To learn more about the principle of no arbitrage and its importance as the foundation for modern finance theory, see S. Ross, *Neoclassical Finance* (Princeton University Press, 2004).

For a discussion of arbitrage and rational trading and their role in determining market prices, see M. Rubinstein, "Rational Markets: Yes or No? The Affirmative Case," *Financial Analysts Journal* (May/June 2001): 15–29.

For a discussion of some of the limitations to arbitrage that may arise in practice, see A. Shleifer and R. Vishny, "Limits of Arbitrage," *Journal of Finance*, 52 (1997): 35–55.

Problems

All problems are available in MyFinanceLab.

Valuing Decisions

1. Honda Motor Company is considering offering a $2000 rebate on its minivan, lowering the vehicle's price from $30,000 to $28,000. The marketing group estimates that this rebate will increase sales over the next year from 40,000 to 55,000 vehicles. Suppose Honda's profit margin with the rebate is $6000 per vehicle. If the change in sales is the only consequence of this decision, what are its costs and benefits? Is it a good idea?

2. You are an international shrimp trader. A food producer in the Czech Republic offers to pay you 2 million Czech koruna today in exchange for a year's supply of frozen shrimp. Your Thai supplier will provide you with the same supply for 3 million Thai baht today. If the current competitive market exchange rates are 25.50 koruna per dollar and 41.25 baht per dollar, what is the value of this deal?

3. Suppose the current market price of corn is $3.75 per bushel. Your firm has a technology that can convert 1 bushel of corn to 3 gallons of ethanol. If the cost of conversion is $1.60 per bushel, at what market price of ethanol does conversion become attractive?

4. Suppose your employer offers you a choice between a $5000 bonus and 100 shares of the company stock. Whichever one you choose will be awarded today. The stock is currently trading for $63 per share.
   a. Suppose that if you receive the stock bonus, you are free to trade it. Which form of the bonus should you choose? What is its value?
   b. Suppose that if you receive the stock bonus, you are required to hold it for at least one year. What can you say about the value of the stock bonus now? What will your decision depend on?

5. You have decided to take your daughter skiing in Utah. The best price you have been able to find for a roundtrip air ticket is $359. You notice that you have 20,000 frequent flier miles that are about to expire, but you need 25,000 miles to get her a free ticket. The airline offers to sell you 5000 additional miles for $0.03 per mile.
   a. Suppose that if you don't use the miles for your daughter's ticket they will become worthless. What should you do?
   b. What additional information would your decision depend on if the miles were not expiring? Why?

Interest Rates and the Time Value of Money

6. Suppose the risk-free interest rate is 4%.
   a. Having $200 today is equivalent to having what amount in one year?
   b. Having $200 in one year is equivalent to having what amount today?
   c. Which would you prefer, $200 today or $200 in one year? Does your answer depend on when you need the money? Why or why not?

7. You have an investment opportunity in Japan. It requires an investment of \$1 million today and will produce a cash flow of ¥ 114 million in one year with no risk. Suppose the risk-free interest rate in the United States is 4%, the risk-free interest rate in Japan is 2%, and the current competitive exchange rate is ¥ 110 per \$1. What is the NPV of this investment? Is it a good opportunity?

8. Your firm has a risk-free investment opportunity where it can invest \$160,000 today and receive \$170,000 in one year. For what level of interest rates is this project attractive?

Present Value and the NPV Decision Rule

9. You run a construction firm. You have just won a contract to construct a government office building. It will take one year to construct it, requiring an investment of \$10 million today and \$5 million in one year. The government will pay you \$20 million upon the building's completion. Suppose the cash flows and their times of payment are certain, and the risk-free interest rate is 10%.

a. What is the NPV of this opportunity?

b. How can your firm turn this NPV into cash today?

