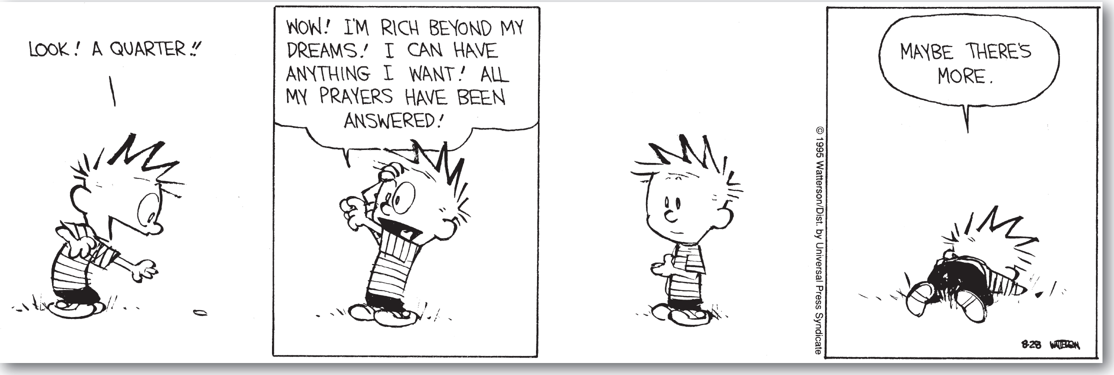
Madeline's Alternatives and Preference Ranking

One bowl of soup, two loaves of bread

	3	11	7	3	1
Bread (loaves)	2	13	8	4	2
	1	15	9	6	5
	0	16	14	12	10
		0	1	2	3
			Soup (bowls)		

According to the Ranking Principle, Madeline can rank all the alternatives potentially available to her. Table 4.2 shows her preference ranking. According to this table, Madeline's top choice (ranked 1 among the 16 bundles) is to eat three loaves of bread and three bowls of soup. Her second best choice (ranked 2) is to eat two loaves of bread and three bowls of soup. Notice that Madeline generally prefers soup to bread. For example, she would rather eat three bowls of soup and two loaves of bread (ranked 2) than two bowls of soup and three loaves of bread (ranked 3). However, since she's hungry, she's happy to trade a bowl of soup for several loaves of bread. For example, she prefers two loaves of bread and no soup (ranked 13) to one bowl of soup and no bread (ranked 14). Her least favorite bundle (ranked 16) is to eat nothing.

The preference ranking shown in Table 4.2 satisfies the More-Is-Better Principle. In any single column (such as the one highlighted in yellow), the numbers at the top are smaller than the numbers at the bottom. This means that, given a fixed amount of soup, Madeline prefers more bread. Similarly, in any row, the numbers at the right-hand side are smaller than the numbers at the left-hand side. This means that, given a fixed amount of bread, Madeline prefers more soup.



CALVIN AND HOBBES © 1995 Watterson. Dist. By UNIVERSAL PRESS SYNDICATE. Reprinted with permission. All rights reserved.

WORKED-OUT PROBLEM 4.1

The Problem According to Table 4.2, if Madeline starts with three bowls of soup and no bread, is she willing to trade one bowl of soup for two loaves of bread?

The Solution She ranks the bundle consisting of three bowls of soup and no bread tenth among the listed alternatives. If she trades one bowl of soup for two loaves of bread, she'll have two bowls of soup and two loaves of bread, which she ranks fourth. According to the Choice Principle, she'll choose the second bundle over the first—that is, she'll make the trade.

IN-TEXT EXERCISE 4.1 **According to Table 4.2, which of the following trades is Madeline willing to make? (a) Starting with one bowl of soup and one loaf of bread, swap one bowl of soup for two loaves of bread. (b) Starting with two bowls of soup and no bread, swap two bowls of soup for three loaves of bread. (c) Starting with three bowls of soup and one loaf of bread, swap two bowls of soup for two loaves of bread.**

Consumer Preferences with Finely Divisible Goods

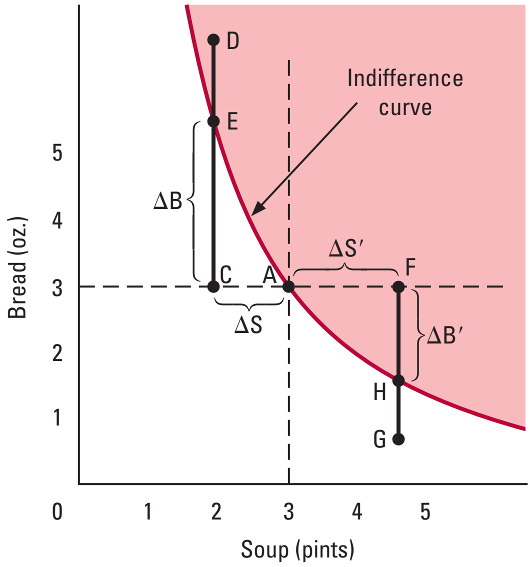
In Example 4.2, each consumption bundle corresponded to a cell in a table. This approach works well when the number of alternatives is small. When the number of alternatives (and cells) is large, such tables are cumbersome, tedious to construct, and difficult to read.

Suppose, for example, that Madeline's favorite restaurant sells soup by the teaspoon and bread by the gram. If we allow for the possibility that she might consume up to 200 teaspoons of soup (a little more than one quart) and 500 grams of bread (a little more than one pound), we have 100,000 (500 × 200) bundles to consider. To depict all of the alternatives, we would need a table with 100,000 cells!

In analyzing decision-making problems involving goods that either are finely divisible or are consumed in large numbers, economists typically assume that consumers can

Figure 4.1

Identifying Alternatives and Indifference Curves. Starting from bundle A, taking away some soup (moving to bundle C) leaves Madeline no better off. But if we then add enough bread (moving to bundle D), she will be better off than with bundle A. Somewhere on the straight line between C and D, there is a bundle (labeled E) that is exactly as good as A. Similarly, starting from bundle A, adding some soup (moving to bundle F) makes Madeline at least as well off. But if we then take away enough bread (moving to bundle G), she will be worse off than with bundle A. Somewhere on the straight line between F and G, there is a bundle (labeled H) that is exactly as good as A. Bundles E and H lie on the indifference curve running through A.



obtain any fraction of a unit, no matter how small. This assumption isn't literally true, but in many situations it's a reasonable approximation. For example, when you prepare your own food, you can vary the amount of soup in a bowl or the size of a loaf of bread.

When goods are available in any fraction of a unit, the number of alternatives is infinite, so we can't show all the consumer's options in a table. Instead, we can represent the alternatives graphically. To illustrate, let's return to Madeline's problem. Here, we'll measure soup in pints and bread in ounces, recognizing that she can obtain any fraction of either. Figure 4.1 shows the set of potential consumption bundles graphically. Each point on the graph corresponds to a possible consumption bundle. For example, point A corresponds to a consumption bundle consisting of three pints of soup and three ounces of bread. Note that the layout of Figure 4.1 resembles Table 4.2 in the sense that the amount of soup is measured on the horizontal axis (columns in Table 4.2), while the amount of bread is measured on the vertical axis (rows in Table 4.2). The main difference is that Figure 4.1 shows the bundles as points rather than as cells.

According to the Ranking Principle, Madeline can rank all the alternatives depicted in Figure 4.1. However, if we tried to write a numerical rank on each point (instead of within each cell, as in Example 4.2), the graph would become completely covered with ink. Clearly, we need to find some other way to represent her preference ranking. We do this by drawing objects called *indifference curves*.

Consumer Indifference Curves

As you learned in Section 4.1, economists say that an individual is indifferent between two alternatives if he or she likes (or dislikes) them equally. In Example 4.1, Ethan is indifferent between eating a hamburger or pasta for dinner (see Table 4.1). This indifference is something of a coincidence; more likely, he would have at least a slight preference for one of those two options. In contrast, when goods are finely divisible, we can start with

Starting with any alternative, an **indifference curve** shows all the other alternatives that a consumer likes equally well.

any alternative and always find others that the consumer likes equally well. An **indifference curve** shows all these alternatives. When we draw an indifference curve, we declare a "tie" between all the points on the curve, much as we declared a tie between pasta and hamburgers in Table 4.1.

To illustrate the concept of an indifference curve, let's return to Madeline's problem. Consider the consumption bundle labeled A in Figure 4.1. How do we go about identifying other consumption bundles that are neither more nor less attractive than A? Let's start by taking away ΔS pints of soup, leaving Madeline with bundle C (as shown in the figure). According to the More-Is-Better Principle, she likes bundle A at least as well as bundle C.[5] Suppose that, if we give her enough bread, moving her from bundle C to, say, bundle D, we can more than compensate for the lost soup, and make her better off than with A. Since A is at least as good as C and worse than D, there must be a bundle somewhere on the straight line connecting C and D that is exactly as good as A. In the figure, that bundle is E. By definition, E lies on the indifference curve running through A. To reach bundle E from bundle C, we add ΔB ounces of bread (shown in the figure). So, starting from bundle A, adding ΔB ounces of bread exactly compensates for the loss of ΔS pints of soup.

We can use this procedure to find other points on the same indifference curve. For example, Madeline likes bundle F at least as well as bundle A because it contains the same amount of bread and an additional $\Delta S'$ pints of soup. Suppose that, if we take away enough bread, moving her from bundle F to, say, bundle G, we can make her worse off than with A. Since A is better than G and no better than F, there must be a bundle somewhere on the straight line connecting F and G—call it H—that is exactly as good as A. By definition, H lies on the indifference curve running through A. To reach bundle H from bundle F, we take away $\Delta B'$ ounces of bread. So, starting from bundle A, taking away $\Delta B'$ ounces of bread exactly compensates for $\Delta S'$ extra pints of soup.

Repeating this procedure over and over, we obtain the solid red line in Figure 4.1. Because Madeline is indifferent between bundle A and all other bundles on the red line, such as E and H, the red line is an indifference curve.

Some Properties of Indifference Curves

When the More-Is-Better Principle holds, two bundles can't be equally attractive unless, in swapping one for the other, you get more of one good and give up some of another good (or at least don't get more of the second). If you get more of everything, you're better off, not indifferent. This observation leads to three important conclusions concerning indifference curves.

1. *Indifference curves are thin.* To see why, look at Figure 4.2(a). Since the red curve is thick, we can start at a bundle like A and move to the northeast, reaching a bundle like B, while staying on the curve. Since B contains more soup and more bread than A, the consumer must like B better than A. But this means the thick red curve can't be an indifference curve.
2. *Indifference curves do not slope upward.* To see why, look at Figure 4.2(b). Since part of the red curve slopes upward, we can start at a bundle like C and move to the northeast, reaching a bundle like D, while staying on the curve. Since D contains more soup and more bread than C, the consumer must like D better than C. But this means the red curve can't be an indifference curve.

