APPENDIX

Indifference Curves Appendix

In the main text of Chapter 5, we showed why the rational spending rule is a simple consequence of diminishing marginal utility. In this appendix, we introduce the concept of indifference curves to develop the same rule in another way.

As before, we begin with the assumption that consumers enter the marketplace with well-defined preferences. Taking prices as given, their task is to allocate their incomes to best serve these preferences.

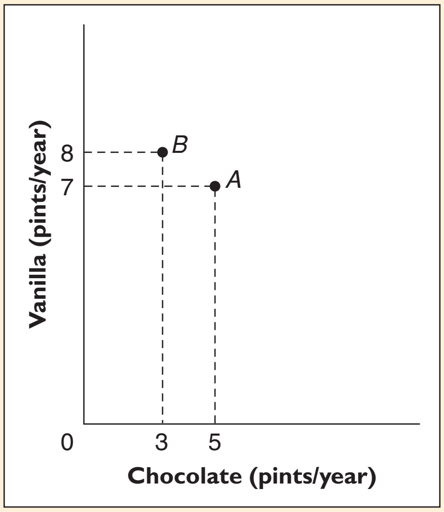
There are two steps required to carry out this task. The first is to describe the various combinations of goods the consumer is *able* to buy. These combinations depend on her income level and on the prices of the goods she faces. The second step is to select from among the feasible combinations the particular one that she *prefers* to all others. This step will require some means of describing her preferences. We begin with the first step, a description of the set of possibilities.

THE BUDGET CONSTRAINT

As before, we keep the discussion simple by focusing on a consumer who spends her entire income on only two goods: superpremium brands of chocolate and vanilla ice cream. A *bundle* of goods is the term used to describe a particular combination of the two types of ice cream, measured in pints per year. Thus, in Figure 5A.1, one bundle (bundle A) might consist of five pints per year of chocolate and seven pints per year of vanilla, while another (bundle B) consists of three pints per year of chocolate and eight pints per year of vanilla. For brevity's sake, we may use the notation (5, 7) to denote bundle A and (3, 8) to denote bundle B. More generally, (C_0, V_0) will denote the bundle with C_0 pints per year of chocolate and V_0 pints per year of vanilla. By convention, the first number of the pair in any bundle represents the good measured along the horizontal axis.

Note that the units on both axes are *flows*, which means physical quantities per unit of time—in this case, pints per year. Consumption is always measured as

FIGURE 5A.1
Two Bundles of Goods.
A bundle is a specific combination of goods. Bundle *A* has five units of chocolate and seven units of vanilla. Bundle *B* has three units of chocolate and eight units of vanilla.



a flow. It is important to keep track of the time dimension because, without it, there would be no way to evaluate whether a given quantity of consumption was large or small. (Again, suppose all you know is that your consumption of vanilla ice cream is four pints. If that's how much you eat each hour, it's a lot. But if that's all you eat in a decade, it's not very much.)

Suppose the consumer's income is M = \$100 per year, all of which she spends on some combination of vanilla and chocolate. (Note that income is also a flow.) Suppose further that the prices of chocolate and vanilla are P_C = \$5 per pint and P_V = \$10 per pint, respectively. If she spent her entire income on chocolate, she could buy M/P_C = (\$100/year) ÷ (\$5/pint) = 20 pints/year. That is to say, she could buy the bundle consisting of 20 pints per year of chocolate and 0 pints per year of vanilla, denoted (20, 0). Alternatively, suppose she spent her entire income on vanilla. She would then get the bundle consisting of M/P_V = (\$100/year) ÷ (\$10/pint) = 10 pints per year of vanilla and 0 pints per year of chocolate, denoted (0, 10)

In Figure 5A.2, these polar cases are labeled *K* and *L*, respectively. The consumer is also able to purchase any other bundle that lies along the straight line that joins points *K* and *L*. (Verify, for example, that the bundle (12, 4) lies on this same line.) This line is called the *budget constraint* and is labeled *B* in the diagram.

Note that the slope of the budget constraint is its vertical intercept (the rise) divided by its horizontal intercept (the corresponding run):

$$-(10 \text{ pints/year})/(20 \text{ pints/year}) = -1/2.$$

The minus sign signifies that the budget line falls as it moves to the right—that it has a negative slope. More generally, if M denotes income and P_C and P_V denote the prices of chocolate and vanilla respectively, the horizontal and vertical intercepts will be given by (M/P_C) and (M/P_V), respectively. Thus, the general formula for the slope of the budget constraint is given by $-(M/P_V)/(M/P_C) = -P_C/P_V$, which is simply the negative of the price ratio of the two goods. Given their respective prices, it is the rate at which vanilla can be exchanged for chocolate. Thus, in Figure 5A.2, one pint of vanilla can be exchanged for two pints of chocolate. In the language of opportunity cost from

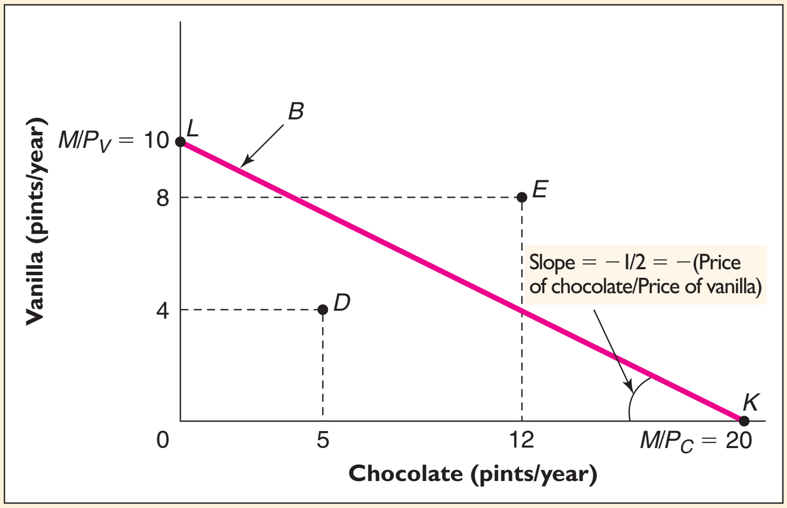


FIGURE 5A.2

The Budget Constraint. The line *B* describes the set of all bundles the consumer can purchase for given values of income and prices. Its slope is the negative of the price of chocolate divided by the price of vanilla. In absolute value, this slope is the opportunity cost of an additional unit of chocolate: the number of pints of vanilla that must be sacrificed in order to purchase one additional pint of chocolate at market prices.

