

# Allocating Goods Over Time

Markets enable people to trade one kind of good for another. In some markets, you can trade an apple for some oranges. In others, you can trade an apple today for some apples tomorrow. In everyday language, the consumer who trades apples for oranges is a “seller” of apples and the consumer who trades apples today for apples tomorrow is a “lender” of apples. But there is no essential difference between the two transactions. In each case, the consumer is faced with a market price (for the lender, the relevant price is the interest rate) and must decide how much to buy or sell at that price. Therefore, many of the tools of consumer theory—most specifically the machinery of indifference curves—can also explain borrowing and lending.

In the first two sections of this chapter, we will emphasize the simple observation that an interest rate is nothing but a measure of relative price. In Section 17.2, we will see that this deceptively simple idea has some extraordinarily powerful applications.

Having come to understand the meaning of interest rates, we will turn to the question of how they are determined. We will answer this question in Section 17.3, using a simple supply and demand model. To simplify the discussion, we will assume that there is no technology available for converting current goods into future goods.

In Section 17.4, we will relax that assumption. This will enable us to study the market for capital and to increase our understanding of the determination of interest rates. However, one thing we will discover is that, despite the artificial assumptions of Section 17.3, many of its conclusions remain true in a far more general context.

## 17.1 Bonds and Interest Rates

When you trade an apple for some oranges, you are called a *seller* of apples, and the number of oranges that you receive is determined by the *relative price* at which you sell. When you trade an apple today for some apples tomorrow, you are called a *lender* of apples, and the number of apples that you receive tomorrow is determined by the *interest rate* at which you lend. Lending is a kind of selling, and an interest rate is a measure of relative price.

By the same token, *borrowing* an apple is precisely the same thing as buying an apple today and paying for it with apples tomorrow. Borrowing is a kind of buying.

In any trade, you are simultaneously a seller and a buyer. If you trade apples for oranges, you are both a seller of apples and a buyer of oranges. If you lend an apple today in exchange for some apples tomorrow, you are both a seller of apples today and a buyer of apples tomorrow. A borrower is both a buyer of apples today and a seller of apples tomorrow.

There is one important difference between buying oranges and buying tomorrow's apples. When you buy an orange, you get to hold it in your hand. When you buy an apple for delivery tomorrow, you hold only a promise. That promise might be strictly oral, it might be written down on a piece of paper, or it might be recorded on a computer disk. Another word for that promise is a **bond**. A bond is a promise to pay.

We have said that a lender simultaneously sells apples today and buys apples tomorrow. More precisely, he sells apples today and buys a *promise* of apples tomorrow; that is, he buys a bond.

**A lender is the buyer of a bond.**

By the same token, a borrower buys apples today in exchange for his promise to deliver apples tomorrow; he buys the current apples that the lender sells and sells the bond that the lender buys.

**A borrower is the seller of a bond.**

### Bond

A promise to pay at some time in the future.

## Relative Prices, Interest Rates, and Present Values

Suppose that you lend an apple at an interest rate of 10% ( $= .10$ ) per day. Tomorrow you receive 1.10 apples in return, so the relative price of an apple today in terms of apples tomorrow is 1.10.

More generally, if the interest rate is  $r$  per day, then the relative price of an apple today in terms of an apple tomorrow is  $1 + r$ . So even though an interest rate is not exactly the same thing as a relative price, it is closely related to a relative price. To go from the interest rate to the relative price, just add 1; to go from the relative price to the interest rate, just subtract 1.

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**Exercise 17.1** If 1 apple today can be traded for 2 apples tomorrow, what is the relative price of 1 apple today? What is the interest rate?

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### Present Values

#### Present value

Relative price in terms of current consumption.

The **present value** of a future delivery is its relative price in terms of current goods. If the interest rate is 50% per day, or  $r = .50$ , then the relative price of an apple today is 1.5 apples tomorrow. Consequently, the relative price of an apple tomorrow in terms of apples today is  $1/1.5 = 2/3$ ; we say that the present value of an apple tomorrow is equal to  $2/3$  apple today.

Because the relative price of today's apples in terms of tomorrow's is always given by  $1 + r$ , it follows that the relative price of tomorrow's apples in terms of today's is given by  $1/(1 + r)$ . If  $r$  is 10% ( $= .10$ ), this works out to about .91. An apple tomorrow is worth .91 apple today.

Another way to say this is that a bond promising 1 apple tomorrow can be purchased for a price of .91 apple today.

The price of a bond is equal to the present value of what it promises to deliver.

Thus, a bond that promises 1 apple tomorrow sells for a price of  $1 / (1 + r)$  apples today. Notice that high values of  $r$  correspond to low bond prices. If  $r = .50$ , then the bond sells for  $2/3 = .67$  apple today (which grows to 1 apple tomorrow at the interest rate of 50%); whereas if  $r = .10$ , the bond sells for .91 apple today (which grows to 1 apple tomorrow at the interest rate of .10).

The **face value** of a bond is the number of future apples that it guarantees. A bond is said to sell at a **discount** equal to the difference between its face value and what it sells for today. Thus, if the interest rate is .50, a bond promising 1 apple tomorrow will sell for  $2/3$  apple today; the face value is 1 apple and the discount is  $1/3$  apple. If the interest rate is .10, a bond promising 10 apples tomorrow will sell for 9.1 apples today; the face value is 10 apples and the discount is .9 apple.

The **maturity date** of a bond is the date on which it promises a delivery. All of the bonds we have considered so far have maturity dates of “tomorrow.”

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**Exercise 17.2** If the interest rate is .25, what are the price, face value, and discount of a bond that promises 5 apples tomorrow?

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## Treasury Bills

When the U.S. government borrows, it does so by issuing bonds called Treasury bills. Treasury bills are issued with a fixed face value and maturity date and then auctioned to the highest bidder. Thus, the size of the discount (and consequently, the interest rate) is determined by the outcome of the auction.

For example, suppose that on January 1, 2005, the Treasury issues a bond reading, “We promise to pay \$10,000 on January 1, 2006.” The Treasury holds a regular weekly auction at which this bond will be offered for sale. Suppose that after much bidding you are able to purchase this bond for \$9,500. This bond has sold at a \$500 discount: you have lent \$9,500 to the Treasury and will receive \$10,000 back. Because you earn \$500 in interest, the annual interest rate is  $\$500 / \$9,500 \approx 5.26\%$ .

After you purchase the bond, you are entitled to resell it to anybody for whatever price you mutually agree upon. The government will make the final payment to whoever holds the bond on its maturity date. Thus, the value of the bond could vary quite a bit between the date of purchase and the date of maturity. For example, suppose that immediately after you purchase the bond, the market rate of interest rises to 12%. Then the value of the bond falls to  $\$10,000 \times 1 / (1 + .12) \approx \$8,928.57$ .

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Students sometimes want to know the direction of causality: Does a change in the interest rate cause the price of the bond to change, or does a change in the bond price cause the interest rate to change? The answer is that the interest rate and the bond price are two different descriptions of exactly the same thing, and therefore neither can be said to cause the other. The interest rate  $r$  is *defined* by the condition that the price of current consumption in terms of future consumption is  $1 + r$ . It is just a restatement of the definition to say that the price of future consumption in terms of current consumption (that is, the price of a bond) is  $1 / (1 + r)$ .

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### Face value

The amount that a bond promises to pay.

### Discount

The face value of a bond minus its current price.

### Maturity date

The date on which a bond promises a delivery.



Dangerous  
Curve

## The More Distant Future

If we know the daily interest rate  $r$ , then we can compute the present value of an apple delivered 2 days from now. An apple delivered 2 days from now is worth  $1 + r$  apples tomorrow, and each apple tomorrow is worth  $1 + r$  apples today. Therefore, an apple delivered 2 days from now has a present value of

$$\frac{1}{(1+r)} \times \frac{1}{(1+r)} = \frac{1}{(1+r)^2}$$

apples today. By the same reasoning, an apple delivered  $n$  days in the future has a present value of  $1 / (1 + r)^n$  apples today.

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**Exercise 17.3** If the daily interest rate is 50%, what is the present value of an apple delivered 2 days from now? Of an apple delivered 3 days from now?

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**Exercise 17.4** Suppose that the daily interest rate is currently 10%, but that tomorrow it will rise to 20%. What is the present value of an apple delivered 2 days from now?

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**Exercise 17.5** Suppose that the daily interest rate is 10%. What is the present value of an apple delivered yesterday?

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## Coupon Bonds

We can also discuss the present value of a basket consisting of several apple deliveries on different dates. Suppose that on Monday Guildenstern promises that he will deliver to Rosencrantz 2 apples on Tuesday, 3 on Wednesday, and 1 on Friday. The present value of this multiple promise is the sum of the present values of the individual promises it comprises. That is, the present value is

$$\left(2 \times \frac{1}{(1+r)}\right) + \left(3 \times \frac{1}{(1+r)^2}\right) + 1 \times \left(\frac{1}{(1+r)^4}\right)$$

apples today (today being Monday). With  $r = 10\%$  ( $= .10$ ), this works out to about 4.98 apples today.

Guildenstern's multiple promise is another example of a bond. A bond of this sort is sometimes called a **coupon bond**. The reason for the terminology is that Guildenstern might seal his promise by providing a set of "coupons," such as those in Exhibit 17.1.

### Coupon bond

A bond that promises a series of payments on different dates.

#### EXHIBIT 17.1

#### A Coupon Bond

THIS COUPON GOOD FOR  
2 APPLES DELIVERED ON  
TUESDAY

THIS COUPON GOOD  
FOR 3 APPLES  
DELIVERED ON WEDNESDAY

THIS COUPON GOOD  
FOR 1 APPLE  
DELIVERED ON FRIDAY

A coupon bond is a promise to make a series of payments at specified dates in the future. To seal his promise, the seller of a coupon bond might issue a set of coupons such as those above.

## Perpetuities

A **perpetuity** is a promise to pay some fixed amount annually forever. A perpetuity is like a coupon bond with an infinite number of coupons.

Imagine a perpetuity that pays you \$1 per year forever, starting one year hence. The present value of such a perpetuity in dollars is

$$\frac{1}{(1+r)} + \frac{1}{(1+r)^2} + \frac{1}{(1+r)^3} + \frac{1}{(1+r)^4} + \dots$$

Perhaps you know how to sum such an infinite series. If not, don't panic. There is a sneaky way to compute the value of a perpetuity without using advanced mathematics.

If you place a dollar in the bank and leave it there forever, it will earn \$ $r$  every year in interest, which you can withdraw and spend as you please. In other words, you can trade your dollar for a perpetuity of \$ $r$  per year. Thus, a perpetuity of \$ $r$  per year has a price—or present value—of exactly \$1. It follows that a perpetuity of \$1 per year must have a present value of exactly  $1/r$  dollars. Our infinite series must sum to  $1/r$ .

For example, if the interest rate is 10%, then a perpetuity paying \$1 per year has a present value of  $\$1/.10 = \$10$ . In other words, \$10 today can be traded for \$1 per year forever. And indeed it can: Deposit \$10 in the bank forever and withdraw the interest each year. Or, if you prefer, you can make the opposite exchange: Trade a \$1 annual perpetuity for \$10 today by borrowing \$10 and paying a \$1 interest charge each year.

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**Exercise 17.6** At an interest rate of 5%, what is the present value of a perpetuity that pays \$1 per year forever?

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## Bonds Denominated in Dollars

A bond that promises to pay 1 apple next year must sell for  $1/(1+r)$  apples today, where  $r$  is the annual interest rate. However, relatively few bonds promise to deliver apples. Far more often, they promise dollars. Such bonds are said to be *denominated* in dollars.

When bonds are denominated in dollars, there is a new complication to consider. We usually assume that an apple delivered in the future is identical to an apple delivered today in every respect except for the date of delivery. The same is *not* true of dollars. A dollar delivered in 1990 had far less purchasing power than one delivered in 1980 because of *inflation*: a general rise in the absolute price level, or, in other words, a fall in the value of the dollar.

Suppose that you deposit \$1 in the bank today at 5% annual interest, so that next year your balance is \$1.05. If there is simultaneously a 5% inflation rate, how much has your purchasing power really grown? The answer is that it has not grown at all. You will be able to buy no more apples with your \$1.05 next year than you can with your \$1 this year.

We distinguish between the **nominal interest rate** at which your *dollars* grow and the **real interest rate** at which your *purchasing power* grows. In the example just considered, you earned a nominal rate of 5% but a real rate of 0%. When a bond is denominated in dollars, the quoted interest rate is a nominal rate; when a bond is denominated in some real good, such as apples, the quoted interest rate is a real rate.

There is a simple equation relating the nominal interest rate  $i$ , the inflation rate  $\pi$ , and the real interest rate  $r$ . Your money grows at rate  $i$ , of which  $\pi$  is necessary just to keep up with inflation. The real growth rate in your purchasing power is equal to the remainder

## Perpetuity

A bond that promises to pay a fixed amount periodically forever.

## Nominal interest rate

The relative price of current dollars in terms of future dollars, minus 1.

## Real interest rate

The relative price of present consumption goods in terms of future consumption goods, minus 1.

$$r = i - \pi$$

or

$$i = r + \pi$$

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**Exercise 17.7** Suppose that your bank account pays 8% interest on your money and that inflation is 5%. What nominal interest rate are you earning? What real interest rate are you earning?

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In general, it is *real* interest rates that are of real interest in microeconomics, and whenever we speak of “the” interest rate we will mean the real interest rate. In times of zero inflation, the real and nominal interest rates will be the same.

