

# RISK AND RETURN

## LEARNING GOALS

- LG1** Understand the meaning and fundamentals of risk, return, and risk preferences.
- LG2** Describe procedures for assessing and measuring the risk of a single asset.
- LG3** Discuss the measurement of return and standard deviation for a portfolio and the various types of correlation that can exist between series of numbers.
- LG4** Understand the risk and return characteristics of a portfolio in terms of correlation and diversification, and the impact of international assets on a portfolio.
- LG5** Review the two types of risk and the derivation and role of beta in measuring the relevant risk of both an individual security and a portfolio.
- LG6** Explain the capital asset pricing model (CAPM), its relationship to the security market line (SML), and shifts in the SML caused by changes in inflationary expectations and risk aversion.

## *Across the Disciplines* WHY THIS CHAPTER MATTERS TO YOU

**Accounting:** You need to understand the relationship between risk and return because of the effect that riskier projects will have on the firm's annual net income and on your efforts to stabilize net income.

**Information systems:** You need to understand how to do sensitivity and correlation analyses in order to build decision packages that help management analyze the risk and return of various business opportunities.

**Management:** You need to understand the relationship between risk and return, and how to measure that relationship in order to evaluate data that come from finance personnel and

translate those data into decisions that increase the value of the firm.

**Marketing:** You need to understand that although higher-risk projects may produce higher returns, they may not be the best choice for the firm if they produce an erratic earnings pattern and do not optimize the value of the firm.

**Operations:** You need to understand how investments in plant assets and purchases of supplies will be measured by the firm and to recognize that decisions about such investments will be made by evaluating the effects of both risk and return on the value of the firm.

# CITIGROUP

## CITIGROUP TAKES ON NEW ASSOCIATES

As they chased after hot new financial services businesses that boosted earnings quickly, many banks ignored a key principle of risk management: Diversification reduces risk. They expanded into risky areas such as investment banking, stock brokerage, wealth management, and equity investment, and they moved away from their traditional services such as mortgage banking, auto financing, and credit cards. Although adding new business lines is a way to diversify, the benefits of diversification come from balancing low-risk and high-risk activities. As the economy changed, banks ran into problems with these new, higher-risk services. Banks that had “hedged their bets” by continuing to offer a variety of services spread across the risk spectrum earned higher returns.

**Citigroup** is a case study for the benefits of diversification. The company, created in 1998 by the merger of Citicorp and Travelers Group, provides a broad range of financial products and services to 100 million consumers, corporations, governments, and institutions in over 100 countries. These offerings include consumer banking and credit, corporate and investment banking, commercial finance, leasing, insurance, securities brokerage, and asset management. Under the leadership of Citigroup CEO Sandy Weill, the company made acquisitions that reduced its dependence on corporate and investment banking. In September 2000, Citigroup bought **Associates First Capital Corp** for \$31 billion.

With the acquisition of Associates, Citigroup shifted the balance of its business more toward consumers than toward institutions. Associates’s target market is the lower-middle economic class. Although these customers are riskier than the traditional bank customer, the rewards are greater too, because Associates can charge higher interest rates and fees to compensate itself for taking on the additional risk. The existing consumer finance businesses of both Associates and Citigroup know how to handle this type of lending and earn solid returns in the process.

A more diversified group of businesses with greater emphasis on the consumer side should reduce Citigroup’s earnings volatility and improve shareholder value. Commenting in spring 2001 on the corporation’s ability to weather the current economic downturn, Weill said, “The strength and diversity of our earnings by business, geography, and customer helped to deliver a strong bottom line in a period of market uncertainty.” Citigroup’s return on equity (ROE) for the first quarter 2001 was 22.5 percent, just above fiscal year 2000’s 22.4 percent and better than its average ROE of 19 percent for the period 1998 to 2000.

Citigroup and its consumer business units demonstrate several key fundamental financial concepts: Risk and return are linked, return should increase if risk increases, and diversification reduces risk. As this chapter will show, firms can use various tools and techniques to quantify and assess the risk and return for individual assets and for groups of assets.



## LG1 5.1 Risk and Return Fundamentals

### portfolio

A collection, or group, of assets.

To maximize share price, the financial manager must learn to assess two key determinants: risk and return.<sup>1</sup> Each financial decision presents certain risk and return characteristics, and the unique combination of these characteristics has an impact on share price. Risk can be viewed as it is related either to a single asset or to a **portfolio**—a collection, or group, of assets. We will look at both, beginning with the risk of a single asset. First, though, it is important to introduce some fundamental ideas about risk, return, and risk preferences.

### Risk Defined

### risk

The chance of financial loss or, more formally, the *variability of returns associated with a given asset*.

In the most basic sense, **risk** is the chance of financial loss. Assets having greater chances of loss are viewed as more risky than those with lesser chances of loss. More formally, the term *risk* is used interchangeably with *uncertainty* to refer to the *variability of returns associated with a given asset*. A \$1,000 government bond that guarantees its holder \$100 interest after 30 days has no risk, because there is no variability associated with the return. A \$1,000 investment in a firm's common stock, which over the same period may earn anywhere from \$0 to \$200, is very risky because of the high variability of its return. The more nearly certain the return from an asset, the less variability and therefore the less risk.

Some risks directly affect both financial managers and shareholders. Table 5.1 briefly describes the common sources of risk that affect both firms and their shareholders. As you can see, business risk and financial risk are more firm-specific and therefore are of greatest interest to financial managers. Interest rate, liquidity, and market risks are more shareholder-specific and therefore are of greatest interest to stockholders. Event, exchange rate, purchasing-power, and tax risk directly affect both firms and shareholders. The nearby box focuses on another risk that affects both firms and shareholders—moral risk. A number of these risks are discussed in more detail later in this text. Clearly, both financial managers and shareholders must assess these and other risks as they make investment decisions.

### Return Defined

### return

The total gain or loss experienced on an investment over a given period of time; calculated by dividing the asset's cash distributions during the period, plus change in value, by its beginning-of-period investment value.

Obviously, if we are going to assess risk on the basis of variability of return, we need to be certain we know what *return* is and how to measure it. The **return** is the total gain or loss experienced on an investment over a given period of time. It is commonly measured as cash distributions during the period plus the change in value, expressed as a percentage of the beginning-of-period investment value. The expression for calculating the rate of return earned on any asset over period  $t$ ,  $k_t$ , is commonly defined as

$$k_t = \frac{C_t + P_t - P_{t-1}}{P_{t-1}} \quad (5.1)$$

1. Two important points should be recognized here: (1) Although for convenience the publicly traded corporation is being discussed, the risk and return concepts presented apply to all firms; and (2) concern centers only on the wealth of common stockholders, because they are the “residual owners” whose returns are in no way specified in advance.

**TABLE 5.1** Popular Sources of Risk Affecting Financial Managers and Shareholders

Source of risk	Description
<b>Firm-Specific Risks</b>	
Business risk	The chance that the firm will be unable to cover its operating costs. Level is driven by the firm's revenue stability and the structure of its operating costs (fixed vs. variable).
Financial risk	The chance that the firm will be unable to cover its financial obligations. Level is driven by the predictability of the firm's operating cash flows and its fixed-cost financial obligations.
<b>Shareholder-Specific Risks</b>	
Interest rate risk	The chance that changes in interest rates will adversely affect the value of an investment. Most investments lose value when the interest rate rises and increase in value when it falls.
Liquidity risk	The chance that an investment cannot be easily liquidated at a reasonable price. Liquidity is significantly affected by the size and depth of the market in which an investment is customarily traded.
Market risk	The chance that the value of an investment will decline because of market factors that are independent of the investment (such as economic, political, and social events). In general, the more a given investment's value responds to the market, the greater its risk; and the less it responds, the smaller its risk.
<b>Firm and Shareholder Risks</b>	
Event risk	The chance that a totally unexpected event will have a significant effect on the value of the firm or a specific investment. These infrequent events, such as government-mandated withdrawal of a popular prescription drug, typically affect only a small group of firms or investments.
Exchange rate risk	The exposure of future expected cash flows to fluctuations in the currency exchange rate. The greater the chance of undesirable exchange rate fluctuations, the greater the risk of the cash flows and therefore the lower the value of the firm or investment.
Purchasing-power risk	The chance that changing price levels caused by inflation or deflation in the economy will adversely affect the firm's or investment's cash flows and value. Typically, firms or investments with cash flows that move with general price levels have a low purchasing-power risk, and those with cash flows that do not move with general price levels have high purchasing-power risk.
Tax risk	The chance that unfavorable changes in tax laws will occur. Firms and investments with values that are sensitive to tax law changes are more risky.

where

$$\begin{aligned}
 k_t &= \text{actual, expected, or required rate of return}^2 \text{ during period } t \\
 C_t &= \text{cash (flow) received from the asset investment in the time period} \\
 &\quad t - 1 \text{ to } t \\
 P_t &= \text{price (value) of asset at time } t \\
 P_{t-1} &= \text{price (value) of asset at time } t - 1
 \end{aligned}$$

2. The terms *expected return* and *required return* are used interchangeably throughout this text, because in an efficient market (discussed later) they would be expected to be equal. The actual return is an *ex post* value, whereas expected and required returns are *ex ante* values. Therefore, the actual return may be greater than, equal to, or less than the expected/required return.

**FOCUS ON ETHICS** What About Moral Risk?

The poster boy for “moral risk,” the devastating effects of unethical behavior for a company’s investors, has to be Nick Leeson. This 28-year-old trader violated his bank’s investing rules while secretly placing huge bets on the direction of the Japanese stock market. When those bets proved to be wrong, the \$1.24-billion losses resulted in the demise of the centuries-old **Barings Bank**.

More than any other single episode in world financial history, Leeson’s misdeeds underscored the importance of character in the financial industry. Forty-one percent of surveyed CFOs admit ethical problems in their organizations (self-reported percents are probably low), and 48 percent of surveyed employees admit to engaging in unethical practices such as cheating on expense accounts and forging signatures. We are reminded again that share-

holder wealth maximization has to be ethically constrained.

What can companies do to instill and maintain ethical corporate practices? They can start by building awareness through a code of ethics. Nearly all Fortune 500 companies and about half of all companies have an ethics code spelling out general principles of right and wrong conduct. Companies such as **Halliburton** and **Texas Instruments** have gone into specifics, because ethical codes are often faulted for being too vague and abstract.

Ethical organizations also reveal their commitments through the following activities: talking about ethical values periodically; including ethics in required training for mid-level managers (as at **Procter & Gamble**); modeling ethics throughout top management and the board (termed “tone at the top,” especially notable at **Johnson**

**& Johnson**); promoting openness for employees with concerns; weeding out employees who do not share the company’s ethics values before those employees can harm the company’s reputation or culture; assigning an individual the role of ethics director; and evaluating leaders’ ethics in performance reviews (as at **Merck & Co.**).

The Leeson saga underscores the difficulty of dealing with the “moral hazard” problem, when the consequences of an individual’s actions are largely borne by others. John Boatright argues in his book *Ethics in Finance* that the best antidote is to attract loyal, hardworking employees. Ethicists Rae and Wong tell us that debating issues is fruitless if we continue to ignore the character traits that empower people for moral behavior.

The return,  $k_t$ , reflects the combined effect of cash flow,  $C_t$ , and changes in value,  $P_t - P_{t-1}$ , over period  $t$ .<sup>3</sup>

Equation 5.1 is used to determine the rate of return over a time period as short as 1 day or as long as 10 years or more. However, in most cases,  $t$  is 1 year, and  $k$  therefore represents an annual rate of return.

**EXAMPLE** ▼ Robin’s Gameroom, a high-traffic video arcade, wishes to determine the return on two of its video machines, Conqueror and Demolition. Conqueror was purchased 1 year ago for \$20,000 and currently has a market value of \$21,500. During the year, it generated \$800 of after-tax cash receipts. Demolition was purchased 4 years ago; its value in the year just completed declined from \$12,000 to \$11,800. During the year, it generated \$1,700 of after-tax cash receipts. Substi-

3. The beginning-of-period value,  $P_{t-1}$ , and the end-of-period value,  $P_t$ , are not necessarily *realized values*. They are often *unrealized*, which means that although the asset was *not* actually purchased at time  $t - 1$  and sold at time  $t$ , values  $P_{t-1}$  and  $P_t$  *could* have been realized had those transactions been made.

tuting into Equation 5.1, we can calculate the annual rate of return,  $k$ , for each video machine.

Conqueror (C):

$$k_C = \frac{\$800 + \$21,500 - \$20,000}{\$20,000} = \frac{\$2,300}{\$20,000} = \underline{\underline{11.5\%}}$$

Demolition (D):

$$k_D = \frac{\$1,700 + \$11,800 - \$12,000}{\$12,000} = \frac{\$1,500}{\$12,000} = \underline{\underline{12.5\%}}$$

Although the market value of Demolition declined during the year, its cash flow caused it to earn a higher rate of return than Conqueror earned during the same period. Clearly, the combined impact of cash flow and changes in value, measured by the rate of return, is important.

### Historical Returns

Investment returns vary both over time and between different types of investments. By averaging historical returns over a long period of time, it is possible to eliminate the impact of market and other types of risk. This enables the financial decision maker to focus on the differences in return that are attributable primarily to the types of investment. Table 5.2 shows the average annual rates of return for a number of popular security investments (and inflation) over the 75-year period January 1, 1926, through December 31, 2000. Each rate represents the average annual rate of return an investor would have realized had he or she purchased the investment on January 1, 1926, and sold it on December 31, 2000. You can see that significant differences exist between the average annual rates of return realized on the various types of stocks, bonds, and bills shown. Later in this chapter, we will see how these differences in return can be linked to differences in the risk of each of these investments.

**TABLE 5.2** Historical Returns for Selected Security Investments (1926–2000)

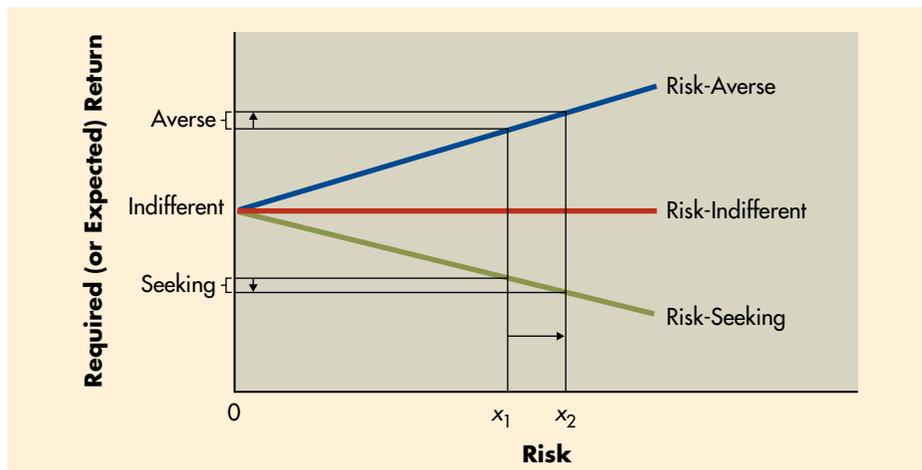
Investment	Average annual return
Large-company stocks	13.0%
Small-company stocks	17.3
Long-term corporate bonds	6.0
Long-term government bonds	5.7
U.S. Treasury bills	3.9
Inflation	3.2%

Source: *Stocks, Bonds, Bills, and Inflation, 2001 Yearbook* (Chicago: Ibbotson Associates, Inc., 2001).

FIGURE 5.1

**Risk Preferences**

Risk preference behaviors

**Risk Preferences**

Feelings about risk differ among managers (and firms).<sup>4</sup> Thus it is important to specify a generally acceptable level of risk. The three basic risk preference behaviors—risk-averse, risk-indifferent, and risk-seeking—are depicted graphically in Figure 5.1.

**risk-indifferent**

The attitude toward risk in which no change in return would be required for an increase in risk.

**risk-averse**

The attitude toward risk in which an increased return would be required for an increase in risk.

**risk-seeking**

The attitude toward risk in which a decreased return would be accepted for an increase in risk.