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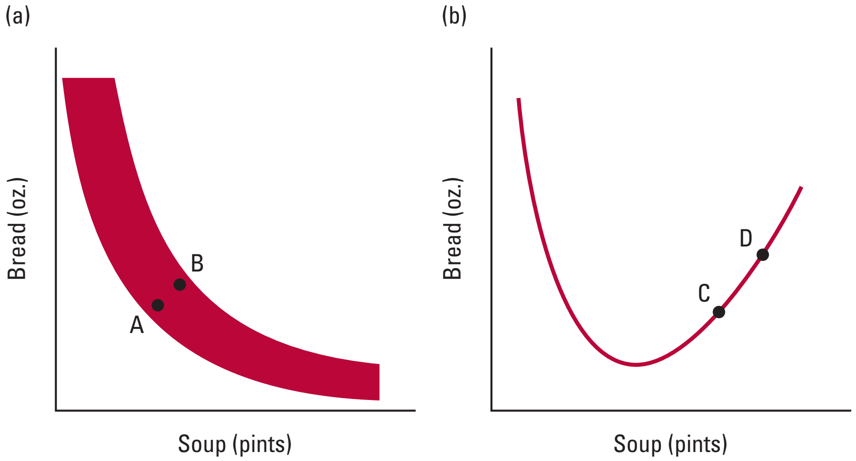
[5] If she liked bundle C better than bundle A, she would also like C better than some new bundle containing both a tiny bit more soup and a tiny bit more bread than A. The More-Is-Better Principle rules this out, since bundle C contains less soup and less bread than the new bundle.

Figure 4.2

Indifference Curves Ruled Out by the More-Is-Better Principle. Figure (a) shows that indifference curves cannot be thick, since points A and B cannot lie on the same indifference curve. Figure (b) shows that indifference curves cannot have upward sloping segments, since points C and D cannot lie on the same indifference curve.



3. *The indifference curve that runs through any consumption bundle—call it A—separates all the better-than-A bundles from the worse-than-A bundles.* Since more is better, the better-than-A bundles lie to the northeast of the indifference curve, while the worse-than-A bundles lie to the southwest. In Figure 4.1, we've shaded the better-than-A bundles light red.

A **family of indifference curves** is a collection of indifference curves that represent the preferences of the same individual.

Families of Indifference Curves In Figure 4.1, we constructed an indifference curve by finding all the bundles that were neither more nor less attractive to the consumer than A. As Figure 4.3 shows, we can construct other indifference curves for Madeline starting from other alternatives, such as C, D, E, and F. This figure illustrates what is called a **family of indifference curves**.[6] Two indifference curves belong to the same family if they reflect the preferences of the same individual. Within a family, each indifference curve corresponds to a different level of well-being.

When the More-Is-Better Principle holds, families of indifference curves have two important properties:

1. *Indifference curves from the same family do not cross.* To see why, look at Figure 4.4, which shows two red curves crossing at bundle A. If the dark red curve is an indifference curve, then the consumer is indifferent between bundles A and B. Since bundle C contains more soup and more bread than bundle B, the consumer prefers C to B, so he also prefers C to A. But that means the light red curve *isn't* one of his indifference curves.

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[6] This is sometimes called an *indifference map*, a phrase which emphasizes its similarity to a topographic map. We explain this analogy in Section 4.4.

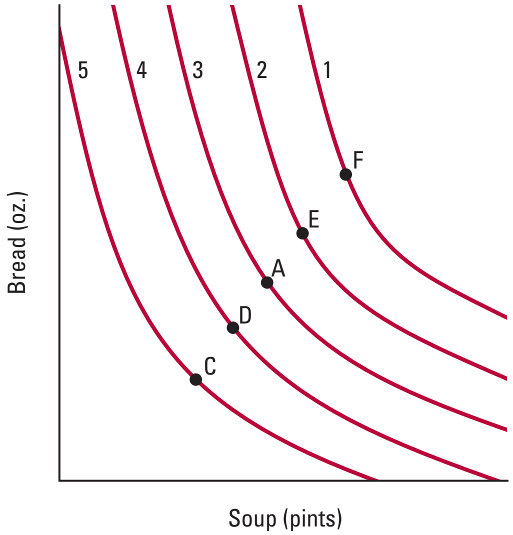

Figure 4.3

A Family of Indifference Curves. This figure illustrates five indifference curves belonging to the same family, all of which represent the preferences of the same consumer. The number next to each curve indicates its rank relative to the other curves. The indifference curve that runs through bundle F receives a rank of 1 because it is the best from the consumer's perspective. The indifference curve that runs through bundle C receives a rank of 5 because it is the worst.

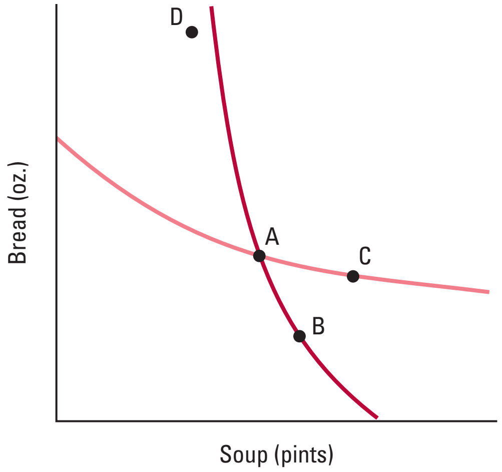

Figure 4.4

Indifference Curves from the Same Family Do Not Cross. If the dark red curve is an indifference curve, then the consumer is indifferent between bundles A and B. Since bundle C contains more soup and more bread than bundle B, the consumer prefers C to B, so he also prefers C to A. But that means the light red curve isn't one of his indifferent curves.

2. *In comparing any two bundles, the consumer prefers the one located on the indifference curve that is furthest from the origin.*[7] This conclusion follows from the fact that, for any bundle A, the better-than-A bundles lie to the northeast of the indifference curve running through A, and the worse-than-A bundles lie to the southwest. For example, Madeline ranks the five indifference curves shown in Figure 4.3 as follows: the curve running through F is first, the curve running through E is second, the curve running through A is third, the curve running through D is fourth, and the curve running through C is last. These ranks appear in the figure.

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[7] This observation does *not* imply that the consumer always prefers the bundle that is furthest from the origin. In Figure 4.4, for example, bundle D is further from the origin than bundle A, but a consumer with the dark red indifference curve would prefer bundle A to bundle D.

Let's summarize what we've learned about indifference curves (assuming that the Ranking Principle and the More-Is-Better Principle hold):

Properties of Indifference Curves and Families of Indifference Curves

1. Indifference curves are thin.
2. Indifference curves do not slope upward.
3. The indifference curve that runs through any consumption bundle—call it A—separates all the better-than-A bundles from all the worse-than-A bundles.
4. Indifference curves from the same family never cross.
5. In comparing any two bundles, the consumer prefers the one located on the indifference curve that is furthest from the origin.

Application 4.2

Preferences for Automobile Characteristics

Why does a consumer choose one type of automobile over another? An automobile is a bundle of characteristics and features—style, comfort, power, handling, fuel efficiency, reliability, and so forth. To comprehend the consumer's choice, we must therefore study his preferences for bundles of these characteristics. As with bundles of goods, we can gain an understanding of his preferences by examining indifference curves.

"Nice—but my heart's still set on a helicopter gunship."

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In one study, economist Pinelopi Goldberg examined data on purchases of large passenger cars in the United States between 1984 and 1987.[8] Figure 4.5, which is based on her results, shows the preferences of the typical new car buyer for two characteristics, horsepower and fuel economy. Since the curves slope downward, the typical buyer is willing to sacrifice some power and acceleration in return for greater fuel efficiency. For example, consumers are willing to give up roughly 40 horsepower to increase fuel efficiency from 10 to 15 miles per gallon (compare points A and B).

Understanding consumers' willingness to trade horsepower for fuel efficiency is important for both automobile manufacturers and public policymakers. Automobile manufacturers can use information of this type to determine whether a particular design change will improve a car's appeal to consumers. Policymakers can use it to evaluate the likely success of policies that encourage consumers to purchase fuel-efficient automobiles.

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[8] Pinelopi Koujianou Goldberg, "Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry," *Econometrica* 63, July 1995, pp. 891–951.

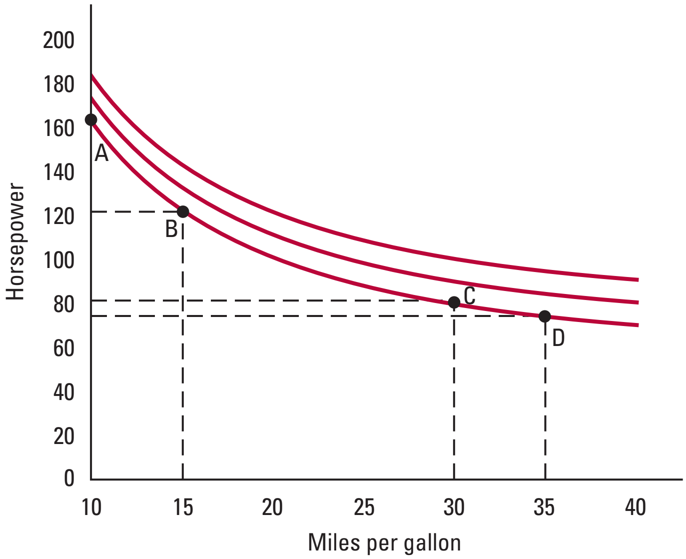

Figure 4.5

Indifference Curves for Horsepower and Fuel Economy. The typical new car buyer's preferences for horsepower and fuel economy correspond to the family of indifference curves shown in this figure. Consumers are willing to give up roughly 40 horsepower to increase fuel efficiency from 10 to 15 miles per gallon (compare points A and B), but they are willing to give up only 6 horsepower to increase fuel efficiency from 30 to 35 miles per gallon (compare points C and D).

Formulas for Indifference Curves So far, we've been studying consumer preferences using graphs. Though the graphical approach helps to build understanding and intuition, it has limitations. First, it isn't quantitative: it doesn't allow us to make precise numerical statements about consumer behavior. Second, graphical illustrations of preferences are always incomplete. A complete family of indifference curves includes curves that run through every single point on the graph. If we tried to draw all of them, the figure would be covered with ink.