## Default Risk

A bond is a promise to pay, and throughout this section we have assumed that promises are always kept. Those economists (perhaps a minority) who have been in love know better. The buyer of a bond that promises an apple tomorrow is buying not an apple tomorrow but a *chance* of receiving an apple tomorrow. When he thinks the chance is smaller, he will pay less for the bond. Thus, everything we have said about the pricing of bonds applies literally only to cases in which the lender feels quite certain that his bond will be redeemed. A less trustworthy borrower has to sell bonds at a greater discount in order to attract lenders. This is why different bonds carry different rates of interest.

The possibility that a borrower will fail to meet his obligations is known as a **default risk**. The higher the default risk, the higher will be the interest rate that the borrower has to pay in order to attract lenders. The additional interest that the borrower receives because of the default risk is called a **risk premium**. We will have more to say on the subject of risk and its effect on asset prices in Chapter 18.

### Default risk

The possibility that the issuer of a bond will not meet obligations.

### Risk premium

Additional interest, in excess of the market rate, that a bondholder receives to compensate him for default risk.

## Treasury Bills: A Risk-Free Asset?

It is widely believed that Treasury bills carry essentially no default risk and that the U.S. Treasury has never defaulted on its obligations. This is untrue. For example, the Treasury defaulted on bill #GS7-2-179-46-6606-1.

In order to purchase a Treasury bill at auction, the investor (that is, the buyer of the bond) must submit a payment equal to the full face value of the bond. Following the auction, the discount is supposed to be returned to the investor immediately. For example, suppose that you want to buy a Treasury bill that promises to pay \$20,000 6 months from now. To do so, you submit a check for \$20,000 before the auction is held. If the bill sells at auction for \$19,000, your discount of \$1,000 should be returned to you immediately following the auction.

One unfortunate investor followed this procedure. His discount, approximately \$1,100, was not returned. Following a series of inquiries, the Treasury took the remarkable position that although the default was entirely due to its own clerical errors, there was a strong possibility that the errors were irreparable and that the discount would never be paid. It required nearly 9 months, considerable expense on the investor's part, and the intervention of several senators and congressmen before the Treasury met its obligation. Even then, the Treasury refused to pay interest for the 9 months in which it unlawfully held the funds.

The frequency of such occurrences is not known. This particular investor went on to write a textbook in price theory, yielding a bit more publicity than might ordinarily



be expected. If there are many more such cases, and if they become well known, then the risk premium on Treasury bills will grow, so that the price of the bills will fall.

## 17.2 Applications

Suppose your company has the opportunity to undertake an investment project that requires \$100 in expenditure today but will return revenues of \$50 a year for 3 years, beginning 2 years from now. Is the project a good one?

Suppose that you buy a used car and the dealer offers you a choice of payment plans. You can make three annual payments of \$400 each (beginning immediately) or you can pay nothing down and then two payments of \$635 each (beginning 1 year from today). Which is better?

Present values give us a standard of comparison for different payment streams. If you are offered a choice between a new car and a Hawaiian vacation, and if you have easy access to resale markets, you should always take the one with the higher market value—even if it's not the one you really want. If the car is worth \$10,000 and the vacation is worth \$8,000, you can take the car, sell it, buy the vacation, and still have \$2,000 left over. So it is with payment streams. After choosing the one with the highest present value, you can always make a sequence of market trades that converts your choice to any of the others and leaves you with extra money in your pocket.

If the market interest rate is 10%, then your company's investment project has a present value of \$113.04 (this is the present value of three annual payments of \$50, beginning in 2 years). Because the project only costs \$100 to undertake, it is a good one. But if the interest rate is 15%, the project's present value is only \$99.27, and not worth the \$100 cost.

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**Exercise 17.8** Using a calculator, verify the numbers in the preceding paragraph.

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At an interest rate of 10%, three annual car payments of \$400 each, beginning immediately, have a present value of \$1,094.21, whereas two payments of \$635 each beginning next year have a present value of \$1,102.07. The first plan is better. But, if the interest rate is 15%, the first set of payments has a present value of \$1,050.28 and the second set has a present value of only \$1,032.33. In this case, you should choose the second plan.

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**Exercise 17.9** Using a calculator, verify the numbers in the preceding paragraph.

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Knowing how to calculate present values and recognizing that a present value is nothing but a relative price are the keys to understanding a wide variety of issues. In the remainder of this section we offer several examples.

### Valuing a Productive Asset

Suppose that you are thinking of buying a tree that will produce 10 apples per year forever. How much is the tree worth? The answer is the present value of a perpetuity of 10 apples per year. If the interest rate is 10%, the tree is worth 100 apples. In a competitive environment, the tree will sell for exactly that price (at any higher price there are no buyers and at any lower price there are no sellers).

The goods produced by a productive asset are called **dividends**. In this case, the dividends are the apples.

### Dividends

Streams of benefits.

The value of a productive asset is equal to the present value of the stream of dividends that it produces.

## Corporate Stocks

Economists distinguish between productive assets such as apple trees and *financial assets* such as corporate stocks and bonds. A share of corporate stock (which is usually nothing but a piece of paper) produces nothing. Instead, it conveys the right to collect a share of the dividends from productive assets that the corporation owns. If General Enterprises owns productive assets yielding dividends worth \$100 per year, and if you own 1% of General Enterprises' stock, then you are entitled to receive dividends of \$1 per year.

Dividends can be paid in either of two forms. One possibility is that General Enterprises can take the \$100 and convert it into cash for distribution among the shareholders. The other possibility is that General Enterprises can take the \$100 that it earns and use it to purchase a new productive asset, such as an apple tree. Because the stockholders all share in ownership of the apple tree, the value of their stocks increases accordingly.

Accountants and stockbrokers distinguish between the two forms of distributing dividends. They call the cash payment a *dividend* and the apple tree purchase *growth*. To an economist, however, this is a distinction without a difference. It is easy enough for a shareholder to convert one to the other. If General Enterprises opts for growth (increasing the value of your shares by \$1) and you would rather have the cash, you can simply sell \$1 worth of your stock. If the company makes a cash payment and you'd rather have growth, you can simply take your cash payment and use it to buy more stock. Regardless of whether the company's income is initially distributed through cash payments or the purchase of new assets, the economist calls the benefit to the stockholder a *dividend*.

Using the economist's definition of a dividend, we can assert that

The value of a financial asset is equal to the present value of the stream of dividends that it provides.

One problem with this "law" is that in many cases nobody can confidently predict the stream of dividends that an asset will provide. A more careful statement would be that the value of a financial asset is equal to the present value of its *expected* stream of dividends, recognizing that there is some uncertainty surrounding any expectation. Even one more qualification is needed: Because shareholders do not like risk, greater uncertainty about performance tends to depress the value of a stock (just as default risk depresses the value of a bond).<sup>1</sup> Often, the present value of the expected stream of dividends is a good approximation to the stock's value; adding in an adjustment for risk makes the approximation better.

## Valuing Durable Commodities: Is Art a Good Investment?

Some assets, like apple trees, yield dividends in the form of physical commodities. Others yield dividends in the form of services. Typically, these assets are durable commodities such as sofas, cars, or houses.

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<sup>1</sup> Even this needs to be qualified. We shall see in Chapter 18 that some risks can be "diversified away." It is only the undiversifiable part of the risk that requires compensation.



How much is a sofa worth? Suppose that the sofa lasts for 4 years before wearing out. During this time it yields a stream of benefits that you value at \$100 per year. That is, \$100 per year is the most you would be willing to pay to use the sofa. The present value of those services is the same as the present value of a coupon bond that pays \$100 per year for 4 years. At 10% interest, this comes to about \$349.<sup>2</sup> If you can buy the sofa for less than \$349, you should grab the opportunity; if not, you are better off without it.

What is the market price of the sofa? The price is equal to the sofa's value to the marginal buyer. If the marginal buyer values the sofa's services at \$100 a year, its price is \$349. If he values its services at more or less than \$100 a year, its price is more or less than \$349.

The same principle applies to any durable commodity, such as a work of art. Paintings yield dividends because people like to look at them; the value of seeing the painting is the dividend. The price of a painting is the present value of those dividends.

Suppose you are given the opportunity to purchase a painting that you expect to hold for 4 years and then sell. During the 4 years that you hold the painting, it yields dividends that the market values at \$100 per year. At the end of 4 years, you expect that the painting can be sold for \$1,500. (This \$1,500 is in turn a reflection of the dividends that the painting is expected to yield in the years after you sell it.) Assuming a 10% interest rate, the present value of this stream of payments is \$1,373.21, and this will be the market value of the painting.

Now suppose that your personal pleasure from looking at this particular painting is only worth \$50 per year. The stream of payments that you get if you buy it is \$50 per year for 4 years and then a selling price of \$1,500. The present value of this stream of payments is only \$1,198.86. If you buy the painting, you will pay \$1,373.21 for something that you value at \$1,198.86. You shouldn't buy it.

What if for some reason the expected selling price 4 years from now rises from \$1,500 to \$2,500? Should this affect your decision? The market price of the painting rises to equal the present value of \$100 per year for 4 years followed by a single payment of \$2,500; your personal valuation rises to equal the present value of \$50 per year for 4 years followed by a single payment of \$2,500. The market price is \$2,056.22 and your personal valuation is \$1,881.88. You still shouldn't buy.

In general, any change in the expected future selling price adds the same amount to both the market price and your personal valuation and therefore makes the painting neither more nor less attractive to purchase than it was before.<sup>3</sup> If the dividends that you collect from looking at the painting exceed the market value of those dividends, then you will do well to buy the painting. Otherwise, you won't.

The bottom line, then, is that you should use the same rule when you shop for art that you use when you shop for clothes or food: Buy what you like. More precisely, buy those things that you value more than the market does.<sup>4</sup>

## Should You Pay with Cash or Credit?

Imagine that you've decided to spend \$100 for a new suit of clothes. Several methods of finance are available. First, you can withdraw \$100 from your bank account and pay for the purchases up front. Second, you can charge the purchases to your credit card and

<sup>2</sup> To simplify the calculation, we assume that each year's benefits are all collected at the beginning of the year.

<sup>3</sup> An exception would occur if you acquired access to information that was not publicly available, so that your personal expectation of the selling price changed while the market's remained constant.

<sup>4</sup> This is not to deny the possibility of remarkable luck, good or bad, that happens when the market's expectation of future prices turns out to be wrong. It says only that you cannot reasonably expect to come out ahead unless you value the dividends at more than their market price.

settle the debt a year from now. In this case, the credit card bill to be paid next year is \$110, assuming a 10% interest rate.

There is also a third option—you can charge the \$100 to your credit card with no intention of *ever* paying off the debt. Instead, you make a \$10 interest payment to the finance company, every year forever.

Now the question is: Which payment scheme do you prefer? The answer is: Because they all have the same present value (\$100 in each case), the options are all equally desirable. To verify this, let us assume that you start with \$1,000 in the bank and compute your financial status 1 year from now under each of the three options.

If you pay for the clothes up front, your bank balance falls to \$900, which earns \$90 interest (continuing to assume a 10% interest rate) over the course of the year. One year from today your balance is \$990.

If you charge to your credit card and pay next year, you leave \$1,000 in the bank, which grows to \$1,100 over the course of the year. You then withdraw \$110 to pay the credit card bill, and your balance is again \$990.

Finally, under the plan where you charge to your credit card and never pay the debt, your bank balance grows to \$1,100, of which you withdraw \$10 to make your first annual interest payment, leaving \$1,090. Of this, there is \$100 that you dare never withdraw, since the income that it yields is necessary to make your future credit card payments of \$10 per year. This leaves you with a usable balance of \$990, exactly as in the first two cases.

In other words, all three plans leave you equally wealthy, as we knew they must.

In this discussion we made the simplifying assumption that you pay the same interest rate on your credit card that you earn at the bank. Typically, these rates differ because you are a somewhat less reliable credit risk than your bank is. In that case, a complete analysis of the optimal financing plan would depend on the particulars of your other options and your opportunity costs. But the moral remains that any preference between cash and credit must be due to *differences* in interest rates. Just because you must pay interest on your credit card loans is not enough to make them undesirable.

## Government Debt

Instead of buying your own clothes, you might imagine hiring a purchasing agent to buy them for you. The agent has two decisions to make: How much should he spend on various sorts of clothes, and how (by spending your cash or by using your credit card) should he finance the purchases?

Regarding the first decision, your agent's choices might please or displease you very much. If he comes home with \$5,000 worth of winter boots and you live in Florida, you might start looking for a new purchasing agent. Regarding the second decision, as we have just seen, the choice is largely a matter of indifference.

The government is like a purchasing agent. On your behalf, it purchases post offices, public radio programs, and strategic missiles. It decides how much to spend on all of these items, and then it decides how to finance them. Among the options, it can pay cash (which it gets by taxing you immediately), it can use "credit" to defer the payment (by borrowing money and taxing you in the future to pay the debt), or it can pay on credit and never pay off the debt (by borrowing money and taxing you annually to make the interest payments).

The parable of the clothes buyer suggests that while you might care very much about what the government spends your money on, and about how much it spends, you will be indifferent among the various methods of finance.

In fact, the argument is far *more* convincing in the case of the government than it is in the case of the clothes buyer. In the case of the clothes buyer, we assumed that the interest rate at which you borrow (the credit card rate) is equal to the interest rate at which you lend (the bank rate). We acknowledged that this equality was unlikely to hold in practice and that therefore the conclusion was only approximately true.