10. Your firm has identified three potential investment projects. The projects and their cash flows are shown here:

Project	Cash Flow Today (\$)	Cash Flow in One Year (\$)
A	−10	20
B	5	5
C	20	−10

Suppose all cash flows are certain and the risk-free interest rate is 10%.

a. What is the NPV of each project?

b. If the firm can choose only one of these projects, which should it choose?

c. If the firm can choose any two of these projects, which should it choose?

11. Your computer manufacturing firm must purchase 10,000 keyboards from a supplier. One supplier demands a payment of \$100,000 today plus \$10 per keyboard payable in one year. Another supplier will charge \$21 per keyboard, also payable in one year. The risk-free interest rate is 6%.

a. What is the difference in their offers in terms of dollars today? Which offer should your firm take?

b. Suppose your firm does not want to spend cash today. How can it take the first offer and not spend \$100,000 of its own cash today?

Arbitrage and the Law of One Price

12. Suppose Bank One offers a risk-free interest rate of 5.5% on both savings and loans, and Bank Enn offers a risk-free interest rate of 6% on both savings and loans.

a. What arbitrage opportunity is available?

b. Which bank would experience a surge in the demand for loans? Which bank would receive a surge in deposits?

c. What would you expect to happen to the interest rates the two banks are offering?

13. Throughout the 1990s, interest rates in Japan were lower than interest rates in the United States. As a result, many Japanese investors were tempted to borrow in Japan and invest the proceeds in the United States. Explain why this strategy does not represent an arbitrage opportunity.

14. An American Depositary Receipt (ADR) is security issued by a U.S. bank and traded on a U.S. stock exchange that represents a specific number of shares of a foreign stock. For example, Nokia Corporation trades as an ADR with symbol NOK on the NYSE. Each ADR represents one share of Nokia Corporation stock, which trades with symbol NOK1V on the Helsinki stock exchange. If the U.S. ADR for Nokia is trading for $17.96 per share, and Nokia stock is trading on the Helsinki exchange for 14.78 € per share, use the Law of One Price to determine the current $/€ exchange rate.

No-Arbitrage and Security Prices

15. The promised cash flows of three securities are listed here. If the cash flows are risk-free, and the risk-free interest rate is 5%, determine the no-arbitrage price of each security before the first cash flow is paid.

Security	Cash Flow Today ($)	Cash Flow in One Year ($)
A	500	500
B	0	1000
C	1000	0

16. An Exchange-Traded Fund (ETF) is a security that represents a portfolio of individual stocks. Consider an ETF for which each share represents a portfolio of two shares of Hewlett-Packard (HPQ), one share of Sears (SHLD), and three shares of General Electric (GE). Suppose the current stock prices of each individual stock are as shown here:

Stock	Current Market Price
HPQ	$28
SHLD	$40
GE	$14

a. What is the price per share of the ETF in a normal market?
b. If the ETF currently trades for $120, what arbitrage opportunity is available? What trades would you make?
c. If the ETF currently trades for $150, what arbitrage opportunity is available? What trades would you make?

17. Consider two securities that pay risk-free cash flows over the next two years and that have the current market prices shown here:

Security	Price Today ($)	Cash Flow in One Year ($)	Cash Flow in Two Years ($)
B1	94	100	0
B2	85	0	100

a. What is the no-arbitrage price of a security that pays cash flows of $100 in one year and $100 in two years?
b. What is the no-arbitrage price of a security that pays cash flows of $100 in one year and $500 in two years?
c. Suppose a security with cash flows of $50 in one year and $100 in two years is trading for a price of $130. What arbitrage opportunity is available?

18. Suppose a security with a risk-free cash flow of $150 in one year trades for $140 today. If there are no arbitrage opportunities, what is the current risk-free interest rate?