**Hint** Remember that most *shareholders* are also risk-averse. Like risk-averse managers, for a given increase in risk, they also require an increase in return on their investment in that firm.

- For the **risk-indifferent** manager, the required return does not change as risk goes from  $x_1$  to  $x_2$ . In essence, no change in return would be required for the increase in risk. Clearly, this attitude is nonsensical in almost any business context.
- For the **risk-averse** manager, the required return increases for an increase in risk. Because they shy away from risk, these managers require higher expected returns to compensate them for taking greater risk.
- For the **risk-seeking** manager, the required return decreases for an increase in risk. Theoretically, because they enjoy risk, these managers are willing to give up some return to take more risk. However, such behavior would not be likely to benefit the firm.

*Most managers are risk-averse; for a given increase in risk, they require an increase in return.* They generally tend to be conservative rather than aggressive when accepting risk for their firm. Accordingly, a *risk-averse financial manager requiring higher returns for greater risk is assumed throughout this text.*

**Review Questions**

- 5–1 What is *risk* in the context of financial decision making?  
 5–2 Define *return*, and describe how to find the rate of return on an investment.

4. The risk preferences of the managers should in theory be consistent with the risk preferences of the firm. Although the *agency problem* suggests that in practice managers may not behave in a manner consistent with the firm's risk preferences, it is assumed here that they do. Therefore, the managers' risk preferences and those of the firm are assumed to be identical.

5-3 Compare the following risk preferences: (a) risk-averse, (b) risk-indifferent, and (c) risk-seeking. Which is most common among financial managers?

**LG2 5.2 Risk of a Single Asset**

The concept of risk can be developed by first considering a single asset held in isolation. We can look at expected-return behaviors to assess risk, and statistics can be used to measure it.

**Risk Assessment**

Sensitivity analysis and probability distributions can be used to assess the general level of risk embodied in a given asset.

**sensitivity analysis**  
An approach for assessing risk that uses several possible-return estimates to obtain a sense of the variability among outcomes.

**range**  
A measure of an asset’s risk, which is found by subtracting the pessimistic (worst) outcome from the optimistic (best) outcome.

**Sensitivity Analysis**

Sensitivity analysis uses several possible-return estimates to obtain a sense of the variability among outcomes.<sup>5</sup> One common method involves making pessimistic (worst), most likely (expected), and optimistic (best) estimates of the returns associated with a given asset. In this case, the asset’s risk can be measured by the range of returns. The **range** is found by subtracting the pessimistic outcome from the optimistic outcome. The greater the range, the more variability, or risk, the asset is said to have.

**EXAMPLE**

Norman Company, a custom golf equipment manufacturer, wants to choose the better of two investments, A and B. Each requires an initial outlay of \$10,000, and each has a *most likely* annual rate of return of 15%. Management has made *pessimistic* and *optimistic* estimates of the returns associated with each. The three estimates for each asset, along with its range, are given in Table 5.3. Asset A appears to be less risky than asset B; its range of 4% (17% – 13%) is less than the range of 16% (23% – 7%) for asset B. The risk-averse decision maker would prefer asset A over asset B, because A offers the same most likely return as B (15%) with lower risk (smaller range).

<b>TABLE 5.3 Assets A and B</b>		
	Asset A	Asset B
Initial investment	\$10,000	\$10,000
Annual rate of return		
Pessimistic	13%	7%
Most likely	15%	15%
Optimistic	17%	23%
Range	4%	16%

5. The term *sensitivity analysis* is intentionally used in a general rather than a technically correct fashion here to simplify this discussion. A more technical and precise definition and discussion of this technique and of “scenario analysis” are presented in Chapter 10.

Although the use of sensitivity analysis and the range is rather crude, it does give the decision maker a feel for the behavior of returns, which can be used to estimate the risk involved.

## Probability Distributions

Probability distributions provide a more quantitative insight into an asset's risk. The **probability** of a given outcome is its *chance* of occurring. An outcome with an 80 percent probability of occurrence would be expected to occur 8 out of 10 times. An outcome with a probability of 100 percent is certain to occur. Outcomes with a probability of zero will never occur.

### probability

The *chance* that a given outcome will occur.

### EXAMPLE ▼

Norman Company's past estimates indicate that the probabilities of the pessimistic, most likely, and optimistic outcomes are 25%, 50%, and 25%, respectively. Note that the sum of these probabilities must equal 100%; that is, they must be based on all the alternatives considered.

### probability distribution

A model that relates probabilities to the associated outcomes.

### bar chart

The simplest type of probability distribution; shows only a limited number of outcomes and associated probabilities for a given event.

### continuous probability distribution

A probability distribution showing all the possible outcomes and associated probabilities for a given event.

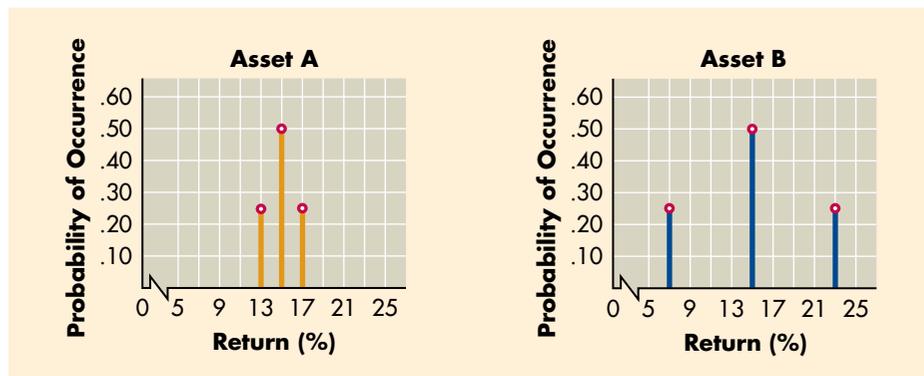
A **probability distribution** is a model that relates probabilities to the associated outcomes. The simplest type of probability distribution is the **bar chart**, which shows only a limited number of outcome–probability coordinates. The bar charts for Norman Company's assets A and B are shown in Figure 5.2. Although both assets have the same most likely return, the range of return is much greater, or more dispersed, for asset B than for asset A—16 percent versus 4 percent.

If we knew all the possible outcomes and associated probabilities, we could develop a **continuous probability distribution**. This type of distribution can be thought of as a bar chart for a very large number of outcomes.<sup>6</sup> Figure 5.3 presents continuous probability distributions for assets A and B.<sup>7</sup> Note that although assets A and B have the same most likely return (15 percent), the distribution of

**FIGURE 5.2**

### Bar Charts

Bar charts for asset A's and asset B's returns

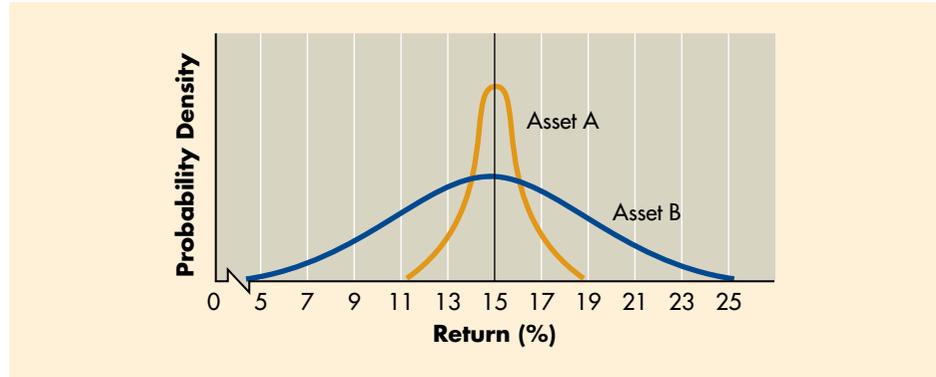


6. To develop a continuous probability distribution, one must have data on a large number of historical occurrences for a given event. Then, by developing a frequency distribution indicating how many times each outcome has occurred over the given time horizon, one can convert these data into a probability distribution. Probability distributions for risky events can also be developed by using *simulation*—a process discussed briefly in Chapter 10.

7. The continuous distribution's probabilities change because of the large number of additional outcomes considered. The area under each of the curves is equal to 1, which means that 100% of the outcomes, or all the possible outcomes, are considered.

**FIGURE 5.3****Continuous Probability Distributions**

Continuous probability distributions for asset A's and asset B's returns



returns for asset B has much greater *dispersion* than the distribution for asset A. Clearly, asset B is more risky than asset A.

## Risk Measurement

In addition to considering its *range*, the risk of an asset can be measured quantitatively by using statistics. Here we consider two statistics—the standard deviation and the coefficient of variation—that can be used to measure the variability of asset returns.

### Standard Deviation

The most common statistical indicator of an asset's risk is the **standard deviation**,  $\sigma_k$ , which measures the dispersion around the *expected value*.<sup>8</sup> The **expected value of a return**,  $\bar{k}$ , is the most likely return on an asset. It is calculated as follows:<sup>9</sup>

$$\bar{k} = \sum_{j=1}^n k_j \times Pr_j \quad (5.2)$$

where

$$\begin{aligned} k_j &= \text{return for the } j\text{th outcome} \\ Pr_j &= \text{probability of occurrence of the } j\text{th outcome} \\ n &= \text{number of outcomes considered} \end{aligned}$$

8. Although risk is typically viewed as determined by the dispersion of outcomes around an expected value, many people believe that risk exists only when outcomes are below the expected value, because only returns below the expected value are considered bad. Nevertheless, the common approach is to view risk as determined by the variability on either side of the expected value, because the greater this variability, the less confident one can be of the outcomes associated with an investment.

9. The formula for finding the expected value of return,  $\bar{k}$ , when all of the outcomes,  $k_j$ , are known *and* their related probabilities are assumed to be equal, is a simple arithmetic average:

$$\bar{k} = \frac{\sum_{j=1}^n k_j}{n} \quad (5.2a)$$

where  $n$  is the number of observations. Equation 5.2 is emphasized in this chapter because returns and related probabilities are often available.

**standard deviation ( $\sigma_k$ )**

The most common statistical indicator of an asset's risk; it measures the dispersion around the *expected value*.

**expected value of a return ( $\bar{k}$ )**

The most likely return on a given asset.

**TABLE 5.4 Expected Values of Returns for Assets A and B**

Possible outcomes	Probability (1)	Returns (2)	Weighted value [(1) × (2)] (3)
<b>Asset A</b>			
Pessimistic	.25	13%	3.25%
Most likely	.50	15	7.50
Optimistic	.25	17	4.25
Total	<u>1.00</u>	Expected return	<u>15.00%</u>
<b>Asset B</b>			
Pessimistic	.25	7%	1.75%
Most likely	.50	15	7.50
Optimistic	.25	23	5.75
Total	<u>1.00</u>	Expected return	<u>15.00%</u>

**EXAMPLE** ▼ The expected values of returns for Norman Company’s assets A and B are presented in Table 5.4. Column 1 gives the  $Pr_j$ ’s and column 2 gives the  $k_j$ ’s. In each case  $n$  equals 3. The expected value for each asset’s return is 15%.

The expression for the *standard deviation of returns*,  $\sigma_k$ , is<sup>10</sup>

$$\sigma_k = \sqrt{\sum_{j=1}^n (k_j - \bar{k})^2 \times Pr_j} \tag{5.3}$$

In general, the higher the standard deviation, the greater the risk.

**EXAMPLE** ▼ Table 5.5 presents the standard deviations for Norman Company’s assets A and B, based on the earlier data. The standard deviation for asset A is 1.41%, and the standard deviation for asset B is 5.66%. The higher risk of asset B is clearly reflected in its higher standard deviation.

**Historical Returns and Risk** We can now use the standard deviation as a measure of risk to assess the historical (1926–2000) investment return data in Table 5.2. Table 5.6 repeats the historical returns and shows the standard deviations associated with each of them. A close relationship can be seen between the investment returns and the standard deviations: Investments with higher returns have higher standard deviations. Because higher standard deviations are associated with greater risk, the historical data confirm the existence of a positive rela-

10. The formula that is commonly used to find the standard deviation of returns,  $\sigma_k$ , in a situation in which *all* outcomes are known *and* their related probabilities are assumed equal, is

$$\sigma_k = \sqrt{\frac{\sum_{j=1}^n (k_j - \bar{k})^2}{n - 1}} \tag{5.3a}$$

where  $n$  is the number of observations. Equation 5.3 is emphasized in this chapter because returns and related probabilities are often available.

**TABLE 5.5** The Calculation of the Standard Deviation of the Returns for Assets A and B<sup>a</sup>

$i$	$k_j$	$\bar{k}$	$k_j - \bar{k}$	$(k_j - \bar{k})^2$	$Pr_j$	$(k_j - \bar{k})^2 \times Pr_j$
Asset A						
1	13%	15%	-2%	4%	.25	1%
2	15	15	0	0	.50	0
3	17	15	2	4	.25	<u>1</u>
						$\sum_{j=1}^3 (k_j - \bar{k})^2 \times Pr_j = 2\%$
$\sigma_{k_A} = \sqrt{\sum_{j=1}^3 (k_j - \bar{k})^2 \times Pr_j} = \sqrt{2\%} = \underline{\underline{1.41\%}}$						
Asset B						
1	7%	15%	-8%	64%	.25	16%
2	15	15	0	0	.50	0
3	23	15	8	64	.25	<u>16</u>
						$\sum_{j=1}^3 (k_j - \bar{k})^2 \times Pr_j = 32\%$
$\sigma_{k_B} = \sqrt{\sum_{j=1}^3 (k_j - \bar{k})^2 \times Pr_j} = \sqrt{32\%} = \underline{\underline{5.66\%}}$						

<sup>a</sup>Calculations in this table are made in percentage form rather than decimal form—e.g., 13% rather than 0.13. As a result, some of the intermediate computations may appear to be inconsistent with those that would result from using decimal form. Regardless, the resulting standard deviations are correct and identical to those that would result from using decimal rather than percentage form.

relationship between risk and return. That relationship reflects *risk aversion* by market participants, who require higher returns as compensation for greater risk. The historical data in Table 5.6 clearly show that during the 1926–2000 period, investors were rewarded with higher returns on higher-risk investments.

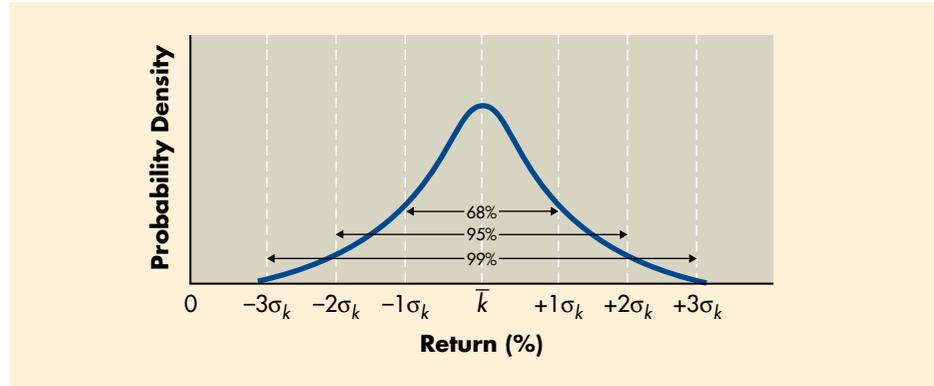
**TABLE 5.6** Historical Returns and Standard Deviations for Selected Security Investments (1926–2000)

Investment	Average annual return	Standard deviation
Large-company stocks	13.0%	20.2%
Small-company stocks	17.3	33.4
Long-term corporate bonds	6.0	8.7
Long-term government bonds	5.7	9.4
U.S. Treasury bills	3.9	3.2
Inflation	3.2%	4.4%

Source: *Stocks, Bonds, Bills, and Inflation, 2001 Yearbook* (Chicago: Ibbotson Associates, Inc., 2001).

**FIGURE 5.4****Bell-Shaped Curve**

Normal probability distribution, with ranges



**normal probability distribution**  
A symmetrical probability distribution whose shape resembles a “bell-shaped” curve.