However, when the government borrows on your behalf, it does so by selling Treasury bills, and the interest rate that it pays is the Treasury bill rate. You can earn the same rate on your savings by the simple expedient of buying Treasury bills.

When the government borrows \$1 to buy a paper clip, it is often alleged that taxpayers end up paying more than \$1: A year down the line, they are taxed not only \$1 to pay for the paper clip but also 10¢ to pay for interest on the loan. In exchange for that interest payment, goes the argument, the taxpayers receive nothing at all.

The argument is certainly wrong. Taxpayers *do* get something of value in exchange for their 10¢ interest payment. They get the right to pay for the paper clip one year hence instead of today, enabling them to keep \$1 in the bank for one additional year and thereby earn 10¢ additional interest on their bank accounts. They spend 10¢ to get 10¢ and are made neither better nor worse off by the transaction.

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Keep in mind that the purchase of the paper clip can certainly make taxpayers either more or less happy than they were before. It is only the choice between paying cash and incurring debt that is a matter of indifference.

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Dangerous  
Curve

This entire discussion goes to show that at a given prevailing interest rate, government debt is of no consequence to the taxpayer. However, it does not address another, more interesting question: Can government debt cause the prevailing interest rate to change? We will return to this question in Section 17.3.

## Planned Obsolescence

Larry's Light Bulb Company can produce light bulbs that burn for 1,000 hours or light bulbs that burn for 3,000 hours. The cost of production is the same in either case. Which kind of light bulb should Larry produce?

Many people think that Larry should produce the inferior light bulbs. They argue that if the average bulb is used 1,000 hours per year, the 3,000-hour bulbs will have to be replaced only once every 3 years, whereas the 1,000-hour bulbs will have to be replaced once every year, resulting in three times as many sales for Larry.

It is not hard to see that this reasoning cannot be correct if light bulbs are produced competitively. If Larry's competitors have access to the same technology that he does, he will be driven out of business as soon as somebody else decides to produce the better bulb.

However, this argument is actually beside the point. In fact, it is in Larry's interest to make the better bulbs regardless of whether he is a competitor, a monopolist, or anything in between.

To see the reason for this, notice that light bulbs are valuable only because they can be used to produce light. Suppose that customers use each light bulb to produce 1,000 hours of light per year and that they value an additional year's worth of light at \$5. Then the price of a 1,000-hour light bulb will be \$5. To compute the price of a 3,000-hour light bulb, think of the bulb as providing \$5 worth of service this year, \$5 worth next year, and \$5 worth the year after that. The present value of this service is

$$\$5 + \frac{\$5}{(1+r)} + \frac{\$5}{(1+r)^2}$$

where  $r$  is the yearly interest rate. When  $r = .10$ , a little arithmetic reveals that this expression is equal to \$13.68, which is the price consumers will be willing to pay for a light bulb.

Larry has a choice between manufacturing a light bulb that he can sell for \$5 and manufacturing a light bulb that he can sell for \$13.68. Each costs him the same to produce. It isn't hard to see what choice he should make.

It is often alleged that firms, and particularly monopolies, engage in the practice of *planned obsolescence*, whereby goods are intentionally designed to wear out more quickly than necessary, without any justification in terms of costs of production. We have just seen that as long as customers are aware of differences in quality, there is never incentive for any firm to engage in this practice. A profit-maximizing firm will always make a longer-lived product, provided that the additional cost of manufacturing such a product is less than the present value of the additional stream of benefits that it provides. (Larry makes the better light bulb as long as its production cost exceeds the production cost of the cheaper bulb by less than \$8.68.)

This decision rule for firms is economically efficient from a social point of view. The cost of providing longevity is weighed against its benefits. Because some of the benefits are delayed, they should be assessed at their present values.

Try the following experiment. Ask 25 of your friends what a camshaft is. Now have your friends ask their grandfathers. You will find that the percentage of correct answers is much higher among the grandfathers. Most of today's grandfathers learned what a camshaft was about 40 years ago when they had to have theirs repaired, often repeatedly. Most of today's college students will never have that experience. When car manufacturers learned how to make camshafts that lasted, they put their knowledge to work.

## Artists' Royalties

Prior to 1990, when artists sold their works, they relinquished any right to benefit from future increases in their value. Sydney J. Harris, formerly a syndicated columnist, argued repeatedly that artists should share in the benefits when their paintings appreciate. Specifically, he proposed that whenever a painting is resold, the artist should receive a percent of the increase in value since the last sale. We will evaluate the effect of this proposal from the artist's point of view.

When the artist first sells the painting, its price is equal to the present value of the stream of benefits that it will provide to future owners. At least this is the case if the stream of benefits can be foreseen. More realistically, we should allow for some uncertainty as to how the painting will be valued in the future. The price of the painting will be equal to the present value of the *expected* stream of benefits. We will study expectations and uncertainty more rigorously in Chapter 18.

Suppose an art lover buying an oil painting expects to derive \$10 per year in pleasure from looking at the painting for each of this year and next year and then expects to be able to sell the painting for \$50. (This \$50 is his estimate of how the next buyer will value the future stream of benefits 2 years from now.) In that case, he will be willing to pay a price of

$$\$10 + \frac{\$10}{(1+r)} + \frac{\$50}{(1+r)^2}$$

where  $r$  is the rate of interest.

Now suppose that the “Harris Plan” is enacted into law. The buyer is required to pay the artist 20% of the painting’s resale price. In that case, the buyer can keep only \$40 when he resells the painting, and its present value to him is reduced to

$$\$10 + \frac{\$10}{(1+r)} + \frac{\$40}{(1+r)^2}$$

This is a reduction of  $\$10/(1+r)^2$  from what the painting was worth before the Harris Plan was enacted. The current price of the painting will fall by  $\$10/(1+r)^2$ , which is a loss to the artist.

On the other hand, when the painting is resold for \$50 in 2 years, the artist will receive a royalty of 20%, or \$10. The present value of that royalty is  $\$10/(1+r)^2$ . From the artist’s point of view, the benefits of the Harris Plan are equal to its costs. He is indifferent to whether it is enacted.

The foregoing supposes that the buyer is correct in his expectation that he can sell the painting in 2 years for \$50. Suppose he turns out to be wrong. Suppose the artist’s reputation blossoms, and the painting is sold for \$100, on which the artist’s royalty is \$20. The present value of that royalty is  $\$20/(1+r)^2$ . The Harris Plan has benefited this artist. The initial value of his painting fell by  $\$10/(1+r)^2$ , but this is offset by a future royalty with twice that present value.

Another possibility is that the buyer has been too rosy in his expectations. Suppose that in 2 years the artist has been forgotten, and his painting sells for only \$15. The royalty is \$3, with a present value of  $\$3/(1+r)^2$ . This is insufficient to offset the initial price reduction of  $\$10/(1+r)^2$ . This artist is a loser under the Harris Plan.

Who gains and who loses? The average artist—the one whose career turns out about as expected—just breaks even. The artist whose career goes much better than expected is a winner, and the artist who is less successful than expected is a loser. Thus, the Harris Plan is a way to transfer income from unsuccessful artists to successful artists.

## Old Taxes Are Fair Taxes

One hundred fifty years ago, Coconino County imposed an annual tax of \$10 per acre on all landowners. Landowners to this day grumble about the tax. The mayor has decided that the tax represents an unfair burden and has called for its repeal, to correct a historical injustice.

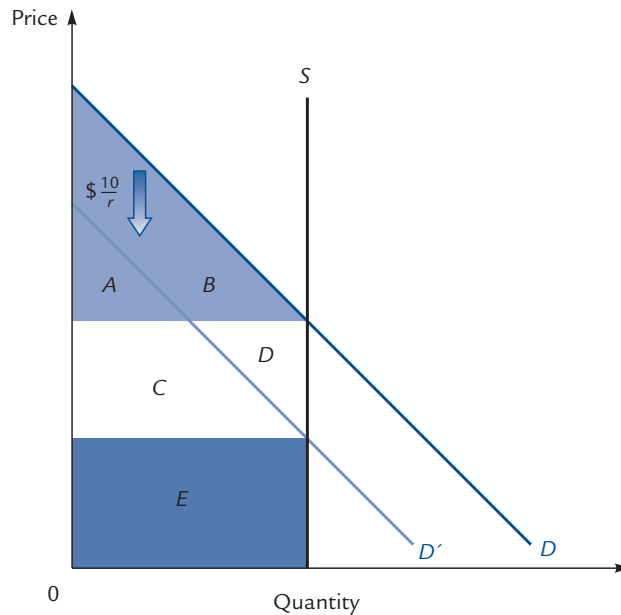
Although the tax might have been a great injustice, repealing the tax is unlikely to correct it. When the tax was imposed, the value of an acre of land plummeted by exactly  $\$10/r$ , the value of a perpetuity of \$10 per year. Any land sold in the last 150 years has been sold at the new depressed value.

Exhibit 17.2 shows the market for land in Coconino County 150 years ago. After the tax was imposed, the demand curve fell by  $\$10/r$  per acre. The price fell from  $P$  to  $P - \$10/r$ . Producers’ surplus fell from  $C + D + E$  to just  $E$ . Consumers’ surplus remained constant at  $A + B$ . Buyers of land lost nothing as a result of the tax; its burden fell completely on the sellers.

Any parcel of land in Coconino County that has been sold at any time in the last 150 years is now owned by somebody who was fully compensated for the infinite stream of future taxes through a reduced purchase price. If the tax is removed now, the current owners will receive a windfall, as the price of the land rises back to  $P$  and its total value increases by  $C + D$ . The full burden of the tax is still being borne by the heirs of the original owners, now probably scattered and unidentifiable.

## EXHIBIT 17.2

## Old Taxes Are Fair Taxes



The graph shows the market for land in Coconino County 150 years ago, when an annual \$10-per-acre tax on landholdings was first instituted. The demand curve fell by  $\$10/r$  per acre, and because of the vertical supply curve, the price fell by  $\$10/r$ . The landowners of Coconino County suffered a loss in producers' surplus of  $C + D$ . The buyers of land lost nothing. The price of the land that they bought was reduced by enough to compensate them for the infinite stream of future taxation.

If the tax is repealed, everyone who has bought Coconino County land in the last 150 years will reap a windfall gain. Except in those cases where the land has never changed hands, the winners will be people who were never hurt by the tax in the first place.

## The Pricing of Exhaustible Resources

A resource is *exhaustible* if every unit consumed today implies that one less unit will be available in the future. Oil is often said to be an exhaustible resource. The coal available from a given mine is a good example.

When a resource is exhaustible, the forgone opportunity to use it in the future becomes a part of the cost of consuming it today. Suppose that coal sells competitively at a going price of  $P_0$  today and is expected to sell at a price of  $P_1$  tomorrow. Suppose also that the cost of digging out any particular nugget of coal is the same on each day. Then any nugget dug out and sold today entails a forgone opportunity to dig out and sell that same nugget tomorrow. The forgone profit on that nugget is  $P_1 - MC$ , where  $MC$  is the marginal cost of physically removing the coal from the ground. The present value of that forgone opportunity is  $(P_1 - MC)/(1 + r)$ .

The full marginal cost of removing and selling a pound of coal is equal to the sum of the marginal cost of digging it out and the present value of the forgone opportunity to sell it tomorrow. This comes to

$$MC + \frac{P_1 - MC}{1 + r}$$



A competitive producer will choose a quantity where the current price is equal to this full marginal cost, or

$$P_0 = MC + \frac{P_1 - MC}{1 + r}$$

Now a little algebra shows that

$$P_1 = P_0 \cdot (1 + r) - r \cdot MC$$

This equation predicts the price of an exhaustible resource next year in terms of its price this year, the interest rate, and the marginal cost of production.

The equation is particularly simple and intuitive when marginal costs are negligible. In this case, we get

$$P_1 = P_0 \cdot (1 + r)$$

The price of the exhaustible resource grows at exactly the rate of interest.

There is a great deal of intuitive content to this result. If the price were growing faster than the rate of interest, coal in the ground would be a good investment and mine owners would increase the amount of coal left unmined. This would raise current prices and lower future prices, reducing the rate at which prices grow.

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**Exercise 17.10** Explain how the rate of growth of prices would adjust if it were less than the rate of interest.

---

## 17.3 The Market for Current Consumption

Up until now, we have been taking market interest rates as given and examining how people react to them. The time has come to ask what determines interest rates.

The answer lies in our earlier observation (near the very beginning of Section 17.1) that the interest rate can be viewed as a measure of the relative price of current consumption in terms of future consumption. More precisely, if the daily interest rate is  $r$ , then the price of an apple today is  $1 + r$  apples tomorrow. Knowing the interest rate is the same thing as knowing the relative price. Price is determined by demand and supply. Thus, we must examine the demand and supply for current consumption.

### The Consumer's Choice

When we want to study how people allocate their consumption between apples and oranges, we begin with an indifference curve diagram in which apples appear on the horizontal axis and oranges appear on the vertical. When we want to study how people allocate their consumption between apples today and apples tomorrow, we begin with an indifference curve diagram in which apples today appear on the horizontal axis and apples tomorrow appear on the vertical. The indifference curves of Ken the Consumer are shown in Exhibit 17.3.