19. Xia Corporation is a company whose sole assets are $100,000 in cash and three projects that it will undertake. The projects are risk-free and have the following cash flows:

Project	Cash Flow Today ($)	Cash Flow in One Year ($)
A	−20,000	30,000
B	−10,000	25,000
C	−60,000	80,000

Xia plans to invest any unused cash today at the risk-free interest rate of 10%. In one year, all cash will be paid to investors and the company will be shut down.

a. What is the NPV of each project? Which projects should Xia undertake and how much cash should it retain?
b. What is the total value of Xia's assets (projects and cash) today?
c. What cash flows will the investors in Xia receive? Based on these cash flows, what is the value of Xia today?
d. Suppose Xia pays any unused cash to investors today, rather than investing it. What are the cash flows to the investors in this case? What is the value of Xia now?
e. Explain the relationship in your answers to parts (b), (c), and (d).

CHAPTER 3 APPENDIX

NOTATION

r_s discount rate for security s

The Price of Risk

Thus far we have considered only cash flows that have no risk. But in many settings, cash flows are risky. In this section, we examine how to determine the present value of a risky cash flow.

Risky Versus Risk-Free Cash Flows

Suppose the risk-free interest rate is 4% and that over the next year the economy is equally likely to strengthen or weaken. Consider an investment in a risk-free bond, and one in the stock market index (a portfolio of all the stocks in the market). The risk-free bond has no risk and will pay \$1100 whatever the state of the economy. The cash flow from an investment in the market index, however, depends on the strength of the economy. Let's assume that the market index will be worth \$1400 if the economy is strong but only \$800 if the economy is weak. Table 3A.1 summarizes these payoffs.

In Section 3.5, we saw that the no-arbitrage price of a security is equal to the present value of its cash flows. For example, the price of the risk-free bond corresponds to the 4% risk-free interest rate:

$$\begin{aligned} \text{Price (Risk-free Bond)} &= \text{PV (Cash Flows)} \\ &= (\$1100 \text{ in one year}) \div (1.04\ \$ \text{ in one year}/\$ \text{ today}) \\ &= \$1058 \text{ today} \end{aligned}$$

Now consider the market index. An investor who buys it today can sell it in one year for a cash flow of either \$800 or \$1400, with an average payoff of $\frac{1}{2}(\$800) + \frac{1}{2}(\$1400) = \$1100$. Although this average payoff is the same as the risk-free bond, the market index has a lower price today. It pays \$1100 *on average*, but its actual cash flow is risky, so investors are only willing to pay \$1000 for it today rather than \$1058. What accounts for this lower price?

Risk Aversion and the Risk Premium

Intuitively, investors pay less to receive \$1100 on average than to receive \$1100 with certainty because they don't like risk. In particular, it seems likely that for most individuals, *the personal cost of losing a dollar in bad times is greater than the benefit of an extra dollar in good times*. Thus, the benefit from receiving an extra \$300 (\$1400 versus \$1100) when the economy is strong is less important than the loss of \$300 (\$800 versus \$1100) when the economy is weak. As a result, investors prefer to receive \$1100 with certainty.

The notion that investors prefer to have a safe income rather than a risky one of the same average amount is called **risk aversion**. It is an aspect of an investor's preferences, and different investors may have different degrees of risk aversion. The more risk averse

TABLE 3A.1 **Cash Flows and Market Prices (in \$) of a Risk-Free Bond and an Investment in the Market Portfolio**

		Cash Flow in One Year	
Security	Market Price Today	Weak Economy	Strong Economy
Risk-free bond	1058	1100	1100
Market index	1000	800	1400

investors are, the lower the current price of the market index will be compared to a risk-free bond with the same average payoff.