**Normal Distribution** A normal probability distribution, depicted in Figure 5.4, always resembles a “bell-shaped” curve. It is symmetrical: From the peak of the graph, the curve’s extensions are mirror images (reflections) of each other. The symmetry of the curve means that half the probability is associated with the values to the left of the peak and half with the values to the right. As noted on the figure, for normal probability distributions, 68 percent of the possible outcomes will lie between  $\pm 1$  standard deviation from the expected value, 95 percent of all outcomes will lie between  $\pm 2$  standard deviations from the expected value, and 99 percent of all outcomes will lie between  $\pm 3$  standard deviations from the expected value.<sup>11</sup>

**EXAMPLE**

If we assume that the probability distribution of returns for the Norman Company is normal, 68% of the possible outcomes would have a return ranging between 13.59 and 16.41% for asset A and between 9.34 and 20.66% for asset B; 95% of the possible return outcomes would range between 12.18 and 17.82% for asset A and between 3.68 and 26.32% for asset B; and 99% of the possible return outcomes would range between 10.77 and 19.23% for asset A and between  $-1.98$  and 31.98% for asset B. The greater risk of asset B is clearly reflected in its much wider range of possible returns for each level of confidence (68%, 95%, etc.).

**coefficient of variation (CV)**  
A measure of relative dispersion that is useful in comparing the risks of assets with differing expected returns.

**Coefficient of Variation**

The coefficient of variation, CV, is a measure of relative dispersion that is useful in comparing the risks of assets with differing expected returns. Equation 5.4 gives the expression for the coefficient of variation:

$$CV = \frac{\sigma_k}{\bar{k}} \quad (5.4)$$

The higher the coefficient of variation, the greater the risk.

11. Tables of values indicating the probabilities associated with various deviations from the expected value of a normal distribution can be found in any basic statistics text. These values can be used to establish confidence limits and make inferences about possible outcomes. Such applications can be found in most basic statistics and upper-level managerial finance textbooks.

**EXAMPLE** ▼ When the standard deviations (from Table 5.5) and the expected returns (from Table 5.4) for assets A and B are substituted into Equation 5.4, the coefficients of variation for A and B are 0.094 ( $1.41\% \div 15\%$ ) and 0.377 ( $5.66\% \div 15\%$ ), respectively. Asset B has the higher coefficient of variation and is therefore more risky than asset A—which we already know from the standard deviation. (Because both assets have the same expected return, the coefficient of variation has not provided any new information.) ▲

The real utility of the coefficient of variation comes in comparing the risks of assets that have *different* expected returns.

**EXAMPLE** ▼ A firm wants to select the less risky of two alternative assets—X and Y. The expected return, standard deviation, and coefficient of variation for each of these assets' returns are

Statistics	Asset X	Asset Y
(1) Expected return	12%	20%
(2) Standard deviation	9% <sup>a</sup>	10%
(3) Coefficient of variation [(2) ÷ (1)]	0.75	0.50 <sup>a</sup>

<sup>a</sup>Preferred asset using the given risk measure.

Judging solely on the basis of their standard deviations, the firm would prefer asset X, which has a lower standard deviation than asset Y (9% versus 10%). However, management would be making a serious error in choosing asset X over asset Y, because the dispersion—the risk—of the asset, as reflected in the coefficient of variation, is lower for Y (0.50) than for X (0.75). Clearly, using the coefficient of variation to compare asset risk is effective because it also considers the relative size, or expected return, of the assets. ▲

## Review Questions

- 5-4 Explain how the *range* is used in sensitivity analysis.
- 5-5 What does a plot of the *probability distribution* of outcomes show a decision maker about an asset's risk?
- 5-6 What relationship exists between the size of the *standard deviation* and the degree of asset risk?
- 5-7 When is the *coefficient of variation* preferred over the standard deviation for comparing asset risk?

### 5.3 Risk of a Portfolio

In real-world situations, the risk of any single investment would not be viewed independently of other assets. (We did so for teaching purposes.) New investments must be considered in light of their impact on the risk and return of the

**efficient portfolio**

A portfolio that maximizes return for a given level of risk or minimizes risk for a given level of return.

portfolio of assets.<sup>12</sup> The financial manager's goal is to create an **efficient portfolio**, one that maximizes return for a given level of risk or minimizes risk for a given level of return. We therefore need a way to measure the return and the standard deviation of a portfolio of assets. Once we can do that, we will look at the statistical concept of *correlation*, which underlies the process of diversification that is used to develop an efficient portfolio.

## Portfolio Return and Standard Deviation

The *return on a portfolio* is a weighted average of the returns on the individual assets from which it is formed. We can use Equation 5.5 to find the portfolio return,  $k_p$ :

$$k_p = (w_1 \times k_1) = (w_2 \times k_2) + \dots + (w_n \times k_n) = \sum_{j=1}^n w_j \times k_j \quad (5.5)$$

where

$w_j$  = proportion of the portfolio's total dollar value represented by asset  $j$   
 $k_j$  = return on asset  $j$

Of course,  $\sum_{j=1}^n w_j = 1$ , which means that 100 percent of the portfolio's assets must be included in this computation.

The *standard deviation of a portfolio's returns* is found by applying the formula for the standard deviation of a single asset. Specifically, Equation 5.3 is used when the probabilities of the returns are known, and Equation 5.3a (from footnote 10) is applied when the outcomes are known and their related probabilities of occurrence are assumed to be equal.

### EXAMPLE ▼

Assume that we wish to determine the expected value and standard deviation of returns for portfolio XY, created by combining equal portions (50%) of assets X and Y. The forecasted returns of assets X and Y for each of the next 5 years (2004–2008) are given in columns 1 and 2, respectively, in part A of Table 5.7. In column 3, the weights of 50% for both assets X and Y along with their respective returns from columns 1 and 2 are substituted into Equation 5.5. Column 4 shows the results of the calculation—an expected portfolio return of 12% for each year, 2004 to 2008.

Furthermore, as shown in part B of Table 5.7, the expected value of these portfolio returns over the 5-year period is also 12% (calculated by using Equation 5.2a, in footnote 9). In part C of Table 5.7, portfolio XY's standard deviation is calculated to be 0% (using Equation 5.3a, in footnote 10). This value should not be surprising because the expected return each year is the same—12%. No variability is exhibited in the expected returns from year to year.

12. The portfolio of a firm, which would consist of its total assets, is not differentiated from the portfolio of an owner, which would probably contain a variety of different investment vehicles (i.e., assets). The differing characteristics of these two types of portfolios should become clear upon completion of Chapter 10.

**TABLE 5.7** Expected Return, Expected Value, and Standard Deviation of Returns for Portfolio XY

## A. Expected portfolio returns

Year	Forecasted return		Portfolio return calculation <sup>a</sup> (3)	Expected portfolio return, $k_p$ (4)
	Asset X (1)	Asset Y (2)		
2004	8%	16%	$(.50 \times 8\%) + (.50 \times 16\%) =$	12%
2005	10	14	$(.50 \times 10\%) + (.50 \times 14\%) =$	12
2006	12	12	$(.50 \times 12\%) + (.50 \times 12\%) =$	12
2007	14	10	$(.50 \times 14\%) + (.50 \times 10\%) =$	12
2008	16	8	$(.50 \times 16\%) + (.50 \times 8\%) =$	12

B. Expected value of portfolio returns, 2004–2008<sup>b</sup>

$$\bar{k}_p = \frac{12\% + 12\% + 12\% + 12\% + 12\%}{5} = \frac{60\%}{5} = \underline{12\%}$$

C. Standard deviation of expected portfolio returns<sup>c</sup>

$$\begin{aligned}\sigma_{k_p} &= \sqrt{\frac{(12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2}{5 - 1}} \\ &= \sqrt{\frac{0\% + 0\% + 0\% + 0\% + 0\%}{4}} \\ &= \sqrt{\frac{0}{4}} \% = \underline{0\%}\end{aligned}$$

<sup>a</sup>Using Equation 5.5.<sup>b</sup>Using Equation 5.2a found in footnote 9.<sup>c</sup>Using Equation 5.3a found in footnote 10.**correlation**

A statistical measure of the relationship between any two series of numbers representing data of any kind.

**positively correlated**

Describes two series that move in the same direction.

**negatively correlated**

Describes two series that move in opposite directions.

**Correlation**

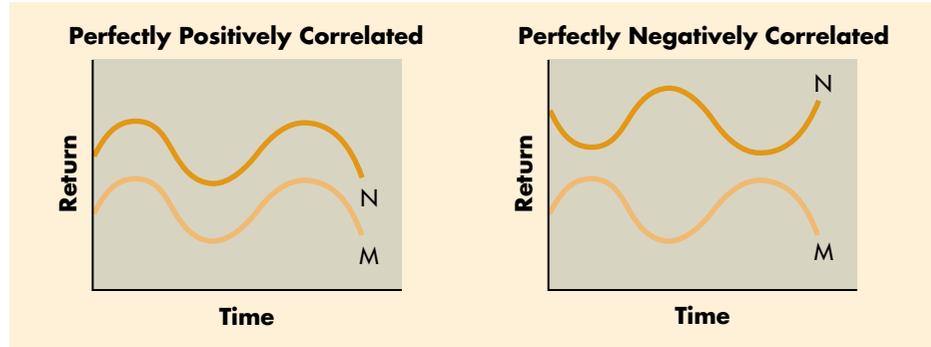
**Correlation** is a statistical measure of the relationship between any two series of numbers. The numbers may represent data of any kind, from returns to test scores. If two series move in the same direction, they are **positively correlated**. If the series move in opposite directions, they are **negatively correlated**.<sup>13</sup>

13. The general *long-term trends* of two series could be the same (both increasing or both decreasing) or different (one increasing, the other decreasing), and the correlation of their *short-term (point-to-point) movements* in both situations could be either positive or negative. In other words, the pattern of movement around the trends could be correlated independent of the actual relationship between the trends. Further clarification of this seemingly inconsistent behavior can be found in most basic statistics texts.

**FIGURE 5.5**

**Correlations**

The correlation between series M and series N



**correlation coefficient**  
A measure of the degree of correlation between two series.

**perfectly positively correlated**  
Describes two *positively* correlated series that have a correlation coefficient of +1.

**perfectly negatively correlated**  
Describes two *negatively* correlated series that have a correlation coefficient of -1.

**uncorrelated**  
Describes two series that lack any interaction and therefore have a correlation coefficient close to zero.

The degree of correlation is measured by the correlation coefficient, which ranges from +1 for perfectly positively correlated series to -1 for perfectly negatively correlated series. These two extremes are depicted for series M and N in Figure 5.5. The perfectly positively correlated series move exactly together; the perfectly negatively correlated series move in exactly opposite directions.

**Diversification**

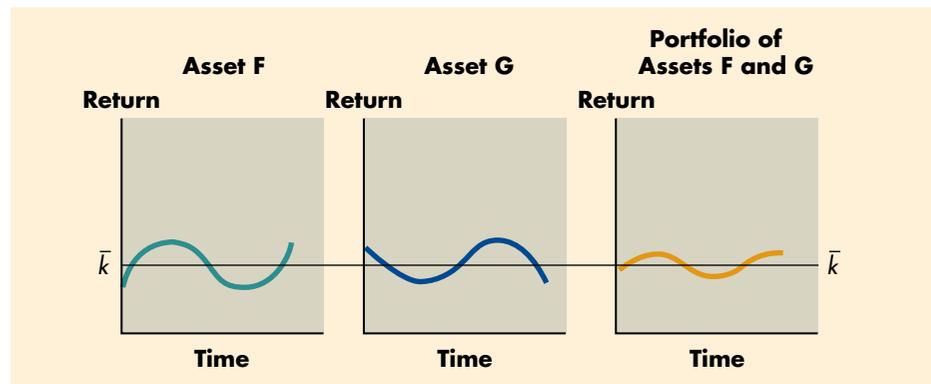
The concept of correlation is essential to developing an efficient portfolio. To reduce overall risk, it is best to combine, or add to the portfolio, assets that have a negative (or a low positive) correlation. Combining negatively correlated assets can reduce the overall variability of returns. Figure 5.6 shows that a portfolio containing the negatively correlated assets F and G, both of which have the same expected return,  $\bar{k}$ , also has that same return  $\bar{k}$  but has less risk (variability) than either of the individual assets. Even if assets are not negatively correlated, the lower the positive correlation between them, the lower the resulting risk.

Some assets are **uncorrelated**—that is, there is no interaction between their returns. Combining uncorrelated assets can reduce risk, not so effectively as combining negatively correlated assets, but more effectively than combining positively correlated assets. The correlation coefficient for uncorrelated assets is close to zero and acts as the midpoint between perfect positive and perfect negative correlation.

**FIGURE 5.6**

**Diversification**

Combining negatively correlated assets to diversify risk



The creation of a portfolio that combines two assets with perfectly positively correlated returns results in overall portfolio risk that at minimum equals that of the least risky asset and at maximum equals that of the most risky asset. However, a portfolio combining two assets with less than perfectly positive correlation *can* reduce total risk to a level below that of either of the components, which in certain situations may be zero. For example, assume that you manufacture machine tools. The business is very *cyclical*, with high sales when the economy is expanding and low sales during a recession. If you acquired another machine-tool company, with sales positively correlated with those of your firm, the combined sales would still be cyclical and risk would remain the same. Alternatively, however, you could acquire a sewing machine manufacturer, whose sales are *countercyclical*. It typically has low sales during economic expansion and high sales during recession (when consumers are more likely to make their own clothes). Combination with the sewing machine manufacturer, which has negatively correlated sales, should reduce risk.

**EXAMPLE** ▼ Table 5.8 presents the forecasted returns from three different assets—X, Y, and Z—over the next 5 years, along with their expected values and standard deviations. Each of the assets has an expected value of return of 12% and a standard

**TABLE 5.8 Forecasted Returns, Expected Values, and Standard Deviations for Assets X, Y, and Z and Portfolios XY and XZ**

Year	Assets			Portfolios	
	X	Y	Z	XY <sup>a</sup> (50%X + 50%Y)	XZ <sup>b</sup> (50%X + 50%Z)
2004	8%	16%	8%	12%	8%
2005	10	14	10	12	10
2006	12	12	12	12	12
2007	14	10	14	12	14
2008	16	8	16	12	16
<b>Statistics:<sup>c</sup></b>					
Expected value	12%	12%	12%	12%	12%
Standard deviation <sup>d</sup>	3.16%	3.16%	3.16%	0%	3.16%

<sup>a</sup>Portfolio XY, which consists of 50% of asset X and 50% of asset Y, illustrates *perfect negative correlation* because these two return streams behave in completely opposite fashion over the 5-year period. Its return values shown here were calculated in part A of Table 5.7.

<sup>b</sup>Portfolio XZ, which consists of 50% of asset X and 50% of asset Z, illustrates *perfect positive correlation* because these two return streams behave identically over the 5-year period. Its return values were calculated by using the same method demonstrated for portfolio XY in part A of Table 5.7.

<sup>c</sup>Because the probabilities associated with the returns are not given, the general equations, Equation 5.2a in footnote 9 and Equation 5.3a in footnote 10, were used to calculate expected values and standard deviations, respectively. Calculation of the expected value and standard deviation for portfolio XY is demonstrated in parts B and C, respectively, of Table 5.7.

<sup>d</sup>The portfolio standard deviations can be directly calculated from the standard deviations of the component assets with the following formula:

$$\sigma_{k_p} = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2r_{1,2}\sigma_1\sigma_2}$$

where  $w_1$  and  $w_2$  are the proportions of component assets 1 and 2,  $\sigma_1$  and  $\sigma_2$  are the standard deviations of component assets 1 and 2, and  $r_{1,2}$  is the correlation coefficient between the returns of component assets 1 and 2.

deviation of 3.16%. The assets therefore have equal return and equal risk. The return patterns of assets X and Y are perfectly negatively correlated. They move in exactly opposite directions over time. The returns of assets X and Z are perfectly positively correlated. They move in precisely the same direction. (*Note:* The returns for X and Z are identical.)<sup>14</sup>

**Portfolio XY** Portfolio XY (shown in Table 5.8) is created by combining equal portions of assets X and Y, the perfectly negatively correlated assets.<sup>15</sup> (Calculation of portfolio XY's annual expected returns, their expected value, and the standard deviation of expected portfolio returns was demonstrated in Table 5.7.) The risk in this portfolio, as reflected by its standard deviation, is reduced to 0%, whereas the expected return remains at 12%. Thus the combination results in the complete elimination of risk. Whenever assets are perfectly negatively correlated, an optimal combination (similar to the 50–50 mix in the case of assets X and Y) exists for which the resulting standard deviation will equal 0.