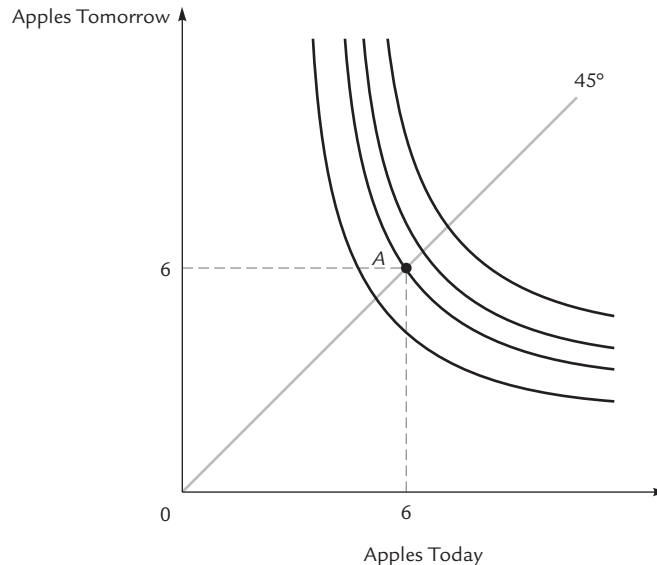
We assume that Ken has an **endowment** of 6 apples today and 6 apples tomorrow. These are the apples that Ken starts with, prior to any trading. Perhaps they come from an apple tree in his backyard, or maybe he has a job that pays a wage of 6 apples per day. Point A represents Ken's endowment.

### Endowment

The basket of goods that somebody starts with, before any trading.

## EXHIBIT 17.3

## The Consumer's Preferences



Ken's preferences are represented by indifference curves. The endowment point *A* depicts his holdings before he does any trading. In this example, the endowment point is on the 45° line, which means that he is endowed with the same number of apples each day. Under these circumstances we expect that Ken values 1 additional apple today more than 1 additional apple tomorrow. Therefore, at a point like *A*, the absolute value of the slope of the indifference curve is greater than 1.

### Time Preference

As we know from consumer theory, the absolute slope of Ken's indifference curve represents the marginal value to Ken of an apple today, measured in terms of apples tomorrow. For a variety of reasons, we expect this slope to be greater than 1. That is, we think that 1 additional apple today is worth more to Ken than 1 additional apple tomorrow.

One reason for this expectation is our belief that people are naturally impatient and would prefer to eat now rather than later. Another reason is that Ken is unsure what the future will bring: Since he might be hit by a truck before tomorrow ever comes, he might never get to enjoy tomorrow's apple. Yet a third reason is that an apple once eaten yields a lifetime's worth of pleasant memories. An apple eaten today yields one more day of these pleasures than does an apple eaten tomorrow.

Without committing ourselves fully or exclusively to any of these combinations, we will assume that Ken prefers 1 more apple today to 1 more apple tomorrow, or, in other words, that the absolute slope of his indifference curve at point *A* is greater than 1.

If Ken had a different endowment, say with 100 apples today and 2 tomorrow, we might have a different expectation. In these circumstances, 1 additional apple today is not likely to be very valuable to Ken. Our belief that his indifference curve has absolute slope greater than 1 is predicated on the fact that his initial endowment contains equal numbers of apples on both days. Geometrically, this means that his initial endowment is on the 45° line. The 45° line is illustrated in Exhibit 17.3.

Our assumption, then, is this: At points on the 45° line, Ken's indifference curves have slopes that are greater than 1 in absolute value. Off the 45° line, this assumption need not hold.

### Opportunities

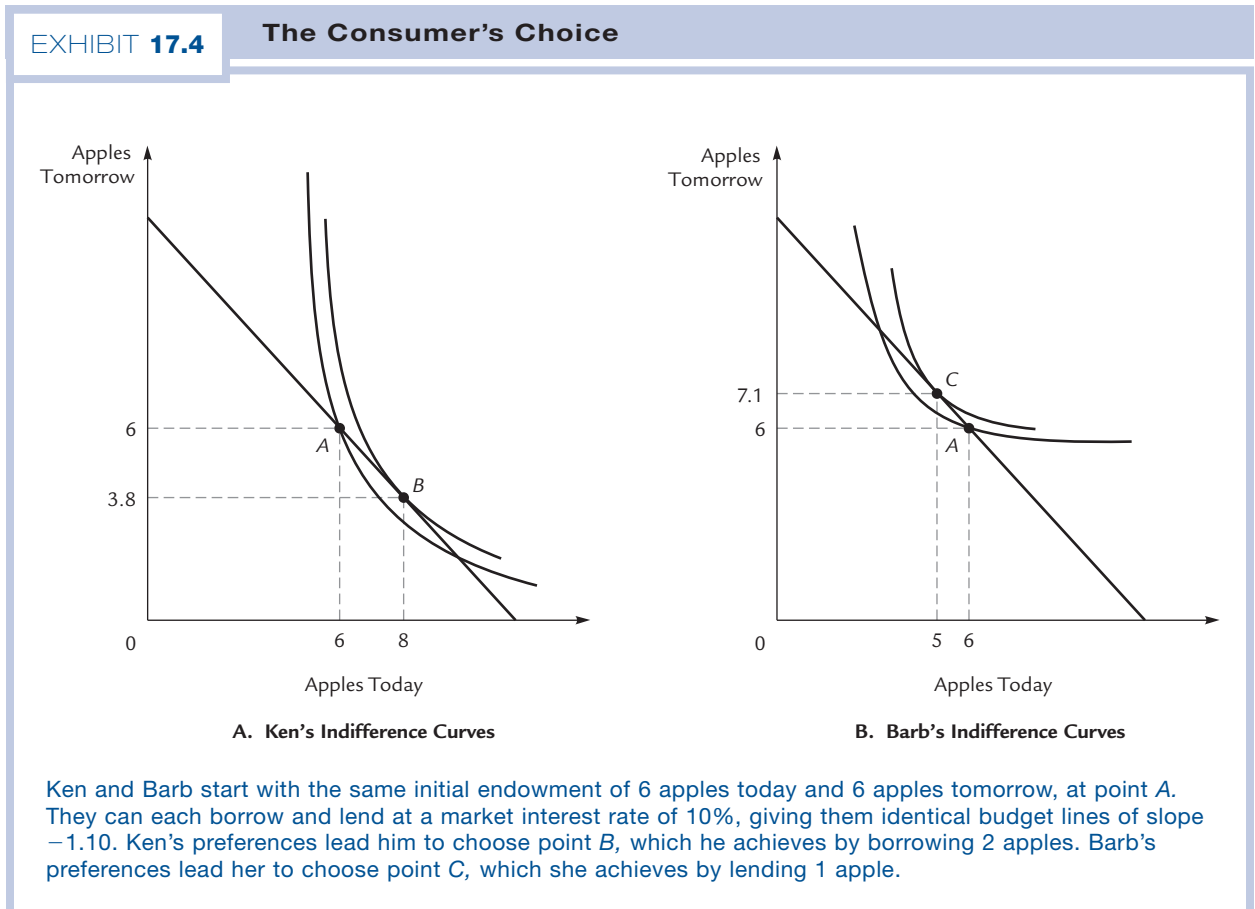
Suppose that Ken is given the opportunity to borrow or lend at a market interest rate of 10%. That is, he can buy and sell “apples today” at a relative price of 1.10 apples tomorrow. This means that he faces a budget line with absolute slope 1.10. We also know that his budget line must pass through his endowment point *A*, since he can achieve point *A* by simply not trading at all. The slope and a point are all we need to draw the budget line. It is illustrated in panel A of Exhibit 17.4.

If the interest rate were to change, Ken’s budget line would rotate around point *A*, becoming steeper for a rise in the interest rate or flatter for a fall in the interest rate.

### The Consumer’s Optimum

Ken chooses the point where his budget line is tangent to an indifference curve, which is point *B* in panel A of Exhibit 17.4. At this point he consumes 8 apples today and 3.8 tomorrow. Ken achieves this outcome by borrowing 2 apples to add to his endowment of 6 today; tomorrow he pays back the loan with 2.2 apples out of his endowment of 6 tomorrow.

Ken’s neighbor Barb has the same endowment as Ken and the same budget line, but she has different preferences. Panel B of Exhibit 17.4 shows that Barb chooses point *C*, with 5 apples today and 7.1 tomorrow. She achieves this by lending 1 apple out of her endowment of 6 today and collecting 1.1 apples to add to her endowment of 6 tomorrow.



The two panels of Exhibit 17.4 illustrate that, depending on preferences, the consumer's optimum could occur on either side of the initial endowment, and therefore he might decide either to borrow or to lend. However, if the interest rate had been 0%, giving the budget lines a slope of  $-1$ , then we know that both Ken and Barb would have been borrowers, consuming more than 6 apples today. The reason is that both Ken and Barb have indifference curves whose slopes at point  $A$  exceed 1 in absolute value; this forces the tangency to occur below and to the right of  $A$ .

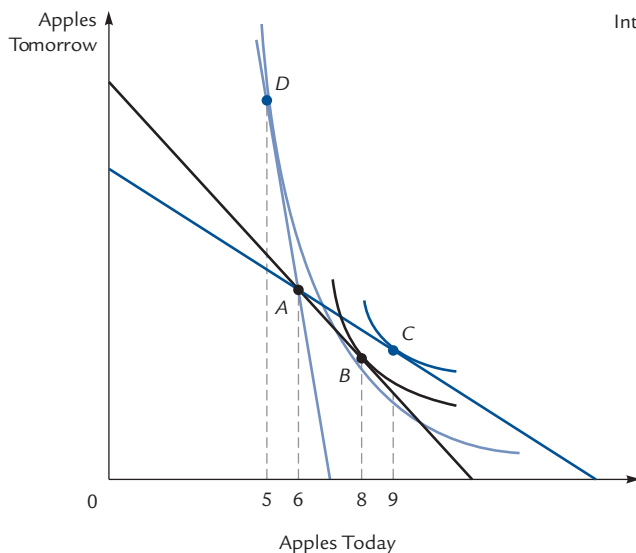
## The Demand for Current Consumption

We can use panel A of Exhibit 17.4 to generate a point on Ken's demand curve for current consumption. The exhibit tells us that when the interest rate is 10%, Ken demands 8 apples today. This information is recorded by point  $B'$  in panel B of Exhibit 17.5.

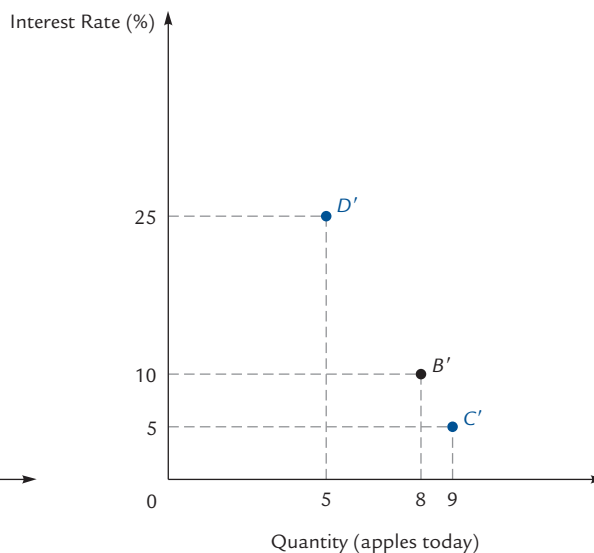
We can generate additional points in the same way. To see how much Ken would demand to borrow at an interest rate of 5%, first draw the corresponding budget line, which passes through his endowment point  $A$  with an absolute slope of 1.05. This

### EXHIBIT 17.5

#### Ken's Demand for Current Consumption



A. Ken's Indifference Curves



B. Ken's Demand for Apples Today

When the interest rate is 10%, Ken has the black budget line with slope  $-1.10$ , passing through his endowment point  $A$ . Ken chooses basket  $B$ , where he consumes 8 apples today, of which 6 come from his endowment and 2 must be borrowed. Point  $B'$  in panel B shows that when the interest rate is 10%, Ken eats 8 apples today.

When the interest rate is 5%, Ken's budget line pivots through point  $A$  to become the color line with slope  $-1.05$ . He chooses point  $C$ , eating 9 apples today (of which 3 are borrowed). This information is recorded by point  $C'$  in panel B.

At some interest rates, Ken chooses to be not a borrower but a lender. When the interest rate is 25%, he has the light-color budget line with slope  $-1.25$  and chooses point  $D$ . He consumes only 5 apples, lending 1 apple out of his endowment of 6. This information is recorded by point  $D'$  in panel B.

line is drawn in color in panel A of Exhibit 17.5. (The drawing is not to scale!) Ken chooses point  $C$ , where he consumes 9 apples, of which 3 must be borrowed (since his endowment contains only 6). This information is recorded by point  $C'$  in panel B of the exhibit.

Generating a series of points in this manner and connecting them, we can derive Ken's entire demand curve for current consumption.

At some interest rates, Ken will not want to borrow at all, but to lend. Suppose that the interest rate rises to 25%. The corresponding budget line, shown in light color in panel A of Exhibit 17.5, passes through the endowment point  $A$  with absolute slope 1.25. The tangency is at point  $D$ , so that Ken wants to consume only 5 apples today, meaning that he seeks to lend an apple. Point  $D'$  in panel B records the information.

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**Exercise 17.11** By examining panel B of Exhibit 17.4, generate a point on Barb's demand curve for current consumption.