Because investors care about risk, we cannot use the risk-free interest rate to compute the present value of a risky future cash flow. When investing in a risky project, investors will expect a return that appropriately compensates them for the risk. For example, investors who buy the market index for its current price of \$1000 receive \$1100 on average at the end of the year, which is an average gain of \$100, or a 10% return on their initial investment. When we compute the return of a security based on the payoff we expect to receive on average, we call it the **expected return**:

$$\text{Expected return of a risky investment} = \frac{\text{Expected gain at end of year}}{\text{Initial cost}} \tag{3A.1}$$

Of course, although the expected return of the market index is 10%, its *actual* return will be higher or lower. If the economy is strong, the market index will rise to 1400, which represents a return of

$$\text{Market return if economy is strong} = (1400 - 1000)/1000 = 40\%$$

If the economy is weak, the index will drop to 800, for a return of

$$\text{Market return if economy is weak} = (800 - 1000)/1000 = -20\%$$

We can also calculate the 10% expected return by computing the average of these actual returns:

$$\tfrac{1}{2}(40\%) + \tfrac{1}{2}(-20\%) = 10\%$$

Thus, investors in the market index earn an expected return of 10% rather than the risk-free interest rate of 4% on their investment. The difference of 6% between these returns is called the market index's **risk premium**. The risk premium of a security represents the additional return that investors expect to earn to compensate them for the security's risk. Because investors are risk averse, the price of a risky security cannot be calculated by simply discounting its expected cash flow at the risk-free interest rate. Rather,

> *When a cash flow is risky, to compute its present value we must discount the cash flow we expect on average at a rate that equals the risk-free interest rate plus an appropriate risk premium.*

The No-Arbitrage Price of a Risky Security

The risk premium of the market index is determined by investors' preferences toward risk. And in the same way we used the risk-free interest rate to determine the no-arbitrage price of other risk-free securities, we can use the risk premium of the market index to value other risky securities. For example, suppose some security "A" will pay investors \$600 if the economy is strong and nothing if it is weak. Let's see how we can determine the market price of security A using the Law of One Price.

As shown in Table 3A.2, if we combine security A with a risk-free bond that pays \$800 in one year, the cash flows of the portfolio in one year are identical to the cash flows of the market index. By the Law of One Price, the total market value of the bond and security A must equal \$1000, the value of the market index. Given a risk-free interest rate of 4%, the market price of the bond is

$$(\$800 \text{ in one year}) \div (1.04 \text{ \$ in one year/\$ today}) = \$769 \text{ today}$$

TABLE 3A.2 Determining the Market Price of Security A (cash flows in $)

		Cash Flow in One Year	
Security	Market Price Today	Weak Economy	Strong Economy
Risk-free bond	769	800	800
Security A	?	0	600
Market index	1000	800	1400

Therefore, the initial market price of security A is $1000 − $769 = $231. If the price of security A were higher or lower than $231, then the value of the portfolio of the bond and security A would differ from the value of the market index, violating the Law of One Price and creating an arbitrage opportunity.

Risk Premiums Depend on Risk

Given an initial price of $231 and an expected payoff of $\frac{1}{2}(0) + \frac{1}{2}(600) = 300$, security A has an expected return of

$$\text{Expected return of security A} = \frac{300 - 231}{231} = 30\%$$

Note that this expected return exceeds the 10% expected return of the market portfolio. Investors in security A earn a risk premium of 30% − 4% = 26% over the risk-free interest rate, compared to a 6% risk premium for the market portfolio. Why are the risk premiums so different?

The reason for the difference becomes clear if we compare the actual returns for the two securities. When the economy is weak, investors in security A lose everything, for a return of −100%, and when the economy is strong, they earn a return of (600 − 231)/231 = 160%. In contrast, the market index loses 20% in a weak economy and gains 40% in a strong economy. Given its much more variable returns, it is not surprising that security A must pay investors a higher risk premium.

Risk Is Relative to the Overall Market

The example of security A suggests that the risk premium of a security will depend on how variable its returns are. But before drawing any conclusions, it is worth considering one further example.

EXAMPLE 3A.1 A Negative Risk Premium

Problem

Suppose security B pays $600 if the economy is weak and $0 if the economy is strong. What are its no-arbitrage price, expected return, and risk premium?

Solution

If we combine the market index and security B together in a portfolio, we earn the same payoff as a risk-free bond that pays $1400, as shown in the following table (cash flows in $).