Chapter 1, we would say that the opportunity cost of an additional pint of chocolate is $P_C/P_V = 1/2$ pint of vanilla.

In addition to being able to buy any of the bundles along her budget constraint, the consumer is also able to purchase any bundle that lies within the *budget triangle* bounded by it and the two axes. *D* is one such bundle in Figure 5A.2. Bundle *D* costs $65 per year, which is well below the consumer's ice cream budget of $100 per year. Bundles like *E* that lie outside the budget triangle are unaffordable. At a cost of $140 per year, *E* is simply beyond the consumer's reach.

If *C* and *V* denote the quantities of chocolate and vanilla, respectively, the budget constraint must satisfy the following equation:

$$P_C C + P_V V = M, \tag{5A.1}$$

which says simply that the consumer's yearly expenditure on chocolate ($P_C C$) plus her yearly expenditure on vanilla ($P_V V$) must add up to her yearly income (M). To express the budget constraint in the manner conventionally used to represent the formula for a straight line, we solve Equation 5A.1 for V in terms of C, which yields

$$V = M/P_V - (P_C/P_V)C. \tag{5A.2}$$

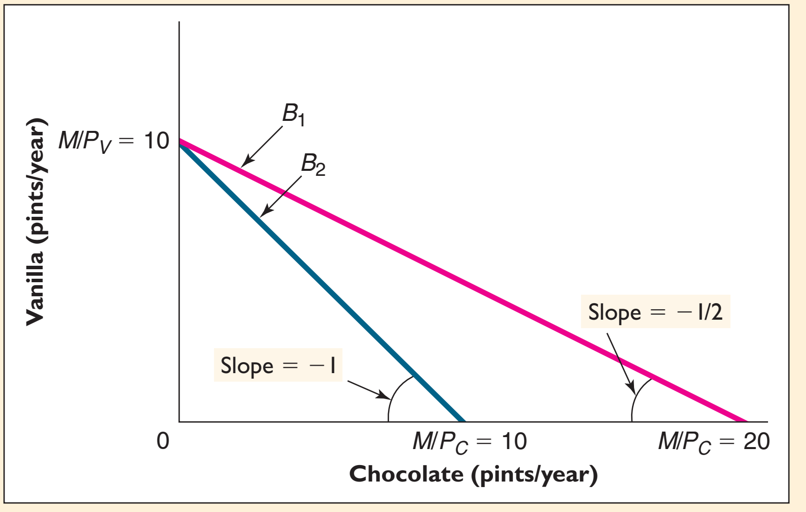
Equation 5A.2 provides another way of seeing that the vertical intercept of the budget constraint is given by M/P_V, and its slope by $-(P_C/P_V)$. The equation for the budget constraint in Figure 5A.2 is $V = 10 - (1/2)C$.

BUDGET SHIFTS DUE TO INCOME OR PRICE CHANGES

Price Changes

The slope and position of the budget constraint are fully determined by the consumer's income and the prices of the respective goods. Change any one of these and we have a new budget constraint. Figure 5A.3 shows the effect of an increase in the price of chocolate from P_{C1} = $5 per pint to P_{C2} = $10 per pint. Since both her budget and the price of vanilla are unchanged, the vertical intercept of the consumer's budget constraint stays the same. The rise in the price of chocolate rotates the budget constraint inward about this intercept, as shown in the diagram.

FIGURE 5A.3
The Effect of a Rise in the Price of Chocolate.
When chocolate goes up in price, the vertical intercept of the budget constraint remains the same. The original budget constraint rotates inward about this intercept.



Note in Figure 5A.3 that even though the price of vanilla has not changed, the new budget constraint, B_2, curtails not only the amount of chocolate the consumer can buy but also the amount of vanilla.[1]

EXERCISE 5A.1

Show the effect on the budget constraint B_1 in Figure 5A.3 of a fall in the price of chocolate from \$5 per pint to \$4 per pint.

In Exercise 5A.1, you saw that a fall in the price of vanilla again leaves the vertical intercept of the budget constraint unchanged. This time the budget constraint rotates outward. Note also in Exercise 5A.1 that although the price of vanilla remains unchanged, the new budget constraint enables the consumer to buy bundles that contain not only more chocolate but also more vanilla than she could afford on the original budget constraint.

EXERCISE 5A.2

Show the effect on the budget constraint B_1 in Figure 5A.3 of a rise in the price of vanilla from \$10 per pint to \$20 per pint.

Exercise 5A.2 demonstrates that when the price of vanilla changes, the budget constraint rotates about its horizontal intercept. Note also that even though income and the price of chocolate remain the same, the new budget constraint curtails not only the amount of vanilla he can buy but also the amount of chocolate.

When we change the price of only one good, we necessarily change the slope of the budget constraint, $-P_C/P_V$. The same is true if we change both prices by different proportions. But as Exercise 5A.3 will illustrate, changing both prices by exactly the same proportion gives rise to a new budget constraint with the same slope as before.

EXERCISE 5A.3

Show the effect on the budget constraint B_1 in Figure 5A.3 of a rise in the price of vanilla from \$10 per pint to \$20 per pint and a rise in the price of chocolate from \$5 per pint to \$10 per pint.

[1]The single exception to this statement involves the vertical intercept, (0, 10), which lies on both the original and the new budget constraints.

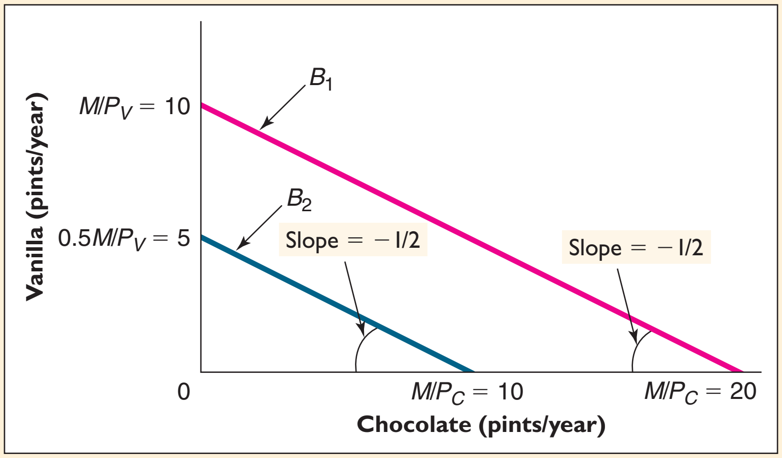


FIGURE 5A.4
The Effect of Cutting Income by Half.
Both horizontal and vertical intercepts fall by half. The new budget constraint has the same slope as the old but is closer to the origin.