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At an interest rate of 10%, Ken is a borrower, whereas at an interest rate of 25%, he is a lender. In classifying people as borrowers or lenders, we refer always to their net borrowing or lending. If Ken borrows 3 apples and lends 1 apple, then he is a net borrower of 2 apples. If he borrows 2 and lends 6, he is a net lender of 4.

If Ken's endowment includes 6 apples today and he wants to eat 8 apples today, he must become a net borrower of 2 apples. Whether he accomplishes this by borrowing 2 and lending none or by borrowing 9 and lending 7 is of little consequence.

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The vertical axis in panel B of Exhibit 17.5 is labeled with an interest rate, whereas the vertical axis for a demand curve should be labeled with a price. However, we know that interest rates can be converted to relative prices simply by adding 1. Therefore, it is legitimate to think of the interest rate axis as nothing but a relabeled price axis, and to think of the curve through  $B'$  and  $C'$  as a demand curve.

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Having generated Ken's demand curves for current consumption, we can repeat the exercise for Barb and every other member of the economy. We can add all the demand curves to generate a market demand curve.

## The Supply of Current Consumption

In this section, we will assume that the supply of current consumption is fixed: A certain number of apples fall from apple trees and must be eaten immediately. There is (by assumption) no way to save an apple until tomorrow and no way to increase the number of apples in the harvest. Therefore, the supply curve for current apple consumption is *vertical*.

In Section 17.4, we will relax the assumption that the quantity of current consumption is fixed. However, the flavor of the conclusions we draw will not be changed. By working first with the simplest possible model, we will get a good feeling for the nature of equilibrium.

## Equilibrium

We can find the market demand curve for current consumption by adding individual demand curves, each of which is derived by the method of Exhibit 17.5. We have a



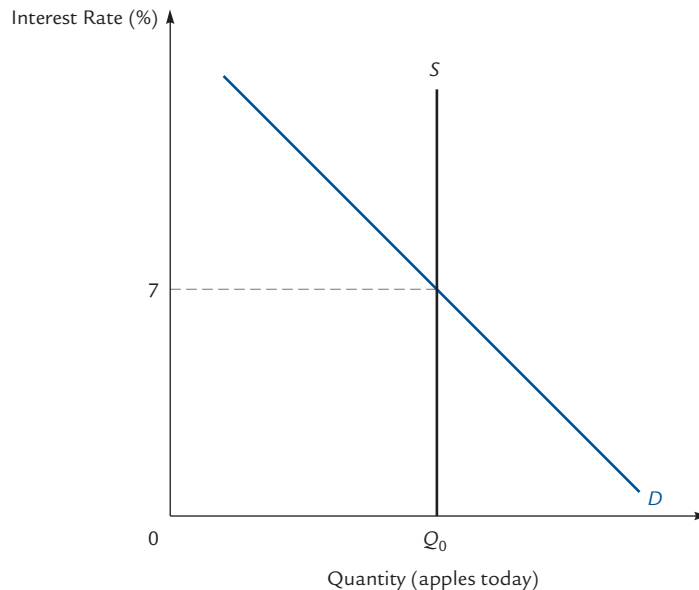
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## EXHIBIT 17.6

## Equilibrium



The demand curve is the sum of individual demand curves, each derived by the method in Exhibit 17.5. The supply curve is vertical at the quantity of apples in the harvest. The equilibrium interest rate in this example is 7%.

market supply curve that is vertical at the quantity of apples that happen to fall from the trees. Market equilibrium is determined by the intersection of the supply and demand curves. In Exhibit 17.6, the number of apples in the harvest is  $Q_0$  and the equilibrium interest rate turns out to be 7%.

## Equilibrium and the Representative Agent

Equilibrium is determined by the intersection of supply and demand. Here we will pursue an alternative approach to the determination of equilibrium. Of course, both methods must lead to the same conclusion, but depending on circumstances one or the other can be easier to apply.

### Representative agent

Someone whose tastes and assets are representative of the entire economy.

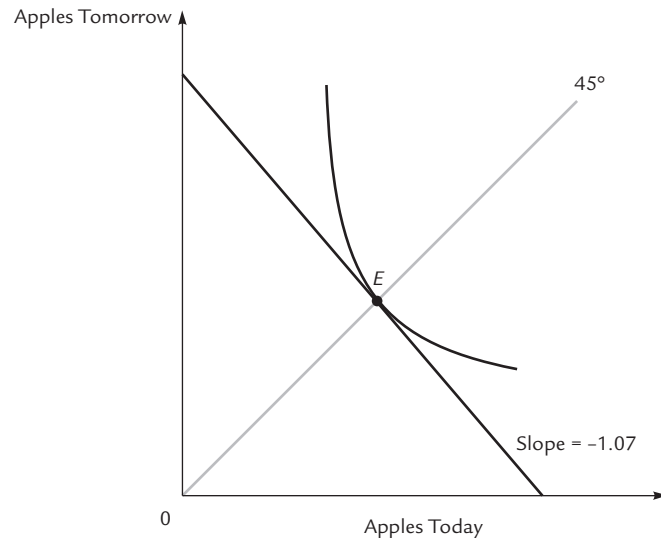
We reintroduce a fictional character who is called the **representative agent** and is a sort of “average” of all the people in the economy. Let us give our representative agent a name and call her Rebecca Representative.

Do you think Rebecca is a net borrower or a net lender? A bit of reflection reveals that she can be neither. Every dollar borrowed is a dollar lent, so the total of all borrowing in the economy must just equal the total of all lending. The average borrower borrows exactly the same amount that the average lender lends. Since Rebecca is an average of all the borrowers *and* all the lenders, she borrows exactly the same amount that she lends. That is, her net borrowing (or net lending) is exactly zero. Another way to say this is that Rebecca consumes exactly her endowment point.



## EXHIBIT 17.7

## The Representative Agent



Rebecca Representative's endowment point  $E$  happens to be on the  $45^\circ$  line. At that point her indifference curve has slope  $-1.07$ . Because the representative agent can be neither a borrower nor a lender, her budget line must be tangent to her indifference curve at the endowment point. Therefore, the budget line has slope  $-1.07$  and the equilibrium interest rate is 7%.

Drawing Rebecca's indifference curves and endowment point as in Exhibit 17.7, we can deduce what her budget line must be. Since she chooses to consume her endowment, her budget line must be tangent to an indifference curve at that point. This tells us the slope of her budget line. In Exhibit 17.7, Rebecca's indifference curve happens to have slope  $-1.07$  at the endowment point  $E$ . Therefore, the necessary budget line also has absolute slope 1.07. We can now infer that the equilibrium interest rate is 7%.

To compute the market interest rate, find the absolute slope of the representative agent's indifference curve at the endowment point, and subtract 1.

To understand this argument better, try thinking about what happens if the interest rate is less than 7%. Rebecca's budget line through point  $E$  is then flatter than in the exhibit, and her optimum lies to the southeast of  $E$ . Rebecca wants to be a net borrower, consuming more than her current endowment. Because she is the representative agent, this means that people on average want to consume more than their current endowments. The quantity of current consumption demanded exceeds the quantity supplied, so the interest rate must rise.

**Exercise 17.12** Explain what happens when the interest rate is greater than 7%.

We can calculate the equilibrium interest rate either by seeking the intersection of supply and demand or by calculating the slope of the representative agent's indifference curve at her endowment point. Because both procedures are correct, they must yield the same answer.

## Why Interest Rates Are Positive

In Exhibit 17.7, we assumed that Rebecca Representative's endowment point is on the 45° line. This is a reasonable assumption, tantamount to assuming that one day's apple harvest is no better or worse than another's. In that case, we know from earlier discussion that the slope of Rebecca's indifference curve at point *E* must be greater than 1 in absolute value. It follows that the interest rate (which we get by taking the absolute value of the slope and subtracting 1) must be positive.

If Rebecca's endowment were elsewhere, this would not have to be the case. Suppose that Rebecca starts with 100 apples today and expects to receive only 1 apple tomorrow. (This is not just a statement about a single individual; since Rebecca is the representative agent it means that people *on average* expect their apple trees to produce far less tomorrow than they do today.) Then her endowment is far to the southeast in the indifference curve diagram, where the curves are very flat. The absolute slope of her indifference curve at the endowment point might then have a value of only .3, making the equilibrium interest rate  $-.7 = -70\%$ .

## Why Low Interest Rates Are Not Better Than High Ones

Politicians often talk about the urgency of bringing down interest rates, to make it easier for people to increase their current consumption of houses, cars, and other commodities. And lower interest rates are indeed a good thing for people who are net borrowers. On the other hand, it is equally clear that lower interest rates are a bad thing for people who are net lenders: If you are saving for your retirement by lending money to a bank, you will want the interest rate to be as high as possible.

When interest rates fall, helping borrowers and hurting lenders, does the good outweigh the bad? or vice versa? When you reflect on the fact that every dollar borrowed is a dollar lent, you will see that the good and the bad exactly cancel. Every penny that a borrower gains from lower interest rates is a penny that a lender loses. Put another way, the representative agent is neither a net borrower nor a net lender and therefore neither gains nor loses from a change in interest rates. Because the representative agent is the typical participant in the economy, people on average are neither helped nor hurt when interest rates change.



Dangerous  
Curve

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Because an interest rate is an equilibrium price, it cannot change without a reason: There must be either a change in supply or a change in demand. That change in supply or demand must, in turn, be caused by some outside disturbance. Typically, that disturbance has either good or bad effects in addition to its effect on interest rates. Therefore, interest rate changes tend to be *accompanied* by changes in welfare, but the changes in welfare are not caused by the changes in interest rates.

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## Changes in Equilibrium

To calculate the effects of a change in market conditions, we can use either supply and demand curves or the method of the representative agent. We will carry out a few exercises illustrating both techniques.

## A Brighter Future

Suppose that a breakthrough in agricultural technology makes it clear that apple trees will become more productive in the future. Although each tree was initially expected to

produce 6 apples per day every day, we now expect the trees to produce 6 apples today and 8 tomorrow. How will the equilibrium interest rate change?

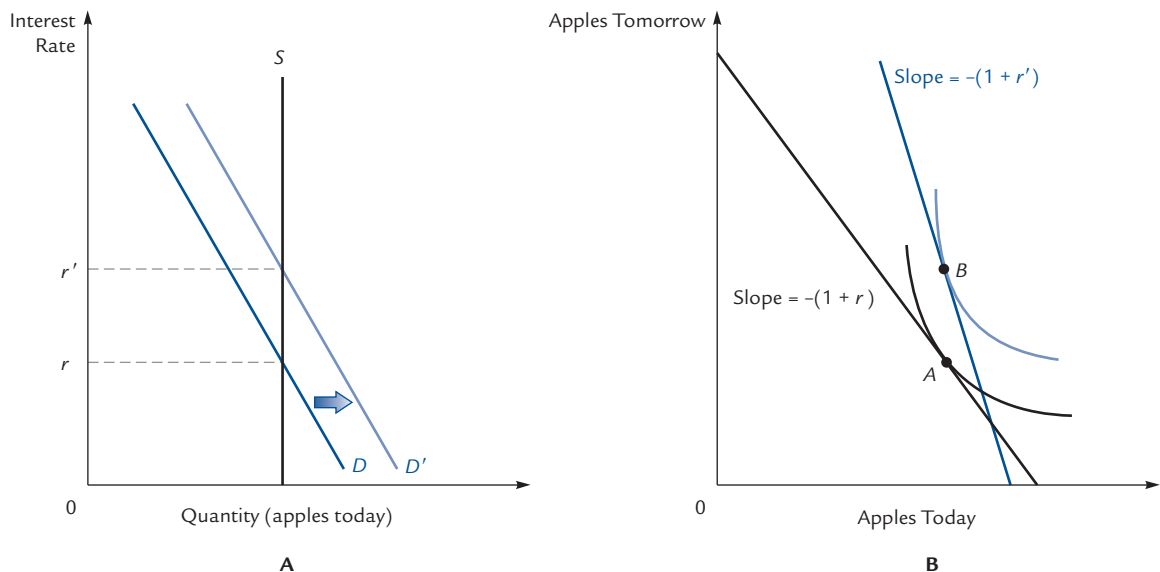
To answer this question, we can consult either the market supply and demand curves or the representative agent's indifference curves. The two approaches are illustrated in the two panels of Exhibit 17.8.

When word gets out that apple harvests will improve in the future, people feel wealthier immediately. Assuming that current consumption is a normal good (as opposed to an inferior good), the demand curve shifts out. The outward shift in demand reflects the fact that when you hear that your future income will increase, you want to start spending part of it today. The supply of current apples is unchanged. Therefore, the market interest rate rises from  $r$  to  $r'$  in panel A of Exhibit 17.8.

Panel B derives the same outcome from Rebecca Representative's point of view. As soon as she hears the good news about tomorrow's apple harvest, Rebecca's endowment point shifts upward from point  $A$  to point  $B$ . At the higher point  $B$ , we expect the indifference curve to be steeper. In fact, it is possible to show that the indifference curve at  $B$  is steeper, provided that we maintain our assumption that current consumption is a normal good. (Verifying this assertion is a somewhat challenging exercise, recommended to the ambitious student.) Therefore, Rebecca's new budget line, tangent at  $B$  instead of  $A$ , must be steeper. In fact, the slope of her original (black) budget line is  $-(1 + r)$ , while the slope of her new color budget line is  $-(1 + r')$ , where  $r$  and  $r'$  are the same equilibrium interest rates that we found in panel A. That the color line is steeper than the black one confirms that  $r' > r$ . When the future turns brighter, the interest rate increases.