		Cash Flow in One Year	
Security	**Market Price Today**	**Weak Economy**	**Strong Economy**
Market index	1000	800	1400
Security B	?	600	0
Risk-free bond	1346	1400	1400

Because the market price of the risk-free bond is $1400 ÷ 1.04 = $1346 today, we can conclude from the Law of One Price that security B must have a market price of $1346 − 1000 = $346 today.

If the economy is weak, security B pays a return of (600 − 346)/346 = 73.4%. If the economy is strong, security B pays nothing, for a return of −100%. The expected return of security B is therefore $\frac{1}{2}(73.4\%) + \frac{1}{2}(-100\%) = -13.3\%$. Its risk premium is $-13.3\% - 4\% = -17.3\%$; that is, security B pays investors 17.3% *less* on average than the risk-free interest rate.

The results for security B are quite striking. Looking at securities A and B in isolation, they seem very similar—both are equally likely to pay $600 or $0. Yet security A has a much lower market price than security B ($231 versus $346). In terms of returns, security A pays investors an expected return of 30%; security B pays −13.3%. Why are their prices and expected returns so different? And why would risk-averse investors be willing to buy a risky security with an expected return below the risk-free interest rate?

To understand this result, note that security A pays $600 when the economy is strong, and B pays $600 when the economy is weak. Recall that our definition of risk aversion is that investors value an extra dollar of income more in bad times than in good times. Thus, because security B pays $600 when the economy is weak and the market index performs poorly, it pays off when investors' wealth is low and they value money the most. In fact, security B is not really "risky" from an investor's point of view; rather, security B is an insurance policy against an economic decline. By holding security B together with the market index, we can eliminate our risk from market fluctuations. Risk-averse investors are willing to pay for this insurance by accepting a return below the risk-free interest rate.

This result illustrates an extremely important principle. The risk of a security cannot be evaluated in isolation. Even when a security's returns are quite variable, if the returns vary in a way that offsets other risks investors are holding, the security will reduce rather than increase investors' risk. As a result, risk can only be assessed relative to the other risks that investors face; that is,

The risk of a security must be evaluated in relation to the fluctuations of other investments in the economy. A security's risk premium will be higher the more its returns tend to vary with the overall economy and the market index. If the security's returns vary in the opposite direction of the market index, it offers insurance and will have a negative risk premium.

Table 3A.3 compares the risk and risk premiums for the different securities we have considered thus far. For each security we compute the difference in its return when the economy is strong versus weak. Note that the risk premium for each security is proportional

TABLE 3A.3 Risk and Risk Premiums for Different Securities

Security	Returns: Weak Economy	Returns: Strong Economy	Difference in Returns	Risk Premium
Risk-free bond	4%	4%	0%	0%
Market index	−20%	40%	60%	6%
Security A	−100%	160%	260%	26%
Security B	73%	−100%	−173%	−17.3%

to this difference, and the risk premium is negative when the returns vary in the opposite direction of the market.

Risk, Return, and Market Prices

We have shown that when cash flows are risky, we can use the Law of One Price to compute present values by constructing a portfolio that produces cash flows with identical risk. As shown in Figure 3A.1, computing prices in this way is equivalent to converting between cash flows today and the *expected* cash flows received in the future using a discount rate r_s that includes a risk premium appropriate for the investment's risk:

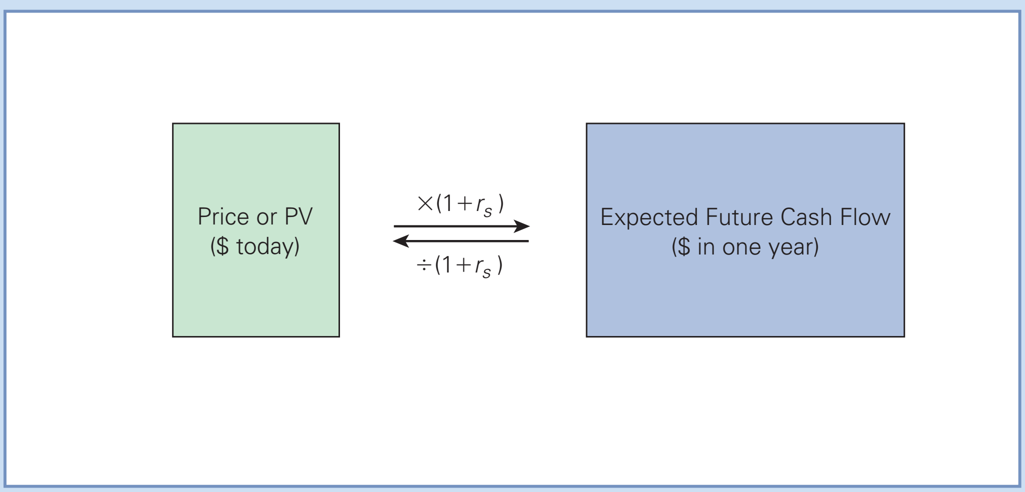
$$r_s = r_f + (\text{risk premium for investment } s) \tag{3A.2}$$

For the simple setting considered here with only a single source of risk (the strength of the economy), we have seen that the risk premium of an investment depends on how its returns vary with the overall economy. In Part IV of the text, we show that this result holds for more general settings with many sources of risk and more than two possible states of the economy.

FIGURE 3A.1

Converting between Dollars Today and Dollars in One Year with Risk

When cash flows are risky, Eq. 3A.2 determines the expected return, r_s, that we can use to convert between prices or present values today and the expected cash flow in the future.



EXAMPLE 3A.2 **Using the Risk Premium to Compute a Price**

Problem

Consider a risky bond with a cash flow of $1100 when the economy is strong and $1000 when the economy is weak. Suppose a 1% risk premium is appropriate for this bond. If the risk-free interest rate is 4%, what is the price of the bond today?

Solution

From Eq. 3A.2, the appropriate discount rate for the bond is

$$r_b = r_f + \text{(Risk Premium for the Bond)} = 4\% + 1\% = 5\%$$

The expected cash flow of the bond is $\frac{1}{2}(\$1100) + \frac{1}{2}(\$1000) = \$1050$ in one year. Thus, the price of the bond today is

$$\begin{aligned}\text{Bond Price} &= \text{(Average cash flow in one year)} \div (1 + r_b \ \$ \text{ in one year/\$ today})\\ &= (\$1050 \text{ in one year}) \div (1.05 \ \$ \text{ in one year/\$ today})\\ &= \$1000 \text{ today}\end{aligned}$$

Given this price, the bond's return is 10% when the economy is strong, and 0% when the economy is weak. (Note that the difference in the returns is 10%, which is 1/6 as variable as the market index; see Table 3A.3. Correspondingly, the risk premium of the bond is 1/6 that of the market index as well.)

CONCEPT CHECK

1. Why does the expected return of a risky security generally differ from the risk-free interest rate? What determines the size of its risk premium?
2. Explain why the risk of a security should not be evaluated in isolation.

Arbitrage with Transactions Costs

In our examples up to this point, we have ignored the costs of buying and selling goods or securities. In most markets, you must pay **transactions costs** to trade securities. As discussed in Chapter 1, when you trade securities in markets such as the NYSE and NASDAQ, you must pay two types of transactions costs. First, you must pay your broker a commission on the trade. Second, because you will generally pay a slightly higher price when you buy a security (the ask price) than you receive when you sell (the bid price), you will also pay the bid-ask spread. For example, a share of Dell Inc. stock (ticker symbol DELL) might be quoted as follows:

Bid:	$12.50
Ask:	$12.70

We can interpret these quotes as if the competitive price for DELL is $12.60, but there is a transaction cost of $0.10 per share when buying or selling.[8]

