RISK AND RATES OF RETURN

No Pain No Gain

Throughout the 1990s, the market soared, and investors became accustomed to great stock market returns. In 2000, though, stocks began a sharp decline, leading to a reassessment of the risks inherent in the stock market. This point was underscored by a *Wall Street Journal* article shortly after the terrorist attacks of September 2001:

> Investing in the stock market can be risky, sometimes very risky. While that may seem obvious after the Dow Jones Industrial Average posted its worst weekly percentage loss in 61 years and its worst-ever weekly point loss, it wasn't something that most investors spent much time thinking about during the bull market of the 1990s.
>
> Now, with the Bush administration warning of a lengthy battle against terrorism, investment advisors say that the risks associated with owning stocks—as opposed to safer securities with more predictable returns, such as bonds—are poised to rise. This is leading to an increase in what analysts call a "risk premium," and as it gets higher, investors require a greater return from stocks compared to bonds.
>
> For most analysts, it is not a question of whether stocks are riskier today than they have been in recent years. Rather, they are asking how much riskier? And for how long will this period of heightened risk continue?

It is also important to understand that some stocks are riskier than others. Moreover, even in years when the overall stock market goes up, many individual stocks go down, so there's less risk to holding a "basket" of stocks than just one stock. Indeed, according to a *BusinessWeek* article, the single best weapon against risk is diversification into stocks that are not highly correlated with one another: "By spreading your money around, you're not tied to the fickleness of a given market, stock, or industry. . . . Correlation, in portfolio-manager speak, helps you diversify properly because it describes how closely two investments

track each other. If they move in tandem, they're likely to suffer from the same bad news. So, you should combine assets with low correlations."

U.S. investors tend to think of "the stock market" as the U.S. stock market. However, U.S. stocks amount to only 35 percent of the value of all stocks. Foreign markets have been quite profitable, and they are not perfectly correlated with U.S. markets. Therefore, global diversification offers U.S. investors an opportunity to raise returns and at the same time reduce risk. However, foreign investing brings some risks of its own, most notably "exchange rate risk," which is the danger that exchange rate shifts will decrease the number of dollars a foreign currency will buy.

Although the central thrust of the *BusinessWeek* article was on measuring and then reducing risk, it also pointed out that some extremely risky instruments have been marketed to naive investors as having very little risk. For example, several mutual funds advertise that their portfolios "contain only securities backed by the U.S. government," but they failed to highlight that the funds themselves were using financial leverage, were investing in "derivatives," or were taking some other action that exposed investors to huge risks.

When you finish this chapter, you should understand what risk is, how it can be measured, and how to minimize it or at least be adequately compensated for bearing it.

Sources: "Figuring Risk: It's Not So Scary," *BusinessWeek,* November 1, 1993, pp. 154–155; "T-Bill Trauma and the Meaning of Risk," *The Wall Street Journal,* February 12, 1993, p. C1; and "Stock Risks Poised to Rise in Changed Postattack World," *The Wall Street Journal*, September 24, 2001, p. C1.

Putting Things In Perspective

We start this chapter from the basic premise that investors like returns and dislike risk and therefore will invest in risky assets only if those assets offer higher expected returns. We define precisely what the term *risk* means as it relates to investments, examine procedures that are used to measure risk, and discuss the relationship between risk and return. Investors should understand these concepts, as should managers as they develop the plans that will shape their firms' futures.

Risk can be measured in different ways, and different conclusions about an asset's riskiness can be reached depending on the measure used. Risk analysis can be confusing, but it will help if you keep the following points in mind:

1. All financial assets are expected to produce *cash flows*, and the riskiness of an asset is based on the riskiness of its cash flows.
2. An asset's risk can be considered in two ways: (a) on a *stand-alone basis*, where the asset's cash flows are analyzed by themselves, or (b) in a *portfolio context*, where the cash flows from a number of assets are combined and then the consolidated cash flows are analyzed.[1] There is an important difference between stand-alone and portfolio risk, and an

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[1] A *portfolio* is a collection of investment securities. If you owned some General Motors stock, some ExxonMobil stock, and some IBM stock, you would be holding a three-stock portfolio. Because diversification lowers risk without sacrificing much if any expected return, most stocks are held in portfolios.

asset that has a great deal of risk if held by itself may be less risky if it is held as part of a larger portfolio.

3. In a portfolio context, an asset's risk can be divided into two components: (a) *diversifiable risk*, which can be diversified away and is thus of little concern to diversified investors, and (b) *market risk*, which reflects the risk of a general stock market decline and which cannot be eliminated by diversification, hence does concern investors. Only market risk is *relevant* to rational investors—diversifiable risk is *irrelevant* because it can and will be eliminated.

4. An asset with a high degree of relevant (market) risk must offer a relatively high expected rate of return to attract investors. Investors in general are *averse to risk*, so they will not buy risky assets unless those assets have high expected returns.

5. If investors on average think a security's expected return is too low to compensate for its risk, then the price of the security will decline, which will boost the expected return. Conversely, if the expected return is more than enough to compensate for the risk, then the security's market price will increase, thus lowering the expected return. The security will be in equilibrium when its expected return is just sufficient to compensate for its risk.

6. In this chapter, we focus on *financial assets* such as stocks and bonds, but the concepts discussed here also apply to *physical assets* such as computers, trucks, or even whole plants.

8.1 STAND-ALONE RISK

Risk
The chance that some unfavorable event will occur.

Risk is defined in *Webster's* as "a hazard; a peril; exposure to loss or injury." Thus, risk refers to the chance that some unfavorable event will occur. If you engage in skydiving, you are taking a chance with your life—skydiving is risky. If you bet on the horses, you are risking your money.

As we saw in previous chapters, both individuals and firms invest funds today with the expectation of receiving additional funds in the future. Bonds offer relatively low returns, but with relatively little risk—at least if you stick to Treasury bonds and high-grade corporates. Stocks offer the chance of higher returns, but, as we saw in Chapter 5, stocks are generally riskier than bonds. If you invest in speculative stocks (or, really, *any* stock), you are taking a significant risk in the hope of making an appreciable return.

An asset's risk can be analyzed in two ways: (1) on a stand-alone basis, where the asset is considered in isolation; and (2) on a portfolio basis, where the asset is held as one of a number of assets in a portfolio. Thus, an asset's **stand-**

Stand-Alone Risk
The risk an investor would face if he or she held only one asset.

alone risk is the risk an investor would face if he or she held only this one asset. Obviously, most assets are held in portfolios, but it is necessary to understand stand-alone risk in order to understand risk in a portfolio context.

To illustrate stand-alone risk, suppose an investor buys $100,000 of short-term Treasury bills with an expected return of 5 percent. In this case, the invest-

ment's return, 5 percent, can be estimated quite precisely, and the investment is defined as being essentially *risk free*. This same investor could also invest the $100,000 in the stock of a company just being organized to prospect for oil in the mid-Atlantic. The returns on the stock would be much harder to predict. In the worst case the company would go bankrupt and the investor would lose all of her money, in which case the return would be −100 percent. In the best-case scenario, the company would discover large amounts of oil and the investor would receive huge positive returns. When evaluating this investment, the investor might analyze the situation and conclude that the *expected* rate of return, in a statistical sense, is 20 percent, but it should also be recognized that the *actual* rate of return could range from, say, +1,000 to −100 percent. Because there is a significant danger of actually earning much less than the expected return, such a stock would be relatively risky.

   No investment would be undertaken unless the expected rate of return was high enough to compensate the investor for the perceived risk. In our example, it is clear that few, if any, investors would be willing to buy the oil exploration company's stock if its expected return were the same as that of the T-bill.

   Risky assets rarely produce their expected rates of return—generally, risky assets earn either more or less than was originally expected. Indeed, if assets always produced their expected returns, they would not be risky. Investment risk, then, is related to the *probability* of actually earning a low or negative return—the greater the chance of a low or negative return, the riskier the investment. However, risk can be defined more precisely, as we demonstrate in the next section.

Probability Distributions

An event's *probability* is defined as the chance that the event will occur. For example, a weather forecaster might state, "There is a 40 percent chance of rain today and a 60 percent chance of no rain." If all possible events, or outcomes, are listed, and if a probability is assigned to each event, the listing is called a **probability distribution.** For our weather forecast, we could set up the following probability distribution:

Outcome (1)	Probability (2)		
Rain	0.4	=	40%
No rain	0.6	=	60
	1.0	=	100%

Probability Distribution
A listing of all possible outcomes, or events, with a probability (chance of occurrence) assigned to each outcome.

The possible outcomes are listed in Column 1, while the probabilities of these outcomes, expressed both as decimals and as percentages, are given in Column 2. Notice that the probabilities must sum to 1.0, or 100 percent.

   Probabilities can also be assigned to the possible outcomes—in this case returns—from an investment. If you plan to buy a one-year bond and hold it for a year, you would expect to receive interest on the bond plus a return of your original investment, and those payments would provide you with a rate of return on your investment. The possible outcomes from this investment are (1) that the issuer will make the required payments or (2) that the issuer will default on the payments. The higher the probability of default, the riskier the bond, and the higher the risk, the higher the required rate of return. If you invest in a stock instead of buying a bond, you would again expect to earn a return on your money. A stock's return would come from dividends plus capital gains. Again, the riskier the stock—which means the higher the probability that the firm will fail to provide the dividends and capital gains you expect—the higher the expected return must be to induce you to invest in the stock.

With this in mind, consider the possible rates of return (dividend yield plus capital gain or loss) that you might earn next year on a $10,000 investment in the stock of either Martin Products Inc. or U.S. Water Company. Martin manufactures and distributes computer terminals and equipment for the rapidly growing data transmission industry. Because it faces intense competition, its new products may or may not be competitive in the marketplace, so its future earnings cannot be predicted very well. Indeed, some new company could develop better products and quickly bankrupt Martin. U.S. Water, on the other hand, supplies an essential service, and it has city franchises that protect it from competition. Therefore, its sales and profits are relatively stable and predictable.

The rate-of-return probability distributions for the two companies are shown in Table 8-1. There is a 30 percent chance of a strong economy and thus strong demand, in which case both companies will have high earnings, pay high dividends, and enjoy capital gains. There is a 40 percent probability of normal demand and moderate returns, and there is a 30 percent probability of weak demand, which will mean low earnings and dividends as well as capital losses. Notice, however, that Martin Products' rate of return could vary far more widely than that of U.S. Water. There is a fairly high probability that the value of Martin's stock will drop substantially, resulting in a 70 percent loss, while the worst that could happen to U.S. Water is a 10 percent return.[2]

Expected Rate of Return

If we multiply each possible outcome by its probability of occurrence and then sum these products, as in Table 8-2, we obtain a *weighted average* of outcomes. The weights are the probabilities, and the weighted average is the **expected rate of return, $\hat{r}$,** called "r-hat."[3] The expected rates of return for both Martin Products and U.S. Water are shown in Table 8-2 to be 15 percent. This type of table is known as a *payoff matrix*.

Expected Rate of Return, $\hat{r}$

The rate of return expected to be realized from an investment; the weighted average of the probability distribution of possible results.

| TABLE 8-1 | *Probability Distributions for Martin Products and U.S. Water* |

		RATE OF RETURN ON STOCK IF THIS DEMAND OCCURS	
Demand for the Company's Products	Probability of this Demand Occurring	Martin Products	U.S. Water
Strong	0.3	100%	20%
Normal	0.4	15	15
Weak	0.3	(70)	10
	1.0		

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[2] It is, of course, completely unrealistic to think that any stock has no chance of a loss. Only in hypothetical examples could this occur. To illustrate, the price of Columbia Gas's stock dropped from $34.50 to $20.00 in just three hours a few years ago. All investors were reminded that any stock is exposed to some risk of loss, and those investors who bought Columbia Gas learned that the hard way.