**Portfolio XZ** Portfolio XZ (shown in Table 5.8) is created by combining equal portions of assets X and Z, the perfectly positively correlated assets. The risk in this portfolio, as reflected by its standard deviation, is unaffected by this combination. Risk remains at 3.16%, and the expected return value remains at 12%. Because assets X and Z have the same standard deviation, the minimum and maximum standard deviations are the same (3.16%).

## Correlation, Diversification, Risk, and Return

**Hint** Remember, low correlation between two series of numbers is less positive and more negative—indicating greater dissimilarity of behavior of the two series.

In general, the lower the correlation between asset returns, the greater the potential diversification of risk. (This should be clear from the behaviors illustrated in Table 5.8.) For each pair of assets, there is a combination that will result in the lowest risk (standard deviation) possible. How much risk can be reduced by this combination depends on the degree of correlation. Many potential combinations (assuming divisibility) could be made, but only one combination of the infinite number of possibilities will minimize risk.

Three possible correlations—perfect positive, uncorrelated, and perfect negative—illustrate the effect of correlation on the diversification of risk and return. Table 5.9 summarizes the impact of correlation on the range of return and risk for various two-asset portfolio combinations. The table shows that as we move from perfect positive correlation to uncorrelated assets to perfect negative correlation, the ability to reduce risk is improved. Note that in no case will a portfolio of assets be riskier than the riskiest asset included in the portfolio.

14. Identical return streams are used in this example to permit clear illustration of the concepts, but it is *not* necessary for return streams to be identical for them to be perfectly positively correlated. Any return streams that move (i.e., vary) exactly together—regardless of the relative magnitude of the returns—are perfectly positively correlated.

15. For illustrative purposes it has been assumed that each of the assets—X, Y, and Z—can be divided up and combined with other assets to create portfolios. This assumption is made only to permit clear illustration of the concepts. The assets are not actually divisible.

**TABLE 5.9** Correlation, Return, and Risk for Various Two-Asset Portfolio Combinations

Correlation coefficient	Range of return	Range of risk
+1 (perfect positive)	Between returns of two assets held in isolation	Between risk of two assets held in isolation
0 (uncorrelated)	Between returns of two assets held in isolation	Between risk of most risky asset and an amount less than risk of least risky asset but greater than 0
-1 (perfect negative)	Between returns of two assets held in isolation	Between risk of most risky asset and 0

**EXAMPLE**

A firm has calculated the expected return and the risk for each of two assets—R and S.

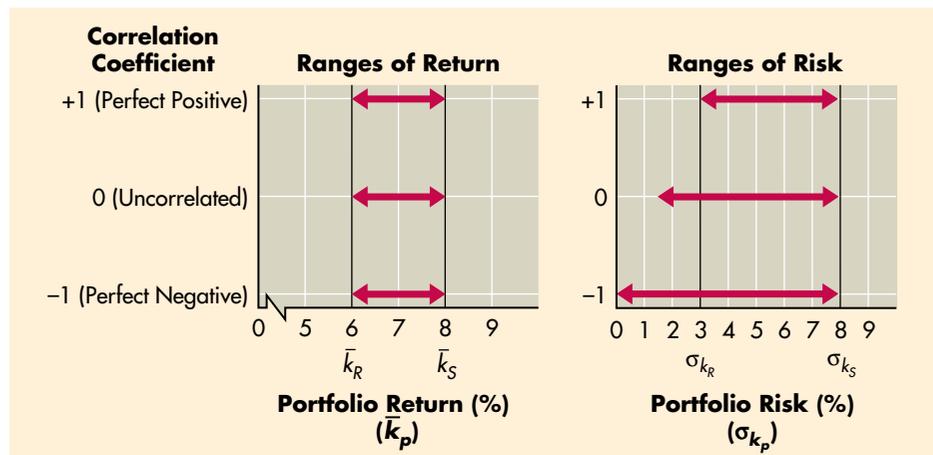
Asset	Expected return, $\bar{k}$	Risk (standard deviation), $\sigma$
R	6%	3%
S	8	8

Clearly, asset R is a lower-return, lower-risk asset than asset S.

To evaluate possible combinations, the firm considered three possible correlations—perfect positive, uncorrelated, and perfect negative. The results of the analysis are shown in Figure 5.7, using the ranges of return and risk noted above. In all cases, the return will range between the 6% return of R and the 8% return of S. The risk, on the other hand, ranges between the individual risks of R and S (from 3% to 8%) in the case of perfect positive correlation, from below 3% (the risk of R) and greater than 0% to 8% (the risk of S) in the uncorrelated case, and between 0% and 8% (the risk of S) in the perfectly negatively correlated case.

**FIGURE 5.7**

**Possible Correlations**  
Range of portfolio return ( $\bar{k}_p$ ) and risk ( $\sigma_{k_p}$ ) for combinations of assets R and S for various correlation coefficients



Note that *only in the case of perfect negative correlation can the risk be reduced to 0*. Also note that as the correlation becomes less positive and more negative (moving from the top of the figure down), the ability to reduce risk improves. The amount of risk reduction achieved depends on the proportions in which the assets are combined. Although determining the risk-minimizing combination is beyond the scope of this discussion, it is an important issue in developing portfolios of assets.

## International Diversification

The ultimate example of portfolio diversification involves including foreign assets in a portfolio. The inclusion of assets from countries with business cycles that are not highly correlated with the U.S. business cycle reduces the portfolio's responsiveness to market movements and to foreign currency fluctuations.

### Returns from International Diversification

Over long periods, returns from internationally diversified portfolios tend to be superior to those of purely domestic ones. This is particularly so if the U.S. economy is performing relatively poorly and the dollar is depreciating in value against most foreign currencies. At such times, the dollar returns to U.S. investors on a portfolio of foreign assets can be very attractive. However, over any single short or intermediate period, international diversification can yield subpar returns, particularly during periods when the dollar is appreciating in value relative to other currencies. When the U.S. currency gains in value, the dollar value of a foreign-currency-denominated portfolio of assets declines. Even if this portfolio yields a satisfactory return in local currency, the return to U.S. investors will be reduced when translated into dollars. Subpar local currency portfolio returns, coupled with an appreciating dollar, can yield truly dismal dollar returns to U.S. investors.

Overall, though, the logic of international portfolio diversification assumes that these fluctuations in currency values and relative performance will average out over long periods. Compared to similar, purely domestic portfolios, an internationally diversified portfolio will tend to yield a comparable return at a lower level of risk.

### Risks of International Diversification

U.S. investors should also be aware of the potential dangers of international investing. In addition to the risk induced by currency fluctuations, several other financial risks are unique to international investing. Most important is **political risk**, which arises from the possibility that a host government will take actions harmful to foreign investors or that political turmoil in a country will endanger investments there. Political risks are particularly acute in developing countries, where unstable or ideologically motivated governments may attempt to block return of profits by foreign investors or even seize (nationalize) their assets in the host country. An example of political risk was the heightened concern after Desert Storm in the early 1990s that Saudi Arabian fundamentalists would take over and nationalize the U.S. oil facilities located there.

#### political risk

Risk that arises from the possibility that a host government will take actions harmful to foreign investors or that political turmoil in a country will endanger investments there.

Even where governments do not impose exchange controls or seize assets, international investors may suffer if a shortage of hard currency prevents payment of dividends or interest to foreigners. When governments are forced to allocate scarce foreign exchange, they rarely give top priority to the interests of foreign investors. Instead, hard-currency reserves are typically used to pay for necessary imports such as food, medicine, and industrial materials and to pay interest on the government's debt. Because most of the debt of developing countries is held by banks rather than individuals, foreign investors are often badly harmed when a country experiences political or economic problems.

## Review Questions

- 5–8 What is an *efficient portfolio*? How can the return and standard deviation of a portfolio be determined?
- 5–9 Why is the *correlation* between asset returns important? How does diversification allow risky assets to be combined so that the risk of the portfolio is less than the risk of the individual assets in it?
- 5–10 How does international diversification enhance risk reduction? When might international diversification result in subpar returns? What are *political risks*, and how do they affect international diversification?



## 5.4 Risk and Return: The Capital Asset Pricing Model (CAPM)

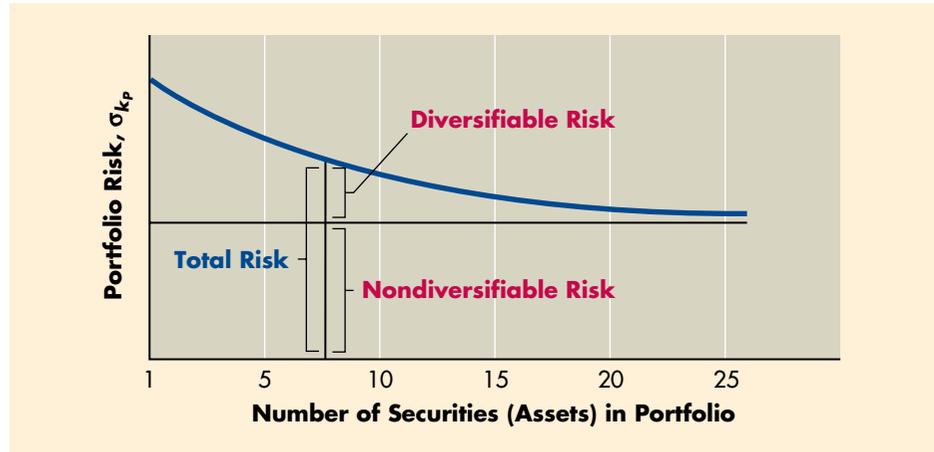
**capital asset pricing model (CAPM)**  
The basic theory that links risk and return for all assets.

The most important aspect of risk is the *overall risk* of the firm as viewed by investors in the marketplace. Overall risk significantly affects investment opportunities and—even more important—the owners' wealth. The basic theory that links risk and return for all assets is the **capital asset pricing model (CAPM)**.<sup>16</sup> We will use CAPM to understand the basic risk–return tradeoffs involved in all types of financial decisions.

### Types of Risk

To understand the basic types of risk, consider what happens to the risk of a portfolio consisting of a single security (asset), to which we add securities randomly selected from, say, the population of all actively traded securities. Using

16. The initial development of this theory is generally attributed to William F. Sharpe, "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk," *Journal of Finance* 19 (September 1964), pp. 425–442, and John Lintner, "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets," *Review of Economics and Statistics* 47 (February 1965), pp. 13–37. A number of authors subsequently advanced, refined, and tested this now widely accepted theory.

**FIGURE 5.8****Risk Reduction**  
Portfolio risk and diversification

the standard deviation of return,  $\sigma_{k_p}$ , to measure the total portfolio risk, Figure 5.8 depicts the behavior of the total portfolio risk ( $y$  axis) as more securities are added ( $x$  axis). With the addition of securities, the total portfolio risk declines, as a result of the effects of diversification, and tends to approach a lower limit. Research has shown that, on average, most of the risk-reduction benefits of diversification can be gained by forming portfolios containing 15 to 20 randomly selected securities.<sup>17</sup>

The **total risk** of a security can be viewed as consisting of two parts:

$$\text{Total security risk} = \text{Nondiversifiable risk} + \text{Diversifiable risk} \quad (5.6)$$

**total risk**

The combination of a security's nondiversifiable and diversifiable risk.

**diversifiable risk**

The portion of an asset's risk that is attributable to firm-specific, random causes; can be eliminated through diversification. Also called *unsystematic risk*.

**nondiversifiable risk**

The relevant portion of an asset's risk attributable to market factors that affect all firms; cannot be eliminated through diversification. Also called *systematic risk*.

**Diversifiable risk** (sometimes called *unsystematic risk*) represents the portion of an asset's risk that is associated with random causes that can be eliminated through diversification. It is attributable to firm-specific events, such as strikes, lawsuits, regulatory actions, and loss of a key account. **Nondiversifiable risk** (also called *systematic risk*) is attributable to market factors that affect all firms; it cannot be eliminated through diversification. (It is the shareholder-specific *market risk* described in Table 5.1.) Factors such as war, inflation, international incidents, and political events account for nondiversifiable risk.

Because any investor can create a portfolio of assets that will eliminate virtually all diversifiable risk, *the only relevant risk is nondiversifiable risk*. Any investor or firm therefore must be concerned solely with nondiversifiable risk. The measurement of nondiversifiable risk is thus of primary importance in selecting assets with the most desired risk–return characteristics.

17. See, for example, W. H. Wagner and S. C. Lau, "The Effect of Diversification on Risk," *Financial Analysts Journal* 26 (November–December 1971), pp. 48–53, and Jack Evans and Stephen H. Archer, "Diversification and the Reduction of Dispersion: An Empirical Analysis," *Journal of Finance* 23 (December 1968), pp. 761–767. A more recent study, Gerald D. Newbould and Percy S. Poon, "The Minimum Number of Stocks Needed for Diversification," *Financial Practice and Education* (Fall 1993), pp. 85–87, shows that because an investor holds but one of a large number of possible  $x$ -security portfolios, it is unlikely that he or she will experience the average outcome. As a consequence, the study suggests that a minimum of 40 stocks is needed to diversify a portfolio fully. This study tends to support the widespread popularity of mutual fund investments.

## The Model: CAPM

The capital asset pricing model (CAPM) links nondiversifiable risk and return for all assets. We will discuss the model in five sections. The first deals with the beta coefficient, which is a measure of nondiversifiable risk. The second section presents an equation of the model itself, and the third graphically describes the relationship between risk and return. The fourth section discusses the effects of changes in inflationary expectations and risk aversion on the relationship between risk and return. The final section offers some comments on the CAPM.

### Beta Coefficient

#### beta coefficient ( $b$ )

A relative measure of nondiversifiable risk. An *index* of the degree of movement of an asset's return in response to a change in the market return.

#### market return

The return on the market portfolio of all traded securities.

The **beta coefficient**,  $b$ , is a relative measure of nondiversifiable risk. It is an *index* of the degree of movement of an asset's return in response to a change in the *market return*. An asset's historical returns are used in finding the asset's beta coefficient. The **market return** is the return on the market portfolio of all traded securities. The *Standard & Poor's 500 Stock Composite Index* or some similar stock index is commonly used as the market return. Betas for actively traded stocks can be obtained from a variety of sources, but you should understand how they are derived and interpreted and how they are applied to portfolios.