To overcome these limitations, economists usually describe consumer preferences using mathematical formulas. As you'll see in Chapter 5, this allows us to treat consumers' decisions as standard mathematical problems.

One way to describe consumer preferences mathematically is to write down the formulas for their indifference curves. For example, the formula for the dark red indifference curve in Figure 4.6 is $B = 10/S$, where B stands for ounces of bread and S for pints of soup. We've graphed this formula by plotting a few points and connecting the dots.[9]

The single formula $B = U/S$ describes an entire family of indifference curves. To obtain a particular indifference curve, we simply plug in a value for the constant U and plot the relationship between B and S. Different values of U will yield different curves. The figure shows curves for the values $U = 10$, $U = 20$, and $U = 30$. Notice that higher values of U lead to indifference curves that are further from the origin. Therefore, the value of U for the indifference curve that runs through any bundle provides an index of the consumer's well-being, or "utility" (hence the letter U), when consuming that bundle. We will elaborate on that interpretation of U in Section 4.4.

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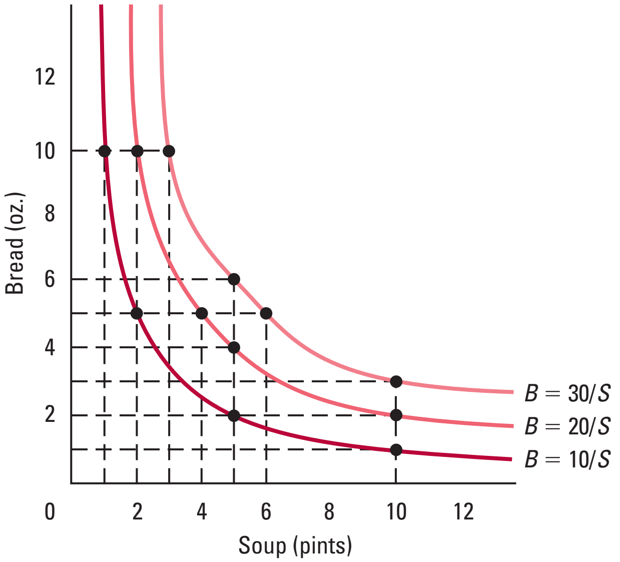
[9] You may recall from an algebra course that $B = 10/S$ is the formula for a rectangular hyperbola.

Figure 4.6

Plotting Indifference Curves from a Formula. Using the formula $B = U/S$, we can plot three indifference curves by substituting values of 10, 20, and 30 for the constant U.



IN-TEXT EXERCISE 4.2 **Judy drinks both Coke and Pepsi. Suppose the formula for her indifference curves is $C = U - 1.2P$, where C stands for liters of Coke and P stands for liters of Pepsi consumed over a month. Draw some of Judy's indifference curves. Which does she prefer, a bundle consisting of one liter of Coke and no Pepsi, or a bundle consisting of one liter of Pepsi and no Coke?**

Goods versus Bads

A **bad** is an object, condition, or activity that makes a consumer worse off.

So far, we have focused on decisions involving things that people desire (goods). But people also often make decisions involving objects, conditions, or activities that make them worse off, and that they wish to avoid (**bads**). Think, for example, about studying for your final exam in this course. Everyone likes to get good grades, and most people like to learn, but few people enjoy studying. (There are, of course, exceptions, such as the odd ones who go on to become professors and write textbooks, but we'll leave them out of this discussion.) Most people are willing to make trade-offs between their grades and their study times. As a consequence, we can summarize their preferences by drawing indifference curves.

Figure 4.7(a) illustrates this trade-off. The vertical axis measures a student's grade on the microeconomics final exam (in percentage points). The horizontal axis measures the number of hours spent studying each evening over some appropriately grueling period, say a full month before the exam. To construct an indifference curve, we first select a starting point. Let's take the professor's ideal: the student spends six hours per evening studying, learns the material perfectly, and receives a perfect score on the final exam.[10] This ideal is

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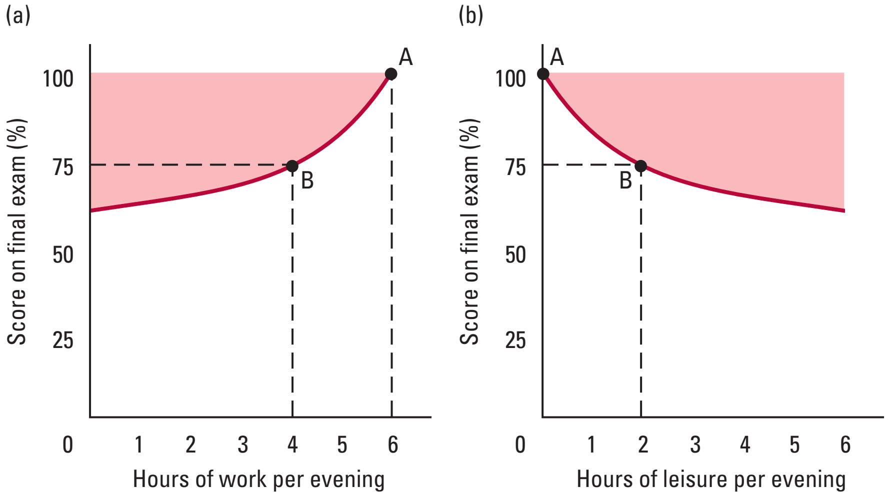
[10] This option, of course, leaves no time to study for other courses, which is reasonable given the importance of microeconomics.

Figure 4.7

Indifference Curves for Studying and Grades. Figure (a) shows an indifference curve for the final exam score, a good, and hours of work per evening, a bad. Figure (b) illustrates the same preferences through an indifference curve for two goods: the final exam score and hours of leisure time per evening.



point A in the figure. Oddly, many students feel that academic perfection is not worth the complete absence of a social life. What is the student willing to sacrifice, in terms of exam performance, to get a life? According to the figure, the student is indifferent between point A and point B, which entails studying four hours per night to receive a score of 75 percent. In other words, the student is willing to accept a score that is 25 percentage points lower in return for reducing nightly study time by two hours.

Note that the indifference curve in Figure 4.7(a) slopes upward instead of downward. That is because the More-Is-Better Principle doesn't hold; the student views study time as a bad rather than a good. To compensate him for a lower grade, we have to *reduce* study time. Likewise, since he would like to score higher while studying less, the better-than-A alternatives lie in the red-shaded area to the *northwest* of the indifference curve, instead of to the northeast as in Figure 4.1.

Does this mean that we need separate theories for goods and bads? Fortunately, it doesn't. We can always think of a bad as the absence of a good. In our example, studying is a bad because it crowds out leisure time. So let's think about choosing leisure time instead of study time. That way, the student's decision involves two goods, instead of a good and a bad.

Figure 4.7(b) illustrates this idea. Its horizontal axis measures hours of leisure time per evening instead of hours of studying. Six hours of studying corresponds to no hours of leisure, four hours of studying to two hours of leisure, and so forth. Points A and B represent the same outcomes as in Figure 4.7 (a). Note that the indifference curve in Figure 4.7(b) is simply the mirror image of the one in Figure 4.7(a). It slopes downward, and the better-than-A points lie to the northeast. Here, the student's indifference between points

A and B reflects a willingness to give up 25 percentage points on the final exam in return for two hours of leisure time per evening.

This example is important because it suggests a way to address one of the central questions in microeconomics: How do people choose the number of hours they work? Most people regard hours of work as a bad, in the sense that they would rather do something more pleasant. We'll attack this question in Chapter 6 by studying the choice of leisure hours (a good) rather than the choice of work hours (a bad).

4.3 SUBSTITUTION BETWEEN GOODS

All economic decisions involve trade-offs. To determine whether a particular choice benefits or harms a consumer, we need to know the rate at which he is willing to make trade-offs. Indifference curves are important in part because they provide us with that information.

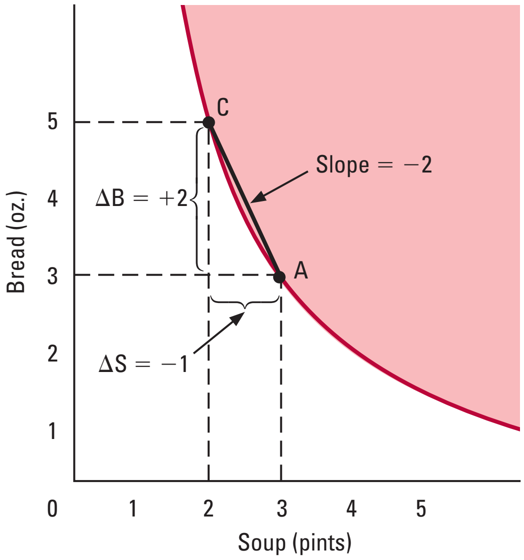
Rates of Substitution

In moving from one bundle to another along an indifference curve, we subtract units of one good and compensate the consumer for the loss by adding units of another good. The slope of the indifference curve is important because it tells us how much of the second good is required to compensate the consumer for giving up some of the first good.

Figure 4.8 illustrates this point using Madeline's preferences. Since bundles A and C lie on the same indifference curve, she is equally happy with either. In moving from bundle A to bundle C, the change in soup, ΔS, is -1 pint, and the change in bread, ΔB, is $+2$ ounces. So starting from bundle A, two additional ounces of bread exactly com-

Figure 4.8

Indifference Curves and Rates of Substitution. In moving from bundle A to bundle C, Madeline loses 1 pint of soup and gains 2 ounces of bread. So the rate at which she is willing to substitute for soup with bread is 2 ounces per pint.



pensate Madeline for the loss of a pint of soup. The rate at which she substitutes for soup with bread in moving from bundle A to bundle C is $-\Delta B/\Delta S = 2$ ounces per pint. The expression $\Delta B/\Delta S$ equals rise over run along the indifference curve between bundles A and C; it is also the slope of the straight line connecting bundles A and C.

In Figure 4.8, the movement from bundle A to bundle C involves relatively large changes in the amounts consumed. Economists usually measure rates of substitution in terms of very small changes in quantities, leading to a concept known as the *marginal rate of substitution*.

Let's refer to the goods in question as X and Y. The **marginal rate of substitution for X with Y**, written MRS_{XY}, is the rate at which a consumer must adjust Y to maintain the same level of well-being when X changes by a tiny amount, from a given starting point. The phrase "for X with Y" means that we measure the rate of substitution *compensating **for** a given change in X **with** an adjustment to Y*. The change in X can be either positive or negative. If it is positive, we must reduce Y to avoid changing the consumer's level of well-being; if it is negative, we must increase Y (as in Figure 4.8). Mathematically, if ΔX is the tiny change in X and ΔY is the adjustment to Y, then $MRS_{XY} = -\Delta Y/\Delta X$. We multiply $\Delta Y/\Delta X$ by negative one because ΔX and ΔY always have opposite signs. Including the negative sign converts the ratio into a positive number, making it easier to interpret (since a larger positive value then indicates that the adjustment to Y must be larger to compensate for a change in X).