[3] In Chapters 7 and 9, we use r_d and r_s to signify the returns on bonds and stocks, respectively. However, this distinction is unnecessary in this chapter, so we just use the general term, r, to signify the expected return on an investment.

TABLE 8-2	*Calculation of Expected Rates of Return: Payoff Matrix*				

		MARTIN PRODUCTS		U.S. WATER	
Demand for the Company's Products (1)	Probability of This Demand Occurring (2)	Rate of Return If This Demand Occurs (3)	Product: (2) × (3) = (4)	Rate of Return If This Demand Occurs (5)	Product: (2) × (5) = (6)
Strong	0.3	100%	30%	20%	6%
Normal	0.4	15	6	15	6
Weak	0.3	(70)	(21)	10	3
	1.0		$\hat{r} = 15\%$		$\hat{r} = 15\%$

The expected rate of return can also be expressed as an equation that does the same thing as the payoff matrix table:[4]

$$\text{Expected rate of return} = \hat{r} = P_1 r_1 + P_2 r_2 + \cdots + P_N r_N$$

$$= \sum_{i=1}^{N} P_i r_i \qquad \text{(8-1)}$$

Here r_i is the ith possible outcome, P_i is the probability of the ith outcome, and N is the number of possible outcomes. Thus, $\hat{r}$ is a weighted average of the possible outcomes (the r_i values), with each outcome's weight being its probability of occurrence. Using the data for Martin Products, we obtain its expected rate of return as follows:

$$\hat{r} = P_1(r_1) + P_2(r_2) + P_3(r_3)$$

$$= 0.3(100\%) + 0.4(15\%) + 0.3(-70\%)$$

$$= 15\%$$

U.S. Water's expected rate of return is also 15 percent:

$$\hat{r} = 0.3(20\%) + 0.4(15\%) + 0.3(10\%)$$

$$= 15\%$$

We can graph the rates of return to obtain a picture of the variability of possible outcomes; this is shown in the Figure 8-1 bar charts. The height of each bar signifies the probability that a given outcome will occur. The range of probable returns for Martin Products is from −70 to +100 percent, and the expected return is 15 percent. The expected return for U.S. Water is also 15 percent, but its possible range is much narrower.

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[4] The second form of the equation is simply a shorthand expression in which sigma ($\sum$) means "sum up," or add the values of n factors. If i = 1, then $P_i r_i = P_1 r_1$; if i = 2, then $P_i r_i = P_2 r_2$; and so on until i = N, the last possible outcome. The symbol $\sum_{i=1}^{N}$ simply says, "Go through the following process: First, let i = 1 and find the first product; then i = 2 and find the second product; then continue until each individual product up to 1 = N has been found, and then add these individual products to find the expected rate of return."

FIGURE 8-1 *Probability Distributions of Martin Products' and U.S. Water's Rates of Return*
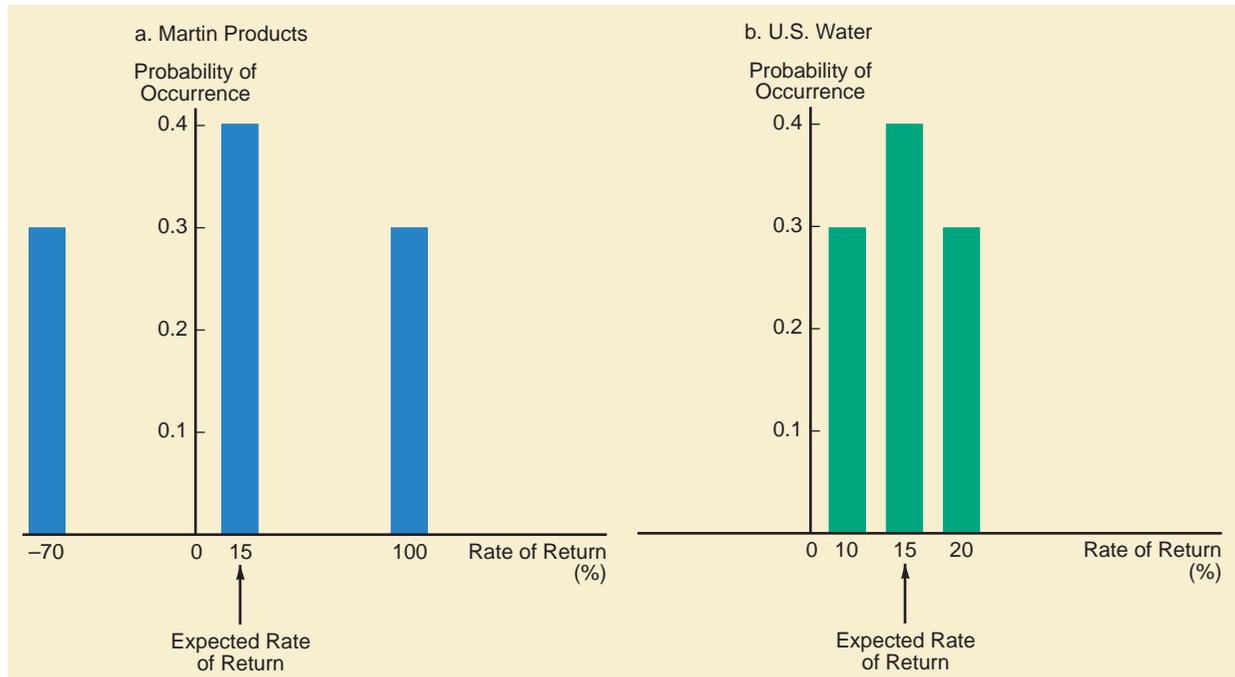

Thus far, we have assumed that only three outcomes could occur: strong, normal, and weak demand. Actually, of course, demand could range from a deep depression to a fantastic boom, and there are an unlimited number of possibilities in between. Suppose we had the time and patience to assign a probability to each possible level of demand (with the sum of the probabilities still equaling 1.0) and to assign a rate of return to each stock for each level of demand. We would have a table similar to Table 8-1, except that it would have many more entries in each column. This table could be used to calculate expected rates of return as shown previously, and the probabilities and outcomes could be represented by continuous curves such as those presented in Figure 8-2. Here we have changed the assumptions so that there is essentially a zero probability that Martin Products' return will be less than −70 percent or more than 100 percent, or that U.S. Water's return will be less than 10 percent or more than 20 percent. However, virtually any return within these limits is possible.

The tighter (or more peaked) the probability distribution, the more likely it is that the actual outcome will be close to the expected value, and, consequently, the less likely it is that the actual return will end up far below the expected return. Thus, the tighter the probability distribution, the lower the risk faced by the owners of a stock. Since U.S. Water has a relatively tight probability distribution, its *actual return* is likely to be closer to its 15 percent *expected return* than is that of Martin Products.

Measuring Stand-Alone Risk: The Standard Deviation

Risk is a difficult concept to grasp, and a great deal of controversy has surrounded attempts to define and measure it. However, a common definition, and one that is satisfactory for many purposes, is stated in terms of probability distributions such as those presented in Figure 8-2: *The tighter the probability distribution of expected future returns, the smaller the risk of a given investment.* According to this

FIGURE 8-2   *Continuous Probability Distributions of Martin Products' and U.S. Water's Rates of Returns*
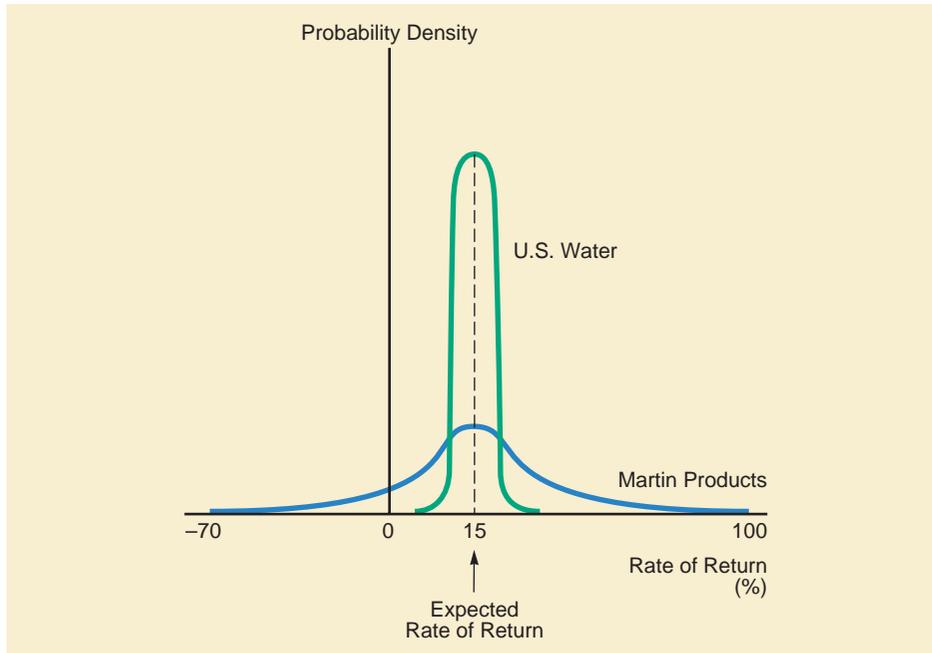
Note: The assumptions regarding the probabilities of various outcomes have been changed from those in Figure 8-1. There the probability of obtaining exactly 15 percent was 40 percent; here it is *much smaller* because there are many possible outcomes instead of just three. With continuous distributions, it is more appropriate to ask what the probability is of obtaining at least some specified rate of return than to ask what the probability is of obtaining exactly that rate. This topic is covered in detail in statistics courses.

definition, U.S. Water is less risky than Martin Products because there is a smaller chance that its actual return will end up far below its expected return.

To be most useful, our risk measure should have a definite value—we need to quantify the tightness of the probability distribution. One such measure is the **standard deviation,** whose symbol is σ, pronounced "sigma." The smaller the standard deviation, the tighter the probability distribution, and, accordingly, the lower the riskiness of the stock. To calculate the standard deviation, we proceed as shown in Table 8-3, taking the following steps:

Standard Deviation, σ
A statistical measure of the variability of a set of observations.

1. Calculate the expected rate of return:

$$\text{Expected rate of return} = \hat{r} = \sum_{i=1}^{N} P_i r_i$$

   For Martin, we previously found $\hat{r} = 15\%$.

2. Subtract the expected rate of return ($\hat{r}$) from each possible outcome (r_i) to obtain a set of deviations about $\hat{r}$ as shown in Column 1 of Table 8-3:

$$\text{Deviation}_i = r_i - \hat{r}$$

3. Square each deviation, then multiply the result by its probability of occurrence, and then sum those products to obtain the **variance** of the probability distribution as shown in Columns 2 and 3 of the table:

Variance, σ²
The square of the standard deviation.

$$\text{Variance} = \sigma^2 = \sum_{i=1}^{N} (r_i - \hat{r})^2 P_i \qquad \text{(8-2)}$$

TABLE 8-3	*Calculating Martin Products' Standard Deviation*

$r_i - \hat{r}$	$(r_i - \hat{r})^2$	$(r_i - \hat{r})^2 P_i$
(1)	(2)	(3)
$100 - 15 = 85$	7,225	$(7,225)(0.3) = 2,167.5$
$15 - 15 = 0$	0	$(0)(0.4) = 0.0$
$-70 - 15 = -85$	7,225	$(7,225)(0.3) = \underline{2,167.5}$
		Variance $= \sigma^2 = \underline{\underline{4,335.0}}$
	Standard deviation $= \sigma = \sqrt{\sigma^2} = \sqrt{4,335} =$	65.84%

4. Finally, find the square root of the variance to obtain the standard deviation:

$$\text{Standard deviation} = \sigma = \sqrt{\sum_{i=1}^{N} (r_i - \hat{r})^2 P_i} \qquad \textbf{(8-3)}$$

Thus, the standard deviation is a weighted average of the deviations from the expected value, and it provides an idea of how far above or below the expected return the actual return is likely to be. Martin's standard deviation is seen in Table 8-3 to be $\sigma = 65.84\%$. Using these same procedures, we find U.S. Water's standard deviation to be 3.87 percent. Martin Products has a much larger standard deviation, which indicates a much greater variation of returns and thus a greater chance that the expected return will not be realized. Therefore, Martin Products is a riskier investment than U.S. Water when held alone.