**Deriving Beta from Return Data** An asset's historical returns are used in finding the asset's beta coefficient. Figure 5.9 plots the relationship between the returns of two assets—R and S—and the market return. Note that the horizontal ( $x$ ) axis measures the historical market returns and that the vertical ( $y$ ) axis measures the individual asset's historical returns. The first step in deriving beta involves plotting the coordinates for the market return and asset returns from various points in time. Such annual “market return–asset return” coordinates are shown *for asset S only* for the years 1996 through 2003. For example, in 2003, asset S's return was 20 percent when the market return was 10 percent. By use of statistical techniques, the “characteristic line” that best explains the relationship between the asset return and the market return coordinates is fit to the data points.<sup>18</sup> The slope of this line is *beta*. The beta for asset R is about .80 and that

18. The empirical measurement of beta is approached by using *least-squares regression analysis* to find the regression coefficient ( $b_j$ ) in the equation for the “characteristic line”:

$$k_j = a_j + b_j k_m + e_j$$

where

$k_j$  = return on asset  $j$

$a_j$  = intercept

$b_j$  = beta coefficient, which equals  $\frac{\text{Cov}(k_j, k_m)}{\sigma_m^2}$

where

$\text{Cov}(k_j, k_m)$  = covariance of the return on asset  $j$ ,  $k_j$ , and the return on the market portfolio,  $k_m$

$\sigma_m^2$  = variance of the return on the market portfolio

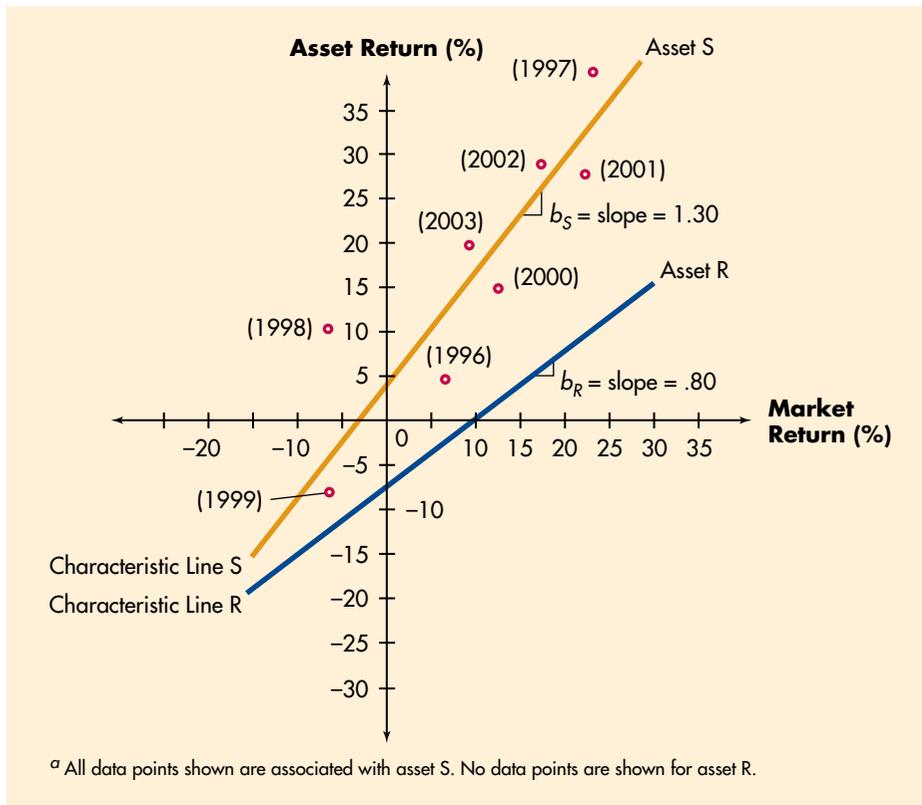
$k_m$  = required rate of return on the market portfolio of securities

$e_j$  = random error term, which reflects the diversifiable, or unsystematic, risk of asset  $j$

The calculations involved in finding betas are somewhat rigorous. If you want to know more about these calculations, consult an advanced managerial finance or investments text.

**FIGURE 5.9****Beta Derivation<sup>a</sup>**

Graphical derivation of beta for assets R and S



for asset S is about 1.30. Asset S's higher beta (steeper characteristic line slope) indicates that its return is more responsive to changing market returns. *Therefore asset S is more risky than asset R.*<sup>19</sup>

**Hint** Remember that published betas are calculated using historical data. When investors use beta for decision making, they should recognize that past performance relative to the market average may not accurately predict future performance.

**Interpreting Betas** The beta coefficient for the market is considered to be equal to 1.0. All other betas are viewed in relation to this value. Asset betas may be positive or negative, but positive betas are the norm. The majority of beta coefficients fall between .5 and 2.0. The return of a stock that is half as responsive as the market ( $b = .5$ ) is expected to change by 1/2 percent for each 1 percent change in the return of the market portfolio. A stock that is twice as responsive as the market ( $b = 2.0$ ) is expected to experience a 2 percent change in its return for each 1 percent change in the return of the market portfolio. Table 5.10 provides various beta values and their interpretations. Beta coefficients for actively traded stocks can be obtained from published sources such as *Value Line Investment Survey*, via the Internet, or through brokerage firms. Betas for some selected stocks are given in Table 5.11.

**Portfolio Betas** The beta of a portfolio can be easily estimated by using the betas of the individual assets it includes. Letting  $w_j$  represent the proportion of

19. The values of beta also depend on the time interval used for return calculations and on the number of returns used in the regression analysis. In other words, betas calculated using monthly returns would not necessarily be comparable to those calculated using a similar number of daily returns.

**TABLE 5.10** Selected Beta Coefficients and Their Interpretations

Beta	Comment	Interpretation
2.0	Move in same direction as market	Twice as responsive as the market
1.0		Same response as the market
.5		Only half as responsive as the market
0		Unaffected by market movement
-.5	Move in opposite direction to market	Only half as responsive as the market
-1.0		Same response as the market
-2.0		Twice as responsive as the market

**TABLE 5.11** Beta Coefficients for Selected Stocks (March 8, 2002)

Stock	Beta	Stock	Beta
Amazon.com	1.95	Int'l Business Machines	1.05
Anheuser-Busch	.60	Merrill Lynch & Co.	1.85
Bank One Corp.	1.25	Microsoft	1.20
Daimler Chrysler AG	1.25	NIKE, Inc.	.90
Disney	1.05	PepsiCo, Inc.	.70
eBay	2.20	Qualcomm	1.30
Exxon Mobil Corp.	.80	Sempra Energy	.60
Gap (The), Inc.	1.60	Wal-Mart Stores	1.15
General Electric	1.30	Xerox	1.25
Intel	1.30	Yahoo! Inc.	2.00

Source: Value Line Investment Survey (New York: Value Line Publishing, March 8, 2002).

the portfolio's total dollar value represented by asset  $j$ , and letting  $b_j$  equal the beta of asset  $j$ , we can use Equation 5.7 to find the portfolio beta,  $b_p$ :

$$b_p = (w_1 \times b_1) + (w_2 \times b_2) + \cdots + (w_n \times b_n) = \sum_{j=1}^n w_j \times b_j \quad (5.7)$$

Of course,  $\sum_{j=1}^n w_j = 1$ , which means that 100 percent of the portfolio's assets must be included in this computation.

Portfolio betas are interpreted in the same way as the betas of individual assets. They indicate the degree of responsiveness of the *portfolio's* return to changes in the market return. For example, when the market return increases by 10 percent, a portfolio with a beta of .75 will experience a 7.5 percent increase in its return ( $.75 \times 10\%$ ); a portfolio with a beta of 1.25 will experience a 12.5 percent increase in its return ( $1.25 \times 10\%$ ). Clearly, a portfolio containing mostly low-beta assets will have a low beta, and one containing mostly high-beta assets will have a high beta.

**Hint** Mutual fund managers are key users of the portfolio beta and return concepts. They are continually evaluating what would happen to the fund's beta and return if the securities of a particular firm were added to or deleted from the fund's portfolio.

**TABLE 5.12** Austin Fund's Portfolios V and W

Asset	Portfolio V		Portfolio W	
	Proportion	Beta	Proportion	Beta
1	.10	1.65	.10	.80
2	.30	1.00	.10	1.00
3	.20	1.30	.20	.65
4	.20	1.10	.10	.75
5	.20	1.25	.50	1.05
Totals	<u>1.00</u>		<u>1.00</u>	

**EXAMPLE** ▼ The Austin Fund, a large investment company, wishes to assess the risk of two portfolios it is considering assembling—V and W. Both portfolios contain five assets, with the proportions and betas shown in Table 5.12. The betas for the two portfolios,  $b_v$  and  $b_w$ , can be calculated by substituting data from the table into Equation 5.7:

$$b_v = (.10 \times 1.65) + (.30 \times 1.00) + (.20 \times 1.30) + (.20 \times 1.10) + (.20 \times 1.25) \\ = .165 + .300 + .260 + .220 + .250 = 1.195 \approx \underline{1.20}$$

$$b_w = (.10 \times .80) + (.10 \times 1.00) + (.20 \times .65) + (.10 \times .75) + (.50 \times 1.05) \\ = .080 + .100 + .130 + .075 + .525 = \underline{.91}$$

Portfolio V's beta is 1.20, and portfolio W's is .91. These values make sense, because portfolio V contains relatively high-beta assets, and portfolio W contains relatively low-beta assets. Clearly, portfolio V's returns are more responsive to changes in market returns and are therefore more risky than portfolio W's.

### The Equation

Using the beta coefficient to measure nondiversifiable risk, the *capital asset pricing model (CAPM)* is given in Equation 5.8:

$$k_j = R_F + [b_j \times (k_m - R_F)] \quad (5.8)$$

where

$k_j$  = required return on asset  $j$

$R_F$  = risk-free rate of return, commonly measured by the return on a U.S. Treasury bill

$b_j$  = beta coefficient or index of nondiversifiable risk for asset  $j$

$k_m$  = market return; return on the market portfolio of assets

**risk-free rate of interest,  $R_F$**   
The required return on a *risk-free asset*, typically a 3-month U.S. Treasury bill.

**U.S. Treasury bills (T-bills)**  
Short-term IOUs issued by the U.S. Treasury; considered the *risk-free asset*.

The CAPM can be divided into two parts: (1) **risk-free of interest,  $R_F$** , which is the required return on a *risk-free asset*, typically a 3-month U.S. Treasury bill (T-bill), a short-term IOU issued by the U.S. Treasury, and (2) the *risk premium*. These are, respectively, the two elements on either side of the plus sign in Equation 5.8. The  $(k_m - R_F)$  portion of the risk premium is called the *market risk pre-*

*mium*, because it represents the premium the investor must receive for taking the average amount of risk associated with holding the market portfolio of assets.<sup>20</sup>

**Historical Risk Premiums** Using the historical return data for selected security investments for the 1926–2000 period shown in Table 5.2, we can calculate the risk premiums for each investment category. The calculation (consistent with Equation 5.8) involves merely subtracting the historical U.S. Treasury bill’s average return from the historical average return for a given investment:

Investment	Risk premium <sup>a</sup>
Large-company stocks	13.0% – 3.9% = 9.1%
Small company stocks	17.3 – 3.9 = 13.4
Long-term corporate bonds	6.0 – 3.9 = 2.1
Long-term government bonds	5.7 – 3.9 = 1.8
U.S. Treasury bills	3.9 – 3.9 = 0.0

<sup>a</sup>Return values obtained from Table 5.2.

Reviewing the risk premiums calculated above, we can see that the risk premium is highest for small-company stocks, followed by large-company stocks, long-term corporate bonds, and long-term government bonds. This outcome makes sense intuitively because small-company stocks are riskier than large-company stocks, which are riskier than long-term corporate bonds (equity is riskier than debt investment). Long-term corporate bonds are riskier than long-term government bonds (because the government is less likely to renege on debt). And of course, U.S. Treasury bills, because of their lack of default risk and their very short maturity, are virtually risk-free, as indicated by their lack of any risk premium.

**EXAMPLE ▼** Benjamin Corporation, a growing computer software developer, wishes to determine the required return on an asset Z, which has a beta of 1.5. The risk-free rate of return is 7%; the return on the market portfolio of assets is 11%. Substituting  $b_z = 1.5$ ,  $R_F = 7\%$ , and  $k_m = 11\%$  into the capital asset pricing model given in Equation 5.8 yields a required return of

$$k_z = 7\% + [1.5 \times (11\% - 7\%)] = 7\% + 6\% = \underline{13\%}$$

▲ The market risk premium of 4% (11% – 7%), when adjusted for the asset’s index of risk (beta) of 1.5, results in a risk premium of 6% (1.5 × 4%). That risk premium, when added to the 7% risk-free rate, results in a 13% required return.

Other things being equal, *the higher the beta, the higher the required return, and the lower the beta, the lower the required return.*

20. Although CAPM has been widely accepted, a broader theory, *arbitrage pricing theory (APT)*, first described by Stephen A. Ross, “The Arbitrage Theory of Capital Asset Pricing,” *Journal of Economic Theory* (December 1976), pp. 341–360, has received a great deal of attention in the financial literature. The theory suggests that the risk premium on securities may be better explained by a number of factors underlying and in place of the market return used in CAPM. The CAPM in effect can be viewed as being derived from APT. Although testing of APT theory confirms the importance of the market return, it has thus far failed to identify other risk factors clearly. As a result of this failure, as well as APT’s lack of practical acceptance and usage, we concentrate our attention here on CAPM.

### The Graph: The Security Market Line (SML)

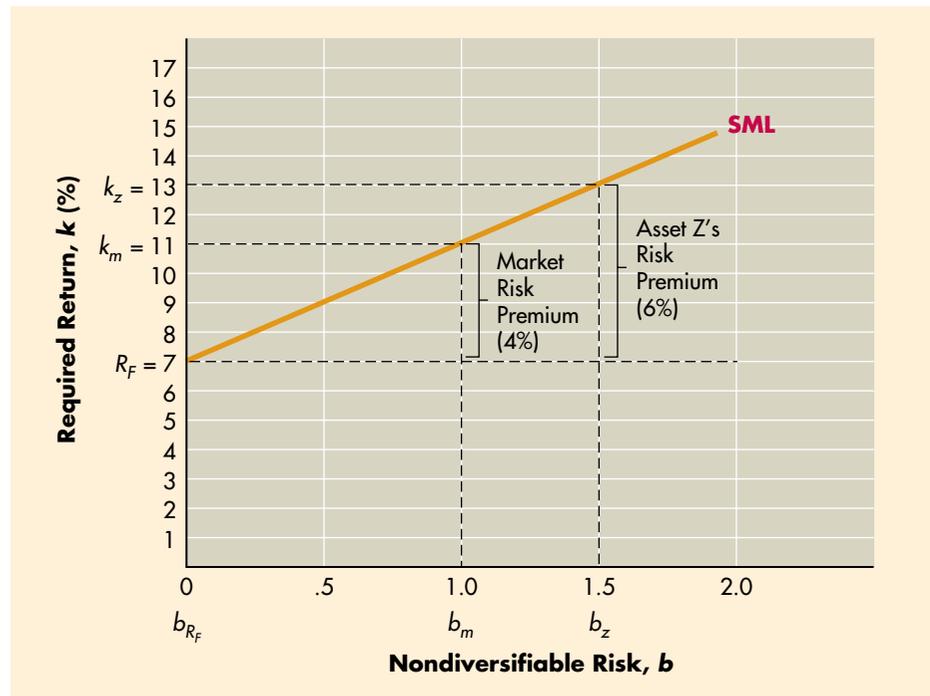
**security market line (SML)**  
 The depiction of the *capital asset pricing model (CAPM)* as a graph that reflects the required return in the marketplace for each level of nondiversifiable risk (beta).

When the capital asset pricing model (Equation 5.8) is depicted graphically, it is called the **security market line (SML)**. The SML will, in fact, be a straight line. It reflects the required return in the marketplace for each level of nondiversifiable risk (beta). In the graph, risk as measured by beta,  $b$ , is plotted on the  $x$  axis, and required returns,  $k$ , are plotted on the  $y$  axis. The risk–return tradeoff is clearly represented by the SML.

**EXAMPLE**

In the preceding example for Benjamin Corporation, the risk-free rate,  $R_F$ , was 7%, and the market return,  $k_m$ , was 11%. The SML can be plotted by using the two sets of coordinates for the betas associated with  $R_F$  and  $k_m$ ,  $b_{R_F}$  and  $b_m$  (that is,  $b_{R_F} = 0$ ,<sup>21</sup>  $R_F = 7\%$ ; and  $b_m = 1.0$ ,  $k_m = 11\%$ ). Figure 5.10 presents the resulting security market line. As traditionally shown, the security market line in Figure 5.10 presents the required return associated with all positive betas. The market risk premium of 4% ( $k_m$  of 11% –  $R_F$  of 7%) has been highlighted. For a beta for asset Z,  $b_z$ , of 1.5, its corresponding required return,  $k_z$ , is 13%. Also shown in the figure is asset Z’s risk premium of 6% ( $k_z$  of 13% –  $R_F$  of 7%). It should be clear that for assets with betas greater than 1, the risk premium is greater than that for the market; for assets with betas less than 1, the risk premium is less than that for the market.

**FIGURE 5.10**  
**Security Market Line**  
 Security market line (SML) with Benjamin Corporation’s asset Z data shown



21. Because  $R_F$  is the rate of return on a risk-free asset, the beta associated with the risk-free asset,  $b_{R_F}$ , would equal 0. The 0 beta on the risk-free asset reflects not only its absence of risk but also that the asset’s return is unaffected by movements in the market return.