## EXHIBIT 17.8

## An Increase in the Future Apple Supply



An increase in the future apple supply moves the representative agent from point  $A$  to point  $B$  in panel B, increasing wealth and hence increasing the demand for all noninferior goods, including apples today. The demand curve shifts outward in panel A and the equilibrium interest rate rises from  $r$  to  $r'$ .

The representative agent's budget line shifts from the black line (with absolute slope  $1 + r$ ) to the color line (with absolute slope  $1 + r'$ ). The fact that the color line is steeper confirms the observation that  $r'$  is greater than  $r$ .

## A Brighter Present

Suppose that this year's apple harvest is unusually large (8 apples per tree instead of the expected 6) through some stroke of good luck that is not expected to persist.

Exhibit 17.9 illustrates. As in the preceding example, people feel wealthier and increase their demand for current consumption. At the same time, the supply of current consumption is increased because of the good apple harvest. It appears from the picture in panel A that the new interest rate  $r''$  could be either below or above the old interest rate  $r$ . However, this is a case where an examination of the representative agent's indifference curves actually yields more information.

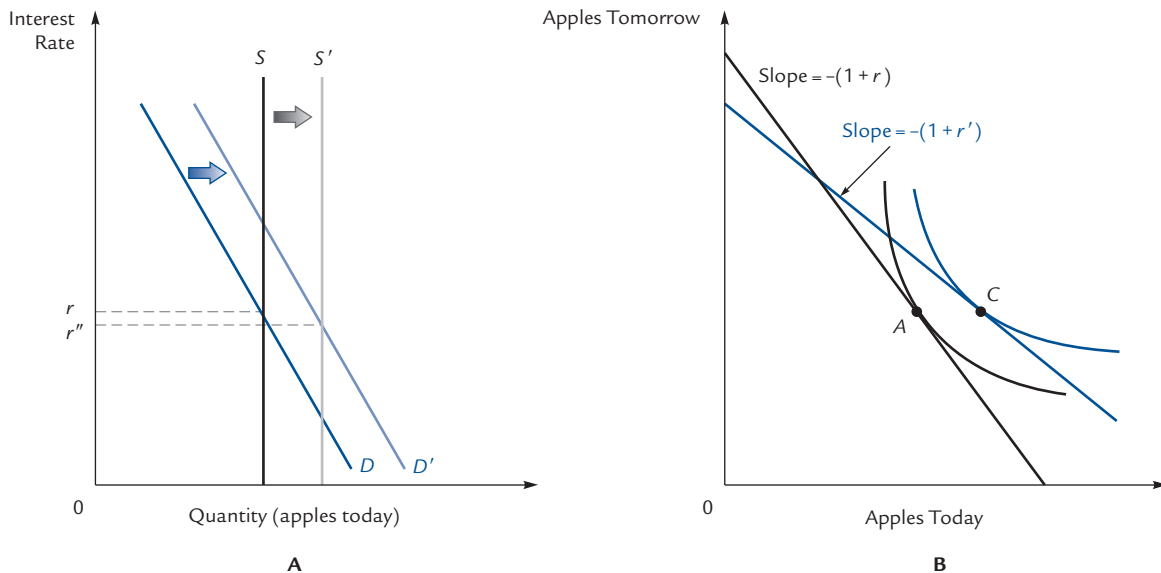
Turning to panel B, we see that Rebecca Representative's endowment moves rightward from point A to point C. At points farther to the right we expect that the indifference curves become flatter. (This can be proved if you start with the assumption that future consumption is not an inferior good.) Therefore, the color budget line with slope  $-(1 + r'')$  is flatter than the black budget line with slope  $-(1 + r)$ . It follows that  $r''$  is less than  $r$ . When the present turns brighter, the interest rate falls.

## A Permanent Productivity Increase

Suppose that apple trees, having always produced 6 apples per year, suddenly begin producing 8 apples per year on a permanent basis, beginning immediately. As in panel

EXHIBIT 17.9

### An Increase in the Current Apple Supply



Because people are wealthier when the current apple supply increases, demand increases as well. The supply and demand graph in panel A does not reveal whether the new equilibrium interest rate  $r''$  is greater or less than the old interest rate  $r$ . However, we can make this determination on the basis of Rebecca Representative's indifference curves. Her endowment moves from point A to point C, so her budget line changes from the black line to the flatter color line. As the slope of the budget line determines the equilibrium interest rate, we conclude that the interest rate falls.

A of Exhibit 17.9, the demand and supply curves for current consumption both shift rightward and the diagram does not reveal whether the new interest rate is higher or lower than the old. An examination of the representative agent's situation does not relieve the ambiguity. In Exhibit 17.10, we see that Rebecca Representative's endowment point moves from (6, 6) to (8, 8), where there is no particular reason to believe that the indifference curve has become either shallower or steeper.

It is common, especially in macroeconomics, to make the additional assumption that at various points along the 45° line, the indifference curves all have the same slope. (Indifference curves with this property are called *homothetic* near the 45° line.) In this case, the black and the color budget lines in Exhibit 17.10 are parallel, and the change in productivity has no effect on the interest rate.

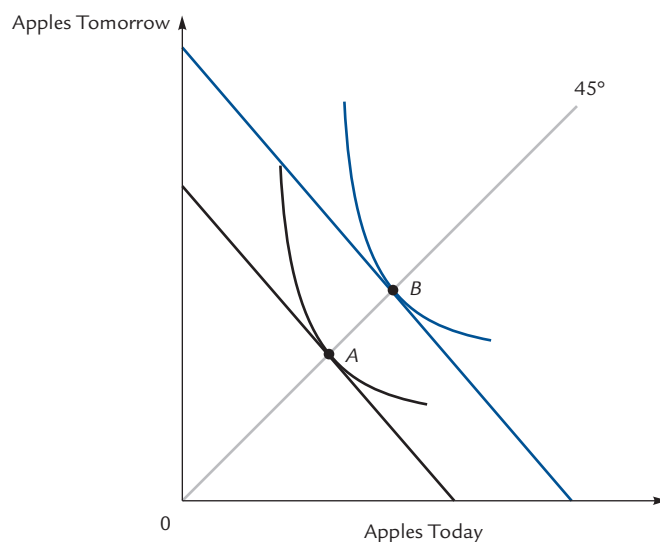
## Government Debt Revisited

When the government wants to spend money, it can either raise taxes immediately or it can borrow, in which case it issues an implicit promise to raise taxes in the future. We saw in Section 17.2 that as long as the market interest rate remains fixed, taxpayers are indifferent between the two methods of finance. Government *spending* can be either good or bad, but government *debt* is a matter of indifference.

In the discussion in Section 17.2, we left open the question of whether government debt can affect the interest rate itself. Here we will take up that question. We will see that in the simplest circumstances, the answer is “no.” We will also see that in more complicated circumstances, the answer is “it depends.” If that strikes you as

EXHIBIT 17.10

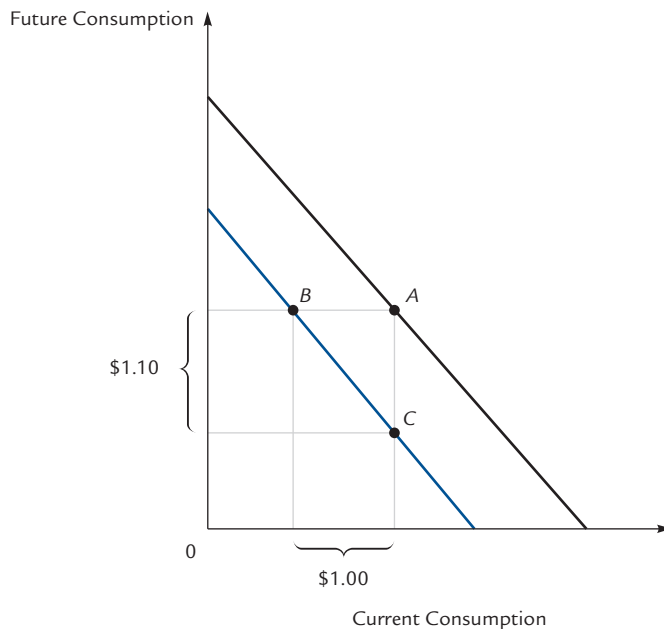
### A Permanent Productivity Increase



When apple trees become permanently more productive, effective immediately, Rebecca Representative's endowment point moves from *A* to *B* along the 45° line. The interest rate could either rise or fall. If Rebecca's indifference curves are homothetic, the slope of the indifference curves at *A* and at *B* are equal, and there is no change in the interest rate.

## EXHIBIT 17.11

## Taxation versus Borrowing



Terry Taxpayer starts with an endowment of  $A$ , faces an interest rate of 10%, and therefore has the black budget line with slope  $-1.10$ . If the government taxes him \$1 to finance wasteful spending, his endowment falls to  $B$  and his budget line moves into the line shown in color. If the government borrows \$1 to finance wasteful spending, Terry is taxed \$1.10 in the future, so his endowment falls to  $C$  and his budget line is again the line shown in color. Because each plan leaves Terry with the same color budget line, each plan leads to the same demand for current consumption. Each plan also leads to the same supply of current consumption. Therefore, each plan leads to the same market interest rate.

depressingly ambiguous, don't despair. We will have a lot to say about what the answer depends on, and we will therefore come to understand the conditions necessary for government debt to matter.

Consider Terry Taxpayer, whose indifference curves are shown in Exhibit 17.11. Terry lives in a world where the market interest rate is 10%, so that his (black) budget line between current and future consumption has a slope of  $-1.10$ . His endowment point is marked  $A$ .

Terry's government has decided to spend \$1 wastefully.<sup>5</sup> It can do so in either of two ways. One is to raise Terry's current taxes by \$1, shifting his endowment point \$1 to the left, to point  $B$ . The other is to borrow and raise Terry's future taxes by \$1.10, shifting his endowment point down \$1.10 to point  $C$ .

If the government raises current taxes, Terry's new budget line is the line with slope  $-1.10$  through his new endowment point  $B$ . If it borrows, his new budget line is the line with slope  $-1.10$  through his new endowment point  $C$ . But these are two descriptions of the same line; it is shown in color in the exhibit.

<sup>5</sup> We assume that the spending is wasteful to simplify the discussion of how Terry's endowment point shifts. If the spending is productive, a similar analysis yields identical conclusions.



Either plan—taxation or borrowing—causes Terry’s current consumption demand to fall, because his budget line shifts in from the black to the colored. Because the color budget line is the same in either case, either plan leads Terry’s demand to fall by the same amount.

What is true of Terry is true of all other taxpayers and hence of the market as a whole: *Government spending causes the demand for current consumption to fall. Demand falls by the same amount regardless of whether the spending is financed by taxation or by debt.*

Now let us turn our attention from demand to supply. When the government spends \$1 to purchase and then wastes \$1 worth of goods, the supply of current consumption falls by exactly \$1 worth, regardless of where the government finds the \$1.

Therefore, the two plans cause the supply of current consumption to fall by the same amount. We have already seen that both cause the demand for current consumption to fall by the same amount. We may conclude that they both lead to the same market interest rate. It doesn’t matter whether the government taxes or borrows.

This result, sometimes summarized in the slogan “Deficits don’t matter,” is called the **Ricardian Equivalence theorem**.<sup>6</sup> The Ricardian Equivalence theorem is undoubtedly true as a matter of mathematical fact under the simple circumstances we have described here. A more interesting question is whether it is true in the world in which we live. Regarding this question, there is no consensus among economists. Some believe that there are important differences between our world and the world of Terry Taxpayer. We will now consider two of those differences.

One possible difference is that taxpayers in the real world, unlike Terry, might not be savvy enough to recognize that when the government borrows today, it must increase taxes tomorrow. Suppose that you start at point *A* in Exhibit 17.11 and the government borrows \$1, implicitly promising to raise your future taxes. This shifts your endowment to point *C*. But if you fail to take notice that future taxes must rise, you will believe that your endowment is still at *A* and will therefore not change your current consumption demand. This contrasts with what happens under taxation, where your endowment point is shifted to *B*, you realize what is happening, and you reduce your current consumption demand accordingly. Under this scenario, borrowing has no effect on demand while taxation shifts demand downward; the interest rate is therefore higher under borrowing than it is under taxation.

According to this scenario, government debt fools people into thinking they are richer than they really are. That hypothesis is very much at odds with the spirit of microeconomics, in which the assumption of rationality plays a central role. As a result, many economists are quite uncomfortable with the notion that such misperceptions could be a significant factor in the determination of interest rates. However, there is insufficient empirical evidence to rule out the possibility.

The second possibly important difference between Terry’s world and ours arises from default risk. Suppose, contrary to the picture in Exhibit 17.11, that Terry Taxpayer, because of his poor credit history, is unable to borrow at the market interest rate of 10%, but only at the higher rate of 25%. Then his budget line is not really the line shown in Exhibit 17.11, but something much steeper. Taxation shifts Terry’s endowment to *B*, leaving him with a budget line through *B* that is steeper than the one in the exhibit and therefore passes below *C*. On the other hand, borrowing shifts Terry’s endowment to *C* and leaves him with a steep budget line through *C*.

### Ricardian Equivalence theorem

The statement that government borrowing has no effect on wealth, consequently no effect on the demand for current consumption, and consequently no effect on the interest rate.

<sup>6</sup> In honor of the nineteenth-century economist David Ricardo.