If a probability distribution is "normal," the *actual* return will be within ±1 standard deviation around the *expected* return 68.26 percent of the time. Figure 8-3 illustrates this point, and it also shows the situation for ±2σ and ±3σ. For Martin Products, $\hat{r} = 15\%$ and $\sigma = 65.84\%$, whereas $\hat{r} = 15\%$ and $\sigma = 3.87\%$ for U.S. Water. Thus, if the two distributions were normal, there would be a 68.26% probability that Martin's actual return would be in the range of 15 ± 65.84%, or from −50.84 to 80.84 percent. For U.S. Water, the 68.26 percent range is 15 ± 3.87%, or from 11.13 to 18.87 percent. With such a small σ, there is only a small probability that U.S. Water's return would be much less than expected, so the stock is not very risky. For the average firm listed on the New York Stock Exchange, σ has generally been in the range of 35 to 40 percent in recent years.

Using Historical Data to Measure Risk

In the example just given, we described the procedure for finding the mean and standard deviation when the data are in the form of a probability distribution. If only sample returns data over some past period are available, the standard deviation of returns should be estimated using this formula:

$$\text{Estimated } \sigma = S = \sqrt{\frac{\sum_{t=1}^{N} (\bar{r}_t - \bar{r}_{Avg})^2}{N - 1}} \qquad \textbf{(8-3a)}$$

Here $\bar{r}_t$ ("r bar t") denotes the past realized rate of return in Period t and $\bar{r}_{Avg}$ is the average annual return earned during the last N years. Here is an example:

Year	$\bar{r}_t$
2003	15%
2004	−5
2005	20

FIGURE 8-3 *Probability Ranges for a Normal Distribution*
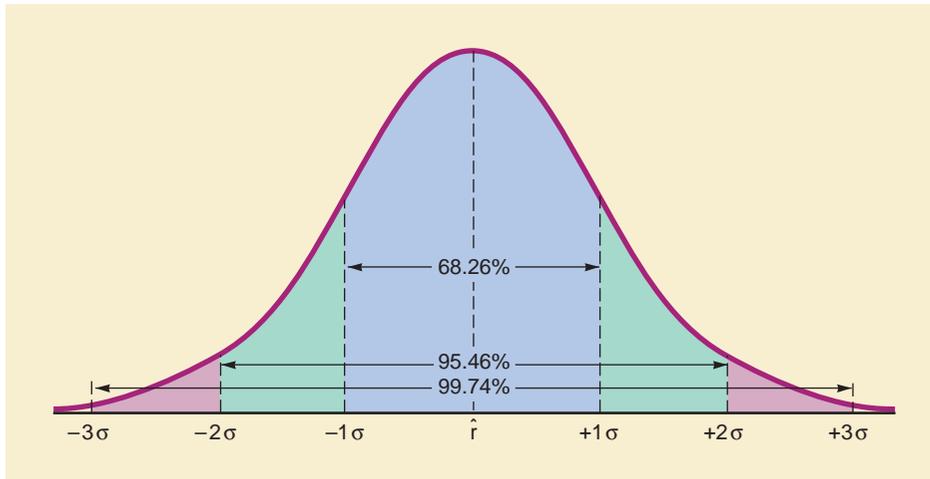
Notes:
a. The area under the normal curve always equals 1.0, or 100 percent. *Thus, the areas under any pair of normal curves drawn on the same scale, whether they are peaked or flat, must be equal.*
b. Half of the area under a normal curve is to the left of the mean, indicating that there is a 50 percent probability that the actual outcome will be less than the mean, and half is to the right of r̂, indicating a 50 percent probability that it will be greater than the mean.
c. Of the area under the curve, 68.26 percent is within ±1σ of the mean, indicating that the probability is 68.26 percent that the actual outcome will be within the range r̂ − 1σ to r̂ + 1σ.
d. Procedures exist for finding the probability of other ranges. These procedures are covered in statistics courses.
e. For a normal distribution, the larger the value of σ, the greater the probability that the actual outcome will vary widely from, and hence perhaps be far below, the expected, or most likely, outcome. *Since the probability of having the actual result turn out to be far below the expected result is one definition of risk, and since σ measures this probability, we can use σ as a measure of risk.* This definition may not be a good one, however, if we are dealing with an asset held in a diversified portfolio. This point is covered later in the chapter.

$$\bar{r}_{Avg} = \frac{(15\% - 5\% + 20\%)}{3} = 10.0\%$$

$$\text{Estimated } \sigma \text{ (or S)} = \sqrt{\frac{(15\% - 10\%)^2 + (-5\% - 10\%)^2 + (20\% - 10\%)^2}{3 - 1}}$$

$$= \sqrt{\frac{350\%}{2}} = 13.2\%$$

The historical σ is often used as an estimate of the future σ. Much less often, and generally incorrectly, r̄_Avg for some past period is used as an estimate of r̂, the expected future return. Because past variability is likely to be repeated, σ may be a good estimate of future risk. However, it is much less reasonable to expect that the average return during any particular past period is the best estimate of what investors think will happen in the future. For instance, from 2000 through 2002 the historical average return on the S&P 500 index was negative, but it is not reasonable to assume that investors expect returns to continue to be negative in the future. If they expected negative returns, they would obviously not have been willing to buy or hold stocks.

Equation 8-3a is built into all financial calculators, and it is easy to use.[5] We simply enter the rates of return and press the key marked S (or S_x) to obtain the standard deviation. However, calculators have no built-in formula for finding σ where probabilistic data are involved. There you must go through the process outlined in Table 8-3 and Equation 8-3. The same situation holds for *Excel* and other computer spreadsheet programs. Both versions of the standard deviation are interpreted and used in the same manner—the only difference is in the way they are calculated.

Measuring Stand-Alone Risk: The Coefficient of Variation

If a choice has to be made between two investments that have the same expected returns but different standard deviations, most people would choose the one with the lower standard deviation and, therefore, the lower risk. Similarly, given a choice between two investments with the same risk (standard deviation) but different expected returns, investors would generally prefer the investment with the higher expected return. To most people, this is common sense—return is "good," risk is "bad," and, consequently, investors want as much return and as little risk as possible. But how do we choose between two investments if one has the higher expected return but the other the lower standard deviation? To help answer this question, we use another measure of risk, the **coefficient of variation (CV),** which is the standard deviation divided by the expected return:

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Coefficient of Variation (CV)

Standardized measure of the risk per unit of return; calculated as the standard deviation divided by the expected return.

</div>

$$\text{Coefficient of variation} = \text{CV} = \frac{\sigma}{\hat{r}} \tag{8-4}$$

The coefficient of variation shows the risk per unit of return, and it provides a more meaningful risk measure when the expected returns on two alternatives are not the same. Since U.S. Water and Martin Products have the same expected return, the coefficient of variation is not necessary in this case. Here the firm with the larger standard deviation, Martin, must have the larger coefficient of variation. In fact, the coefficient of variation for Martin is $65.84/15 = 4.39$ and that for U.S. Water is $3.87/15 = 0.26$. Thus, Martin is almost 17 times riskier than U.S. Water on the basis of this criterion.

For a case where the coefficient of variation is actually necessary, consider Projects X and Y in Figure 8-4. These projects have different expected rates of return and different standard deviations. Project X has a 60 percent expected rate of return and a 15 percent standard deviation, while Y has an 8 percent expected return but only a 3 percent standard deviation. Is Project X riskier, on a relative basis, because it has the larger standard deviation? If we calculate the coefficients of variation for these two projects, we find that Project X has a coefficient of variation of $15/60 = 0.25$, and Project Y has a coefficient of variation of $3/8 = 0.375$. Thus, Project Y actually has more risk per unit of return than Project X, in spite of the fact that X's standard deviation is larger. Therefore, even though Project Y has the lower standard deviation, according to the coefficient of variation it is riskier than Project X.

Project Y has the smaller standard deviation, hence the more peaked probability distribution, but it is clear from the graph that the chances of a really low return are higher for Y than for X because X's expected return is so high. Because

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[5] See our tutorials or your calculator manual for instructions on calculating historical standard deviations.

FIGURE 8-4 *Comparison of Probability Distributions and Rates of Return for Projects X and Y*
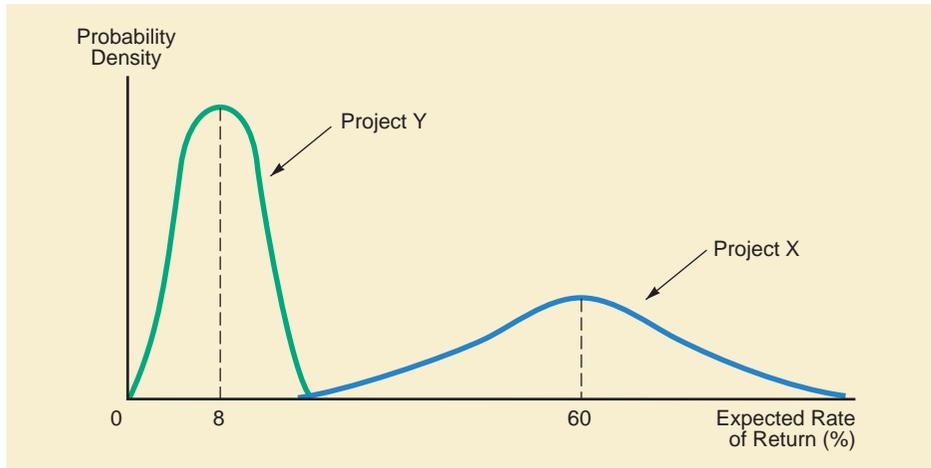
the coefficient of variation captures the effects of both risk and return, it is a better measure for evaluating risk in situations where investments have substantially different expected returns.

Risk Aversion and Required Returns

Suppose you have worked hard and saved $1 million, and you now plan to invest it and retire on the income it produces. You can buy a 5 percent U.S. Treasury bill, and at the end of one year you will have a sure $1.05 million, which is your original investment plus $50,000 in interest. Alternatively, you can buy stock in R&D Enterprises. If R&D's research programs are successful, your stock will increase in value to $2.1 million. However, if the research is a failure, the value of your stock will be zero, and you will be penniless. You regard R&D's chances of success or failure as being 50–50, so the expected value of the stock investment is 0.5($0) + 0.5($2,100,000) = $1,050,000. Subtracting the $1 million cost of the stock leaves an expected profit of $50,000, or an expected (but risky) 5 percent rate of return, the same as for the T-bill:

$$\text{Expected rate of return} = \frac{\text{Expected ending value} - \text{Cost}}{\text{Cost}}$$

$$= \frac{\$1,050,000 - \$1,000,000}{\$1,000,000}$$

$$= \frac{\$50,000}{\$1,000,000} = 5\%$$

Thus, you have a choice between a sure $50,000 profit (representing a 5 percent rate of return) on the Treasury bill and a risky expected $50,000 profit (also representing a 5 percent expected rate of return) on the R&D Enterprises stock. Which one would you choose? *If you choose the less risky investment, you are risk averse. Most investors are indeed risk averse, and certainly the average investor is risk averse with regard to his or her "serious money." Because this is a well-documented fact, we assume* **risk aversion** *in our discussions throughout the remainder of the book.*

Risk Aversion
Risk-averse investors dislike risk and require higher rates of return as an inducement to buy riskier securities.