The marginal rate of substitution for X with Y, written MRS_{XY}, is the rate at which a consumer must adjust Y to maintain the same level of well-being when X changes by a tiny amount, from a given starting point. Mathematically, if ΔX is the tiny change in X and ΔY is the adjustment to Y, then $MRS_{XY} = -\Delta Y/\Delta X$.

Intuitively, the marginal rate of substitution for X with Y tells us how much Y we need to give a consumer, per unit of X, to compensate for losing a little bit of X. It also tells us how much Y we need to take away from a consumer, per unit of X, to compensate for gaining a little bit of X.

Figure 4.9 illustrates Madeline's marginal rate of substitution for soup with bread, using bundle A as the starting point. Notice that the figure includes a line that lies tangent to her indifference curve at bundle A. (See Section 3.2 for a discussion of tangent lines.)

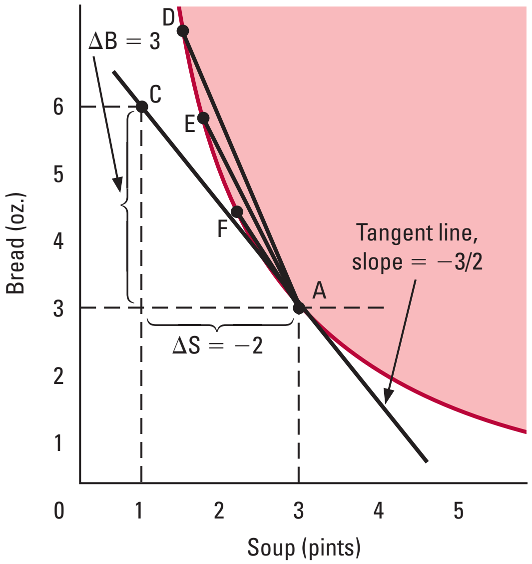


Figure 4.9

Indifference Curves and the Marginal Rate of Substitution. The marginal rate of substitution for soup with bread at bundle A is equal to the slope of the line drawn tangent to the indifference curve running through point A times −1. For smaller and smaller changes in the amounts of soup and bread, the slope of the line between A and the new consumption bundle (first D, then E, then F) grows closer and closer to the slope of the tangent line.

By definition, the slope of the tangent line equals rise over run—that is, $\Delta B/\Delta S$—for very small movements along the indifference curve, starting from bundle A. Therefore, the marginal rate of substitution for soup with bread, MRS_{SB}, at bundle A is simply the slope of this tangent line times negative one.[11] We can measure the slope of the tangent line by selecting a second bundle on that line, like C, and computing $\Delta B/\Delta S$ between the bundles A and C.[12] In this case, since $\Delta B = 3$ ounces and $\Delta S = -2$ pints, we have $\Delta B/\Delta S = -1.5$ ounces per pint. So Madeline's marginal rate of substitution for soup with bread at bundle A is 1.5 ounces per pint.[13]

The value 1.5 ounces per pint signifies that starting at bundle A, Madeline is just willing to give up a small quantity of soup, ΔS pints, in exchange for approximately $\Delta B = 1.5 \times \Delta S$ additional ounces of bread, or to accept ΔS pints of soup in exchange for giving up approximately $\Delta B = 1.5 \times \Delta S$ ounces of bread. The quality of this approximation is better for smaller values of ΔS than for larger values. Figure 4.9 illustrates this point. As we consider smaller and smaller changes in the amounts of soup and bread, the slope of the line between A and the new consumption bundle (first D, then E, then F) grows closer and closer to the slope of the tangent line.

Note that MRS_{XY} is *not* the same as MRS_{YX}. For MRS_{XY}, we compensate for a given change in X with an adjustment to Y, and divide this adjustment by the change in X (that is, we compute $-\Delta Y/\Delta X$). For MRS_{YX}, we compensate for a given change in Y with an adjustment to X and divide this adjustment by the change in Y (that is, we compute $-\Delta X/\Delta Y$).[14]

What Determines Rates of Substitution? Rates of substitution depend on consumers' tastes in predictable and intuitive ways. Figure 4.10 illustrates this point by showing the indifference curves for two consumers. Angie loves soup and likes bread, while Marcus loves bread and likes soup. How do these differences in taste affect their rates of substitution? Starting at bundle A in Figure 4.10, imagine reducing the amount of soup by one pint. Angie needs a large amount of bread, which she likes, to compensate for the lost soup, which she loves. So at A, Angie's marginal rate of substitution for soup with bread is high and her indifference curve, shown in dark red, is relatively steep (it runs through bundle B). In contrast, Marcus needs only a small amount of bread, which he loves, to compensate him for the lost soup, which he likes. So at A, Marcus's marginal rate of substitution for soup with bread is low and his indifference curve, shown in light red, is relatively flat (it runs through C).[15]

Rates of substitution also depend on the consumer's starting point. For example, in Figure 4.11, the slope of the line drawn tangent to Madeline's indifference curve, and therefore her marginal rate of substitution for soup with bread, is different at bundles A, B, and C.

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[11] Mathematically, the slope of the tangent line is by definition the derivative of the formula for the indifference curve, evaluated at point A.

[12] The location of this second bundle doesn't matter, as long as it's on the tangent line. Because the tangent line is straight, its slope is constant.

[13] Naturally, the value of MRS_{XY} depends on the scale used to measure X and Y. For example, since there are two pints in a quart, substituting for soup with bread at the rate of 1.5 ounces per pint is equivalent to substituting at the rate of 3 ounces per quart.

[14] Though MRS_{XY} and MRS_{YX} measure different things, there is a simple relationship between them. Since $\Delta X/\Delta Y = 1/(\Delta Y/\Delta X)$, it follows that $MRS_{XY} = 1/MRS_{YX}$. So, for example, if the marginal rate of substitution for soup with bread is 1.5 ounces per pint, then the marginal rate of substitution for bread with soup is 0.667 pint per ounce.

[15] Note that the two indifference curves shown in Figure 4.10 cross. Unlike indifference curves that belong to the *same* consumer, indifference curves belonging to *different* consumers with different tastes always cross.

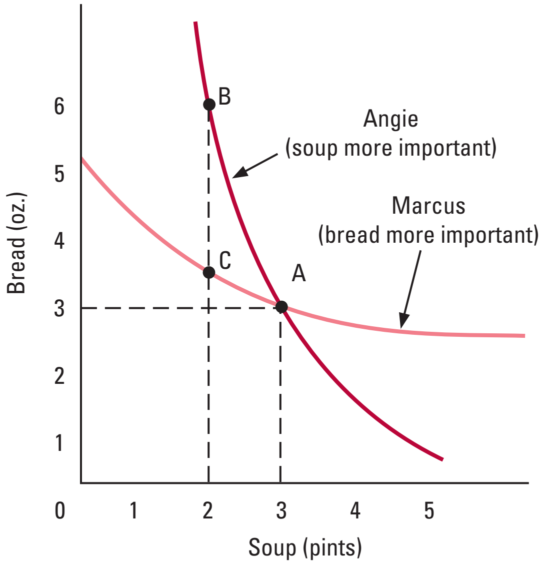

Figure 4.10

Indifference Curves, Marginal Rates of Substitution, and Consumer Tastes. The slope of an indifference curve depends on the consumer's taste. Angie attaches more importance to soup and less to bread than does Marcus. Her MRS for soup with bread is higher than Marcus's, and her indifference curve is steeper.

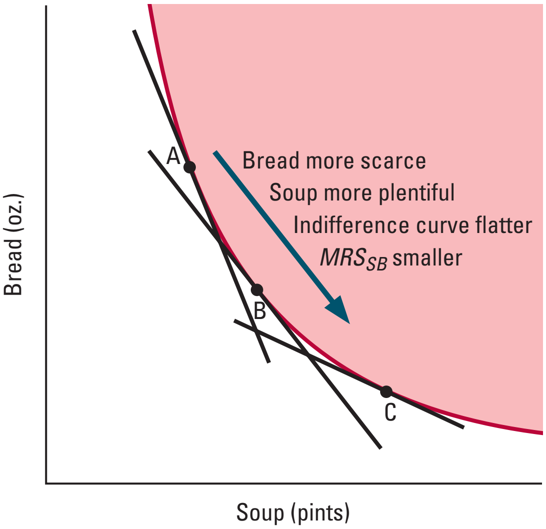

Figure 4.11

The MRS at Different Points on the Same Indifference Curve. The red indifference curve has a declining MRS. Moving in the direction of the blue arrow, bread becomes more scarce and soup becomes more plentiful, so that the MRS for soup with bread falls, and the indifference curve becomes flatter.

Notice that the indifference curve in Figure 4.11 becomes flatter as we move in the direction of the blue arrow, from the northwest (top left) to the southeast (bottom right). This pattern implies that MRS_{SB} declines as we progress toward bundles offering more soup and less bread (for example, from A to B to C). In other words, when soup is more plentiful and bread more scarce, less bread is needed to compensate for the loss of a pint of soup and more soup is needed to compensate for the loss of an ounce of bread.

Why should MRS_{SB} decline when moving from northwest to southeast on an indifference curve? One important reason is that people like variety. To illustrate, suppose we start Madeline off with a great deal of bread but little soup (at a bundle like A in Figure 4.11). As a result, she becomes less enthusiastic about bread and craves soup. This means it would take a great deal of bread to compensate her for the loss of a pint of soup—in other words, her MRS_{SB} is high. Now suppose we start her off with a great deal of soup but little bread (at a bundle like C in Figure 4.11). As a result, she becomes less enthusiastic about soup and craves bread. This means it would take only a small amount of bread to compensate her for the loss of a pint of soup—in other words, her MRS_{SB} is low.

The logic of this discussion applies across a wide range of circumstances. If an indifference curve becomes flatter as we move along the curve from the northwest to the southeast (as in Figure 4.11), we will say that it has a **declining MRS**.[16] When an indifference curve has a declining MRS, the amount of one good, Y, required to compensate a consumer for a given change in another good, X, and hence MRS_{XY}, declines as X becomes more plentiful and Y becomes more scarce.

We will say that an indifference curve has a **declining MRS** if it becomes flatter as we move along the curve from the northwest to the southeast.