### Shifts in the Security Market Line

The security market line is not stable over time, and shifts in the security market line can result in a change in required return. The position and slope of the SML are affected by two major forces—inflationary expectations and risk aversion—which are analyzed next.<sup>22</sup>

**Changes in Inflationary Expectations** Changes in inflationary expectations affect the risk-free rate of return,  $R_F$ . The equation for the risk-free rate of return is

$$R_F = k^* + IP \quad (5.9)$$

This equation shows that, assuming a constant real rate of interest,  $k^*$ , changes in inflationary expectations, reflected in an inflation premium,  $IP$ , will result in corresponding changes in the risk-free rate. Therefore, a change in inflationary expectations that results from events such as international trade embargoes or major changes in Federal Reserve policy will result in a shift in the SML. Because the risk-free rate is a basic component of all rates of return, any change in  $R_F$  will be reflected in *all* required rates of return.

Changes in inflationary expectations result in parallel shifts in the SML in direct response to the magnitude and direction of the change. This effect can best be illustrated by an example.

#### EXAMPLE ▼

In the preceding example, using CAPM, the required return for asset Z,  $k_Z$ , was found to be 13%. Assuming that the risk-free rate of 7% includes a 2% real rate of interest,  $k^*$ , and a 5% inflation premium,  $IP$ , then Equation 5.9 confirms that

$$R_F = 2\% + 5\% = 7\%$$

Now assume that recent economic events have resulted in an *increase of 3% in inflationary expectations, raising the inflation premium to 8% ( $IP_1$ )*. As a result, all returns likewise rise by 3%. In this case, the new returns (noted by subscript 1) are

$$R_{F_1} = 10\% \text{ (rises from 7\% to 10\%)}$$

$$k_{m_1} = 14\% \text{ (rises from 11\% to 14\%)}$$

Substituting these values, along with asset Z's beta ( $b_Z$ ) of 1.5, into the CAPM (Equation 5.8), we find that asset Z's new required return ( $k_{Z_1}$ ) can be calculated:

$$k_{Z_1} = 10\% + [1.5 \times (14\% - 10\%)] = 10\% + 6\% = \underline{\underline{16\%}}$$

Comparing  $k_{Z_1}$  of 16% to  $k_Z$  of 13%, we see that the change of 3% in asset Z's required return exactly equals the change in the inflation premium. The same 3% increase results for all assets.

22. A firm's beta can change over time as a result of changes in the firm's asset mix, in its financing mix, or in external factors not within management's control, such as earthquakes, toxic spills, and so on. The impacts of changes in beta on value are discussed in Chapter 7.

**FIGURE 5.11**

**Inflation Shifts SML**  
Impact of increased inflationary expectations on the SML

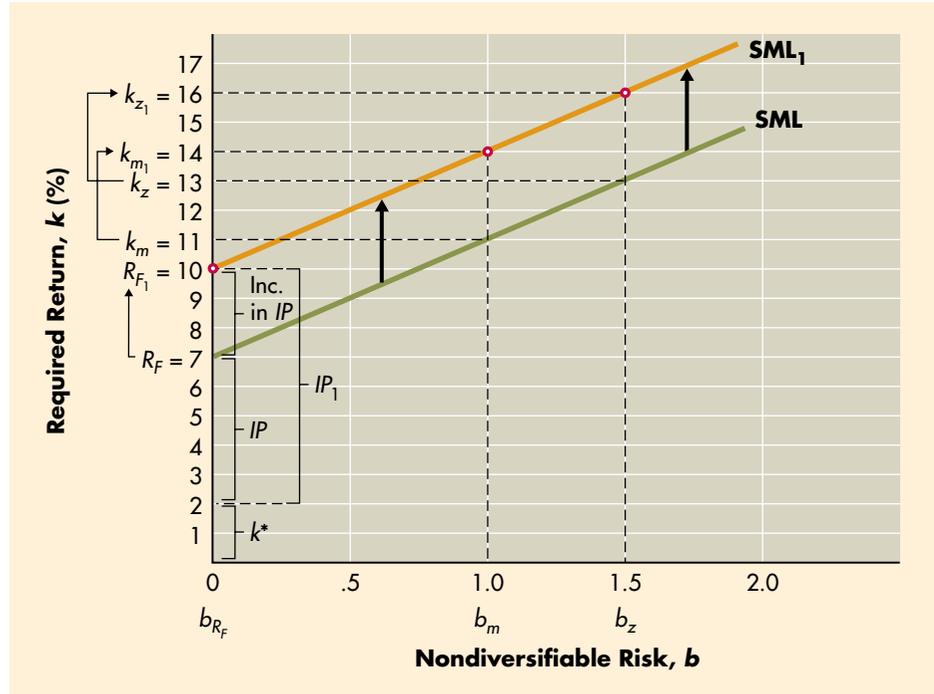


Figure 5.11 depicts the situation just described. It shows that the 3% increase in inflationary expectations results in a parallel shift upward of 3% in the SML. Clearly, the required returns on all assets rise by 3%. Note that the rise in the inflation premium from 5% to 8% ( $IP$  to  $IP_1$ ) causes the risk-free rate to rise from 7% to 10% ( $R_F$  to  $R_{F_1}$ ) and the market return to increase from 11% to 14% ( $k_m$  to  $k_{m_1}$ ). The security market line therefore shifts upward by 3% ( $SML$  to  $SML_1$ ), causing the required return on all risky assets, such as asset Z, to rise by 3%. It should now be clear that *a given change in inflationary expectations will be fully reflected in a corresponding change in the returns of all assets, as reflected graphically in a parallel shift of the SML.*

**Changes in Risk Aversion** The slope of the security market line reflects the general risk preferences of investors in the marketplace. As discussed earlier and shown in Figure 5.1, most investors are risk-averse—they require increased returns for increased risk. This positive relationship between risk and return is graphically represented by the SML, which depicts the relationship between nondiversifiable risk as measured by beta ( $x$  axis) and the required return ( $y$  axis). The slope of the SML reflects the degree of risk aversion: *the steeper its slope, the greater the degree of risk aversion*, because a higher level of return will be required for each level of risk as measured by beta. In other words, *risk premiums increase with increasing risk avoidance.*

Changes in risk aversion, and therefore shifts in the SML, result from changing preferences of investors, which generally result from economic, political, and social events. Examples of events that *increase* risk aversion include a stock mar-

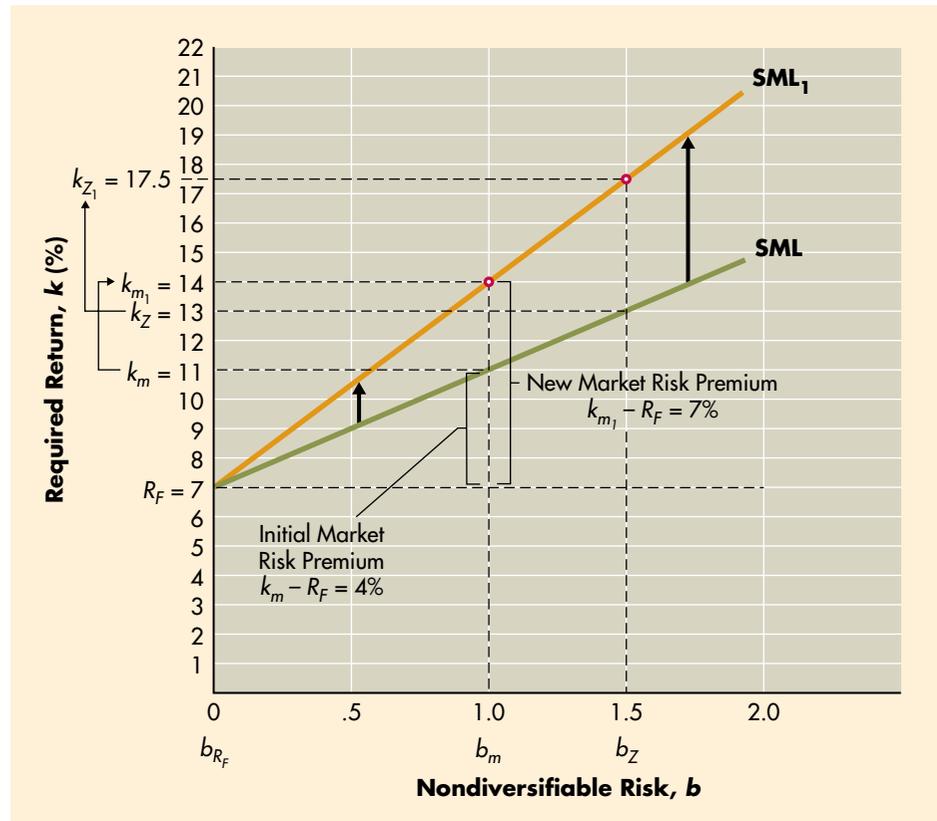
ket crash, assassination of a key political leader, and the outbreak of war. In general, widely accepted expectations of hard times ahead tend to cause investors to become more risk-averse, requiring higher returns as compensation for accepting a given level of risk. The impact of increased risk aversion on the SML can best be demonstrated by an example.

**EXAMPLE** In the preceding examples, the SML in Figure 5.10 reflected a risk-free rate ( $R_F$ ) of 7%, a market return ( $k_m$ ) of 11%, a market risk premium ( $k_m - R_F$ ) of 4%, and a required return on asset Z ( $k_Z$ ) of 13% with a beta ( $b_Z$ ) of 1.5. Assume that recent economic events have made investors more risk-averse, causing a new higher market return ( $k_{m_1}$ ) of 14%. Graphically, this change would cause the SML to shift upward as shown in Figure 5.12, causing a new market risk premium ( $k_{m_1} - R_F$ ) of 7%. As a result, the required return on all risky assets will increase. For asset Z, with a beta of 1.5, the new required return ( $k_{Z_1}$ ) can be calculated by using CAPM (Equation 5.8):

$$k_{Z_1} = 7\% + [1.5 \times (14\% - 7\%)] = 7\% + 10.5\% = \underline{17.5\%}$$

This value can be seen on the new security market line ( $SML_1$ ) in Figure 5.12. Note that although asset Z's risk, as measured by beta, did not change, its required return has increased because of the increased risk aversion reflected in

**FIGURE 5.12**  
**Risk Aversion Shifts SML**  
 Impact of increased risk aversion on the SML



**FOCUS ON PRACTICE** What's at Risk? VAR Has the Answer

Financial managers, always on the lookout for new ways to measure and manage risk, have added *value-at-risk (VAR)* techniques to their repertoire. VAR is a statistical measure of risk exposure that reflects the potential loss from an unlikely, adverse event in a normal, everyday market environment. It predicts the drop in a company's value that will occur if things go wrong by calculating the financial risk in the future market value of a portfolio of assets, liabilities, and equity.

First used by banks and brokerage firms to measure the risk of market movements, VAR now has proponents among nonfinancial companies such as **Xerox**, **General Motors**, and **GTE**. Unlike other risk tools that measure risk using standard deviation, VAR is stated in currency units: for example, VAR

would represent an amount, let's call it  $D$  dollars, where the chance of losing more than  $D$  dollars is, say, 1 in 50 over some future time interval, perhaps a week.

VAR shows companies whether they are properly diversified and also whether they have sufficient capital. Among its other benefits, it tells managers whether their actions are too cautious, identifies risk trouble spots that might not be caught, and provides a way to compare business units that measure performance differently for internal reporting.

For example, a bank could take a diverse portfolio of financial assets and calculate price swings by measuring performance on specific days in the past. Plotting the percentage gain or loss for hundreds of days would reveal the

value at risk of that portfolio. If it was riskier than previously thought, traders could take corrective action—selling a particular type of security, for example—to reduce risk.

Like any quantitative model, VAR has its limitations. Perhaps its biggest drawback is its reliance on historical patterns that may not hold true in the future.

*Sources:* Steve Bergsman, "Delivering the Risk Management Goods," *Treasury & Risk Management*, downloaded from [www.treasuryandrisk.com/trmtechguide/article13.cgi](http://www.treasuryandrisk.com/trmtechguide/article13.cgi); Peter Coy, "Taking the Angst Out of Taking a Gamble," *Business Week* (July 14, 1997), pp. 52–53; and Paul Hom and Ron Tonuzi, "Value-at-Risk: Safety Net or Abyss?" *Treasury & Risk Management* (November/December 1998), downloaded from [www.cfonet.com](http://www.cfonet.com); Barry Schachter, "An Irreverent Guide to Value at Risk," *All About Value-at-Risk* (Web site), downloaded from [www.gloriamundi.com](http://www.gloriamundi.com).

the market risk premium. It should now be clear that *greater risk aversion results in higher required returns for each level of risk. Similarly, a reduction in risk aversion causes the required return for each level of risk to decline.*

**Some Comments on CAPM**

The capital asset pricing model generally relies on historical data. The betas may or may not actually reflect the *future* variability of returns. Therefore, the required returns specified by the model can be viewed only as rough approximations. Users of betas commonly make subjective adjustments to the historically determined betas to reflect their expectations of the future.

The CAPM was developed to explain the behavior of security prices and provide a mechanism whereby investors could assess the impact of a proposed security investment on their portfolio's overall risk and return. It is based on an assumed **efficient market** with the following characteristics: many small investors, all having the same information and expectations with respect to securities; no restrictions on investment, no taxes, and no transaction costs; and rational investors, who view securities similarly and are risk-averse, preferring higher returns and lower risk.

Although the perfect world of the efficient market appears to be unrealistic, studies have provided support for the existence of the expectational relationship

**efficient market**

A market with the following characteristics: many small investors, all having the same information and expectations with respect to securities; no restrictions on investment, no taxes, and no transaction costs; and rational investors, who view securities similarly and are risk-averse, preferring higher returns and lower risk.

described by CAPM in active markets such as the New York Stock Exchange.<sup>23</sup> In the case of real corporate assets, such as plant and equipment, research thus far has failed to prove the general applicability of CAPM because of indivisibility, relatively large size, limited number of transactions, and absence of an efficient market for such assets.

Despite the limitations of CAPM, it provides a useful conceptual framework for evaluating and linking risk and return. An awareness of this tradeoff and an attempt to consider risk as well as return in financial decision making should help financial managers achieve their goals.

### Review Questions

- 5–11 How are total risk, nondiversifiable risk, and diversifiable risk related? Why is nondiversifiable risk the *only relevant risk*?
- 5–12 What risk does *beta* measure? How can you find the beta of a portfolio?
- 5–13 Explain the meaning of each variable in the *capital asset pricing model (CAPM)* equation. What is the *security market line (SML)*?
- 5–14 What impact would the following changes have on the security market line and therefore on the required return for a given level of risk? (a) An *increase* in inflationary expectations. (b) Investors become *less* risk-averse.
- 5–15 Why do financial managers have some difficulty applying CAPM in financial decision making? Generally, what benefit does CAPM provide them?

## SUMMARY

### FOCUS ON VALUE

A firm's risk and expected return directly affect its share price. As we shall see in Chapter 7, risk and return are the two key determinants of the firm's value. It is therefore the financial manager's responsibility to assess carefully the risk and return of all major decisions in order to make sure that the expected returns justify the level of risk being introduced.

The way the financial manager can expect to achieve **the firm's goal of increasing its share price** (and thereby benefiting its owners) is to take only those actions that earn returns at least commensurate with their risk. Clearly, financial managers need to recognize, measure, and evaluate risk–return tradeoffs in order to ensure that their decisions contribute to the creation of value for owners.

23. A study by Eugene F. Fama and Kenneth R. French, "The Cross-Section of Expected Stock Returns," *Journal of Finance* 47 (June 1992), pp. 427–465, raised serious questions about the validity of CAPM. The study failed to find a significant relationship between the *historical* betas and *historical* returns on over 2,000 stocks during 1963–1990. In other words, it found that the magnitude of a stock's *historical* beta had no relationship to the level of its *historical* return. Although Fama and French's study continues to receive attention, CAPM has not been abandoned because its rejection as a *historical* model fails to discredit its validity as an *expectational* model. Therefore, in spite of this challenge, CAPM continues to be viewed as a logical and useful framework—both conceptually and operationally—for linking *expected* nondiversifiable risk and return.