The Trade-Off between Risk and Return

The table accompanying this box summarizes the historical trade-off between risk and return for different classes of investments from 1926 through 2004. As the table shows, those assets that produced the highest average returns also had the highest standard deviations and the widest ranges of returns. For example, small-company stocks had the highest average annual return, 17.5 percent, but the standard deviation of their returns, 33.1 percent, was also the highest. By contrast, U.S. Treasury bills had the lowest standard deviation, 3.1 percent, but they also had the lowest average return, 3.8 percent. While there is no guarantee that history will repeat itself, the returns and standard deviations observed in the past are a good starting point for estimating investments' future returns.

Risk Premium, RP
The difference between the expected rate of return on a given risky asset and that on a less risky asset.

What are the implications of risk aversion for security prices and rates of return? *The answer is that, other things held constant, the higher a security's risk the lower its price and the higher its required return.* To see how risk aversion affects security prices, look back at Figure 8-2 and consider again U.S. Water's and Martin Products' stocks. Suppose each stock sold for $100 per share and each had an expected rate of return of 15 percent. Investors are averse to risk, so under those conditions there would be a general preference for U.S. Water. People with money to invest would bid for U.S. Water rather than Martin stock, and Martin's stockholders would start selling their stock and using the money to buy U.S. Water. Buying pressure would drive up U.S. Water's stock, and selling pressure would simultaneously cause Martin's price to decline.

These price changes, in turn, would cause changes in the expected returns of the two securities. In general, if expected future cash flows remain the same, your expected return would be higher if you were able to purchase the stock at a lower price. Suppose, for example, that U.S. Water's stock price were bid up from $100 to $150, whereas Martin's stock price declined from $100 to $75. These price changes would cause U.S. Water's expected return to fall to 10 percent, and Martin's expected return to rise to 20 percent.[6] The difference in returns, $20\% - 10\% = 10\%$, would be a **risk premium, RP,** which represents the additional compensation investors require for bearing Martin's higher risk.

This example demonstrates a very important principle: *In a market dominated by risk-averse investors, riskier securities must have higher expected returns as estimated by investors at the margin than less risky securities. If this situation does not exist, buying and selling will occur in the market until it does exist.* We will consider the question of how much higher the returns on risky securities must be later in the chapter, after we see how diversification affects the way risk should be measured.

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[6] To understand how we might arrive at these numbers, assume that each stock is expected to pay shareholders $15 a year in perpetuity. The price of this perpetuity can be found by dividing the annual cash flow by the stock's return. Thus, in this example, if the stock's expected return is 15 percent, the price of the stock would be $15/0.15 = $100. Likewise, a 10 percent expected return would be consistent with a $150 stock price ($15/0.10), and a 20 percent expected return would be consistent with a $75 stock price ($15/0.20).

Selected Realized Returns, 1926–2004

	Average Return	Standard Deviation
Small-company stocks	17.5%	33.1%
Large-company stocks	12.4	20.3
Long-term corporate bonds	6.2	8.6
Long-term government bonds	5.8	9.3
U.S. Treasury bills	3.8	3.1

Source: Based on *Stocks, Bonds, Bills, and Inflation: (Valuation Edition) 2005 Yearbook* (Chicago: Ibbotson Associates, 2005), p. 28.

SELF TEST

What does "investment risk" mean?

Set up an illustrative probability distribution table, or "payoff matrix," for an investment with probabilities for different conditions, returns under those conditions, and the expected return.

Which of the two stocks graphed in Figure 8-2 is less risky? Why?

How is the standard deviation calculated based on (1) a probability distribution of returns and (b) historical returns?

Which is a better measure of risk if assets have different expected returns: (1) the standard deviation or (2) the coefficient of variation? Why?

Explain why you agree or disagree with the following statement: "Most investors are risk averse."

How does risk aversion affect rates of return?

An investment has a 50 percent chance of producing a 20 percent return, a 25 percent chance of producing an 8 percent return, and a 25 percent chance of producing a −12 percent return. What is its expected return? (9%)

An investment has an expected return of 10 percent and a standard deviation of 30 percent. What is its coefficient of variation? (3.0)

8.2 RISK IN A PORTFOLIO CONTEXT

Thus far we have considered the riskiness of assets when they are held in isolation. Now we analyze the riskiness of assets held as a part of a portfolio. As we shall see, an asset held in a portfolio is less risky than the same asset held in isolation. Since investors dislike risk, and since risk can be reduced by holding

portfolios—that is, by diversifying—most financial assets are indeed held in portfolios. Banks, pension funds, insurance companies, mutual funds, and other financial institutions are required by law to hold diversified portfolios. Even individual investors—at least those whose security holdings constitute a significant part of their total wealth—generally hold portfolios, not the stock of a single firm. Therefore, the fact that a particular stock goes up or down is not very important—*what is important is the return on the investor's portfolio, and the risk of that portfolio. Logically, then, the risk and return of an individual security should be analyzed in terms of how the security affects the risk and return of the portfolio in which it is held.*

To illustrate, Pay Up Inc. is a collection agency company that operates nationwide through 37 offices. The company is not well known, its stock is not very liquid, and its earnings have fluctuated quite a bit in the past. This suggests that Pay Up is risky and that its required rate of return, r, should be relatively high. However, Pay Up's required rate of return in 2005 (and all other years) was actually quite low in comparison to that of most other companies. This indicates that investors regard Pay Up as being a low-risk company in spite of its uncertain profits. The reason for this counterintuitive finding has to do with diversification and its effect on risk. Pay Up's earnings rise during recessions, whereas most other companies' earnings tend to decline when the economy slumps. Thus, Pay Up's stock is like fire insurance—it pays off when other things go bad. Therefore, adding Pay Up to a portfolio of "normal" stocks stabilizes returns on the portfolio, thus making the portfolio less risky.

Expected Portfolio Returns, $\hat{r}_p$

Expected Return on a Portfolio, $\hat{r}_p$
The weighted average of the expected returns on the assets held in the portfolio.

The **expected return on a portfolio, $\hat{r}_p$,** is simply the weighted average of the expected returns on the individual assets in the portfolio, with the weights being the percentage of the total portfolio invested in each asset:

$$\hat{r}_p = w_1\hat{r}_1 + w_2\hat{r}_2 + \cdots + w_N\hat{r}_N$$

$$= \sum_{i=1}^{N} w_i\hat{r}_i \qquad \text{(8-5)}$$

Here the $\hat{r}_i$'s are the expected returns on the individual stocks, the w_i's are the weights, and there are N stocks in the portfolio. Note that (1) w_i is the fraction of the portfolio's dollar value invested in Stock i (that is, the value of the investment in Stock i divided by the total value of the portfolio) and (2) the w_i's must sum to 1.0.

Assume that in March 2005, a security analyst estimated that the following returns could be expected on the stocks of four large companies:

	Expected Return, $\hat{r}$
Microsoft	12.0%
General Electric	11.5
Pfizer	10.0
Coca-Cola	9.5

Realized Rate of Return, $\bar{r}$
The return that was actually earned during some past period. The actual return ($\bar{r}$) usually turns out to be different from the expected return ($\hat{r}$) except for riskless assets.

If we formed a $100,000 portfolio, investing $25,000 in each stock, the portfolio's expected return would be 10.75 percent:

$$\hat{r}_p = w_1\hat{r}_1 + w_2\hat{r}_2 + w_3\hat{r}_3 + w_4\hat{r}_4$$

$$= 0.25(12\%) + 0.25(11.5\%) + 0.25(10\%) + 0.25(9.5\%)$$

$$= 10.75\%$$

Of course, after the fact and a year later, the actual **realized rates of return, $\bar{r}_i$,** on the individual stocks—the $\bar{r}_i$, or "r-bar," values—will almost certainly be dif-

ferent from their expected values, so $\bar{r}_p$ will be different from $\hat{r}_p = 10.75\%$. For example, Coca-Cola's price might double and thus provide a return of $+100$ percent, whereas Microsoft might have a terrible year, fall sharply, and have a return of -75 percent. Note, though, that those two events would be offsetting, so the portfolio's return might still be close to its expected return, even though the individual stocks' returns were far from their expected values.

Portfolio Risk

Although the expected return on a portfolio is simply the weighted average of the expected returns of the individual assets in the portfolio, the riskiness of the portfolio, σ_p, is *not* the weighted average of the individual assets' standard deviations. The portfolio's risk is generally *smaller* than the average of the assets' σ's.

To illustrate the effect of combining assets, consider the situation in Figure 8-5. The bottom section gives data on rates of return for Stocks W and M individually, and also for a portfolio invested 50 percent in each stock. The three top graphs show plots of the data in a time series format, and the lower graphs show the probability distributions of returns, assuming that the future is expected to be like the past. The two stocks would be quite risky if they were held in isolation, but when they are combined to form Portfolio WM, they are not risky at all. (Note: These stocks are called W and M because the graphs of their returns in Figure 8-5 resemble a W and an M.)

Stocks W and M can be combined to form a riskless portfolio because their returns move countercyclically to each other—when W's returns fall, those of M rise, and vice versa. The tendency of two variables to move together is called **correlation,** and the **correlation coefficient, ρ** (pronounced "rho"), measures this tendency.[7] In statistical terms, we say that the returns on Stocks W and M are *perfectly negatively correlated*, with $\rho = -1.0$.

The opposite of perfect negative correlation, with $\rho = -1.0$, is *perfect positive correlation*, with $\rho = +1.0$. Returns on two perfectly positively correlated stocks (M and M′) would move up and down together, and a portfolio consisting of two such stocks would be exactly as risky as the individual stocks. This point is illustrated in Figure 8-6, where we see that the portfolio's standard deviation is equal to that of the individual stocks. *Thus, diversification does nothing to reduce risk if the portfolio consists of perfectly positively correlated stocks*.

Figures 8-5 and 8-6 demonstrate that when stocks are perfectly negatively correlated ($\rho = -1.0$), all risk can be diversified away, but when stocks are perfectly positively correlated ($\rho = +1.0$), diversification does no good whatever. In reality, virtually all stocks are positively correlated, but not perfectly so. Past studies have estimated that on average the correlation coefficient for the monthly returns on two randomly selected stocks is about 0.3.[8] *Under this condition, combining*

Correlation
*The tendency of two variables to move together.*

Correlation Coefficient, ρ
A measure of the degree of relationship between two variables.

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[7] The correlation coefficient, ρ, can range from $+1.0$, denoting that the two variables move up and down in perfect synchronization, to -1.0, denoting that the variables always move in exactly opposite directions. A correlation coefficient of zero indicates that the two variables are not related to each other—that is, changes in one variable are independent of changes in the other. It is easy to calculate correlation coefficients with a financial calculator. Simply enter the returns on the two stocks and then press a key labeled "r." For W and M, $\rho = -1.0$. See our tutorial or your calculator manual for the exact steps. Also, note that the correlation coefficient is often denoted by the term "r." We use ρ here to avoid confusion with r as used to denote the rate of return.