Note from Exercise 5A.3 that the effect of doubling the prices of both vanilla and chocolate is to shift the budget constraint inward and parallel to the original budget constraint. The important lesson of this exercise is that the slope of the budget constraint tells us only about *relative prices*, nothing about how high prices are in absolute terms. When the prices of vanilla and chocolate change in the same proportion, the opportunity cost of chocolate in terms of vanilla remains the same as before.

Income Changes

The effect of a change in income is much like the effect of an equal proportional change in all prices. Suppose, for example, that our hypothetical consumer's income is cut by half, from \$100 per year to \$50 per year. The horizontal intercept of her budget constraint will then fall from 20 pints per year to 10 pints per year and the vertical intercept from 10 pints per year to 5 pints per year, as shown in Figure 5A.4. Thus, the new budget, B_2, is parallel to the old, B_1, each with a slope of $-1/2$. In terms of its effect on what the consumer can buy, cutting income by half is thus no different from doubling each price. Precisely the same budget constraint results from both changes.

EXERCISE 5A.4

Show the effect on the budget constraint B_1 in Figure 5A.3 of an increase in income from \$100 per year to \$120 per year.

Exercise 5A.4 illustrates that an increase in income shifts the budget constraint parallel outwards. As in the case of an income reduction, the slope of the budget constraint remains the same.

BUDGETS INVOLVING MORE THAN TWO GOODS

The examples discussed so far have all been ones in which the consumer is faced with the opportunity to buy only two different goods. Needless to say, not many consumers have such narrow options. In its most general form, the consumer budgeting problem can be posed as a choice between not two but N different goods, where N can be an indefinitely large number. With only two goods ($N = 2$), the budget constraint is a straight line, as we have just seen. With three goods ($N = 3$), it is a plane. When we have more than three goods, the budget constraint becomes what mathematicians call a *hyperplane*, or multidimensional plane. The only real difficulty is in representing this multidimensional case geometrically. We are just not very good at visualizing surfaces that have more than three dimensions.

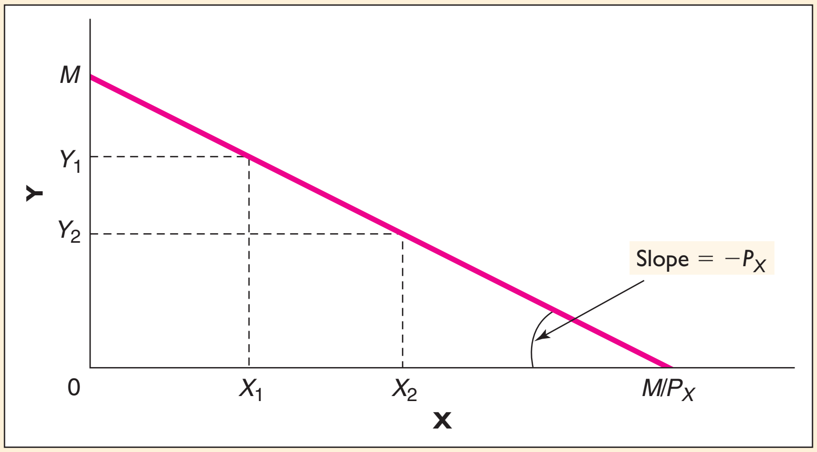


FIGURE 5A.5
The Budget Constraint with the Composite Good.
The vertical axis measures the amount of money spent each month on all goods other than *X*.

The nineteenth-century economist Alfred Marshall proposed a disarmingly simple solution to this problem. It is to view the consumer's choice as being one between a particular good—call it *X*—and an amalgam of other goods denoted *Y*. This amalgam is called the *composite good*. We may think of the composite good as the amount of income the consumer has left over after buying the good *X*.

To illustrate how this concept is used, suppose the consumer has an income level of $M per year and the price of *X* is given by P_X. The consumer's budget constraint may then be represented as a straight line in the *X*,*Y* plane, as shown in Figure 5A.5. For simplicity, the price of a unit of the composite good is taken to be one, so that if the consumer devotes none of his income to *X*, he will be able to buy *M* units of the composite good. All this means is that he will have $M available to spend on other goods if he buys no *X*. Alternatively, if he spends all his income on *X*, he will be able to purchase the bundle $(M/P_X, 0)$. Since the price of *Y* is assumed to be one, the slope of the budget constraint is simply $-P_X$.

As before, the budget constraint summarizes the various combinations of bundles that are affordable. For example, the consumer can have X_1 units of *X* and Y_1 units of the composite good in Figure 5A.5, or X_2 and Y_2, or any other combination that lies on the budget constraint.

Summing up briefly, the budget constraint or opportunity set summarizes the combinations of bundles that the consumer is able to buy. Its position is determined jointly by income and prices. From the set of feasible bundles, the consumer's task is to pick the particular one she likes best. To identify this bundle, we need some means of summarizing the consumer's preferences over all possible bundles she might consume. To this task we now turn.