In this case, the “government borrowing” budget line through *C* is higher than the “current taxation” budget line through *B*. Terry is richer when the government borrows for him at 10% than when he has to borrow for himself at 25%. Therefore, he demands more current consumption when the government borrows. Because government borrowing means higher current consumption demand, it also means a higher interest rate.

It is sometimes argued that default risk is especially important in view of the finiteness of life. People who would like to borrow and obligate their children to pay the debt are unable to do so, because there is no legal mechanism by which the children can be bound to fulfill their parents’ obligations. The certainty of default on such debts makes the interest rate on them essentially infinite. Government borrowing reduces this rate from infinity to something on the order of 10%.

On the other hand, this is a significant consideration only if there are a significant number of people who would really like to live well at their children’s expense. The commonly observed phenomenon of parents working hard in order to leave bequests to their children (or for that matter, in order to send them to college) is evidence to the contrary.

The current thinking of most economists is that Ricardian Equivalence must hold—government debt does not matter—unless either misperceptions or default risks are of serious consequence. There is great controversy over the question of whether these phenomena in fact *are* of serious consequence. However, these are very concrete questions that are amenable to empirical investigation, and one is entitled to hope that the controversies surrounding them will be resolved in the not-too-distant future.

## 17.4 Production and Investment

In Section 17.3, we treated the number of apples available today and tomorrow as fixed and unchangeable. Any individual was able to shift consumption from one period to another by borrowing or lending, but for the economy as a whole such transfers were impossible.

A more complete model should take account of opportunities for current goods to be converted into future goods on an economy-wide basis. There are many ways to do this. The simplest is *storage*. An apple placed in the refrigerator today becomes an apple available for consumption tomorrow. An economy equipped with refrigerators can choose to consume fewer apples today in exchange for additional apples tomorrow—not just for some individuals, but for the economy as a whole.

Even more important, there is the possibility of *production*. Grain can be either eaten today or planted to produce even more grain tomorrow. Much production involves the use of machinery and other capital equipment, which must itself be produced. To produce capital, people must forgo the opportunity to produce goods for current consumption. People can choose whether to spend their time picking apples or planting apple trees. In the first case, there are more apples today; in the second, more apples tomorrow.

In fact, understanding the decision to invest in producing capital is the key to this entire subject. We now turn to the market for capital.

### The Demand for Capital

Recall that the word *capital* in economics always refers to goods that are inputs to the physical production process. An apple tree, which is used in the production of apples, is

an example of capital. In this section, we will measure the value of goods and the value of capital in terms of dollars. As always, those dollars are just stand-ins for physical goods.

### The Marginal Product of Capital

The *marginal product of capital (MPK)*, first introduced in Chapter 6, is the additional output available when one additional unit of capital is employed. There are many possible units in which to measure the *MPK*. We shall measure it as a percent of the cost of the capital. If it costs \$10 to plant a tree that produces \$1 worth of apples each year, we will say that the *MPK* is 10%. If it costs \$200 to plant a tree that produces \$50 worth of apples per year, we will say that the *MPK* is 25%.

Typically, the marginal product of capital decreases as more capital is added. Holding all other inputs fixed, the 100th apple tree adds less to the harvest than the 99th does, because the orchards become crowded, the water and nutrients must be shared, and the apple-pickers have only a limited amount of time. This observation is not new; we made it first in Chapter 6.

### The Marginal Product of Capital versus the Interest Rate

Suppose that the market interest rate is 10% and the marginal product of capital is 15%. Then there is an easy way to make a profit. Borrow \$100 and use it to plant a tree that produces \$15 worth of apples per year. Each year, harvest the fruit from your tree, make a \$10 interest payment, and pocket the remaining \$5.

This is a no-lose proposition, and everybody wants to undertake it. As they do, two things happen. First, because everybody wants to borrow and nobody wants to lend, there is upward pressure on the interest rate. Second, all the new apple trees drive down the marginal product of capital. The interest rate and the *MPK* move closer together, and the process continues until they are equal.

The same sort of thing happens if the numbers are initially reversed. Suppose that the market interest rate is 15% and the marginal product of capital is 10%. Now nobody is willing to borrow to plant apple trees. Of course, people might still want to borrow for other reasons, so the interest rate need not fall. However, as old apple trees die off, there is no incentive to replace them. Over time, the number of apple trees (that is, the quantity of capital) falls, and so the *MPK* rises. Eventually, the interest rate and the *MPK* are brought back to equality. This tells us the following:

**In equilibrium, the quantity of capital adjusts until the interest rate is equal to the marginal product of capital.**

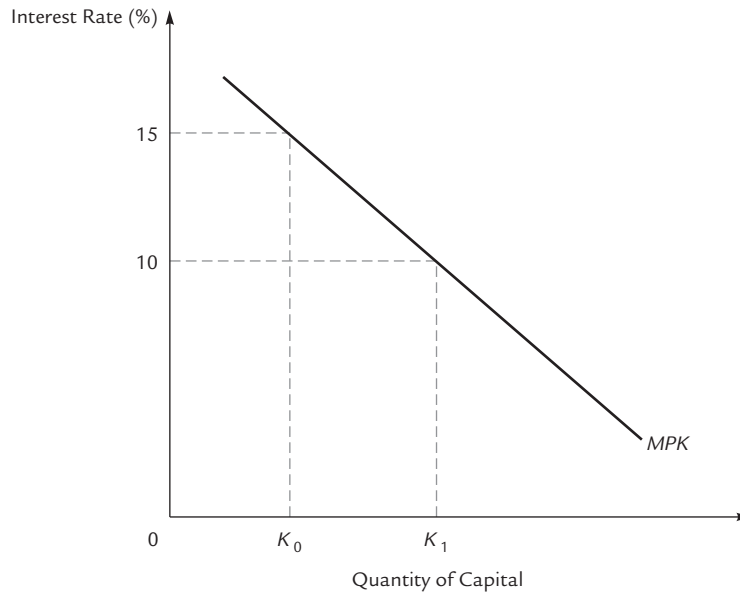
There is another way to view this proposition. To a planter, the price of capital is measured by the interest rate, because meeting expenses means either borrowing or forgoing the opportunity to lend. We saw in Chapter 15 that the demand curve for a factor of production is equal to its marginal product curve. Exhibit 17.12 shows the *MPK* curve. If the rate of interest is 10%, then the quantity of capital demanded is  $K_1$ . The quantity of capital adjusts until the *MPK* is equal to the interest rate.

### The Supply of Current Consumption

Imagine a world with \$10 worth of resources that can be devoted either to consumption or to the production of capital. If producers demand \$2 worth of capital, then there is \$8 left for current consumption. If they demand \$7 worth of capital, then there is only

## EXHIBIT 17.12

## The Demand for Capital



Suppose that the market interest rate is 10% but the marginal product of capital is 15% (so that the quantity of capital must be  $K_0$ ). Then everybody wants to borrow to invest in capital. The quantity of capital increases and the marginal product of capital falls. This process continues until the quantity of capital reaches  $K_1$ , and the marginal product of capital is equal to the interest rate of 10%.

This argument shows that in equilibrium, the *MPK* must be equal to the interest rate. Put another way, the *MPK* curve is the demand curve for capital.

\$3 left for current consumption. The more capital that is demanded, the less current consumption is supplied.

We know from Exhibit 17.12 that the demand for capital slopes downward as a function of the interest rate. It follows that the supply of capital slopes upward as a function of the interest rate. When the interest rate is low, much capital is demanded and few resources are available for current consumption. When the interest rate is high, little capital is demanded and many resources are available for current consumption.

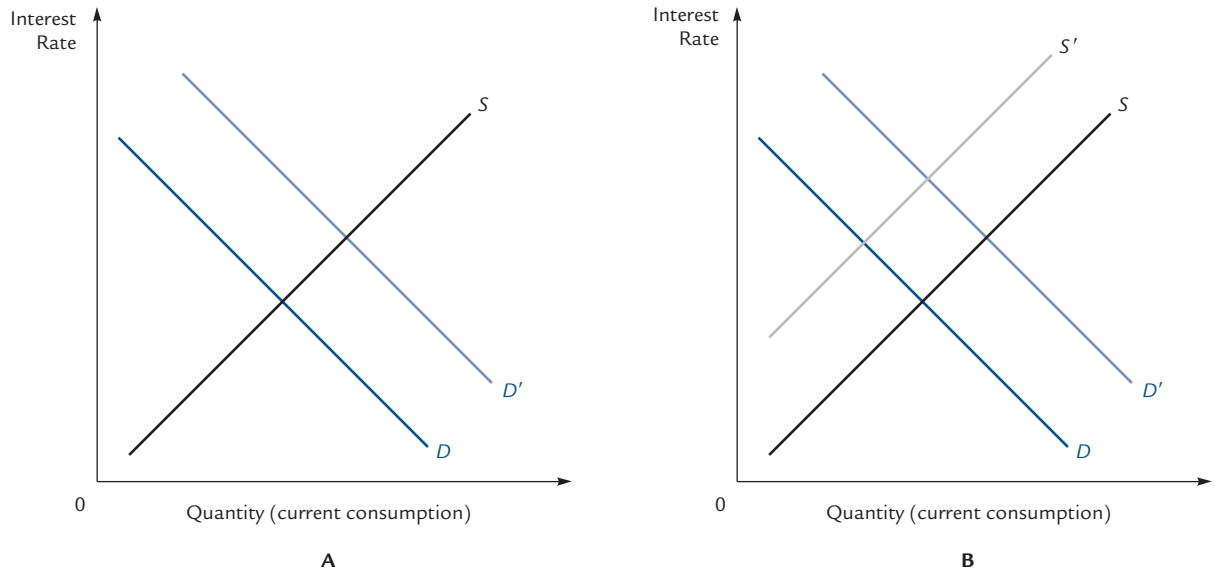
## Equilibrium

In Exhibit 17.5, we derived the demand curve for current consumption, and in subsequent exhibits we made extensive use of this demand curve. There is no need to modify our theory of demand. However, throughout Section 17.3, we adopted a very naive theory of the supply for current consumption: We assumed that it was vertical. In an economy with production and capital investment, we now know that the supply curve can slope upward.

It turns out that this new observation does not necessitate any change in our earlier conclusions. We learned in Exhibit 17.8 that a brightening of the future causes

## EXHIBIT 17.13

## A Brighter Future



When the future looks brighter, the demand for current consumption increases. If the expected future windfall is unrelated to the productivity of capital, then there is no change in the supply of current consumption. If capital is expected to be more productive, the demand for capital increases, so the supply of current consumption falls.

In either case, the interest rate rises, though it rises by more in the second case. In the first case, current consumption increases, whereas in the second case current consumption moves ambiguously.

the interest rate to rise; we learned in Exhibit 17.9 that a current bumper crop causes the interest rate to fall. All of this remains true when the supply curve slopes upward, although the magnitudes of the shifts might be different.

By way of example, Exhibit 17.13 illustrates two scenarios in which something happens to make the future look brighter. In scenario A, it is discovered that people will be wealthier next year for some reason that has nothing to do with the productivity of capital. In scenario B, it is discovered that capital will be more productive than previously thought.

In either case, people are wealthier, so the demand curve for current consumption shifts out. In the first case, there is no change in the marginal product of capital, and so no change in the demand for capital, and so no change in the supply of current consumption. In the second case, the *MPK*, and consequently the demand for capital, goes up; when more resources are demanded for capital, fewer are supplied for current consumption. That is why the supply curve in panel B shifts back.

In each scenario, the interest rate rises (just as it did in Exhibit 17.8), though it rises by more in the second case. In the first case, current consumption increases, while in the second, current consumption moves ambiguously.

## Summary

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The interest rate is a measure of the relative price of current consumption in terms of future consumption. More precisely, the relative price of current consumption is  $1 + r$ , where  $r$  is the interest rate.

The relative price of future consumption in terms of current consumption is  $1/(1 + r)$ . This is also called the present value of a unit of future consumption. A bond that promises a unit of future consumption will sell today for the price  $1/(1 + r)$ .

Present values can be used to assign a value to any income stream and to compare the desirability of different income streams. The stream with the higher present value can always be traded for the stream with the lower present value, with something extra left over.

A consumer chooses between current and future consumption by seeking a tangency between his budget line and an indifference curve. The budget line has a slope of  $-(1 + r)$  and passes through the consumer's endowment point. Using the machinery of indifference curves, we can derive the consumer's demand for current consumption. Adding up over all consumers, we can derive the market demand for current consumption.

The simplest assumption about the supply of current consumption is that it is fixed; that is, there is no way to convert current consumption to future consumption. In that case, the market supply curve for current consumption is vertical.

The equilibrium interest rate occurs at the intersection of supply with demand. The same equilibrium can be found from the condition that the representative agent must voluntarily consume his endowment. If the slope of his indifference curve at the endowment point is  $-(1 + r)$ , then  $r$  must be the equilibrium interest rate.

In an economy where current consumption can be converted to capital, the quantity of capital always adjusts until the marginal product of capital is equal to the interest rate. When the interest rate is high, there is little capital demanded, so the quantity of current consumption supplied is high. When the interest rate is low, there is a lot of capital demanded, so the quantity of current consumption supplied is low. From these considerations, we derive an upward-sloping supply curve for current consumption. This can be combined with the demand curve for current consumption that was derived earlier to find the market equilibrium.

## Author Commentary [www.cengage.com/economics/landsburg](http://www.cengage.com/economics/landsburg)

- AC1.** See this article for more information on the effects of government debt.
- AC2.** This article provides further discussion of the difficulty of righting past wrongs.
- AC3.** Read this for more information on bequests.