[8] A recent study by Chan, Karceski, and Lakonishok (1999) estimated that the average correlation coefficient between two randomly selected stocks was 0.28, while the average correlation coefficient between two large-company stocks was 0.33. The time period of their sample was 1968 to 1998. See Louis K. C. Chan, Jason Karceski, and Josef Lakonishok, "On Portfolio Optimization: Forecasting Covariance and Choosing the Risk Model," *The Review of Financial Studies*, Vol. 12, no. 5 (Winter 1999), pp. 937–974.

FIGURE 8-5 *Rate of Return Distributions for Two Perfectly Negatively Correlated Stocks ($\rho = -1.0$) and for Portfolio WM*
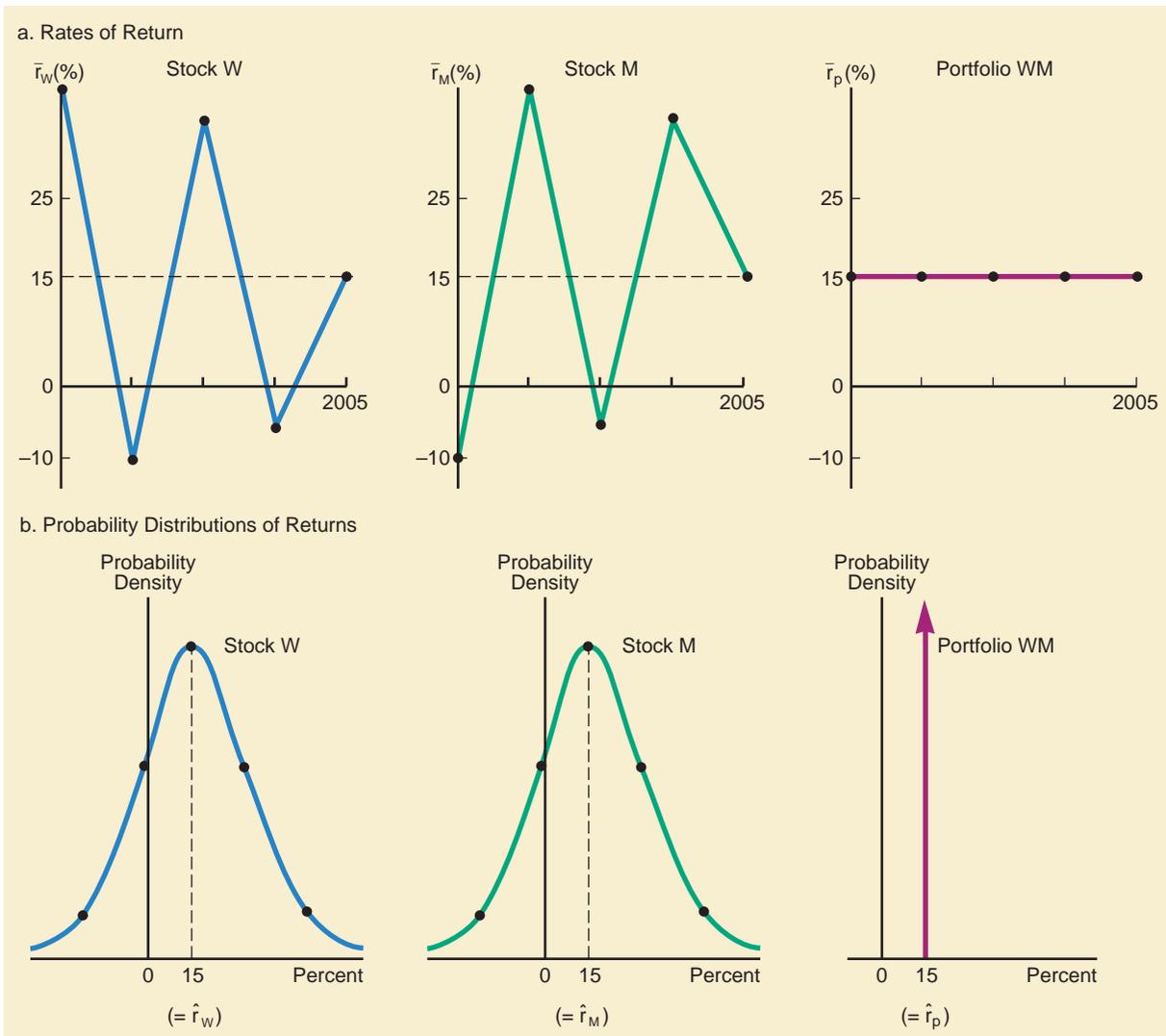
Year	Stock W ($\bar{r}_w$)	Stock M ($\bar{r}_M$)	Portfolio WM ($\bar{r}_p$)
2001	40.0%	(10.0%)	15.0%
2002	(10.0)	40.0	15.0
2003	35.0	(5.0)	15.0
2004	(5.0)	35.0	15.0
2005	15.0	15.0	15.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	0.0%

stocks into portfolios reduces risk but does not completely eliminate it. Figure 8-7 illustrates this point with two stocks whose correlation coefficient is $\rho = +0.35$. The portfolio's average return is 15 percent, which is exactly the same as the average return for our other two illustrative portfolios, but its standard deviation is 18.6 percent, which is between the other two portfolios' standard deviations.

FIGURE 8-6 · *Rate of Return Distributions for Two Perfectly Correlated Stocks ($\rho = +1.0$) and for Portfolio MM'*

a. Rates of Return

b. Probability Distributions of Returns
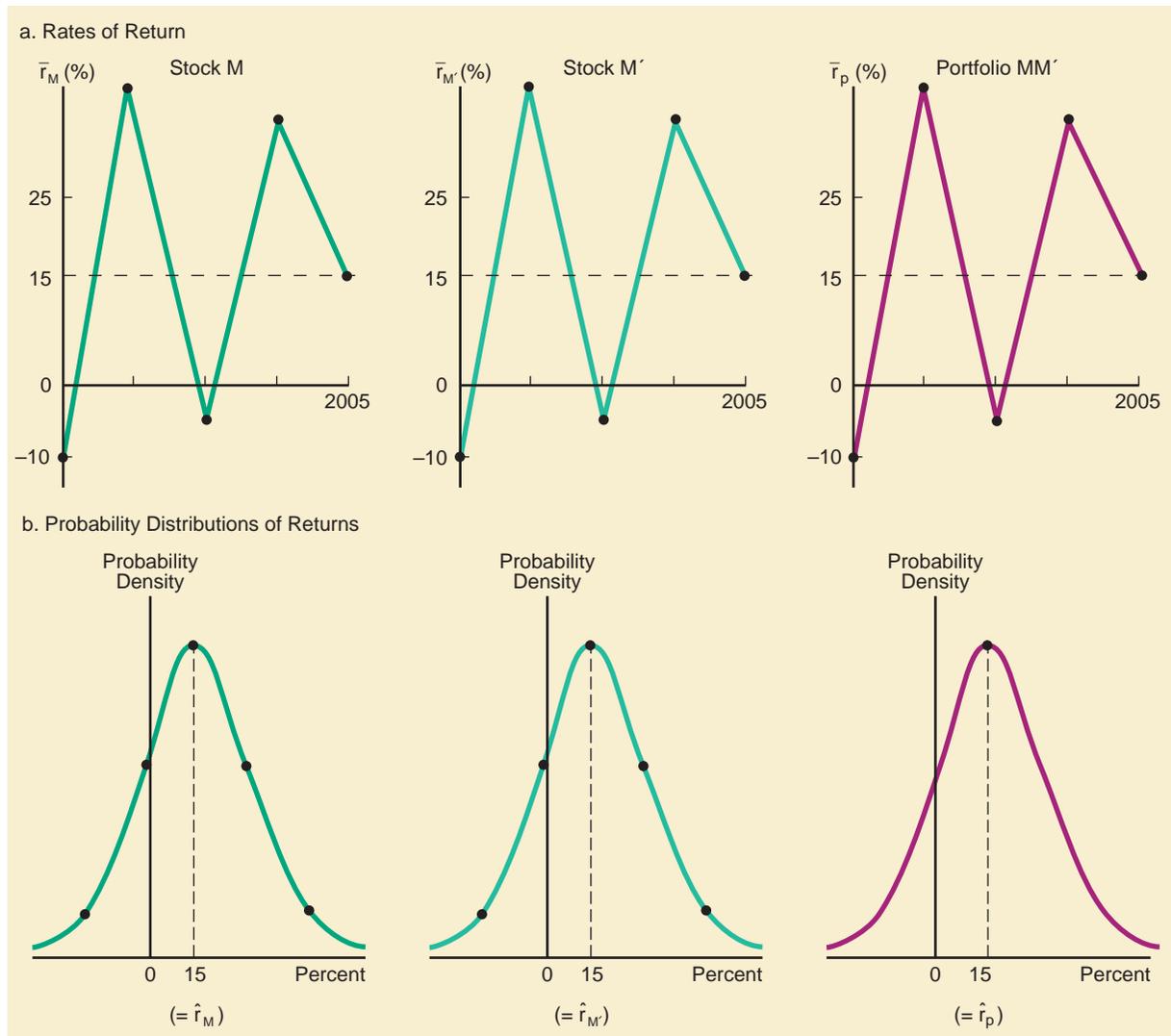
	Stock M	**Stock M'**	**Portfolio MM'**
Year	**($\bar{r}_M$)**	**($\bar{r}_{M'}$)**	**($\bar{r}_p$)**
2001	(10.0%)	(10.0%)	(10.0%)
2002	40.0	40.0	40.0
2003	(5.0)	(5.0)	(5.0)
2004	35.0	35.0	35.0
2005	15.0	15.0	15.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	22.6%

These examples demonstrate that in one extreme case ($\rho = -1.0$), risk can be completely eliminated, while in the other extreme case ($\rho = +1.0$), diversification does no good whatever. The real world lies between these extremes, so combining stocks into portfolios reduces, but does not eliminate, the risk inherent in the individual stocks. Also, we should note that in the real world, it is *impossible* to

FIGURE 8-7 *Rate of Return Distributions for Two Partially Correlated Stocks ($\rho = +0.35$) and for Portfolio WV*