Notice that each of the indifference curves in Figure 4.5, which reflects the typical new car buyer's actual preferences for horsepower and fuel efficiency, has a declining MRS. For example, consumers are willing to give up roughly 40 horsepower to increase fuel efficiency from 10 to 15 miles per gallon (compare points A and B), but they are willing to give up only 6 horsepower to increase fuel efficiency from 30 to 35 miles per gallon (compare points C and D).

Formulas for Rates of Substitution

As we've seen, one way to describe consumers' preferences mathematically is to write formulas for their indifference curves. Another way is to write formulas for their marginal rates of substitution. An MRS formula tells us the rate at which the consumer is willing to exchange one good for another, given the amounts consumed. For many purposes, that is all we need to know about a consumer's preferences.

To illustrate, suppose the rate at which a particular consumer is willing to substitute for soup with bread is given by the formula $MRS_{SB} = B/S$, where B stands for ounces of bread and S stands for pints of soup. In other words, if the consumer starts out with B ounces of bread and S ounces of soup, tiny changes in the amounts of bread and soup, ΔB and ΔS, will leave him (roughly) on the same indifference curve as long as $\Delta B/\Delta S = -B/S$. When $S = 12$ and $B = 2$, the MRS for soup with bread is 1/6 ounce per pint. In other words, starting with 12 pints of soup and 2 ounces of bread, the consumer must receive $(1/6) \times \Delta S$ ounces of bread to compensate for the loss of ΔS pints of soup (where ΔS is tiny). Likewise, when $S = 5$ and $B = 5$, the MRS for soup with bread is one ounce per pint. In other words, starting with 5 pints of soup and 5 ounces of bread, the consumer must receive ΔS ounces of bread to compensate for the loss of ΔS pints of soup (where again ΔS is tiny).

Checking whether a consumer's indifference curves have declining MRSs using a formula for the MRS is usually easy. For example, when $MRS_{SB} = B/S$, the MRS for soup with bread increases with the amount of bread and decreases with the amount of soup. Every indifference curve must therefore become flatter as we move along the curve from

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[16] The notion of a declining MRS is associated with a mathematical concept called *convexity*. Notice that, in Figure 4.11, the set of better-than-A alternatives (shaded light red) is shaped like a convex lens that bulges in the direction of the origin. Economists and mathematicians refer to this type of set as *convex*. The indifference curve illustrated in Figure 4.11 is also called a *convex function*, in the sense that the slope of the line drawn tangent to it increases (becomes less negative) as we move from left to right. These characteristics of preferences are both mathematically equivalent to a declining MRS.

the northwest to the southeast, toward bundles with less bread and more soup. Therefore, those indifference curves have declining MRSs.

For every indifference curve formula, there is an MRS formula that describes the same preferences, and vice versa. In fact, the marginal rate of substitution formula examined here, $MRS_{SB} = B/S$, describes the same preferences as the indifference curve formula discussed in Section 4.2, $B = U/S$. How do we know this? In Section 4.4, we'll see why these two particular formulas correspond to the same preferences. Generally, however, the most direct way to obtain an MRS formula from an indifference curve formula involves calculus.[17] In this book, we do not assume that you know calculus. So whenever you need an MRS formula, we'll give it to you.

Why Are Rates of Substitution Important? We'll emphasize throughout this book that the MRS plays a central role in microeconomic theory. To illustrate its importance, let's consider a basic question that lies at the core of microeconomic theory. Suppose two people meet, and each has something the other wants. Will they voluntarily trade with each other? We can assume they will if doing so is *mutually beneficial*—that is, if they can arrange a swap that benefits both parties. Whether or not the trade is mutually beneficial depends in turn on the parties' rates of substitution. A simple example will illustrate this principle.

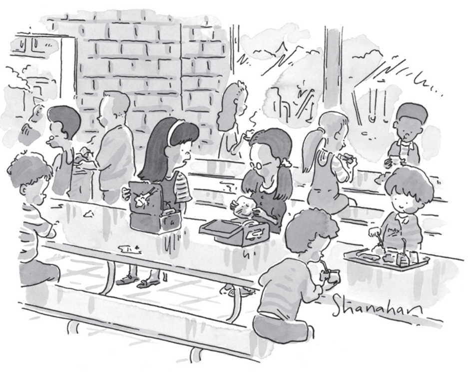
Example 4.3

The Lunch Box Problem and Mutual Gains from Trade

Kate and Antonio meet in their school cafeteria and examine the contents of their lunch boxes. Tossing their sandwiches aside, they focus on dessert. Kate discovers a bag of M&Ms, while Antonio finds a box of Milk Duds. Each eyes the other's dessert. Will they exchange some M&Ms for some Milk Duds? The answer depends on their marginal rates of substitution.

Suppose Kate's MRS for Milk Duds with M&Ms is eight M&Ms per Dud, while Antonio's is two M&Ms per Dud. To keep things simple, let's assume that these rates of substitution don't depend on the amounts consumed. In that case, swapping one Milk Dud for, say, five M&Ms makes both of them better off. From Kate's MRS, we know that she is willing to part with up to eight M&Ms for a Milk Dud; since she parts with fewer than eight, she's better off. Likewise, from Antonio's MRS, we know that he requires only two M&Ms to compensate for the loss of a Milk Dud; since he receives more than two, he's also better off. In this example, the same conclusion holds for any trade involving Y Milk Duds and $Y \times Z$ M&Ms, as long as the number Z is between two and eight. (Why?)

Under some circumstances, mutually beneficial trade cannot occur. Suppose, for example, that Kate's MRS for Milk Duds with M&Ms is two M&Ms per Dud, while Antonio's is three. Then Kate is willing to part with no more than two M&Ms for a Milk Dud, while Antonio requires at least three M&Ms to compensate for the loss of a Milk Dud. Meeting both of their requirements is impossible. If Kate and Antonio were to trade, say, 2.5 M&Ms for one Milk Dud, both would be worse off.



"I'd trade, but peanut butter sticks to my tongue stud."

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[17] If $B = U/S$, then $dB/dS = -U/S^2 = -B/S$, so $MRS_{SB} = B/S$.

IN-TEXT EXERCISE 4.3 **Suppose you don't know anything specific about Kate and Antonio's preferences. You do know, however, that they were given a chance to swap eight M&Ms for five Milk Duds, and they both voluntarily agreed to this swap. What can you say about Kate's MRS for Milk Duds with M&Ms? About Antonio's? (As in Example 4.3, assume that these rates of substitution don't depend on the amounts consumed.)**

Special Cases: Perfect Substitutes and Complements

Two products are **perfect substitutes** if their functions are identical, so that a consumer is willing to swap one for the other at a fixed rate.

Two products are **perfect complements** if they are valuable only when used together in fixed proportions.

Sometimes consumers use different products to serve essentially the same purpose. When two products' functions are literally identical, so that a consumer is willing to swap one for the other at a fixed rate, we call them **perfect substitutes**. While thinking of products that serve very similar purposes is easy—Coke and Pepsi, Corn Flakes and Special K, Sony PlayStation and Nintendo GameCube—in each case there are some differences. In practice, then, substitutability is a matter of degree. We study the case of *perfect* substitutes because it is one end of the theoretical spectrum.

Sometimes consumers use different products *together* to serve a single purpose. If two goods are valuable only when used together in fixed proportions, we call them **perfect complements**. Again, thinking of examples of products that consumers use together is easy—bicycle tires and frames, left and right shoes, and left and right gloves. However, it is not quite true that these goods are always used in fixed proportions. For example, though most people wear gloves in pairs, some view a single glove as a fashion statement, and others keep unmatched gloves as spares. So in practice, complementarity is also a matter of degree. We study the case of perfect complements because it is the opposite end of the theoretical spectrum.

Graphically, you can identify cases of perfect substitutes and perfect complements by examining families of indifference curves. We'll illustrate this point with a practical application (Application 4.3) and an example.

Application 4.3

Perfect Substitutability Among Pharmaceutical Products

Many examples of near-perfect substitutes can be found in the over-the-counter (OTC) pharmaceutical market, in which products are often differentiated only by dosage. Advil, for example, comes in 200-milligram regular-strength tablets and 400-milligram extra-stength tablets. Obviously, two regular-strength tablets serve exactly the same purpose as one extra-strength tablet. Moreover, as long as a consumer can break a tablet in half, one extra-strength tablet serves exactly the same purpose as two regular-strength tablets. In practice, however, the degree of substitutability may not be perfect; splitting an extra-strength pill in two may be difficult, and some consumers may incorrectly believe that "extra-strength" implies characteristics other than (or in addition to) a higher dosage. Even so, these products are highly substitutable. For illustrative purposes, we'll assume they are perfectly interchangeable.

As a rule, families of indifference curves for perfectly substitutable products are drawn as parallel straight lines. Figure 4.12 shows the indifference curves for regular-strength and extra-strength Advil tablets. Notice that they have a common slope of $-1/2$. Regardless of the starting point, a consumer must receive one extra-strength tablet to compensate for the loss of two regular-strength tablets. Since the consumer cares only about the total number of milligrams of Advil purchased, the marginal rate of substitution for regular tablets with extra-strength tablets is necessarily fixed at one-half extra-strength per regular strength tablet.

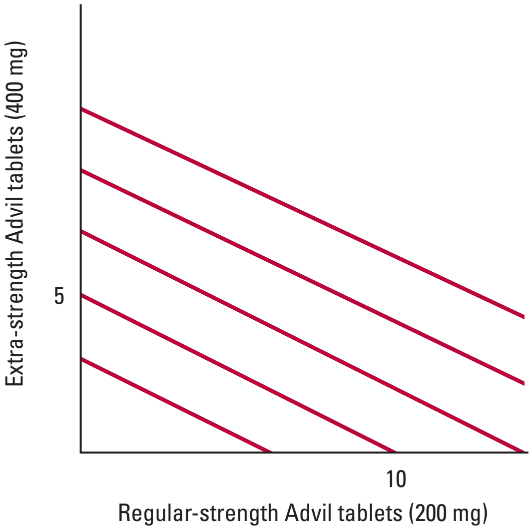


Figure 4.12

Indifference Curves for Perfect Substitutes. The indifference curves for perfect substitutes are straight lines. Because the consumer only cares about the total amount of Advil purchased, two 200-milligram extra-strength tablets are a perfect substitute for one 400-milligram extra-strength tablet.