## REVIEW OF LEARNING GOALS

**LG1 Understand the meaning and fundamentals of risk, return, and risk preferences.** Risk is the chance of loss or, more formally, the variability of returns. A number of sources of firm-specific and shareholder-specific risks exists. Return is any cash distributions plus the change in value expressed as a percentage of the initial value. Investment returns vary both over time and between different types of investments. The equation for the rate of return is given in Table 5.13. The three basic risk preference behaviors are risk-averse, risk-indifferent, and risk-seeking. Most financial decision makers are risk-averse. They generally prefer less risky alternatives, and they require higher expected returns as compensation for taking greater risk.

**LG2 Describe procedures for assessing and measuring the risk of a single asset.** The risk of a single asset is measured in much the same way as the risk of a portfolio, or collection, of assets. Sensitivity analysis and probability distributions can be used to assess risk. In addition to the range, the standard deviation and the coefficient of variation are statistics that can be used to measure risk quantitatively. The key equations for the expected value of a return, the standard deviation of a return, and the coefficient of variation are summarized in Table 5.13.

**LG3 Discuss the measurement of return and standard deviation for a portfolio and the various types of correlation that can exist between series of numbers.** The return of a portfolio is calculated as the weighted average of returns on the individual assets from which it is formed. The equation for portfolio return is given in Table 5.13. The portfolio standard deviation is found by using the formula for the standard deviation of a single asset. Correlation—the statistical relationship between any two series of numbers—can be positive (the series move in the same direction), negative (the series move in opposite directions), or uncorrelated (the series exhibit no discernible relationship). At the extremes, the series can be perfectly positively correlated (have a correlation coefficient of  $+1$ ) or perfectly negatively correlated (have a correlation coefficient of  $-1$ ).

**LG4 Understand the risk and return characteristics of a portfolio in terms of correlation and diversification, and the impact of international assets on a portfolio.** Diversification involves combining assets with low (less positive and more negative) correlation to reduce the risk of the portfolio. Although the return on a two-asset portfolio will lie between the returns of the two assets held in isolation, the range of risk depends on the correlation between the two assets. If they are perfectly positively correlated, the portfolio's risk will be between the individual asset's risks. If they are uncorrelated, the portfolio's risk will be between the risk of the most risky asset and an amount less than the risk of the least risky asset but greater than zero. If they are negatively correlated, the portfolio's risk will be between the risk of the most risky asset and zero. International diversification can be used to reduce a portfolio's risk further. With foreign assets come the risk of currency fluctuation and political risks.

**LG5 Review the two types of risk and the derivation and role of beta in measuring the relevant risk of both an individual security and a portfolio.** The total risk of a security consists of nondiversifiable and diversifiable risk. Nondiversifiable risk is the only relevant risk; diversifiable risk can be eliminated through diversification. Nondiversifiable risk is measured by the beta coefficient, which is a relative measure of the relationship between an asset's return and the market return. Beta is derived by finding the slope of the "characteristic line" that best explains the historical relationship between the asset's return and the market return. The beta of a portfolio is a weighted average of the betas of the individual assets that it includes. The equations for total risk and the portfolio beta are given in Table 5.13.

**LG6 Explain the capital asset pricing model (CAPM), its relationship to the security market line (SML), and shifts in the SML caused by changes in inflationary expectations and risk aversion.** The capital asset pricing model (CAPM) uses beta to relate an asset's risk relative to the market to the asset's required return. The equation for CAPM is

**TABLE 5.13 Summary of Key Definitions and Formulas for Risk and Return**

**Definitions of variables**

- $b_j$  = beta coefficient or index of nondiversifiable risk for asset  $j$
- $b_p$  = portfolio beta
- $C_t$  = cash received from the asset investment in the time period  $t - 1$  to  $t$
- CV = coefficient of variation
- $\bar{k}$  = expected value of a return
- $k_j$  = return for the  $j$ th outcome; return on asset  $j$ ; required return on asset  $j$
- $k_m$  = market return; the return on the market portfolio of assets
- $k_p$  = portfolio return
- $k_t$  = actual, expected, or required rate of return during period  $t$
- $n$  = number of outcomes considered
- $P_t$  = price (value) of asset at time  $t$
- $P_{t-1}$  = price (value) of asset at time  $t - 1$
- $Pr_j$  = probability of occurrence of the  $j$ th outcome
- $R_F$  = risk-free rate of return
- $\sigma_k$  = standard deviation of returns
- $w_j$  = proportion of total portfolio dollar value represented by asset  $j$

**Risk and return formulas**

Rate of return during period  $t$ :

$$k_t = \frac{C_t + P_t - P_{t-1}}{P_{t-1}} \quad [\text{Eq. 5.1}]$$

Coefficient of variation:

$$CV = \frac{\sigma_k}{k} \quad [\text{Eq. 5.4}]$$

Expected value of a return:  
for probabilistic data:

$$\bar{k} = \sum_{j=1}^n k_j \times Pr_j \quad [\text{Eq. 5.2}]$$

Portfolio return:

$$k_p = \sum_{j=1}^n w_j \times k_j \quad [\text{Eq. 5.5}]$$

general formula:

$$\bar{k} = \frac{\sum_{j=1}^n k_j}{n} \quad [\text{Eq. 5.2a}]$$

Total security risk = Nondiversifiable risk  
+ Diversifiable risk

[Eq. 5.6]

Portfolio beta:

$$b_p = \sum_{j=1}^n w_j \times b_j \quad [\text{Eq. 5.7}]$$

Standard deviation of return:  
for probabilistic data:

$$\sigma_k = \sqrt{\sum_{j=1}^n (k_j - \bar{k})^2 \times Pr_j} \quad [\text{Eq. 5.3}]$$

Capital asset pricing model  
(CAPM):

$$k_j = R_F + [b_j \times (k_m - R_F)] \quad [\text{Eq. 5.8}]$$

general formula:

$$\sigma_k = \sqrt{\frac{\sum_{j=1}^n (k_j - \bar{k})^2}{n - 1}} \quad [\text{Eq. 5.3a}]$$

given in Table 5.13. The graphical depiction of CAPM is the security market line (SML), which shifts over time in response to changing inflationary expectations and/or changes in investor risk aversion. Changes in inflationary expectations result in parallel shifts in the SML in direct response to the

magnitude and direction of change. Increasing risk aversion results in a steepening in the slope of the SML, and decreasing risk aversion reduces the slope of the SML. Although it has some shortcomings, CAPM provides a useful conceptual framework for evaluating and linking risk and return.

## SELF-TEST PROBLEMS (Solutions in Appendix B)



**ST 5–1 Portfolio analysis** You have been asked for your advice in selecting a portfolio of assets and have been given the following data:

Year	Expected return		
	Asset A	Asset B	Asset C
2004	12%	16%	12%
2005	14	14	14
2006	16	12	16

No probabilities have been supplied. You have been told that you can create two portfolios—one consisting of assets A and B and the other consisting of assets A and C—by investing equal proportions (50%) in each of the two component assets.

- What is the expected return for each asset over the 3-year period?
- What is the standard deviation for each asset's return?
- What is the expected return for each of the two portfolios?
- How would you characterize the correlations of returns of the two assets making up each of the two portfolios identified in part c?
- What is the standard deviation for each portfolio?
- Which portfolio do you recommend? Why?



**ST 5–2 Beta and CAPM** Currently under consideration is a project with a beta,  $b$ , of 1.50. At this time, the risk-free rate of return,  $R_F$ , is 7%, and the return on the market portfolio of assets,  $k_m$ , is 10%. The project is actually *expected* to earn an annual rate of return of 11%.

- If the return on the market portfolio were to increase by 10%, what would you expect to happen to the project's *required return*? What if the market return were to decline by 10%?
- Use the capital asset pricing model (CAPM) to find the *required return* on this investment.
- On the basis of your calculation in part b, would you recommend this investment? Why or why not?
- Assume that as a result of investors becoming less risk-averse, the market return drops by 1% to 9%. What impact would this change have on your responses in parts b and c?

## PROBLEMS

- LG1** 5-1 **Rate of return** Douglas Keel, a financial analyst for Orange Industries, wishes to estimate the rate of return for two similar-risk investments, X and Y. Keel's research indicates that the immediate past returns will serve as reasonable estimates of future returns. A year earlier, investment X had a market value of \$20,000, investment Y of \$55,000. During the year, investment X generated cash flow of \$1,500 and investment Y generated cash flow of \$6,800. The current market values of investments X and Y are \$21,000 and \$55,000, respectively.
- Calculate the expected rate of return on investments X and Y using the most recent year's data.
  - Assuming that the two investments are equally risky, which one should Keel recommend? Why?

- LG1** 5-2 **Return calculations** For each of the investments shown in the following table, calculate the rate of return earned over the unspecified time period.

Investment	Cash flow during period	Beginning-of-period value	End-of-period value
A	-\$ 100	\$ 800	\$ 1,100
B	15,000	120,000	118,000
C	7,000	45,000	48,000
D	80	600	500
E	1,500	12,500	12,400

- LG1** 5-3 **Risk preferences** Sharon Smith, the financial manager for Barnett Corporation, wishes to evaluate three prospective investments: X, Y, and Z. Currently, the firm earns 12% on its investments, which have a risk index of 6%. The expected return and expected risk of the investments are as follows:

Investment	Expected return	Expected risk index
X	14%	7%
Y	12	8
Z	10	9

- If Sharon Smith were *risk-indifferent*, which investments would she select? Explain why.
  - If she were *risk-averse*, which investments would she select? Why?
  - If she were *risk-seeking*, which investments would she select? Why?
  - Given the traditional risk preference behavior exhibited by financial managers, which investment would be preferred? Why?
- LG2** 5-4 **Risk analysis** Solar Designs is considering an investment in an expanded product line. Two possible types of expansion are being considered. After investigating

the possible outcomes, the company made the estimates shown in the following table

	Expansion A	Expansion B
Initial investment	\$12,000	\$12,000
Annual rate of return		
Pessimistic	16%	10%
Most likely	20%	20%
Optimistic	24%	30%

- Determine the *range* of the rates of return for each of the two projects.
- Which project is less risky? Why?
- If you were making the investment decision, which one would you choose? Why? What does this imply about your feelings toward risk?
- Assume that expansion B's most likely outcome is 21% per year and that all other facts remain the same. Does this change your answer to part c? Why?



**5-5 Risk and probability** Micro-Pub, Inc., is considering the purchase of one of two microfilm cameras, R and S. Both should provide benefits over a 10-year period, and each requires an initial investment of \$4,000. Management has constructed the following table of estimates of rates of return and probabilities for pessimistic, most likely, and optimistic results:

	Camera R		Camera S	
	Amount	Probability	Amount	Probability
Initial investment	\$4,000	1.00	\$4,000	1.00
Annual rate of return				
Pessimistic	20%	.25	15%	.20
Most likely	25%	.50	25%	.55
Optimistic	30%	.25	35%	.25

- Determine the *range* for the rate of return for each of the two cameras.
- Determine the *expected value* of return for each camera.
- Purchase of which camera is riskier? Why?



**5-6 Bar charts and risk** Swan's Sportswear is considering bringing out a line of designer jeans. Currently, it is negotiating with two different well-known designers. Because of the highly competitive nature of the industry, the two lines of jeans have been given code names. After market research, the firm has established the expectations shown in the following table about the annual rates of return

Market acceptance	Probability	Annual rate of return	
		Line J	Line K
Very poor	.05	.0075	.010
Poor	.15	.0125	.025
Average	.60	.0850	.080
Good	.15	.1475	.135
Excellent	.05	.1625	.150

Use the table to:

- Construct a bar chart for each line's annual rate of return.
- Calculate the *expected value* of return for each line.
- Evaluate the relative riskiness for each line's rate of return using the bar charts.



LG2

- 5-7 **Coefficient of variation** Metal Manufacturing has isolated four alternatives for meeting its need for increased production capacity. The data gathered relative to each of these alternatives is summarized in the following table.

Alternative	Expected return	Standard deviation of return
A	20%	7.0%
B	22	9.5
C	19	6.0
D	16	5.5

- Calculate the *coefficient of variation* for each alternative.
- If the firm wishes to minimize risk, which alternative do you recommend? Why?

LG2

- 5-8 **Standard deviation versus coefficient of variation as measures of risk** Greengage, Inc., a successful nursery, is considering several expansion projects. All of the alternatives promise to produce an acceptable return. The owners are extremely risk-averse; therefore, they will choose the least risky of the alternatives. Data on four possible projects follow.

Project	Expected return	Range	Standard deviation
A	12.0%	.040	.029
B	12.5	.050	.032
C	13.0	.060	.035
D	12.8	.045	.030

- a. Which project is least risky, judging on the basis of range?
- b. Which project has the lowest standard deviation? Explain why standard deviation is not an appropriate measure of risk for purposes of this comparison.
- c. Calculate the coefficient of variation for each project. Which project will Greengage’s owners choose? Explain why this may be the best measure of risk for comparing this set of opportunities.



5–9 **Assessing return and risk** Swift Manufacturing must choose between two asset purchases. The annual rate of return and the related probabilities given in the following table summarize the firm’s analysis to this point.

Project 257		Project 432	
Rate of return	Probability	Rate of return	Probability
– 10%	.01	10%	.05
10	.04	15	.10
20	.05	20	.10
30	.10	25	.15
40	.15	30	.20
45	.30	35	.15
50	.15	40	.10
60	.10	45	.10
70	.05	50	.05
80	.04		
100	.01		

- a. For each project, compute:
  - (1) The range of possible rates of return.
  - (2) The expected value of return.
  - (3) The standard deviation of the returns.
  - (4) The coefficient of variation of the returns.
- b. Construct a bar chart of each distribution of rates of return.
- c. Which project would you consider less risky? Why?



5–10 **Integrative—Expected return, standard deviation, and coefficient of variation** Three assets—F, G, and H—are currently being considered by Perth Industries. The probability distributions of expected returns for these assets are shown in the following table.

<i>j</i>	Asset F		Asset G		Asset H	
	$Pr_j$	Return, $k_j$	$Pr_j$	Return, $k_j$	$Pr_j$	Return, $k_j$
1	.10	40%	.40	35%	.10	40%
2	.20	10	.30	10	.20	20
3	.40	0	.30	–20	.40	10
4	.20	–5			.20	0
5	.10	–10			.10	–20

- a. Calculate the expected value of return,  $\bar{k}$ , for each of the three assets. Which provides the largest expected return?

- b. Calculate the standard deviation,  $\sigma_k$ , for each of the three assets' returns. Which appears to have the greatest risk?
- c. Calculate the coefficient of variation, CV, for each of the three assets' returns. Which appears to have the greatest *relative* risk?

LG2

**5–11 Normal probability distribution** Assuming that the rates of return associated with a given asset investment are normally distributed and that the expected return,  $\bar{k}$ , is 18.9% and the coefficient of variation, CV, is .75, answer the following questions.

- a. Find the standard deviation of returns,  $\sigma_k$ .
- b. Calculate the range of expected return outcomes associated with the following probabilities of occurrence: (1) 68%, (2) 95%, (3) 99%.
- c. Draw the probability distribution associated with your findings in parts a and b.

LG3

**5–12 Portfolio return and standard deviation** Jamie Wong is considering building a portfolio containing two assets, L and M. Asset L will represent 40% of the dollar value of the portfolio, and asset M will account for the other 60%. The expected returns over the next 6 years, 2004–2009, for each of these assets, are shown in the following table.

Year	Expected return	
	Asset L	Asset M
2004	14%	20%
2005	14	18
2006	16	16
2007	17	14
2008	17	12
2009	19	10

- a. Calculate the expected portfolio return,  $k_p$ , for *each* of the 6 years.
- b. Calculate the expected value of portfolio returns,  $\bar{k}_p$ , over the 6-year period.
- c. Calculate the standard deviation of expected portfolio returns,  $\sigma_{k_p}$ , over the 6-year period.
- d. How would you characterize the correlation of returns of the two assets L and M?
- e. Discuss any benefits of diversification achieved through creation of the portfolio.