CONSUMER PREFERENCES

For simplicity, we again begin by considering a world with only two goods, chocolate and vanilla ice cream, and assume that a particular consumer is able to rank different bundles of goods in terms of their desirability or order of preference. Suppose this consumer currently has bundle *A* in Figure 5A.6, which has six pints per year of chocolate and four pints per year of vanilla. If we then take one pint per year of chocolate away from her, she is left with bundle *D*, which has only five pints per year of chocolate and the same four pints per year of vanilla. Let us suppose that this consumer feels worse off than before, as most people would, because although *D* has just as much vanilla as *A*, it has less chocolate. We can undo the damage by giving her some additional vanilla. If our

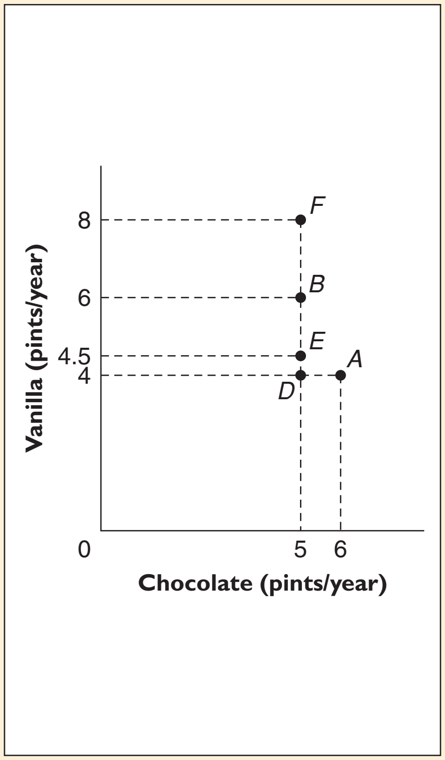


FIGURE 5A.6
Ranking Bundles.
This consumer will prefer *A* to *D* because *A* has more chocolate than *D* and just as much vanilla. She is assumed to prefer bundle *A* to bundle *E* and to prefer bundle *F* to bundle *A*. This means there must be a bundle between *E* and *F* (shown here as *B*) that she likes equally well as *A*. This consumer is said to be indifferent between *A* and *B*. If she moves from *A* to *B*, her gain of two pints per year of vanilla exactly compensates for her loss of one pint per year of chocolate. She will prefer *F* to *B* because *F* has more vanilla than *B* and just as much chocolate. For the same reason, she will prefer *B* to *E* and *E* to *D*.

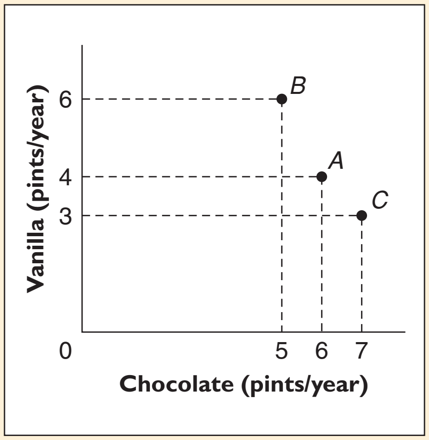
goal is to compensate for exactly her loss, how much extra vanilla do we need to give her?

Suppose we start by giving her an additional half pint per year, which would move her to bundle *E* in Figure 5A.6. For some consumers, that might be enough to make up for the lost pint of chocolate, even though the total amount of ice cream at *E* (9.5 pints per year) is smaller than at *A* (10 pints per year). Indeed, consumers who *really* like vanilla might actually prefer *E* to *A*. But we'll assume that this particular consumer would still prefer *A* to *E*. So to compensate fully for her lost pint of chocolate, we would have to give her more than an additional half pint of vanilla. Suppose we gave her a *lot* more vanilla—say, an additional four pints per year. This would move her to bundle *F* in Figure 5A.6, and we'll assume that she regards the extra four pints per year of vanilla at *E* as more than enough to compensate for the lost pint of chocolate.

The fact that this particular consumer prefers *F* to *A* but prefers *A* to *E* tells us that the amount of extra vanilla needed to *exactly* compensate for the lost pint of chocolate must be between one-half pint per year (the amount of extra vanilla at *E*) and four pints per year (the amount of extra vanilla at *F*). Suppose, for the sake of discussion, that she would feel exactly compensated if we gave her an additional two pints of vanilla. This consumer would then be said to be indifferent between bundles *A* and *B* in Figure 5A.6. Alternatively, we could say that she likes the bundles *A* and *B* equally well, or that she regards these bundles as equivalent.

Now suppose that we again start at bundle *A* and pose a different question: How many pints of vanilla would this consumer be willing to sacrifice in order to obtain an additional pint of chocolate? This time let's suppose that her answer is exactly one pint. We have thus identified another point—call it *C*—that is equally preferred to *A*. In Figure 5A.7, *C* is shown as the bundle (7, 3). *C* is also equally preferred to *B* (since *C* is equally preferred to *A*, which is equally preferred to *B*).

FIGURE 5A.7
Equally Preferred Bundles.
This consumer is assumed to be indifferent between the bundles *A* and *C*. In moving from *A* to *C*, her gain of one pint per year of chocolate exactly compensates for her loss of one pint per year of vanilla. And since she was indifferent between *A* and *B*, she also must be indifferent between *B* and *C*.

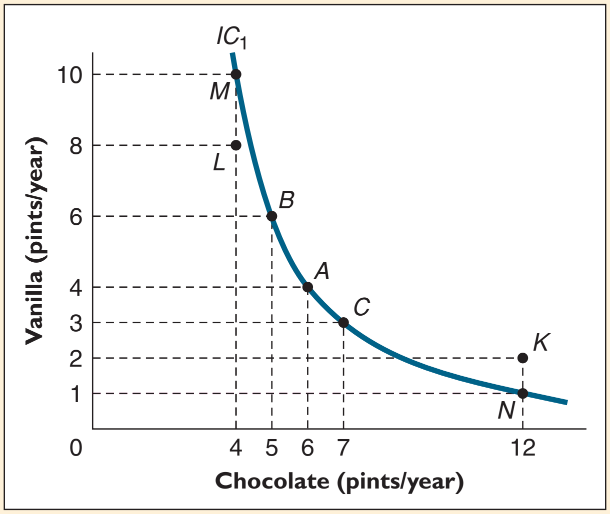


If we continue to generate additional bundles that the consumer likes equally well as bundle *A*, the end result is an *indifference curve*, a set of bundles all of which the consumer views as equivalent to the original bundle *A*, and hence also equivalent to one another. This set is shown as the curve labeled IC_1 in Figure 5A.8. It is called an indifference curve because the consumer is indifferent among all the bundles that lie along it.

An indifference curve also permits us to compare the satisfaction implicit in bundles that lie along it with those that lie either above or below it. It permits us, for example, to compare bundle *C* (7, 3) to a bundle like *K* (12, 2), which has less vanilla and more chocolate than *C* has. We know that *C* is equally preferred to *N* (12, 1) because both bundles lie along the same indifference curve. *K*, in turn, is preferred to *N* because it has just as much chocolate as *N* and one pint per year more vanilla. So if *K* is preferred to *N*, and *N* is just as attractive as *C*, then *K* must be preferred to *C*.