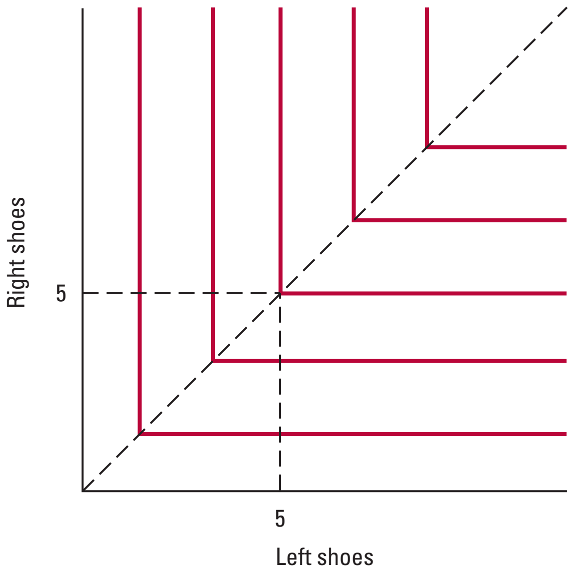
Example 4.4

Perfect Complementarity between Left and Right Shoes

Figure 4.13 shows a family of indifference curves for left and right shoes, assuming they are perfect complements. For every bundle on the dashed 45-degree line that runs through the origin, the number of left shoes equals the number of right shoes. Consider the point corresponding to five left shoes and five right shoes. What bundles would a consumer find equally attractive? Since extra right shoes are worthless on their own, the consumer would gain nothing from their addition without left shoes. He is therefore indifferent between five left shoes and five right shoes, five left shoes and six right shoes, five left shoes and seven right shoes, and so forth. This conclusion implies that the indifference curve is vertical above the 45-degree line. Similarly, the consumer would gain nothing from the addition of extra left shoes without right shoes. He is therefore indifferent between five left shoes and five right shoes, six left shoes and five right shoes, seven left shoes and five right shoes, and so forth. This conclusion implies that the indifference curve is horizontal below the 45-degree line. Combining these observations, we obtain an L-shaped indifference curve, with a “kink” where it intersects the 45-degree line, as shown in the figure.

Figure 4.13

Indifference Curves for Perfect Complements. Indifference curves for perfect complements are L-shaped. Assuming that a left shoe is of no value without a right shoe and vice versa, a consumer's indifference curves for left and right shoes are vertical above the 45-degree line and horizontal below it, with a kink where they meet.



In the real world, product pairs tend to fall somewhere along the spectrum between perfect substitutes and perfect complements. When consumers' indifference curves are reasonably close to straight lines, the degree of substitutability between products is high, and the degree of complementarity is low. When consumers' indifference curves bend sharply, the degree of complementarity between products is high, and the degree of substitutability is low.

4.4 UTILITY

Utility is a numeric value indicating the consumer's relative well-being. Higher utility indicates greater satisfaction than lower utility.

To summarize everything that is known about a consumer's preferences, economists use a concept called **utility**. This is simply a numeric value indicating the consumer's relative well-being—higher utility indicates greater satisfaction than lower utility. The word *utility* reminds us that our objective is to capture the use or benefit that someone receives from the goods he consumes. Every time you rate something from, say, one to ten points, or one to five stars, you're using a utility scale.

To describe a consumer's preferences over consumption bundles, we assign a utility value to each bundle; the better the bundle, the higher the value. To determine which of any two bundles is better, we can simply compare their utility values. The consumer prefers the one with the higher value and is indifferent between bundles whose values are identical.

A **utility function** is a mathematical formula that assigns a utility value to each consumption bundle.

We assign utility values to consumption bundles using mathematical formulas called **utility functions**. For example, the formula $U(S, B) = 2S + 5(S \times B)$ assigns utility values to consumption bundles based on pints of soup, S, and ounces of bread, B. For this function,

$U(12, 3)$, the utility value associated with 12 pints of soup and 3 ounces of bread is 204 $= (2 \times 12) + (5 \times 12 \times 3)$. Likewise, $U(9, 4)$, the utility value associated with 9 pints of soup and 4 ounces of bread is $198 = (2 \times 9) + (5 \times 9 \times 4)$. And $U(17, 2)$, the utility value associated with 17 pints of soup and 2 ounces of bread, is $204 = (2 \times 17) + (5 \times 17 \times 2)$. In this case, the utilities associated with the first and third bundles are the same, and both are higher than the utility associated with the second bundle. Therefore, the consumer is indifferent between the first and third bundles, and prefers both to the second bundle.

WORKED-OUT PROBLEM 4.2

The Problem Mitra enjoys reading books and watching movies. Her utility function is $U(M, B) = M \times B^2$, where M stands for the number of movies and B stands for the number of books enjoyed during a month. How does Mitra rank the following bundles? (1) 4 movies and 5 books, (2) 10 movies and 4 books, (3) 25 movies and 2 books, (4) 40 movies and 1 book, (5) 100 movies and no books.

The Solution Applying Mitra's utility function, we find that (1) $U(4, 5) = 100$, (2) $U(10, 4) = 160$, (3) $U(25, 2) = 100$, (4) $U(40, 1) = 40$, and (5) $U(100, 0) = 0$. Therefore, Mitra ranks the bundles listed in the problem, in order of preference, as follows: first, 10 movies and 4 books; next, either 4 movies and 5 books or 25 movies and 2 books (she is indifferent between those two bundles); next, 40 movies and 1 book; and last, 100 movies and no books.

IN-TEXT EXERCISE 4.4 **Bert enjoys both Coke and Mountain Dew. His preferences correspond to the utility function $U(C, M) = C + 3\sqrt{M}$, where C stands for liters of Coke and M stands for liters of Mountain Dew consumed in a month. How does Bert rank the following alternatives? (1) 5 liters of Coke and 4 liters of Mountain Dew, (2) 20 liters of Coke and no Mountain Dew, (3) 10 liters of Mountain Dew and no Coke, (4) 8 liters of Coke and 7 liters of Mountain Dew, (5) 1 liter of Coke and 6 liters of Mountain Dew.**

From Indifference Curves to Utility Functions and Back

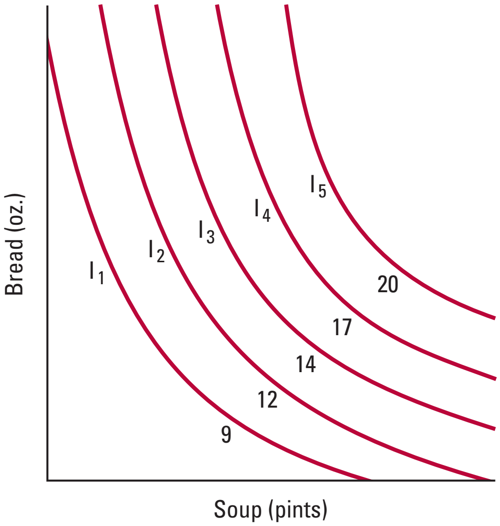
Of course, consumers don't actually have utility functions; they have preferences. A utility function is a formula that an economist develops to summarize consumer preferences. Starting with information about preferences, then, how do we derive an appropriate utility function?

Naturally, a utility function must assign the same value to all the bundles on a single indifference curve. So all we need to do is choose a utility value for each indifference curve, picking higher values for indifference curves that correspond to higher levels of well-being.

When the More-Is-Better Principle holds, we assign higher utility values to indifference curves that are further from the origin. For an illustration, look at Figure 4.14, which shows five indifference curves (labeled I_1 through I_5) for someone who consumes soup and bread. As shown in the figure, we've assigned utility values of 9 to I_1, 12 to I_2, 14 to I_3, 17 to I_4, and 20 to I_5. Between any two bundles, the consumer will always prefer the

Figure 4.14

Representing Preferences with a Utility Function. To create a utility function, we assign the same value to all points on a single indifference curve, using higher values for indifference curves that correspond to higher levels of well-being. Following the More-Is-Better Principle, we assign higher values to indifference curves that are further from the origin.



one with the higher utility value, because it lies on a higher indifference curve. The consumer will be indifferent between any two bundles with the same utility value, because they lie on the same indifference curve. Thus, the utility function faithfully represents the consumer's preferences.

We can also start with a utility function and construct the associated indifference curves. To find an indifference curve, all we need to do is fix a level of utility and identify all the bundles that will deliver it. To illustrate, take the utility function $U(S, B) = S \times B$. Choose any utility value, say 10. The consumer will be indifferent between all combinations of soup and bread that satisfy the equation $10 = S \times B$. We can rewrite this equation as $B = 10/S$, a formula that describes a single indifference curve. If we select any other utility value, call it U, the consumer will be indifferent between all combinations of soup and bread that satisfy the formula $U = S \times B$, so the formula $B = U/S$ describes the associated indifference curve. In other words, the utility function $U(S, B) = S \times B$ and the indifference curve formula $B = U/S$ summarize the same preferences. We graphed these indifference curves in Figure 4.6 (page 104).

Figure 4.15 illustrates another way to think about the relation between utility functions and indifference curves. It is the same as Figure 4.14, except that we've laid the figure on its side and added a third dimension (the vertical axis) measuring Madeline's utility. For any consumption bundle, like A, Madeline's level of utility corresponds to the height of the hill pictured in the figure. The light red curve shows all the points on the hill that are just as high as the point corresponding to bundle A. The dark red curve directly below it (at "ground level") shows the combinations of soup and bread that are associated with the points on the light red curve. The dark red curve is the indifference curve passing through bundle A.

If you've gone on a camping trip or taken a geography course, you may have seen contour lines on topographic maps. Each contour line shows all the locations that are at a single elevation. Figure 4.14 is essentially a topographic map for the hill shown in Figure 4.15; each indifference curve in Figure 4.14 is a contour line for a particular elevation.

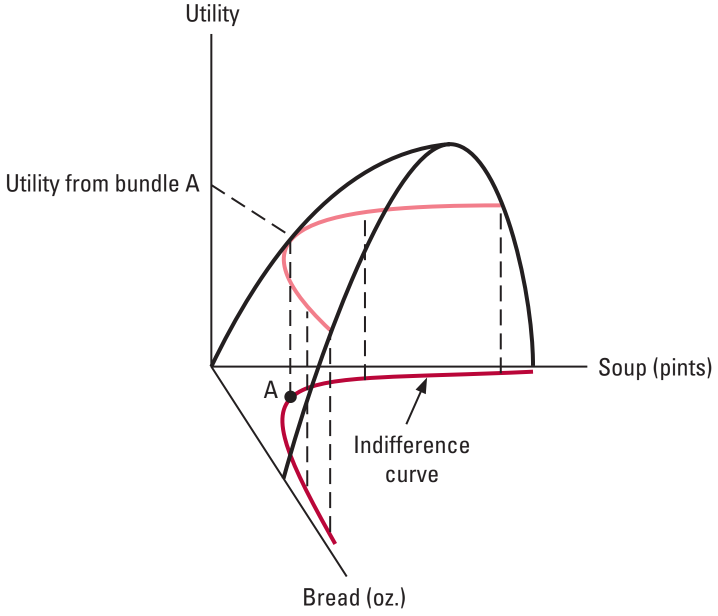


Figure 4.15

Deriving Indifference Curves from a Utility Function. For any consumption bundle, like A, Madeline's utility corresponds to the height of the utility "hill." The indifference curve passing through A consists of all the bundles for which the height of the hill is the same.