What consequence do these transactions costs have for no-arbitrage prices and the Law of One Price? Earlier we stated that the price of gold in New York and London must be identical in competitive markets. Suppose, however, that total transactions costs of $5 per

[8]Any price in between the bid price and the ask price could be the competitive price, with differing transaction costs for buying and selling.

ounce are associated with buying gold in one market and selling it in the other. Then if the price of gold is \$1450 per ounce in New York and \$1452 per ounce in London, the "Buy low, sell high" strategy no longer works:

Cost:	\$1450 per ounce (buy gold in New York) + \$5 (transactions costs)
Benefit:	\$1452 per ounce (sell gold in London)
NPV:	\$1452 − \$1450 − \$5 = −\$3 per ounce

Indeed, there is no arbitrage opportunity in this case until the prices diverge by more than \$5, the amount of the transactions costs.

In general, we need to modify our previous conclusions about no-arbitrage prices by appending the phrase "up to transactions costs." In this example, there is only one competitive price for gold—up to a discrepancy of the \$5 transactions cost. The other conclusions of this chapter have the same qualifier. The package price should equal the à la carte price, up to the transactions costs associated with packaging and unpackaging. The price of a security should equal the present value of its cash flows, up to the transactions costs of trading the security and the cash flows.

Fortunately, for most financial markets, these costs are small. For example, in 2012, typical bid-ask spreads for large NYSE stocks were between 2 and 5 cents per share. As a first approximation we can ignore these spreads in our analysis. Only in situations in which the NPV is small (relative to the transactions costs) will any discrepancy matter. In that case, we will need to carefully account for all transactions costs to decide whether the NPV is positive or negative.

EXAMPLE 3A.3 The No-Arbitrage Price Range

Problem

Consider a bond that pays \$1000 at the end of the year. Suppose the market interest rate for deposits is 6%, but the market interest rate for borrowing is 6.5%. What is the no-arbitrage price *range* for the bond? That is, what is the highest and lowest price the bond could trade for without creating an arbitrage opportunity?

Solution

The no-arbitrage price for the bond equals the present value of the cash flows. In this case, however, the interest rate we should use depends on whether we are borrowing or lending. For example, the amount we would need to put in the bank today to receive \$1000 in one year is

$$(\$1000 \text{ in one year}) \div (1.06 \text{ \$ in one year/\$ today}) = \$943.40 \text{ today}$$

where we have used the 6% interest rate that we will earn on our deposit. The amount that we can borrow today if we plan to repay \$1000 in one year is

$$(\$1000 \text{ in one year}) \div (1.065 \text{ \$ in one year/\$ today}) = \$938.97 \text{ today}$$

where we have used the higher 6.5% rate that we will have to pay if we borrow.

Suppose the bond price P exceeded \$943.40. Then you could profit by selling the bond at its current price and investing \$943.40 of the proceeds at the 6% interest rate. You would still receive \$1000 at the end of the year, but you would get to keep the difference $\$(P - 943.40)$ today. This arbitrage opportunity will keep the price of the bond from going higher than \$943.40.

Alternatively, suppose the bond price P were less than \$938.97. Then you could borrow \$938.97 at 6.5% and use P of it to buy the bond. This would leave you with $\$(938.97 - P)$

today, and no obligation in the future because you can use the $1000 bond payoff to repay the loan. This arbitrage opportunity will keep the price of the bond from falling below $938.97.

If the bond price P is between $938.97 and $943.40, then both of the preceding strategies will lose money, and there is no arbitrage opportunity. Thus no arbitrage implies a narrow range of possible prices for the bond ($938.97 to $943.40), rather than an exact price.

To summarize, when there are transactions costs, arbitrage keeps prices of equivalent goods and securities close to each other. Prices can deviate, but not by more than the transactions costs of the arbitrage.

CONCEPT CHECK

1. In the presence of transactions costs, why might different investors disagree about the value of an investment opportunity?
2. By how much could this value differ?