a. Rates of Return

b. Probability Distributions of Returns
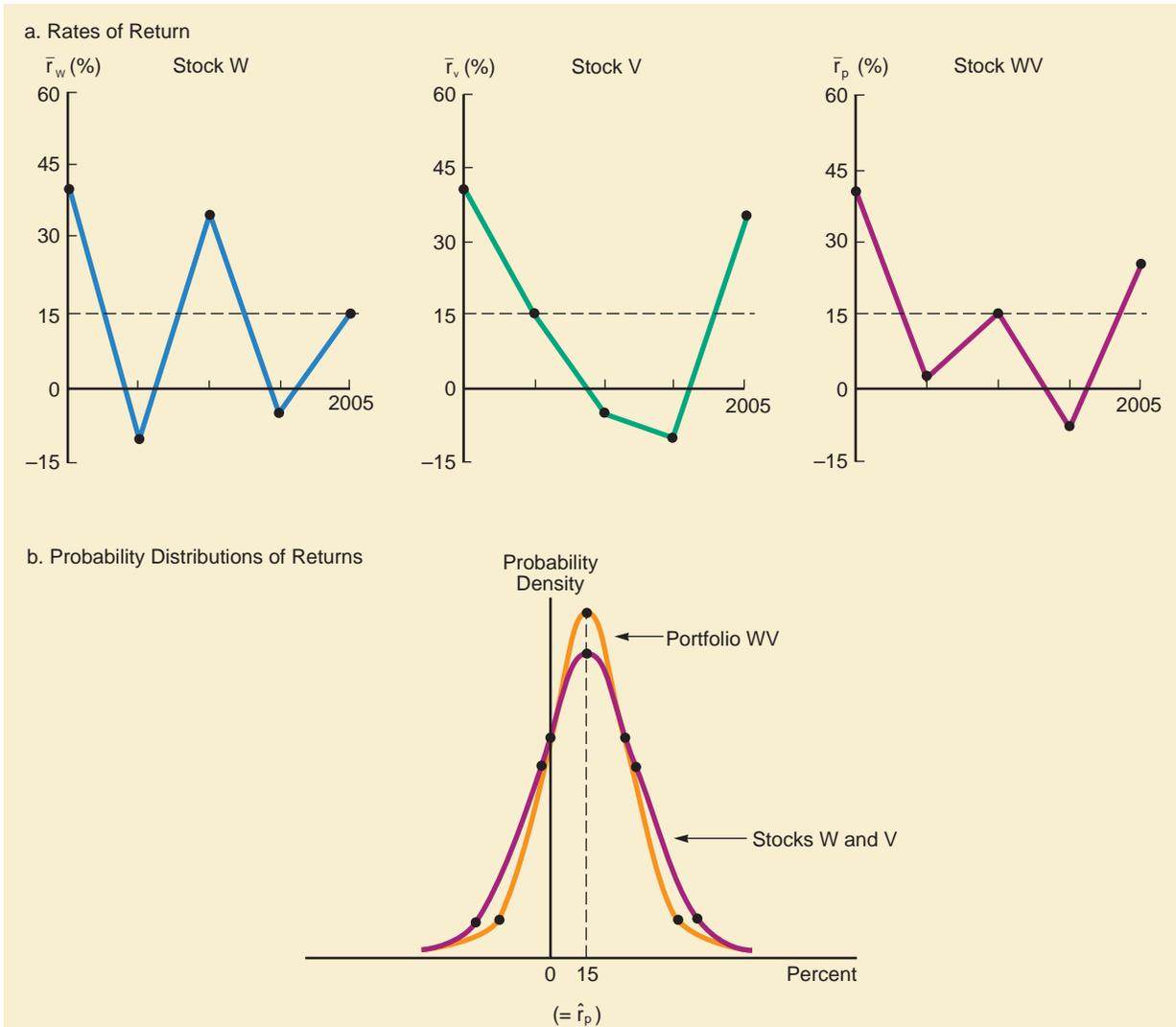
Year	Stock W ($\bar{r}_w$)	Stock V ($\bar{r}_v$)	Portfolio WV ($\bar{r}_p$)
2001	40.0%	40.0%	40.0%
2002	(10.0)	15.0	2.5
2003	35.0	(5.0)	15.0
2004	(5.0)	(10.0)	(7.5)
2005	15.0	35.0	25.0
Average return	15.0%	15.0%	15.0%
Standard deviation	22.6%	22.6%	18.6%

find stocks like W and M, whose returns are expected to be perfectly negatively correlated. *Therefore, it is impossible to form completely riskless stock portfolios.* Diversification can reduce risk but not eliminate it, so the real world is similar to the situation depicted in Figure 8-7.

What would happen if we included more than two stocks in the portfolio? *As a rule, portfolio risk declines as the number of stocks in the portfolio increases.* If we

The Benefits of Diversification Are More Important Than Ever

Have stocks become riskier in recent years? Looking at what's happened to their individual portfolios, many investors may answer that question with a resounding yes. Furthermore, academic studies confirm this intuition—the average volatility of individual stocks has increased over time. However, studies have also found that volatility in the overall stock market has not increased. The reason for this apparent discrepancy is that the correlation between individual stocks has fallen in recent years, so declines in one stock are offset by gains in others, and this reduces overall market volatility. A study by Campbell, Lettau, Malkiel, and Xu found that the average correlation fell from around 0.35 in the late 1970s to less than 0.10 by the late 1990s.

What does this mean for the average investor? Individual stocks have become riskier, increasing the danger of putting all of your eggs in one basket, but at the same time, lower correlations between individual stocks mean that diversification is more useful than ever for reducing portfolio risk. Diversify, diversify, diversify!

Source: John Y. Campbell, Martin Lettau, Burton G. Malkiel, and Yexiao Xu, "Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk," *Journal of Finance*, Vol. 56, no. 1 (February 2001), pp.1–43.

added enough partially correlated stocks, could we completely eliminate risk? In general, the answer is no, but here are two points worth noting:

1. The extent to which adding stocks to a portfolio reduces its risk depends on the *degree of correlation* among the stocks: The smaller the correlation coefficients, the lower the risk in a large portfolio. If we could find a set of stocks whose correlations were zero or negative, all risk could be eliminated. *However, in the real world, the correlations among the individual stocks are generally positive but less than +1.0, so some but not all risk can be eliminated*.
2. Some individual stocks are riskier than others, so some stocks will help more than others in terms of reducing the portfolio's risk. This point will be explored further in the next section, where we measure stocks' risks in a portfolio context.

To test your understanding up to this point, would you expect to find higher correlations between the returns on two companies in the same or in different industries? For example, is it likely that the correlation between Ford's and General Motors' stocks would be higher, or would the correlation be higher between either Ford or GM and Coke, and how would those correlations affect the risk of portfolios containing them?

Answer: Ford's and GM's returns are highly correlated with one another because both are affected by similar forces. These stocks are positively correlated with Coke, but the correlation is lower because stocks in different industries are subject to different factors. For example, people reduce auto purchases more than Coke consumption when interest rates rise.

Implications: A two-stock portfolio consisting of Ford and GM would be less well diversified than a two-stock portfolio consisting of Ford or GM, plus Coke. Thus, to minimize risk, portfolios should be diversified across industries.

Diversifiable Risk versus Market Risk

As noted earlier, it is difficult if not impossible to find stocks whose expected returns are negatively correlated to one another—most stocks tend to do well

when the national economy is strong and badly when it is weak.[9] Thus, even very large portfolios end up with a substantial amount of risk, but not as much as if all the money were invested in only one stock.

To see more precisely how portfolio size affects portfolio risk, consider Figure 8-8, which shows how a portfolio's risk is affected by adding more and more randomly selected New York Stock Exchange (NYSE) stocks. Standard deviations are plotted for an average one-stock portfolio, a two-stock portfolio, and so on, up to a portfolio consisting of all 2,000-plus common stocks that were listed on the NYSE at the time the data were graphed. The graph illustrates that, in general, the riskiness of a portfolio consisting of large-company stocks tends to decline and to approach a minimum level as the size of the portfolio increases. According to data accumulated in recent years, σ_1, the standard deviation of a one-stock portfolio (or an average stock) is approximately 35 percent. A portfolio consisting of all stocks, which is called the **market portfolio,** would have a much lower standard deviation, σ_M, about 20 percent, as represented by the horizontal dashed line in Figure 8-8.

Thus, almost half of the riskiness inherent in an average individual stock can be eliminated if the stock is held in a reasonably well-diversified portfolio, which is one containing 40 or more stocks. Some risk will always remain, however, so it is virtually impossible to diversify away the effects of broad stock market movements that affect almost all stocks.

The part of a stock's risk that *can* be eliminated is called **diversifiable risk,** while the part that *cannot* be eliminated is called **market risk.**[10] Diversifiable risk is caused by such random events as lawsuits, strikes, successful and unsuccessful marketing programs, winning or losing a major contract, and other events that are unique to a particular firm. Because these events are random, their effects on a portfolio can be eliminated by diversification—bad events in one firm will be offset by good events in another. Market risk, on the other hand, stems from factors that systematically affect most firms: war, inflation, recessions, and high interest rates. Because most stocks are negatively affected by these factors, market risk cannot be eliminated by diversification.

We know that investors demand a premium for bearing risk; that is, the higher the riskiness of a security, the higher its expected return must be to induce investors to buy (or to hold) it. However, rational investors are primarily concerned with the riskiness of their *portfolios* rather than the riskiness of the individual securities in the portfolio, so the riskiness of an individual stock should be judged by its effect on the riskiness of the portfolio in which it is held. This type of risk is addressed by the **Capital Asset Pricing Model (CAPM),** which describes the relationship between risk and rates of return.[11] According to the CAPM, *the relevant riskiness of an individual stock is its contribution to the riski-*

Market Portfolio

A portfolio consisting of all stocks.

Diversifiable Risk

That part of a security's risk associated with random events; it can be eliminated by proper diversification.

Market Risk

That part of a security's risk that cannot *be eliminated by diversification.*

Capital Asset Pricing Model (CAPM)

A model based on the proposition that any stock's required rate of return is equal to the risk-free rate of return plus a risk premium that reflects only the risk remaining after diversification.

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[9] It is not too hard to find a few stocks that happened to have risen because of a particular set of circumstances in the past while most other stocks were declining, but it is much harder to find stocks that could logically be *expected* to increase in the future when other stocks are falling.

[10] Diversifiable risk is also known as *company-specific*, or *unsystematic*, risk. Market risk is also known as *nondiversifiable*, or *systematic*, or beta, risk; it is the risk that remains after diversification.

[11] Indeed, the 1990 Nobel Prize was awarded to the developers of the CAPM, Professors Harry Markowitz and William F. Sharpe. The CAPM is a relatively complex subject, and only its basic elements are presented in this text. For a more detailed discussion, see any standard investments textbook.

The basic concepts of the CAPM were developed specifically for common stocks, and, therefore, the theory is examined first in this context. However, it has become common practice to extend CAPM concepts to capital budgeting and to speak of firms having "portfolios of tangible assets and projects." Capital budgeting is discussed in Part 4.

FIGURE 8-8 *Effects of Portfolio Size on Portfolio Risk for Average Stocks*
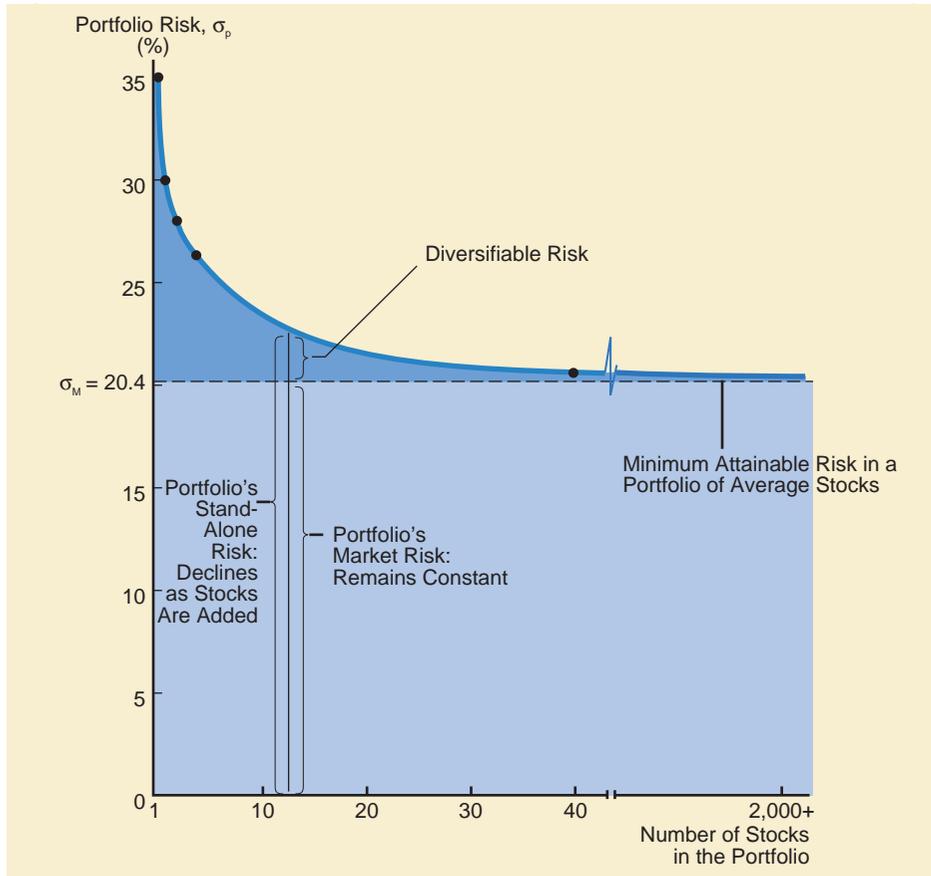
ness of a well-diversified portfolio. In other words, the riskiness of General Electric's stock to a doctor who has a portfolio of 40 stocks or to a trust officer managing a 150-stock portfolio is the contribution GE's stock makes to the portfolio's riskiness. The stock might be quite risky if held by itself, but if half of its risk can be eliminated by diversification, then its **relevant risk,** which is its *contribution to the portfolio's risk*, is much smaller than its stand-alone risk.