LG3

**5–13 Portfolio analysis** You have been given the return data shown in the first table on three assets—F, G, and H—over the period 2004–2007.

Year	Expected return		
	Asset F	Asset G	Asset H
2004	16%	17%	14%
2005	17	16	15
2006	18	15	16
2007	19	14	17

Using these assets, you have isolated the three investment alternatives shown in the following table:

Alternative	Investment
1	100% of asset F
2	50% of asset F and 50% of asset G
3	50% of asset F and 50% of asset H

- Calculate the expected return over the 4-year period for each of the three alternatives.
- Calculate the standard deviation of returns over the 4-year period for each of the three alternatives.
- Use your findings in parts a and b to calculate the coefficient of variation for each of the three alternatives.
- On the basis of your findings, which of the three investment alternatives do you recommend? Why?



**5–14 Correlation, risk, and return** Matt Peters wishes to evaluate the risk and return behaviors associated with various combinations of assets V and W under three assumed degrees of correlation: perfect positive, uncorrelated, and perfect negative. The expected return and risk values calculated for each of the assets are shown in the following table.

Asset	Expected return, $\bar{k}$	Risk (standard deviation), $\sigma_k$
V	8%	5%
W	13	10

- If the returns of assets V and W are *perfectly positively correlated* (correlation coefficient = +1), describe the *range* of (1) expected return and (2) risk associated with all possible portfolio combinations.
- If the returns of assets V and W are *uncorrelated* (correlation coefficient = 0), describe the *approximate range* of (1) expected return and (2) risk associated with all possible portfolio combinations.
- If the returns of assets V and W are *perfectly negatively correlated* (correlation coefficient = -1), describe the *range* of (1) expected return and (2) risk associated with all possible portfolio combinations.



**5–15 International investment returns** Joe Martinez, a U.S. citizen living in Brownsville, Texas, invested in the common stock of Telmex, a Mexican corporation. He purchased 1,000 shares at 20.50 pesos per share. Twelve months later, he sold them at 24.75 pesos per share. He received no dividends during that time.

- What was Joe's investment return (in percentage terms) for the year, on the basis of the peso value of the shares?
- The exchange rate for pesos was 9.21 pesos per \$US1.00 at the time of the purchase. At the time of the sale, the exchange rate was 9.85 pesos per \$US1.00. Translate the purchase and sale prices into \$US.
- Calculate Joe's investment return on the basis of the \$US value of the shares.

- d. Explain why the two returns are different. Which one is more important to Joe? Why?



**5-16 Total, nondiversifiable, and diversifiable risk** David Talbot randomly selected securities from all those listed on the New York Stock Exchange for his portfolio. He began with a single security and added securities one by one until a total of 20 securities were held in the portfolio. After each security was added, David calculated the portfolio standard deviation,  $\sigma_{kp}$ . The calculated values are shown in the following table.

Number of securities	Portfolio risk, $\sigma_{kp}$	Number of securities	Portfolio risk, $\sigma_{kp}$
1	14.50%	11	7.00%
2	13.30	12	6.80
3	12.20	13	6.70
4	11.20	14	6.65
5	10.30	15	6.60
6	9.50	16	6.56
7	8.80	17	6.52
8	8.20	18	6.50
9	7.70	19	6.48
10	7.30	20	6.47

- On a set of “number of securities in portfolio ( $x$  axis)—portfolio risk ( $y$  axis)” axes, plot the portfolio risk data given in the preceding table.
- Divide the total portfolio risk in the graph into its *nondiversifiable* and *diversifiable* risk components and label each of these on the graph.
- Describe which of the two risk components is the *relevant risk*, and explain why it is relevant. How much of this risk exists in David Talbot’s portfolio?



**5-17 Graphical derivation of beta** A firm wishes to estimate graphically the betas for two assets, A and B. It has gathered the return data shown in the following table for the market portfolio and for both assets over the last ten years, 1994–2003.

Year	Actual return		
	Market portfolio	Asset A	Asset B
1994	6%	11%	16%
1995	2	8	11
1996	−13	−4	−10
1997	−4	3	3
1998	−8	0	−3
1999	16	19	30
2000	10	14	22
2001	15	18	29
2002	8	12	19
2003	13	17	26

- a. On a set of “market return ( $x$  axis)–asset return ( $y$  axis)” axes, use the data given to draw the characteristic line for asset A and for asset B.
- b. Use the characteristic lines from part a to estimate the betas for assets A and B.
- c. Use the betas found in part b to comment on the relative risks of assets A and B.



**5–18 Interpreting beta** A firm wishes to assess the impact of changes in the market return on an asset that has a beta of 1.20.

- a. If the market return increased by 15%, what impact would this change be expected to have on the asset’s return?
- b. If the market return decreased by 8%, what impact would this change be expected to have on the asset’s return?
- c. If the market return did not change, what impact, if any, would be expected on the asset’s return?
- d. Would this asset be considered more or less risky than the market? Explain.



**5–19 Betas** Answer the following questions for assets A to D shown in the following table.

Asset	Beta
A	.50
B	1.60
C	–.20
D	.90

- a. What impact would a 10% *increase* in the market return be expected to have on each asset’s return?
- b. What impact would a 10% *decrease* in the market return be expected to have on each asset’s return?
- c. If you were certain that the market return would *increase* in the near future, which asset would you prefer? Why?
- d. If you were certain that the market return would *decrease* in the near future, which asset would you prefer? Why?



**5–20 Betas and risk rankings** Stock A has a beta of .80, stock B has a beta of 1.40, and stock C has a beta of –.30.

- a. Rank these stocks from the most risky to the least risky.
- b. If the return on the market portfolio increased by 12%, what change would you expect in the return for each of the stocks?
- c. If the return on the market portfolio decreased by 5%, what change would you expect in the return for each of the stocks?
- d. If you felt that the stock market was just ready to experience a significant decline, which stock would you probably add to your portfolio? Why?
- e. If you anticipated a major stock market rally, which stock would you add to your portfolio? Why?



**5–21 Portfolio betas** Rose Berry is attempting to evaluate two possible portfolios, which consist of the same five assets held in different proportions. She is particu-

larly interested in using beta to compare the risks of the portfolios, so she has gathered the data shown in the following table.

Asset	Asset beta	Portfolio weights	
		Portfolio A	Portfolio B
1	1.30	10%	30%
2	.70	30	10
3	1.25	10	20
4	1.10	10	20
5	.90	40	20
Totals		<u>100%</u>	<u>100%</u>

- Calculate the betas for portfolios A and B.
- Compare the risks of these portfolios to the market as well as to each other. Which portfolio is more risky?

**LG6** 5–22 **Capital asset pricing model (CAPM)** For each of the cases shown in the following table, use the capital asset pricing model to find the required return.

Case	Risk-free rate, $R_F$	Market return, $k_m$	Beta, $b$
A	5%	8%	1.30
B	8	13	.90
C	9	12	-.20
D	10	15	1.00
E	6	10	.60

**LG5** **LG6** 5–23 **Beta coefficients and the capital asset pricing model** Katherine Wilson is wondering how much risk she must undertake in order to generate an acceptable return on her portfolio. The risk-free return currently is 5%. The return on the average stock (market return) is 16%. Use the CAPM to calculate the beta coefficient associated with each of the following portfolio returns.

- 10%
- 15%
- 18%
- 20%
- Katherine is risk-averse. What is the highest return she can expect if she is unwilling to take more than an average risk?

**LG6** 5–24 **Manipulating CAPM** Use the basic equation for the capital asset pricing model (CAPM) to work each of the following problems.

- Find the *required return* for an asset with a beta of .90 when the risk-free rate and market return are 8% and 12%, respectively.

- Find the *risk-free rate* for a firm with a required return of 15% and a beta of 1.25 when the market return is 14%.
- Find the *market return* for an asset with a required return of 16% and a beta of 1.10 when the risk-free rate is 9%.
- Find the *beta* for an asset with a required return of 15% when the risk-free rate and market return are 10% and 12.5%, respectively.



5–25 **Portfolio return and beta** Jamie Peters invested \$100,000 to set up the following portfolio one year ago:

Asset	Cost	Beta at purchase	Yearly income	Value today
A	\$20,000	.80	\$1,600	\$20,000
B	35,000	.95	1,400	36,000
C	30,000	1.50	—	34,500
D	15,000	1.25	375	16,500

- Calculate the portfolio beta on the basis of the original cost figures.
- Calculate the percentage return of each asset in the portfolio for the year.
- Calculate the percentage return of the portfolio on the basis of original cost, using income and gains during the year.
- At the time Jamie made his investments, investors were estimating that the market return for the coming year would be 10%. The estimate of the risk-free rate of return averaged 4% for the coming year. Calculate an expected rate of return for each stock on the basis of its beta and the expectations of market and risk-free returns.
- On the basis of the actual results, explain how each stock in the portfolio performed relative to those CAPM-generated expectations of performance. What factors could explain these differences?



5–26 **Security market line, SML** Assume that the risk-free rate,  $R_F$ , is currently 9% and that the market return,  $k_m$ , is currently 13%.

- Draw the security market line (SML) on a set of “nondiversifiable risk ( $x$  axis)–required return ( $y$  axis)” axes.
- Calculate and label the *market risk premium* on the axes in part a.
- Given the previous data, calculate the required return on asset A having a beta of .80 and asset B having a beta of 1.30.
- Draw in the betas and required returns from part c for assets A and B on the axes in part a. Label the *risk premium* associated with each of these assets, and discuss them.



5–27 **Shifts in the security market line** Assume that the risk-free rate,  $R_F$ , is currently 8%, the market return,  $k_m$ , is 12%, and asset A has a beta,  $b_A$ , of 1.10.

- Draw the security market line (SML) on a set of “nondiversifiable risk ( $x$  axis)–required return ( $y$  axis)” axes.
- Use the CAPM to calculate the required return,  $k_A$ , on asset A, and depict asset A’s beta and required return on the SML drawn in part a.
- Assume that as a result of recent economic events, inflationary expectations have declined by 2%, lowering  $R_F$  and  $k_m$  to 6% and 10%, respectively.

Draw the new SML on the axes in part a, and calculate and show the new required return for asset A.

- d. Assume that as a result of recent events, investors have become more risk-averse, causing the market return to rise by 1%, to 13%. Ignoring the shift in part c, draw the new SML on the same set of axes that you used before, and calculate and show the new required return for asset A.
- e. From the previous changes, what conclusions can be drawn about the impact of (1) decreased inflationary expectations and (2) increased risk aversion on the required returns of risky assets?



**5–28 Integrative—Risk, return, and CAPM** Wolff Enterprises must consider several investment projects, A through E, using the capital asset pricing model (CAPM) and its graphical representation, the security market line (SML). Relevant information is presented in the following table.

Item	Rate of return	Beta, <i>b</i>
Risk-free asset	9%	0
Market portfolio	14	1.00
Project A	—	1.50
Project B	—	.75
Project C	—	2.00
Project D	—	0
Project E	—	–.50

- a. Calculate the required rate of return and risk premium for each project, given its level of nondiversifiable risk.
- b. Use your findings in part a to draw the security market line (required return relative to nondiversifiable risk).
- c. Discuss the relative nondiversifiable risk of projects A through E.
- d. Assume that recent economic events have caused investors to become less risk-averse, causing the market return to decline by 2%, to 12%. Calculate the new required returns for assets A through E, and draw the new security market line on the same set of axes that you used in part b.
- e. Compare your findings in parts a and b with those in part d. What conclusion can you draw about the impact of a decline in investor risk aversion on the required returns of risky assets?

## CHAPTER 5 CASE

### Analyzing Risk and Return on Chargers Products' Investments

Junior Sayou, a financial analyst for Chargers Products, a manufacturer of stadium benches, must evaluate the risk and return of two assets, X and Y. The firm is considering adding these assets to its diversified asset portfolio. To assess the return and risk of each asset, Junior gathered data on the annual cash flow and beginning- and end-of-year values of each asset over the immediately preceding 10 years, 1994–2003. These data are summarized in the accompanying table. Junior's investigation suggests that both assets, on average, will tend to

Return Data for Assets X and Y, 1994–2003						
Year	Asset X			Asset Y		
	Cash flow	Value		Cash flow	Value	
		Beginning	Ending		Beginning	Ending
1994	\$1,000	\$20,000	\$22,000	\$1,500	\$20,000	\$20,000
1995	1,500	22,000	21,000	1,600	20,000	20,000
1996	1,400	21,000	24,000	1,700	20,000	21,000
1997	1,700	24,000	22,000	1,800	21,000	21,000
1998	1,900	22,000	23,000	1,900	21,000	22,000
1999	1,600	23,000	26,000	2,000	22,000	23,000
2000	1,700	26,000	25,000	2,100	23,000	23,000
2001	2,000	25,000	24,000	2,200	23,000	24,000
2002	2,100	24,000	27,000	2,300	24,000	25,000
2003	2,200	27,000	30,000	2,400	25,000	25,000

perform in the future just as they have during the past 10 years. He therefore believes that the expected annual return can be estimated by finding the average annual return for each asset over the past 10 years.

Junior believes that each asset's risk can be assessed in two ways: in isolation and as part of the firm's diversified portfolio of assets. The risk of the assets in isolation can be found by using the standard deviation and coefficient of variation of returns over the past 10 years. The capital asset pricing model (CAPM) can be used to assess the asset's risk as part of the firm's portfolio of assets. Applying some sophisticated quantitative techniques, Junior estimated betas for assets X and Y of 1.60 and 1.10, respectively. In addition, he found that the risk-free rate is currently 7% and that the market return is 10%.

### Required

- Calculate the annual rate of return for each asset in *each* of the 10 preceding years, and use those values to find the average annual return for each asset over the 10-year period.
- Use the returns calculated in part **a** to find (1) the standard deviation and (2) the coefficient of variation of the returns for each asset over the 10-year period 1994–2003.
- Use your findings in parts **a** and **b** to evaluate and discuss the return and risk associated with each asset. Which asset appears to be preferable? Explain.
- Use the CAPM to find the required return for each asset. Compare this value with the average annual returns calculated in part **a**.
- Compare and contrast your findings in parts **c** and **d**. What recommendations would you give Junior with regard to investing in either of the two assets? Explain to Junior why he is better off using beta rather than the standard deviation and coefficient of variation to assess the risk of each asset.

- f. Rework parts d and e under each of the following circumstances:
- (1) A rise of 1% in inflationary expectations causes the risk-free rate to rise to 8% and the market return to rise to 11%.
  - (2) As a result of favorable political events, investors suddenly become less risk-averse, causing the market return to drop by 1%, to 9%.

## WEB EXERCISE



Go to the RiskGrades Web site, [www.riskgrades.com](http://www.riskgrades.com). This site, from RiskMetrics Group, provides another way to assess the riskiness of stocks and mutual funds. RiskGrades provide a way to compare investment risk across all asset classes, regions, and currencies. They vary over time to reflect asset-specific information (such as the price of a stock reacting to an earnings release) and general market conditions. RiskGrades operate differently from traditional risk measures, such as standard deviation and beta.

1. First, learn more about RiskGrades by clicking on **RiskGrades Help Center** and reviewing the material. How are RiskGrades calculated? What differences can you identify when you compare them to standard deviation and beta techniques? What are the advantages and disadvantages of this measure, in your opinion?
2. Get RiskGrades for the following stocks using the **Get RiskGrade** pull-down menu at the site's upper right corner. You can enter multiple symbols separated by commas. Select **all dates** to get a historical view.

Company	Symbol
Citigroup	C
Intel	INTC
Microsoft	MSFT
Washington Mutual	WM

What do the results tell you?

3. Select one of the foregoing stocks and find other stocks with similar risk grades. Click on **By RiskGrade** to pull up a list.
4. How much risk can you tolerate? Use a hypothetical portfolio to find out. Click on **Grade Yourself**, take a short quiz, and get your personal RiskGrade measure. Did the results surprise you?

**Remember to check the book's Web site at**

[www.aw.com/gitman](http://www.aw.com/gitman)

**for additional resources, including additional Web exercises.**