By analogous reasoning, we can say that bundle *A* is preferred to *L*. *A* and *M* are equivalent, and *M* is preferred to *L* since *M* has just as much chocolate as *L* and two pints per year more of vanilla. *In general, bundles that lie above an indifference curve are all preferred to the bundles that lie on it. Similarly, those that lie on an indifference curve are all preferred to those that lie below it.*

FIGURE 5A.8
An Indifference Curve.
An indifference curve, such as IC_1, is a set of bundles that the consumer prefers equally. Any bundle, such as *K*, that lies above an indifference curve is preferred to any bundle on the indifference curve. Any bundle on the indifference curve, in turn, is preferred to any bundle, such as *L*, that lies below the indifference curve.



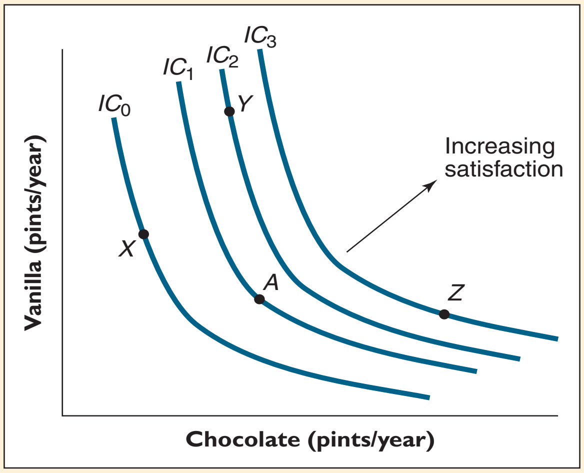


FIGURE 5A.9
Part of an Indifference Map.
The entire set of a consumer's indifference curves is called the consumer's indifference map. Bundles on any indifference curve are less preferred than bundles on a higher indifference curve and more preferred than bundles on a lower indifference curve. Thus, *Z* is preferred to *Y*, which is preferred to *A*, which is preferred to *X*.

We can represent a useful summary of the consumer's preferences with an *indifference map*, an example of which is shown in Figure 5A.9. This indifference map shows just four of the infinitely many indifference curves that, taken together, yield a complete description of the consumer's preferences. As we move to the northeast on an indifference map, successive indifference curves represent higher levels of satisfaction. If we want to know how a consumer ranks any given pair of bundles, we simply compare the indifference curves on which they lie. The indifference map shown tells us, for example, that *Z* is preferred to *Y* because *Z* lies on a higher indifference curve (IC_3) than *Y* does (IC_2). By the same token, *Y* is preferred to *A*, and *A* is preferred to *X*.

TRADE-OFFS BETWEEN GOODS

An important property of a consumer's preferences is the rate at which she is willing to exchange, or "trade off," one good for another. This property is represented at any point on an indifference curve by the *marginal rate of substitution* (MRS), which is defined as the absolute value of the slope of the indifference curve at that point. In Figure 5A.10, for example, the marginal rate of substitution at point *T* is given by the absolute value of the slope of the tangent to the indifference curve at *T*, which is the ratio $\Delta V_T/\Delta C_T$. (The notation ΔV_T means "small change in vanilla from the amount at point *T*.") If we take ΔC_T units of chocolate away from the

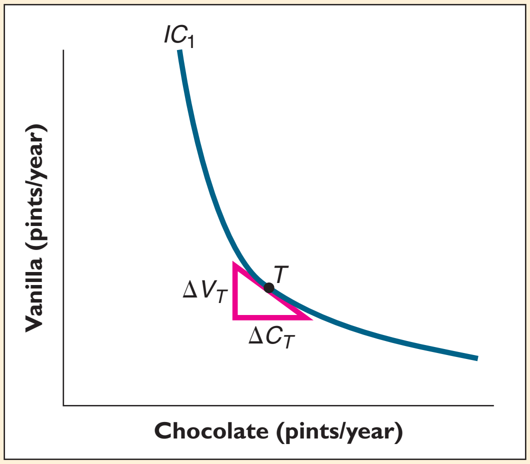
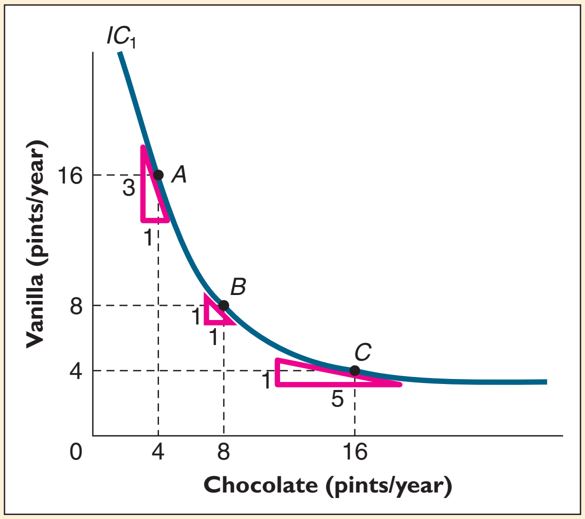


FIGURE 5A.10
The Marginal Rate of Substitution.
MRS at any point along an indifference curve is defined as the absolute value of the slope of the indifference curve at that point. It is the amount of vanilla the consumer must be given to compensate for the loss of one unit of chocolate.

FIGURE 5A.11
Diminishing Marginal Rate of Substitution.
The more vanilla the consumer has, the more she is willing to give up to obtain an additional unit of chocolate. The marginal rates of substitution at bundles *A*, *B*, and *C* are 3, 1, and 1/5, respectively.



consumer at point T, we have to give her ΔV_T additional units of vanilla to make her just as well off as before. If the marginal rate of substitution at T is 1.5, that means that the consumer must be given 1.5 pints per year of vanilla in order to make up for the loss of 1 pint per year of chocolate.

Whereas the slope of the budget constraint tells us the rate at which we can substitute vanilla for chocolate without changing total expenditure, the MRS tells us the rate at which we can substitute vanilla for chocolate without changing total satisfaction. Put another way, the slope of the budget constraint is the marginal cost of chocolate in terms of vanilla, while the MRS is the marginal benefit of chocolate in terms of vanilla.