Ordinal versus Cardinal Utility

Information about preferences can be either **ordinal** or **cardinal**. Ordinal information allows us to determine only whether one alternative is better or worse than another. Cardinal information tells us something about the *intensity* of those preferences—it answers the question "How much worse?" or "How much better?"

Information about preferences is **ordinal** if it allows us to determine only whether one alternative is better or worse than another. **Cardinal** information tells us something about the *intensity* of those preferences—it answers the question "How much worse?" or "How much better?"

During the 19th century and for much of the 20th century, many prominent scholars, including the influential moral philosopher Jeremy Bentham (1748–1832), thought that utility functions should provide cardinal information about preferences. According to this view, people are "pleasure machines"—they use consumption goods as inputs to produce utility as an output. Bentham and others argued that the aim of public policy should be to maximize the total utility generated through economic activity.

In modern microeconomic theory, utility functions are only intended to summarize ordinal information. If one consumption bundle has a utility value of 10 and a second has a utility value of 5, we know the consumer prefers the first to the second, but it doesn't necessarily make him twice as happy. Today, most economists believe that there's no meaningful way to measure human well-being on an absolute scale, so they reject cardinal interpretations of utility.[18] To understand why this is so, think about your own state of mind. You can probably say whether you're generally happier today than you were yesterday; that's an ordinal statement. But you can't *measure* the difference in your happiness.

From the modern "ordinalist" perspective, the scale used to measure utility is completely arbitrary. Netflix uses a five-star system for rating movies, but it could just as easily have used seven happy faces or ten bowls of popcorn. Likewise, when we measure

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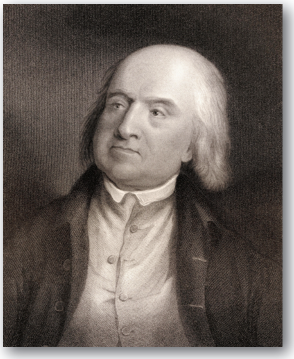
[18] Though psychologists have developed reasonably reliable measures of human happiness, these measures also convey ordinal information, rather than meaningful cardinal information. In other words, they can tell us whether someone is happier in one situation than another, but they measure the difference in happiness on an arbitrary scale.



Jeremy Bentham (1748–1832) is regarded as one of the founders of the school of thought on moral philosophy known as "utilitarianism." He continues to be a physical presence at University College London, where, at his request, his skeleton is preserved in a wooden cabinet, dressed in his own clothes and adorned with a wax head. According to one unconfirmed legend, the cabinet is solemnly wheeled into each meeting of the College Council, and the minutes record his presence as "Jeremy Bentham—present but not voting."

the height of the consumer's utility hill (like the one shown in Figure 4.15), we make up the scale and units of measurement. So, for example, in Figure 4.14, we assigned a utility value of 20 to the indifference curve labeled I_5, but we could have just as well used 21, 200, 2,000,000, or any other number greater than the value assigned to I_4.

When we change the scale used to measure utility, the consumer's family of indifference curves, and therefore his preferences, remain unchanged. To illustrate this principle, let's examine the utility function $U(S, B) = 0.5 \times S \times B$, which assigns exactly half as many "utils" (units of utility) to each consumption bundle as the utility function $U(S, B) = S \times B$, considered above. With this new function, the consumer's indifference curve formula is $B = 2U/S$ instead of $B = U/S$. For any given value of U, these two formulas generate different indifference curves. But if we plug any value of U into the formula $B = 2U/S$, and plug a value twice as large into the formula $B = U/S$, we generate the *same* indifference curve. Therefore, the two formulas generate the same family of indifference curves.

Utility Functions and the Marginal Rate of Substitution

Because the marginal rate of substitution tells us the rate at which a consumer is willing to make trade-offs, it's a central concept in microeconomics. In this section, we'll introduce a useful shortcut for deriving an MRS formula, starting from a utility function.

The shortcut involves a new concept, known as **marginal utility**. Marginal utility is defined as the change in the consumer's utility resulting from the addition of a very small amount of some good, divided by the amount added.[19] Mathematically, if ΔX is the tiny change in the amount of a good X and ΔU is the resulting change in the utility value, then the marginal utility of X, written MU_X, is:

Marginal utility is the change in the consumer's utility resulting from the addition of a very small amount of some good, divided by the amount added.

$$MU_X = \frac{\Delta U}{\Delta X}$$

Usually, the calculation of marginal utility requires calculus. However, as illustrated below, there are many special cases for which simple algebra suffices.

The marginal rate of substitution for any good, call it X, with any other good, call it Y, equals the ratio of the marginal utility of X to the marginal utility of Y. In mathematical terms,

$$MRS_{XY} = \frac{MU_X}{MU_Y}$$

Why does this relationship hold? A small change in X, call it ΔX, causes utility to change by approximately $MU_X \Delta X$. Similarly, a small change in Y, call it ΔY, causes utility to change by approximately $MU_Y \Delta Y$. If the combination of these changes leaves us on the same indifference curve, then utility is unaffected, so the changes offset: $MU_X \Delta X = -MU_Y \Delta Y$. Rearranging this formula, we learn that along an indifference curve, $-\Delta Y/\Delta X = MU_X/MU_Y$. Suppose, for example, that an additional unit of X adds 12 utils ($MU_X = 12$) and an additional unit of Y adds 4 utils ($MU_Y = 4$). While utils are meaningless units, a comparison of these numbers nevertheless tells us that the consumer is just willing to exchange one unit of X for three units of Y. Sacrificing one unit of X reduces utility by

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[19] If you've taken calculus, you may recognize this as the definition of the derivative of the utility function with respect to the amount of the good in question.

12 utils, but gaining three units of Y increases utility by 12 utils, so the exchange does not alter the consumer's well-being. Therefore, the MRS for X with Y is 3. The preceding formula gives the same answer: $MU_X/MU_Y = 3$.

To illustrate the use of the shortcut, let's again consider the utility function $U(S, B) = S \times B$. For this function, the marginal utility of soup is B (adding ΔS pints of soup increases the utility value by $B \times \Delta S$ units, so $\Delta U/\Delta S = B$), and the marginal utility of bread is S (adding ΔB ounces of bread increases the utility value by $S \times \Delta B$ units, so $\Delta U/\Delta B = S$). Therefore, for this utility function, $MRS_{SB} = B/S$ ounces per pint. As we've explained, the formula $B = U/S$ describes the indifference curves associated with this utility function. Consequently, the formula $MRS_{SB} = B/S$ and the indifference curve formula $B = U/S$ correspond to the same preferences, just as we claimed on page 111.

The concept of marginal utility, though useful, is also the source of much confusion. From our discussion of ordinal and cardinal utility, it should be clear that, by itself, the marginal utility associated with a particular good is completely meaningless. Suppose that Madeline's marginal utility of soup (which we will write as MU_S) is 5. You should be asking yourself, five what? Happy faces? Gold stars? Utils? None of these units has any practical meaning.

If marginal utility is not meaningful by itself, how can the ratio of marginal utilities give us the marginal rate of substitution, which is meaningful? The answer is that when we change the units used to measure utility, we don't change the *ratio* of marginal utilities. To illustrate this point, let's change a utility scale by using the utility function $U(S, B) = 2 \times S \times B$, instead of $U(S, B) = S \times B$, as above. For the new utility function, the marginal utility of soup is $2B$ instead of B (adding ΔS pints of soup increases the utility value by $2 \times B \times \Delta S$ units, so $\Delta U/\Delta S = 2B$), and the marginal utility of bread is $2S$ instead of S (adding ΔB ounces of bread increases the utility value by $2 \times S \times \Delta B$ units, so $\Delta U/\Delta B = 2S$). However, the *ratio* of marginal utilities, and therefore the marginal rate of substitution for soup with bread, remains unchanged: $MRS_{SB} = MU_S/MU_B = B/S$ ounces per pint.

WORKED-OUT PROBLEM 4.3

The Problem Bobby enjoys reading books and watching movies. His utility function is $U(M, B) = M + 2B$. Find a formula for his indifference curves. What do these curves look like? What is Bobby's marginal utility of movies? Of books? What is his MRS for movies with books? From his perspective, are movies and books perfect substitutes, perfect complements, or something else?

The Solution Fixing any utility value U, Bobby will be indifferent between all combinations of books and movies that satisfy the equation $U = M + 2B$. To find the formula for his indifference curves, we just rearrange this: $B = U/2 - M/2$. So each of his indifference curves is a straight line with a slope of $-1/2$ (just like the ones in Figure 4.12, page 113). From his utility function, we see that $MU_M = 1$ (adding ΔM movies increases the utility value by ΔM units, so $\Delta U/\Delta M = 1$) and $MU_B = 2$ (adding ΔB books increases the utility value by $2 \times \Delta B$ units, so $\Delta U/\Delta B = 2$). His MRS for movies with books is therefore $MU_M/MU_B = {}^1\!/_2$ book per movie—the same as the slope of his indifference curves, times negative one. From his perspective, movies and books are perfect substitutes.

IN-TEXT EXERCISE 4.5 **Bert's preferences for Coke and Mountain Dew correspond to the utility function given in in-text exercise 4.4 (page 115). Find a formula for his indifference curves. Pick a level of utility, plot a few points on the corresponding indifference curve, and sketch the curve. From Bert's perspective, are Coke and Mountain Dew perfect substitutes, perfect complements, or something else? How would your answer change if his preferences corresponded to the utility function $U(C, M) = C + 3\sqrt{M} + 4$? What about $U(C, M) = (C + 3\sqrt{M})^2$? Or $U(C, M) = 2(C + 3\sqrt{M})$?**

Application 4.4

Ranking College Football Teams

Historically, the identity of the nation's top college football team has been a matter of opinion. The best teams have not always met in season-ending bowl games. Instead, national champions were unofficially crowned according to their standings in nationwide polls of coaches and sports writers. Fifteen times between 1950 and 1979, the college football season ended with more than one team claiming the top spot. Twice, three separate teams finished on top in at least one poll.