A simple example will help make this point clear. Suppose you are offered the chance to flip a coin once. If a head comes up, you win $20,000, but if a tail comes up, you lose $16,000. This is a good bet—the expected return is 0.5($20,000) + 0.5(−$16,000) = $2,000. However, it is a highly risky proposition, because you have a 50 percent chance of losing $16,000. Thus, you might well refuse to make the bet. Alternatively, suppose you were offered the chance to flip a coin 100 times, and you would win $200 for each head but lose $160 for each tail. It is possible that you would flip all heads and win $20,000, and it is also possible that you would flip all tails and lose $16,000, but the chances are very high that you would actually flip about 50 heads and about 50 tails, winning a net of about $2,000. Although each individual flip is a risky bet, collectively you have a low-risk proposition because multiple flipping diversifies away most of the risk. This is the idea behind holding portfolios of stocks rather

Relevant Risk
The risk of a security that cannot be diversified away. This is the risk that affects portfolio risk and thus is relevant to a rational investor.

than just one stock, except that with stocks all of the risk cannot be eliminated by diversification—those risks that are related to broad, systematic changes in the stock market will remain even in a highly diversified portfolio.

Are all stocks equally risky in the sense that adding them to a well-diversified portfolio would have the same effect on the portfolio's riskiness? The answer is no. Different stocks will affect the portfolio differently, so different securities have different degrees of relevant risk. How can the relevant risk of an individual stock be measured? As we have seen, all risk except that related to broad market movements can, and presumably will, be diversified away by most investors. After all, why accept a risk that can easily be eliminated? *The risk that remains after diversifying is market risk, or the risk that is inherent in the market, and it can be measured by the degree to which a given stock tends to move up or down with the market.* In the next section, we explain how to measure a stock's market risk, and then, in a later section, we introduce an equation for determining a stock's required rate of return, given its market risk.

## The Concept of Beta

Beta Coefficient, b
A metric that shows the extent to which a given stock's returns move up and down with the stock market. Beta thus measures market risk.

The tendency of a stock to move up and down with the market, and thus its *market risk,* is reflected in its **beta coefficient, b.** Beta is a key element of the CAPM. An *average-risk stock* is defined as one that tends to move up and down in step with the general market as measured by some index such as the Dow Jones Industrials, the S&P 500, or the New York Stock Exchange Index. Such a stock is, *by definition,* assigned a beta of b = 1.0. Thus, a stock with b = 1.0 will, in general, move up by 10 percent if the market moves up by 10 percent, while if the market falls by 10 percent, the stock will likewise fall by 10 percent. A portfolio of such b = 1.0 stocks will thus move up and down with the broad market averages, and it will be just as risky as the averages. If b = 0.5, the stock would be only half as volatile as the market—it would rise and fall only half as much—and a portfolio of such stocks would be only half as risky as a portfolio of b = 1.0 stocks. On the other hand, if b = 2.0, the stock would be twice as volatile as an average stock, so a portfolio of such stocks would be twice as risky as an average portfolio. The value of such a portfolio could double—or halve—in a short time, and if you held such a portfolio, you could quickly go from millionaire to pauper.

Figure 8-9 graphs the three stocks' returns to show their relative volatility. The illustrative data below the graph show that in Year 1, the "market," as defined by a portfolio containing all stocks, had a total return (dividend yield plus capital gains yield) of $r_M = 10\%$, and Stocks H, A, and L (for High, Average, and Low risk) also all had returns of 10 percent. In Year 2, the market went up sharply, and its return was $r_M = 20\%$. Returns on the three stocks were also high: H soared by 30 percent; A returned 20 percent, the same as the market; and L returned only 15 percent. In Year 3 the market dropped sharply, and its return was $\bar{r}_M = -10\%$. The three stocks' returns also fell, H plunging by -30 percent, A falling by -10 percent, and L returning $\bar{r}_L = 0\%$. Thus, the three stocks all moved in the same direction as the market, but H was by far the most volatile, A was exactly as volatile as the market, and L was less volatile.

Beta measures a given stock's volatility relative to an average stock, which by definition has b = 1.0, and the stock's beta can be calculated by plotting a line like those in Figure 8-9. The slopes of the lines show how each stock moves in response to a movement in the general market—*indeed, the slope coefficient of such a "regression line" is defined as the stock's beta coefficient.* (Procedures for calculating betas are described in Web Appendix 8A, which can be accessed through the ThomsonNOW Web site. Betas for literally thousands of companies are calculated and published by Merrill Lynch, Value Line, and numerous other organiza-

FIGURE 8-9 | *Relative Volatility of Stocks H, A, and L*
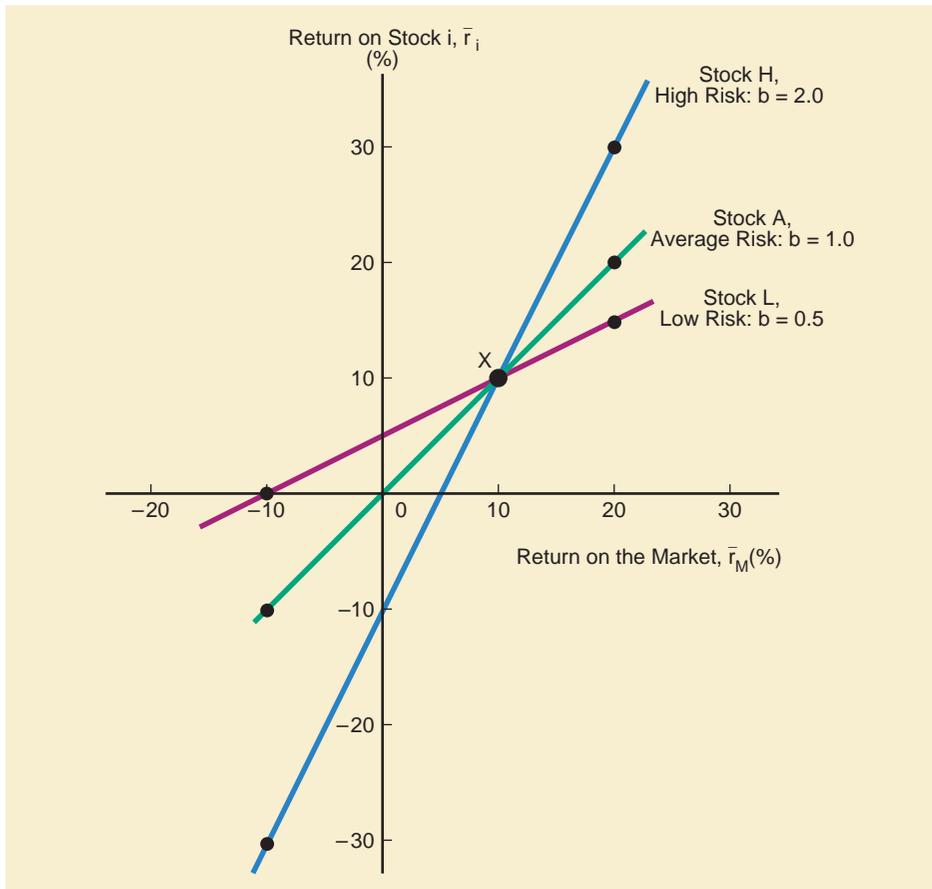
Year	$\bar{r}_H$	$\bar{r}_A$	$\bar{r}_L$	$\bar{r}_M$
1	10%	10%	10%	10%
2	30	20	15	20
3	(30)	(10)	0	(10)

Note: These three stocks plot exactly on their regression lines. This indicates that they are exposed only to market risk. Mutual funds that concentrate on stocks with betas of 2, 1, and 0.5 would have patterns similar to those shown in the graph.

tions, and the beta coefficients of some well-known companies are shown in Table 8-4. Most stocks have betas in the range of 0.50 to 1.50, and the average for all stocks is 1.0 by definition.

Theoretically, it would be possible for a stock to have a negative beta. In this case, the stock's returns would tend to rise whenever the returns on other stocks fall. However, we have never seen a negative beta as reported by one of the many organizations that publish betas for publicly held firms. Moreover, even though a stock may have a positive long-run beta, company-specific problems might cause its realized return to decline even when the general market is strong.

If a stock whose beta is greater than 1.0 is added to a $b_p = 1.0$ portfolio, then the portfolio's beta, and consequently its risk, will increase. Conversely, if

TABLE 8-4	*Illustrative List of Beta Coefficients*

Stock	Beta
Merrill Lynch	1.50
eBay	1.45
General Electric	1.30
Best Buy	1.25
Microsoft	1.15
ExxonMobil	0.80
FPL Group	0.70
Coca-Cola	0.60
Procter & Gamble	0.60
Heinz	0.55

Source: Adapted from *Value Line*, March 2005.

a stock whose beta is less than 1.0 is added to a $b_p = 1.0$ portfolio, the portfolio's beta and risk will decline. *Thus, because a stock's beta measures its contribution to the riskiness of a portfolio, beta is theoretically the correct measure of the stock's riskiness.*

The preceding analysis of risk in a portfolio context is part of the Capital Asset Pricing Model (CAPM), and we can summarize our discussion up to this point as follows:

1. A stock's risk consists of two components, market risk and diversifiable risk.
2. Diversifiable risk can be eliminated by diversification, and most investors do indeed diversify, either by holding large portfolios or by purchasing shares in a mutual fund. We are left, then, with market risk, which is caused by general movements in the stock market and which reflects the fact that most stocks are systematically affected by events like wars, recessions, and inflation. Market risk is the only relevant risk to a rational, diversified investor because such an investor would eliminate diversifiable risk.
3. Investors must be compensated for bearing risk—the greater the riskiness of a stock, the higher its required return. However, compensation is required only for risk that cannot be eliminated by diversification. If risk premiums existed on a stock due to its diversifiable risk, then that stock would be a bargain to well-diversified investors. They would start buying it and bidding up its price, and the stock's final (equilibrium) price would result in an expected return that reflected only its non-diversifiable market risk.

    If this point is not clear, an example may help clarify it. Suppose half of Stock A's risk is market risk (it occurs because Stock A moves up and down with the market), while the other half of A's risk is diversifiable. You are thinking of buying Stock A and holding it as a one-stock portfolio, so if you buy it you will be exposed to all of its risk. As compensation for bearing so much risk, you want a risk premium of 8 percent over the 6 percent T-bond rate, so your required return is $r_A = 6\% + 8\% = 14\%$. But suppose other investors, including your professor, are well diversified; they are also looking at Stock A, but they would hold it in diversified portfolios, eliminate its diversifiable risk, and thus be exposed to only half as much risk as you. Therefore, their risk premium would be only half as large as yours, and their required rate of return would be $r_A = 6\% + 4\% = 10\%$.