A common (but not universal) property of indifference curves is that the more a consumer has of one good, the more she must be given of that good before she will be willing to give up a unit of the other good. Stated differently, MRS generally declines as we move downward to the right along an indifference curve. Indifference curves that exhibit diminishing marginal rates of substitution are thus convex—or bowed outward—when viewed from the origin. The indifference curves shown in Figures 5A.8, 5A.9, and 5A.10 all have this property, as does the curve shown in Figure 5A.11. This property is the indifference curve analog of the concept of diminishing marginal utility discussed in the main text of Chapter 5.

In Figure 5A.11, note that at bundle *A*, vanilla is relatively plentiful and the consumer would be willing to sacrifice three pints per year of it in order to obtain an additional pint of chocolate. Her MRS at *A* is 3. At *B*, the quantities of vanilla and chocolate are more balanced, and there she would be willing to give up only one pint per year to obtain an additional pint per year of chocolate. Her MRS at *B* is 1. Finally, note that vanilla is relatively scarce at *C*, where the consumer would need five additional pints per year of chocolate in return for giving up one pint per year of vanilla. Her MRS at *C* is 1/5.

Intuitively, diminishing MRS means that consumers like variety. We are usually willing to give up goods we already have a lot of in order to obtain more of those goods we now have only little of.

USING INDIFFERENCE CURVES TO DESCRIBE PREFERENCES

To get a feel for how indifference maps describe a consumer's preferences, it is helpful to work through a simple example. Suppose that Tom and Mary like both chocolate

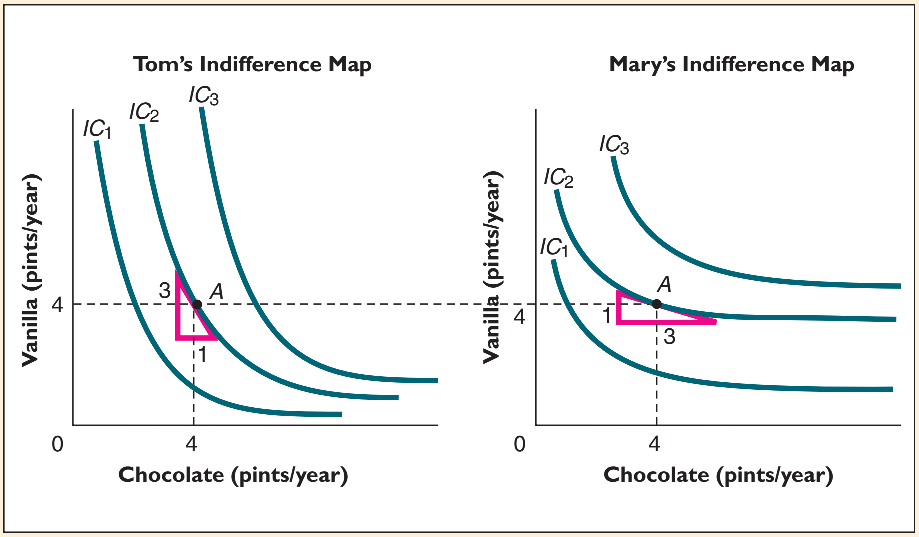


FIGURE 5A.12
People with Different Tastes.
Relatively speaking, Tom is a chocolate lover, Mary a vanilla lover. This difference shows up in the fact that at any given bundle, Tom's marginal rate of substitution of vanilla for chocolate is greater than Mary's. At bundle *A*, for example, Tom would give up three pints of vanilla to get another pint of chocolate, whereas Mary would give up three pints of chocolate to get another pint of vanilla.

and vanilla ice cream but that Tom's favorite flavor is chocolate while Mary's favorite is vanilla. This difference in their preferences is captured by the differing slopes of their indifference curves in Figure 5A.12. Note in the left panel, which shows Tom's indifference map, that he would be willing to exchange three pints of vanilla for one pint of chocolate at the bundle *A*. But at the corresponding bundle in the right panel, which shows Mary's indifference map, we see that Mary would trade three pints of chocolate to get another pint of vanilla. Their difference in preferences shows up clearly in this difference in their marginal rates of substitution of vanilla for chocolate.

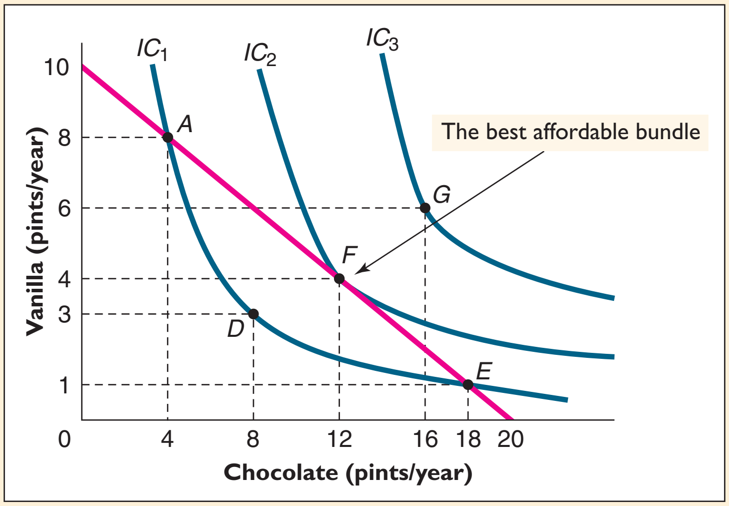
THE BEST AFFORDABLE BUNDLE

We now have all the tools we need to determine how the consumer should allocate her income between two goods. The indifference map tells us how the various bundles are ranked in order of preference. The budget constraint, in turn, tells us which bundles are affordable. The consumer's task is to put the two together and choose the most preferred affordable bundle. (Recall from Chapter 1 that we need not suppose that consumers think explicitly about budget constraints and indifference maps when deciding what to buy. It is sufficient that people make decisions *as if* they were thinking in these terms, just as experienced bicyclists ride as if they knew the relevant laws of physics.)