## Review Questions

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- R1.** What is the relationship among (a) the present value of an apple delivered tomorrow, (b) the price of a bond having a face value of one apple and a maturity date of tomorrow, and (c) the rate of interest?



- R2.** If you can either buy a house for \$10,000 or rent the same house for \$1,000 per year, should you buy or rent? In what way does your answer depend on the interest rate?
- R3.** Is the buyer of a bond a borrower or a lender?
- R4.** What is the present value of a perpetuity that pays \$1 per year forever?
- R5.** What determines the value of a productive asset?
- R6.** What determines the value of a financial asset?
- R7.** What determines the value of a durable commodity?
- R8.** Explain why the purchaser of a new suit of clothes is indifferent between paying now and paying by credit card, provided that he can borrow and lend at the market interest rate.
- R9.** Explain why the taxpayer is indifferent between higher current taxes and government borrowing.
- R10.** In general, will the price of an exhaustible resource grow at a rate higher or lower than the rate of interest? Why? Under what circumstances will it grow at exactly the rate of interest?
- R11.** Explain how to derive a point on the consumer's demand curve for current consumption.
- R12.** What assumptions lead to a vertical supply curve for current consumption?
- R13.** Explain how the equilibrium interest rate can be computed from an examination of the representative agent's indifference curves.
- R14.** Explain why the marginal product of capital must equal the interest rate in equilibrium.
- R15.** Explain why, when there are opportunities for capital investment, the supply curve for current consumption slopes upward.

## Problem Set

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- 1.** **True or False:** When the interest rate falls, people want to borrow more and the additional borrowing tends to drive the interest rate back up.
- 2.** **True or False:** If the interest rate and the price of bonds both rise simultaneously, the quantity of borrowing could go either up or down.
- 3.** John bought a refrigerator and sold it 3 years later for exactly what he paid for it.  
**True or False:** It cost John nothing to have the use of the refrigerator for 3 years.
- 4.** Under the U.S. patent law, an inventor can be granted a patent that confers the exclusive right to produce and market his invention for 17 years. After that time, anybody can produce and market the invention. Assume that the annual profits that can be earned from the invention never change and that the interest rate is 10%. **True or False:** A 17-year patent is approximately 80% as valuable as a patent that lasts forever.

5. You have just been informed that you have 2 years to live and are considering a night of debauchery to take your mind off the news. The consequence of such behavior is eternal damnation, beginning on the date of your death. One year of fire and brimstone is equal in unpleasantness to the loss of  $\$P$ . The interest rate is  $r$ .
- How pleasant would a night of sin have to be in order to be worth the cost?
  - Which is more likely to deter you from sinning: a doubling of the torments of the underworld, or a halving of the interest rate?
6. Suppose that apartments in San Francisco typically sell for \$300,000 and rent for \$1,500 a month. The market interest rate is 10%. **True or False:** The market must be anticipating a rise in apartment rentals at some time in the future.
7. **True or False:** If a house in New York and a house in California are identical in every way except for the fact that the California house is susceptible to being destroyed by earthquakes, then the California homeowner must earn a greater rate of return than the New York homeowner to compensate him for the risk. Therefore, houses in California will increase in value more rapidly than houses in New York.
8. Textbook publishers typically issue new editions every 3 years, in order to keep copies of the old edition from circulating on the used-textbook market. Suppose that each student keeps his or her textbook for 1 year and values his possession of the textbook at \$20 for that year. Suppose also that a new edition is no more intrinsically valuable than an old edition, but that the appearance of a new edition makes the old edition worthless. The market interest rate is 10%.
- If new editions cause old editions to become completely obsolete, what is the price of a new textbook?
  - If the publisher issued just one edition of each book and credibly promised never to issue another one, what would be the price of a new textbook?
  - If it is possible to issue a promise as in part (b), and if it is costly to bring out new editions, what is the publisher's optimal strategy?
  - Suppose that publishers would like to issue a promise as in part (b), but that there is no way for them to legally bind themselves to keeping the promise. If students suspect publishers of dishonesty, what will be the price of a new textbook? Now what is the publisher's optimal strategy?
  - True or False:** Even though publishers voluntarily bring out new editions every 3 years, they might be better off if they were legally forbidden to do so.
9. **True or False:** The government's responsibility to bail out failed savings and loan institutions is monumentally expensive. But the longer it delays, the more expensive the bailout will be, since interest charges continue to build.
10. George F. Will, a humor columnist for the *Washington Post*, notes that interest payments on the federal debt in a recent year were equal to approximately one-half of all personal income tax receipts. He concludes that this represents "a transfer of wealth from labor to capital unprecedented in U.S. history. Tax revenues are being collected from average Americans and given to the buyers of U.S. government bonds—buyers in Beverly Hills, Lake Forest, Shaker Heights, and Grosse Point, and Tokyo and Riyadh."

Suppose it were the case that the *Washington Post* employed a columnist who viewed thinking as part of his job. What might such a columnist reply?

11. Explain exactly what is wrong with the following argument: If the government buys me a suit of clothes with borrowed money and never pays off the debt, then my grandchildren will be taxed to make interest payments even though they have never seen the clothes. Therefore, government borrowing allows me to live high on the hog at my grandchildren's expense.
12. a. Jeeter owes \$1,000 on his student loan. The debt is growing at the market interest rate of 10%. Jeeter would like to pay off the loan now, but the bank will not allow him to do so until 5 years from now. What strategy can Jeeter follow that is equivalent to paying off the loan today?
- b. Jeeter is also concerned about his share of the national debt, which he reckons to be \$10,000. He wishes that the government would just tax him today and pay off the debt so that the accumulation of interest will not cause him to have to pay even more tomorrow. What would you suggest that Jeeter do?
13. Write a brief letter in response to the following column:<sup>7</sup>

**DEAR ANN LANDERS:** This is going to seem like a terrifically trivial problem compared to most you receive, but I've got to get it off my chest.

I'm sure almost every woman in America has gone through this slow burn. You spend two or three bucks for a pair of new pantyhose, and within a week, you have a big ugly runner and have to throw the pair away. Or, they're so stretchy they droop down around your knees and run within the week. Or, they're so NON-stretchy you can't get 'em up above your knees, and they still run within the week!

Why can't the hosiery manufacturers figure out how to make a nylon stocking that fits with a proper degree of stretch and doesn't fall to shreds in six days? Isn't nylon supposed to be one of the toughest substances made by man?

To put this into economic focus: Wanda Worker spends two bucks on nylons every week. That's over a hundred dollars a year, not to mention the aggravation and time spent running to the drugstore on a lunch hour to replace the pair that self-destructed on her way to work.

As I said, Ann, it seems terrifically trivial, but it's maddening. You have contacts all over. Will you please ask somebody who is big in hosiery manufacturing what gives—besides my stockings, that is.

Ladder Legs in Lima, Ohio

**Ann says:** You really hit a hot button! I contacted four of the leading hosiery manufacturers, and I have never heard so much double-talk, triple-talk and fancy ways of saying "no comment." All those contacted by my office asked that they not be identified—and would I please not name their companies. I am respecting their wishes.

But, of this you can be sure:

The hosiery industry has a mighty sweet thing going and has no intention of letting go. We have been ripped off, if you will pardon the pun, for lo, these many years, ladies. And they will continue to rip us off because the no-run nylons, which they know how to make, would put a serious crimp in their sales. In other words, we are at the mercy of a conspiracy of self-interest.

My advice is this: Shop around. Low-priced, good-fitting nylons are out there. (I wear them myself, and they look as good as the top-dollar variety. Sorry, I can't publish the brand name.) For daily wear, buy nylons with reinforced toe and heel. One final way to get a leg up: If you rip one stocking, cut it off and sew on the good stocking from another pair that similarly failed you.

- 14.** In New York City, every taxicab driver must own a license (called a medallion) to drive a cab. The city has issued a fixed number of medallions, and they are traded on the open market. Because the number of medallions is small, the price of cab rides is higher than it otherwise would be. Suppose that the city decides to abolish the medallion program and allow free entry to the taxicab industry. **True or False:** The owners of medallions will be just as well off after the program is abolished as if it had never existed.
- 15. True or False:** If a monopolist owned an exhaustible resource, he would control its availability so that the price rose faster than the rate of interest.
- 16. True or False:** A net borrower is always made worse off by a rise in the rate of interest.
- 17.** Herman has an income of \$2 this year and will have an income of \$3 next year. At the current rate of interest he chooses neither to borrow nor to lend. **True or False:** If the interest rate goes up, Herman will become a lender and be better off.
- 18.** Contrast the effects on the interest rate of (a) a year of bad weather resulting in low agricultural productivity and (b) nuclear contamination that permanently lowers agricultural productivity.
- 19.** Contrast the effects on current consumption and the interest rate of (a) a tax on production that is expected to be in effect for 1 year only and (b) a tax on production that is expected to be permanent. Assume in each case that the proceeds from the tax will be completely wasted.
- 20.** Suppose that the interest rate is 12% and that the representative agent's tastes are such that the interest rate would have to rise to 20% to get him to voluntarily cut current consumption by \$1,000. Suppose now that there is a war that destroys \$1,000 worth of consumption goods for every agent in the economy. **True or False:** The interest rate must rise to 20% to restore equilibrium.
- 21.** The discussion surrounding Exhibit 17.11 suggests that when the government spends \$1 wastefully, it does not matter (for determining the equilibrium interest rate) whether the government gets the \$1 by taxation or by borrowing. Draw a similar diagram to show that the same conclusion holds when the government spends \$1 productively, say by using it to purchase \$1 worth of goods for Terry Taxpayer.
- 22.** Repeat problem 21 assuming that the government manages to spend the \$1 *superproductively*, using it to provide Terry Taxpayer with goods that he values at \$2.
- 23. True or False:** When the government spends \$1, the equilibrium interest rate is unaffected by whether the dollar is spent wastefully or productively.
- 24.** Felix G. Rohatyn, a well-known financier, published a letter on the editorial page of the *New York Times* on July 1, 1990. He wrote:

I was startled and dismayed by [an earlier *Times* editorial] supporting Government borrowing as the appropriate way to deal with the bailout of bankrupt savings and loan institutions. Borrowing may be politically expedient; it is, however, wrong, from both an economic and moral point of view. The straightforward, and least damaging, way to deal with this fiasco, is to pay off the \$130 billion loss with a temporary three- to four-year surcharge on income taxes.

The economics are simple:

(1) Borrowing will turn a \$130 billion loss into a \$500 billion drain over 20 to 30 years. It will maintain pressure on the credit markets and lead to higher interest rates. It will add \$10 billion to \$15 billion annually in interest costs to the Federal budget deficit, when interest costs constitute, after defense, the largest Federal expenditure. It will require continued high inflows of foreign capital. It will squeeze out badly needed domestic programs.

(2) A three- to four-year temporary tax surcharge will eliminate \$300 billion to \$400 billion in interest costs and contribute to lower interest rates and capital costs. This will foster economic growth. The tax will not have negative economic impact because the bailout is basically a transfer program from taxpayers to depositors.

(3) A basic economic principle justifies borrowing only for assets with a useful life. Nothing is more remote from that definition than borrowing to finance losses that have already been incurred.

The moral issue is even simpler. Borrowing burdens the next generation with repayment of our foolishness and burdens lower-income Americans with the interest costs. The income tax puts the burden where it belongs: on the present generation and on higher-income Americans.

- a. Find at least one elementary economic error per each paragraph.
- b. Focus on the “basic economic principle” articulated under point 3. In an indifference curve diagram, show what happens if, after you have optimized, a tragedy destroys a substantial chunk of your current consumption. Is it better to reduce your consumption by that full amount in the current period? Or is it better to spread out the loss over the present and future by “borrowing to finance losses that have already been incurred”?
- c. Suppose that the government does follow Mr. Rohatyn’s advice and raises current taxes to meet the costs of the bailout in what is essentially the immediate present. How might individual taxpayers adjust their private borrowing and lending? Will the costs really be paid in the present, or will they be spread out over time despite the government policy? Explain why the Rohatyn plan might have no effect on any important economic variable.
- d. Suppose that contrary to your argument in part (c), the Rohatyn plan does have a real effect, either because people are unable to borrow as much as they would like at the market interest rate or because they are insufficiently sophisticated to borrow their way through the higher tax years. In that case, does the Rohatyn plan make people better off or worse off?

**25. True or False:** When the interest rate goes up, investment becomes more desirable.

**26.** You are thinking of purchasing the house that you currently rent for \$10,000 per year. What is the most you would pay for the house?

**27.** Suppose that scientists discover a new method of harnessing nuclear fusion as a practical energy source. At the moment, the method is still on the drawing boards, but it is clear that within 10 years this discovery will be the basis of a technological revolution. What happens to the interest rate?

**28.** Suppose that an increase in world tensions makes it more likely than before that there will soon be a nuclear war that destroys all life on earth. What happens to the interest rate?

- 29.** Suppose that an increase in world tensions makes it more likely than before that there will be a nuclear war within 10 years. Such a war would kill half the world's population and destroy 90% of the world's physical wealth. What happens to the interest rate?
- 30.** Consider an agricultural society in which seeds can either be planted immediately to produce food almost instantly or stored for planting next year to produce food then. Suppose that this society becomes convinced that the weather will improve dramatically next year. Show the effects on the amount of food produced this year and on the interest rate.