MyFinanceLab Here is what you should know after reading this chapter. MyFinanceLab will help you identify what you know and where to go when you need to practice.

- When cash flows are risky, we cannot use the risk-free interest rate to compute present values. Instead, we can determine the present value by constructing a portfolio that produces cash flows with identical risk, and then applying the Law of One Price. Alternatively, we can discount the expected cash flows using a discount rate that includes an appropriate risk premium.
- The risk of a security must be evaluated in relation to the fluctuations of other investments in the economy. A security's risk premium will be higher the more its returns tend to vary with the overall economy and the market index. If the security's returns vary in the opposite direction of the market index, it offers insurance and will have a negative risk premium.
- When there are transactions costs, the prices of equivalent securities can deviate from each other, but not by more than the transactions costs of the arbitrage.

Key Terms

expected return *p. 86*
risk aversion *p. 85*
risk premium *p. 86*
transactions costs *p. 90*

Problems

Problems are available in MyFinanceLab. *An asterisk (*) indicates problems with a higher level of difficulty.*

Risky Versus Risk-Free Cash Flows

A.1. The table here shows the no-arbitrage prices of securities A and B that we calculated.

		Cash Flow in One Year	
Security	**Market Price Today**	**Weak Economy**	**Strong Economy**
Security A	231	0	600
Security B	346	600	0

a. What are the payoffs of a portfolio of one share of security A and one share of security B?

b. What is the market price of this portfolio? What expected return will you earn from holding this portfolio?

A.2. Suppose security C has a payoff of $600 when the economy is weak and $1800 when the economy is strong. The risk-free interest rate is 4%.

a. Security C has the same payoffs as which portfolio of the securities A and B in Problem A.1?

b. What is the no-arbitrage price of security C?

c. What is the expected return of security C if both states are equally likely? What is its risk premium?

d. What is the difference between the return of security C when the economy is strong and when it is weak?

e. If security C had a risk premium of 10%, what arbitrage opportunity would be available?

***A.3.** You work for Innovation Partners and are considering creating a new security. This security would pay out $1000 in one year if the last digit in the closing value of the Dow Jones Industrial index in one year is an even number and zero if it is odd. The one-year risk-free interest rate is 5%. Assume that all investors are averse to risk.

a. What can you say about the price of this security if it were traded today?

b. Say the security paid out $1000 if the last digit of the Dow is odd and zero otherwise. Would your answer to part (a) change?

c. Assume both securities (the one that paid out on even digits and the one that paid out on odd digits) trade in the market today. Would that affect your answers?

***A.4.** Suppose a risky security pays an expected cash flow of $80 in one year. The risk-free rate is 4%, and the expected return on the market index is 10%.

a. If the returns of this security are high when the economy is strong and low when the economy is weak, but the returns vary by only half as much as the market index, what risk premium is appropriate for this security?

b. What is the security's market price?

Arbitrage with Transactions Costs

A.5. Suppose Hewlett-Packard (HPQ) stock is currently trading on the NYSE with a bid price of $28.00 and an ask price of $28.10. At the same time, a NASDAQ dealer posts a bid price for HPQ of $27.85 and an ask price of $27.95.

a. Is there an arbitrage opportunity in this case? If so, how would you exploit it?

b. Suppose the NASDAQ dealer revises his quotes to a bid price of $27.95 and an ask price of $28.05. Is there an arbitrage opportunity now? If so, how would you exploit it?

c. What must be true of the highest bid price and the lowest ask price for no arbitrage opportunity to exist?

***A.6.** Consider a portfolio of two securities: one share of Johnson and Johnson (JNJ) stock and a bond that pays $100 in one year. Suppose this portfolio is currently trading with a bid price of $141.65 and an ask price of $142.25, and the bond is trading with a bid price of $91.75 and an ask price of $91.95. In this case, what is the no-arbitrage price range for JNJ stock?