For the sake of concreteness, we again consider the choice between vanilla and chocolate ice cream that confronts a consumer with an income of $M = \$100$ per year facing prices of $P_V = \$10$ per pint and $P_C = \$5$ per pint. Figure 5A.13 shows this consumer's budget constraint and part of her indifference map. Of the five labeled bundles—*A*, *D*, *E*, *F*, and *G*—in the diagram, *G* is the most preferred because it lies on the highest indifference curve. *G*, however, is not affordable, nor is any other bundle that lies beyond the budget constraint. In general, the best affordable bundle will lie on the budget constraint, not inside it. (Any bundle inside the budget constraint would be less desirable than one just slightly to the northeast, which also would be affordable.)

Where, exactly, is the best affordable bundle located along the budget constraint? We know that it cannot be on an indifference curve that lies partly inside the budget constraint. On the indifference curve IC_1, for example, the only points that are even candidates for the best affordable bundle are the two that lie on the budget constraint, namely *A* and *E*. But *A* cannot be the best affordable bundle because it is equally preferred to *D*, which in turn is less desirable than *F*. So *A* also must be less desirable than *F*. For the same reason, *E* cannot be the best affordable bundle.

FIGURE 5A.13
The Best Affordable Bundle.
The best the consumer can do is to choose the bundle on the budget constraint that lies on the highest attainable indifference curve. Here, that is bundle *F*, which lies at a tangency between the indifference curve and the budget constraint.



Since the best affordable bundle cannot lie on an indifference curve that lies partly inside the budget constraint, and since it must lie on the budget constraint itself, we know it has to lie on an indifference curve that intersects the budget constraint only once. In Figure 5A.13, that indifference curve is the one labeled IC_2, and the best affordable bundle is *F*, which lies at the point of tangency between IC_2 and the budget constraint. With an income of $100 per year and facing prices of $5 per pint for chocolate and $10 per pint of vanilla, the best this consumer can do is to buy 4 pints per year of vanilla and 12 pints per year of chocolate.

The choice of bundle *F* makes perfect sense on intuitive grounds. The consumer's goal, after all, is to reach the highest indifference curve she can, given her budget constraint. Her strategy is to keep moving to higher and higher indifference curves until she reaches the highest one that is still affordable. For indifference maps for which a tangency point exists, as in Figure 5A.13, the best bundle will always lie at the point of tangency. (See problem 6 below for an example in which a tangency does not exist.)

In Figure 5A.13, note that the marginal rate of substitution at *F* is exactly the same as the absolute value of the slope of the budget constraint. This will always be so when the best affordable bundle occurs at a point of tangency. The condition that must be satisfied in such cases is therefore

$$\text{MRS} = P_C/P_V. \qquad (5A.3)$$

In the indifference curve framework, Equation 5A.3 is the counterpart to the rational spending rule developed in the main text of Chapter 5. The right-hand side of Equation 5A.3 represents the opportunity cost of chocolate in terms of vanilla. Thus, with P_C = $5 per pint and P_V = $10 per pint, the opportunity cost of an additional pint of chocolate is one-half pint of vanilla. The left-hand side of Equation 5A.3 is $|\Delta V/\Delta C|$, the absolute value of the slope of the indifference curve at the point of tangency. It is the amount of additional vanilla the consumer must be given in order to compensate her fully for the loss of one pint of chocolate. In the language of cost-benefit analysis discussed in Chapter 1, the slope of the budget constraint represents the opportunity cost of chocolate in terms of vanilla, while the slope of the indifference curve represents the benefits of consuming chocolate as compared with consuming vanilla. Since the slope of the budget constraint is $-1/2$ in this example, the tangency condition tells us that one-half pint of vanilla would be required to compensate for the benefits given up with the loss of one pint of chocolate.

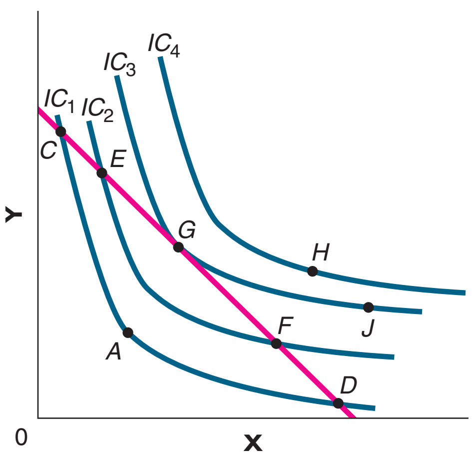
If the consumer were at some bundle on the budget line for which the two slopes were not the same, then it would always be possible for her to purchase a better bundle. To see why, suppose she were at a point where the slope of the indifference curve (in absolute value) is less than the slope of the budget constraint, as at point *E* in Figure 5A.13. Suppose, for instance, that the MRS at *E* is only 1/4. This tells us that the consumer can be compensated for the loss of one pint of chocolate by being given an additional one-quarter pint of vanilla. But the slope of the budget constraint tells us that by giving up one pint of chocolate, he can purchase an additional one-half pint of vanilla. Since this is one-quarter pint more than he needs to remain equally satisfied, he will clearly be better off if he purchases more vanilla and less chocolate than at point *E*. The opportunity cost of an additional pint of vanilla is less than the benefit it confers.

EXERCISE 5A.5

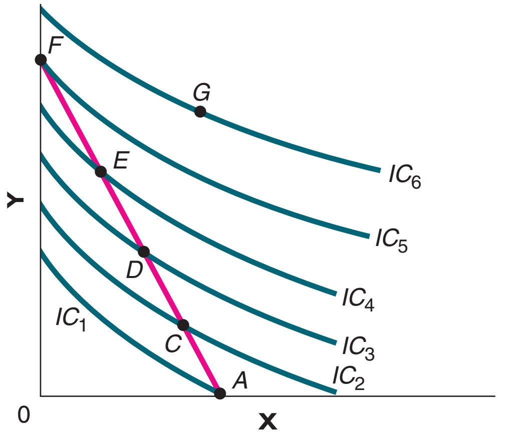
Suppose that the marginal rate of substitution at point *A* in Figure 5A.13 is 1.0. Show that this means that the consumer will be better off if he purchases less vanilla and more chocolate than at *A*.