Since 1998, the end-of-season bowl match-ups have been governed by a comprehensive agreement known as the Bowl Championship Series (BCS). A central objective of the BCS is to avoid controversy by inviting the two most highly regarded teams to play each other in the national championship game. Selecting those teams, however, can be controversial.[20] There are many possible measures of a team's standing, including various polls and computer rankings. How does the BCS reach a decision? Although BCS officials don't put it this way, their procedure amounts to creating and applying a utility function.

From the perspective of the BCS, each team is a bundle of rankings—one from the USA Today Coaches Poll, one from the Harris Interactive College Football Poll, and six from various computer rankings. Each poll is comparable to a good; a team that has a higher ranking on a particular poll is comparable to a bundle that contains more of that particular good. In selecting teams for the national championship game, the BCS's objective—to minimize controversy by selecting the two most highly regarded teams—is comparable to selecting the best two bundles. When the polls disagree, this objective requires the BCS to make trade-offs. For example, the BCS must decide how much of a lead in the computer rankings is required to compensate for a lower ranking in the Harris Poll. Each year, the BCS uses a formula to assign each team an overall score based on its bundle of rankings. The scores are then used to rank the teams. The formula is in effect a utility function, and the scores are utility values.

For the 2006 season, each team's BCS score was based on (1) the total points it received from voters in the USA Today Coaches Poll, (2) the total points it received from voters in the Harris Interactive College Football Poll, and (3) the total points it received in six computer rankings (throwing out the lowest and highest for each team). The BCS formula averaged these three components after dividing each by the highest possible point score for that component (2,850 for the USA Today Coaches Poll, 1,550 for the Harris Poll, and 100 for the computer rankings).

Knowing this formula, we can identify changes in a team's results that would leave the BCS "indifferent" (that is, the team would end up with the same overall BCS score). As an example, if a team loses 1,000 points in the Harris Poll, its BCS score falls by 1,000/2,850 = 0.351 point. To offset this, its score in the USA Today Coaches Poll would have to be roughly 544 points higher (since 544/1,550 = 0.351). So the BCS's marginal rate of substitution for the Harris Score with the USA Today score is roughly 0.544 USA Today points per Harris point. If we drew a graph with Harris points on the horizontal axis and USA Today points on the vertical axis, each BCS indifference curve would be a straight line with a slope of −0.544.

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[20] For example, in 2003, USC was not selected for the BCS championship game, despite finishing the regular season first in both major polls.

CHAPTER SUMMARY

1. **Principles of decision making**
   a. Consumer preferences tell us about people's likes and dislikes.
   b. Consumer theory assumes that consumers' preferences are coherent, in the sense that they respect the Ranking Principle. It also assumes that their decisions reflect preferences, in the sense that they respect the Choice Principle.
2. **Consumer preferences**
   a. Since many consumer decisions are interdependent, decision makers need to compare consumption bundles.
   b. For the typical decision, it's reasonable to assume that consumers prefer more to less. In summarizing the properties of indifference curves below, we make this assumption.
   c. Indifference curves for goods are thin and never slope upward.
   d. The indifference curve that runs through any consumption bundle, call it *X*, is the boundary that separates all the better-than-*X* alternatives from all other options. The better-than-*X* alternatives lie to the northeast of the indifference curve. The worse-than-*X* alternatives lie to the southwest.
   e. Indifference curves from the same family never cross.
   f. In comparing any two alternatives, the consumer prefers the one located on the indifference curve furthest from the origin.
   g. One way to describe consumers' preferences mathematically is to write formulas for their indifference curves.
   h. For every bad there is an associated good. We can apply consumer theory to bads by thinking about the associated goods.
3. **Substitution between goods**
   a. The marginal rate of substitution varies from one consumer to another according to the relative importance the consumer attaches to the goods in question.
   b. As we move along an indifference curve from the northwest to the southeast, the curve usually becomes flatter. Equivalently, the amount of one good, *Y*, required to compensate a consumer for a fixed change in another good, *X*—and hence the MRS for *X* with *Y*—declines as *X* becomes more plentiful and *Y* becomes more scarce. This feature is known as a declining MRS.
   c. A second way to describe consumers' preferences mathematically is to write formulas for their marginal rates of substitution.
   d. Whether or not two individuals can engage in mutually beneficial trade depends on their marginal rates of substitution.
   e. The indifference curves for perfect substitutes are straight lines.
   f. The indifference curves for perfect complements are L-shaped—vertical above a kink point, and horizontal below it.
4. **Utility**
   a. Economists use the concept of utility to summarize everything that is known about a consumer's preferences.
   b. We can create a utility function from a family of indifference curves by assigning the same utility value to all bundles on an indifference curve, with higher values assigned to indifference curves that correspond to higher levels of well-being. We can construct indifference curves from a utility function by setting the function equal to a constant.
   c. In modern microeconomic theory, utility functions are only intended to summarize ordinal information.
   d. By itself, the marginal utility of a good does not measure anything meaningful. However, the ratio of the marginal utilities for two goods is equal to the marginal rate of substitution between them.

ADDITIONAL EXERCISES

Exercise 4.1: After reading this chapter, a student complains, "What I like and dislike isn't always the same; it depends on my mood." Is this a problem with consumer preference theory? Why or why not?

Exercise 4.2: Suppose there are two types of food, meat and bread. Draw indifference curves for the following consumers.

a. Ed likes variety and prefers to eat meat and bread together.

b. Francis dislikes variety; she likes to eat the same thing all the time.

c. Mia is a vegetarian who doesn't care (one way or the other) about meat.

d. Taka, a sumo wrestler, cares only about the number of calories he consumes; he wants to consume as many calories as possible.

e. Larry loves to eat and enjoys variety, but he also wants to lose weight. He therefore thinks that food is a good at low quantities, and a bad at high quantities.

Exercise 4.3: Gary has two children, Kevin and Dora. Each one consumes "yummies" and nothing else. Gary loves both children equally. For example, he is equally happy when Kevin has two yummies and Dora has three, or when Kevin has three yummies and Dora has two. But he is happier when their consumption is more equal. Draw Gary's indifference curves. What would they look like if he loved one child more than the other?

Exercise 4.4: As in the previous question, suppose that Gary loves Kevin and Dora equally. What is his marginal rate of substitution between Kevin's yummies and Dora's yummies when each has the same number of yummies? Does it become larger or smaller when Kevin has more yummies than Dora? What about when Dora has more yummies than Kevin?

Exercise 4.5: For lunch, Ada prefers to eat soup and bread in fixed proportions. When she eats X pints of soup, she prefers to eat $\sqrt{X}$ ounces of bread. If she has X pints of soup and more than $\sqrt{X}$ ounces of bread, she eats all the soup along with $\sqrt{X}$ ounces of bread, and throws the extra bread away. If she has X pints of soup and fewer than $\sqrt{X}$ ounces of bread (say Y ounces), she eats all the bread along with Y^2 ounces of soup and throws the extra soup away. Draw Ada's indifference curves between soup and bread.

Exercise 4.6: Think of five examples of bads. In each case, what is the associated good? (For example, air pollution is a bad; clean air is the associated good.)

Exercise 4.7: Ryan hates both water pollution and air pollution. He thinks that the harm caused when water pollution increases by a fixed amount rises with the total amount of water pollution, and that the harm caused when air pollution increases by a fixed amount rises with the total amount of air pollution. Sketch Ryan's indifference curves for the amount of water pollution and the amount of air pollution. Indicate how he ranks the curves you've drawn.

Exercise 4.8: Suppose bundles A and B lie on the same indifference curve. Bundle C lies between bundles A and B, on a straight line that connects them. The consumer's preferences satisfy the Declining MRS Principle. Does the consumer prefer C to A and B, or does he prefer A and B to C?

Exercise 4.9: Nora likes to breed rabbits. Clearly, she can't get very far with one rabbit. Thinking about the trade-offs between rabbits and other goods, would you expect the Declining MRS Principle to hold? Can you think of other situations in which it might be violated?

Exercise 4.10: What do you think the indifference curves in Figure 4.5 would look like for the type of person who prefers to purchase a sports car? What about the type of person who prefers to purchase a subcompact?

Exercise 4.11: John's MRS for reading books with watching movies is three movies per book regardless of the amounts consumed. Would he rather read two books and watch no movies, or read no books and watch two movies? What is the formula for his family of indifference curves? What do these curves look like? In this example, are movies and books perfect substitutes, perfect complements, or neither?

Exercise 4.12: Do the following pairs of products serve as complements or substitutes? In each case, is the degree of complementarity or substitutability high or low? Do your answers depend on the contexts in which the goods are used? (1) Bread and butter. (2) Ball point pens and computers. (3) Facsimile service and mail service. (4) Movies and video games. (5) Gasoline and ethanol. (6) Wireless telephone service and standard (wireline) telephone service. (7) Different CDs recorded by the same rock group. (8) Lettuce and ground beef.

Exercise 4.13: Kate has 25 M&Ms and Antonio has 10 Milk Duds. Suppose Kate's MRS for Milk Duds with M&Ms is 4 regardless of what she consumes, and that Antonio's is 3 regardless of what he consumes. Kate and Antonio trade until there is no further opportunity for mutual gain. Can you say anything about what they've traded (how many M&Ms for how many Milk Duds)?

Exercise 4.14: Latanya likes to talk on the telephone. We can represent her preferences with the utility function $U(B, J) = 18B + 20J$, where B and J are minutes of conversation per month with Bill and Jackie, respectively. If Latanya plans to use the phone for one hour to talk with only one person, with whom would she rather speak? Why? What is the formula for her indifference curves? Plot a few of those curves.

Exercise 4.15: Do you think there is a workable way to obtain meaningful *cardinal* information about a consumer's preferences? If so, how might you go about it? If not, why not?

Exercise 4.16: In Exercise 4.14, we discussed Latanya's preferences for telephone conversation. According to our assumption, we can represent her preferences with the utility function $U(B, J) = 18B + 20J$, where B and J are minutes of conversation per month with Bill and Jackie, respectively. What is Latanya's implied marginal utility of speaking with Bill? What is her implied marginal utility of speaking with Jackie? What is her MRS for minutes talking to Bill with minutes talking to Jackie?

Exercise 4.17: Esteban likes both chocolate ice cream and lemon sorbet. His preferences correspond to the utility function $U(C, S) = C^{1/3}S^{2/3}$, where C stands for ounces of chocolate ice cream and S stands for ounces of lemon sorbet. Write a formula for Esteban's family of indifference curves. Plot some of those curves on a graph. Would Esteban rather have four ounces of chocolate ice cream and two ounces of lemon sorbet or two ounces of chocolate ice cream and four ounces of lemon sorbet?