PROBLEMS

1. Suppose a consumer's income is M = $1,200 per month, all of which he spends on some combination of rent and restaurant meals. If restaurant meals cost $12 each and if the monthly rent for an apartment is $3 per square foot, draw this consumer's budget constraint, with his monthly quantities of restaurant meals per month on the vertical axis and apartment size on the horizontal axis. Is the bundle (300 square feet/month, 50 meals/month) affordable?
2. Show what happens to the budget constraint in problem 1 if the price of restaurant meals falls to $8. Is the bundle (300, 50) affordable?
3. What happens to the budget constraint in problem 2 if the monthly rent for apartments falls to $2 per square foot? Is the bundle (300, 50) affordable?
4. When inflation happens, prices and incomes generally rise at about the same rate each year. What happens to the budget constraint from problem 1 if the consumer's income rises by 10 percent and the prices of restaurant meals and apartment rents also rise by 10 percent? Has the consumer been harmed by inflation?
5. A consumer spends all his income on two goods, *X* and *Y*. Of the labeled points on his indifference map, indicate which ones are affordable and which ones are unaffordable. Indicate how the consumer ranks these bundles, ranging from most preferred to least preferred. Identify the best affordable bundle.

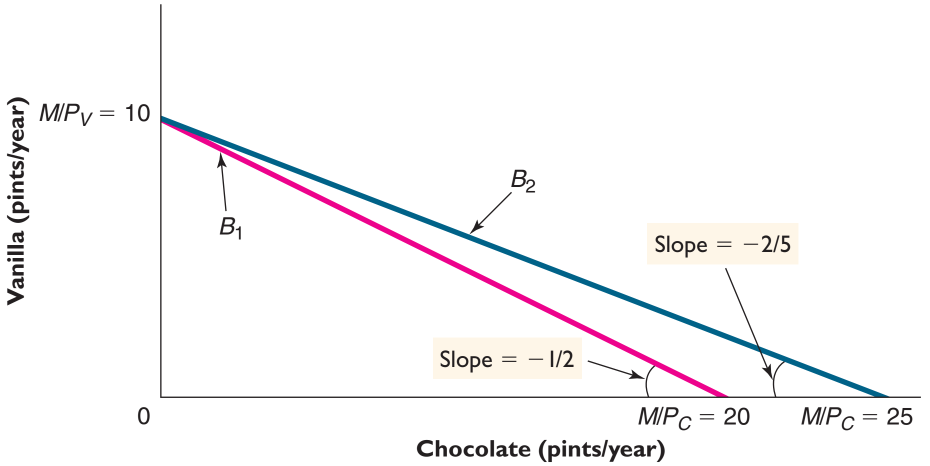


6. A consumer spends all his income on two goods, *X* and *Y*. His income and the prices of *X* and *Y* are such that his budget constraint is the line *AF*. Of the labeled points on his indifference map, indicate which is the best affordable bundle. (Hint: This problem does not have a tangency solution.)

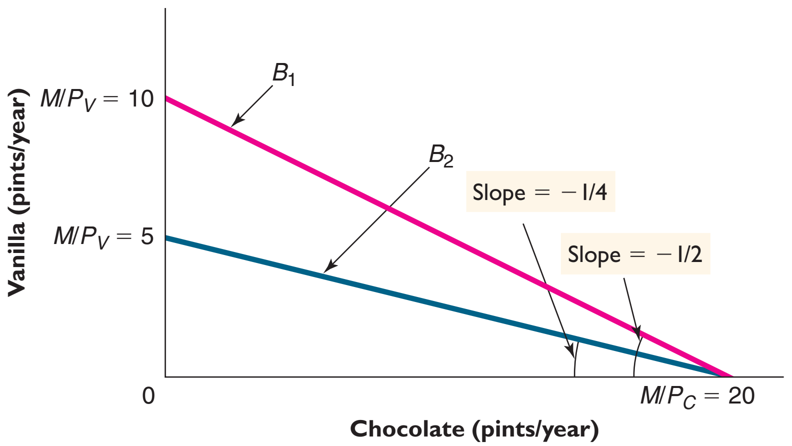


ANSWERS TO IN-APPENDIX EXERCISES

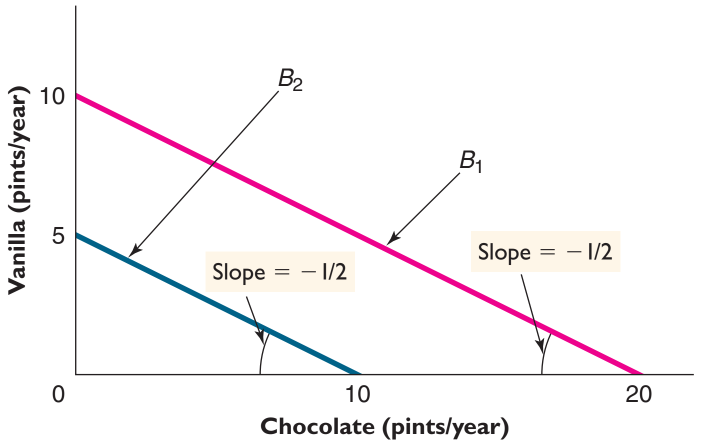
5A.1



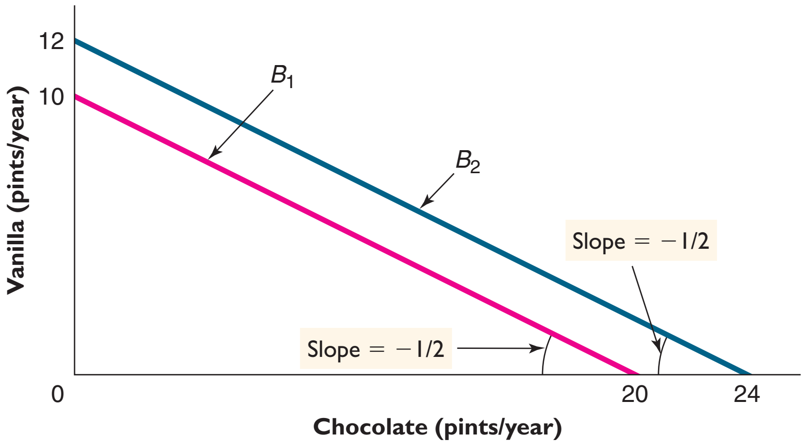
5A.2



5A.3



5A.4



5A.5 At bundle *A*, the consumer is willing to give up one pint of vanilla in order to get an additional pint of chocolate. But at market prices it is necessary to give up only one-half pint of vanilla in order to buy an additional pint of chocolate. It follows that the consumer will be better off than at bundle *A* if he buys one pint less of vanilla and 2 pints more of chocolate.