If the stock were priced to yield the 14 percent you require, then diversified investors, including your professor, would rush to buy it. That would push its price up and its yield down; hence, you could not buy it at a price low enough to provide you with the 14 percent return. In the end, you would have to accept a 10 percent return or else keep your money in the bank. Thus, risk premiums in a market populated by rational, diversified investors can reflect only market risk.

4. The market risk of a stock is measured by its beta coefficient, which is an index of the stock's relative volatility. Some benchmark betas follow:

   $b = 0.5$: Stock is only half as volatile, or risky, as an average stock.

   $b = 1.0$: Stock is of average risk.

   $b = 2.0$: Stock is twice as risky as an average stock.

5. A portfolio consisting of low-beta securities will itself have a low beta, because the beta of a portfolio is a weighted average of its individual securities' betas:

$$b_p = w_1 b_1 + w_2 b_2 + \cdots + w_N b_N$$

$$= \sum_{i=1}^{N} w_i b_i \qquad \text{(8-6)}$$

Here b_p is the beta of the portfolio, and it shows how volatile the portfolio is relative to the market; w_i is the fraction of the portfolio invested in the ith stock; and b_i is the beta coefficient of the ith stock. For example, if an investor holds a $100,000 portfolio consisting of $33,333.33 invested in each of three stocks, and if each of the stocks has a beta of 0.7, then the portfolio's beta will be $b_p = 0.7$:

$$b_p = 0.3333(0.7) + 0.3333(0.7) + 0.3333(0.7) = 0.7$$

Such a portfolio will be less risky than the market, so it should experience relatively narrow price swings and have relatively small rate-of-return fluctuations. In terms of Figure 8-9, the slope of its regression line would be 0.7, which is less than that for a portfolio of average stocks.

Now suppose one of the existing stocks is sold and replaced by a stock with $b_i = 2.0$. This action will increase the beta of the portfolio from $b_{p1} = 0.7$ to $b_{p2} = 1.13$:

$$b_{p2} = 0.333(0.7) + 0.3333(0.7) + 0.3333(2.0)$$

$$= 1.13$$

Had a stock with $b_i = 0.2$ been added, the portfolio's beta would have declined from 0.7 to 0.53. Adding a low-beta stock would therefore reduce the portfolio's riskiness. Consequently, changing the stocks in a portfolio can change the riskiness of that portfolio.

6. *Because a stock's beta coefficient determines how the stock affects the riskiness of a diversified portfolio, beta is the most relevant measure of any stock's risk.*

Explain the following statement: "An asset held as part of a portfolio is generally less risky than the same asset held in isolation."

What is meant by *perfect positive correlation, perfect negative correlation,* and *zero correlation*?

In general, can the riskiness of a portfolio be reduced to zero by increasing the number of stocks in the portfolio? Explain.

GLOBAL PERSPECTIVES

The Benefits of Diversifying Overseas

The increasing availability of international securities is making it possible to achieve a better risk-return trade-off than could be obtained by investing only in U.S. securities. So, investing overseas might result in a portfolio with less risk but a higher expected return. This result occurs because of low correlations between the returns on U.S. and international securities, along with potentially high returns on overseas stocks.

Figure 8-8, presented earlier, demonstrated that an investor can reduce the risk of his or her portfolio by holding a number of stocks. The figure accompanying this box suggests that investors may be able to reduce risk even further by holding a portfolio of stocks from all around the world, given the fact that the returns on domestic and international stocks are not perfectly correlated.

Even though foreign stocks represent roughly 60 percent of the worldwide equity market, and despite the apparent benefits from investing overseas, the typical U.S. investor still puts less than 10 percent of his or her money in foreign stocks. One possible explanation for this reluctance to invest overseas is that investors prefer domestic stocks because of lower transactions costs. However, this explanation is questionable because recent studies reveal that investors buy and sell overseas stocks more frequently than they trade their domestic stocks. Other explanations for the domestic bias include the additional risks from investing overseas (for example, exchange rate risk) and the fact that the typical U.S. investor is uninformed about international investments and/or thinks that international investments are extremely risky. It has been argued that world capital markets have become more integrated, causing the correlation of returns between different countries to increase, which reduces the benefits from international diversification. In addition U.S. corporations are investing more internationally, providing U.S. investors with international diversification even if they buy only U.S. stocks.

Whatever the reason for their relatively small holdings of international assets, our guess is that in the future U.S. investors will shift more of their assets to overseas investments.

Source: For further reading, see also Kenneth Kasa, "Measuring the Gains from International Portfolio Diversification," *Federal Reserve Bank of San Francisco Weekly Letter*, Number 94–14, April 8, 1994.
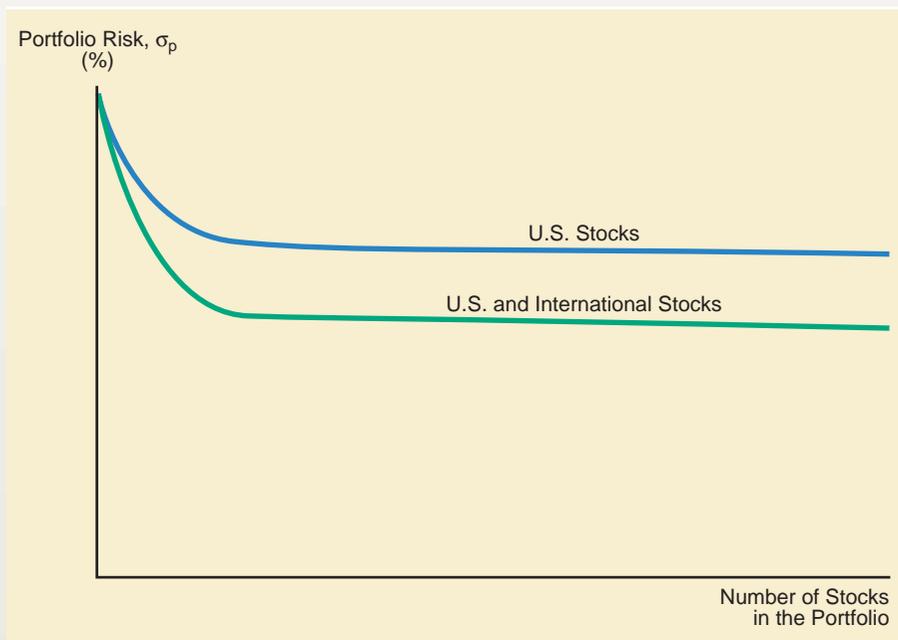
What is an average-risk stock? What is the beta of such a stock?

Why is it argued that beta is the best measure of a stock's risk?

If you plotted a particular stock's returns versus those on the Dow Jones Index over the past five years, what would the slope of the regression line indicate about the stock's risk?

An investor has a two-stock portfolio with $25,000 invested in Merrill Lynch and $50,000 invested in Coca-Cola. Merrill Lynch's beta is estimated to be 1.50 and Coca-Cola's beta is estimated to be 0.60. What is the estimated beta of the investor's portfolio? (0.90)

8.3 THE RELATIONSHIP BETWEEN RISK AND RATES OF RETURN

The preceding section demonstrated that under the CAPM theory, beta is the most appropriate measure of a stock's relevant risk. The next issue is this: For a given level of risk as measured by beta, what rate of return is required to compensate investors for bearing that risk? To begin, let us define the following terms:

$\hat{r}_i$ = *expected* rate of return on the *i*th stock.

r_i = *required* rate of return on the *i*th stock. Note that if $\hat{r}_i$ is less than r_i, the typical investor would not purchase this stock or would sell it if he or she owned it. If $\hat{r}_i$ were greater than r_i, the investor would buy the stock because it would look like a bargain. Investors would be indifferent if $\hat{r}_i = r_i$.

$\bar{r}$ = realized, after-the-fact return. One obviously does not know $\bar{r}$ at the time he or she is considering the purchase of a stock.

r_{RF} = risk-free rate of return. In this context, r_{RF} is generally measured by the return on long-term U.S. Treasury bonds.

b_i = beta coefficient of the *i*th stock. The beta of an average stock is $b_A = 1.0$.

r_M = required rate of return on a portfolio consisting of all stocks, which is called the *market portfolio*. r_M is also the required rate of return on an average ($b_A = 1.0$) stock.

$RP_M = (r_M - r_{RF})$ = risk premium on "the market," and also the premium on an average stock. This is the additional return over the risk-free rate required to compensate an average investor for assuming an average amount of risk. Average risk means a stock where $b_i = b_A = 1.0$.

$RP_i = (r_M - r_{RF})b_i = (RP_M)b_i$ = risk premium on the *i*th stock. A stock's risk premium will be less than, equal to, or greater than the premium on an average stock, RP_M, depending on whether its beta is less than, equal to, or greater than 1.0. If $b_i = b_A = 1.0$, then $RP_i = RP_M$.

The **market risk premium, RP_M,** shows the premium investors require for bearing the risk of an average stock. The size of this premium depends on how risky investors think the stock market is and on their degree of risk aversion. Let us assume that at the current time Treasury bonds yield $r_{RF} = 6\%$ and an average share of stock has a required rate of return of $r_M = 11\%$. Therefore, the market risk premium is 5 percent, calculated as follows:

$$RP_M = r_M - r_{RF} = 11\% - 6\% = 5\%$$

Market Risk Premium, RP_M

The additional return over the risk-free rate needed to compensate investors for assuming an average amount of risk.

Estimating the Market Risk Premium

The Capital Asset Pricing Model (CAPM) is more than a theory describing the trade-off between risk and return—it is also widely used in practice. As we will see later, investors use the CAPM to determine the discount rate for valuing stocks, and corporate managers use it to estimate the cost of equity capital.

The market risk premium is a key component of the CAPM, and it should be the difference between the *expected future return on the overall stock market* and the *expected future return on a riskless investment.* However, we cannot obtain investors' expectations, so instead academicians and practitioners often use a historical risk premium as a proxy for the expected risk premium. The historical premium is found by first taking the difference between the actual return on the overall stock market and the risk-free rate in a number of different years and then averaging the annual results. Ibbotson Associates, which provides perhaps the most comprehensive estimates of historical risk premiums, reports that the annual premiums have averaged 7.2 percent over the past 79 years.

However, there are three potential problems with historical risk premiums. First, what is the proper number of years over which to compute the average? Ibbotson goes back to 1926, when good data first became available, but that is a rather arbitrary choice, and the starting and ending points make a major difference in the calculated premium.

Second, historical premiums are likely to be misleading at times when the market risk premium is changing. To illustrate, the stock market was very strong from 1995 through 1999, *in part because investors were becoming less risk averse, which means that they applied a lower risk premium when* *they valued stocks.* The strong market resulted in stock returns of about 30 percent per year, and when bond yields were subtracted the resulting annual risk premiums averaged 22.3 percent a year. When those high numbers were added to data from prior years, they caused the long-run historical risk premium as reported by Ibbotson to increase. Thus, a declining "true" risk premium led to very high stock returns, which, in turn, led to an increase in the calculated historical risk premium. That's a worrisome result, to say the least.

The third concern is that historical estimates may be biased upward because they only include the returns of firms that have survived—they do not reflect the losses incurred on investments in failed firms. Stephen Brown, William Goetzmann, and Stephen Ross discussed the implications of this "survivorship bias" in a 1995 *Journal of Finance* article. Putting these ideas into practice, Tim Koller, Marc Goedhart, and David Wessels recently suggested that "survivorship bias" increases historical returns by 1 to 2 percent a year. Therefore, they suggest that practitioners subtract 1 to 2 percent from the historical estimates to obtain a risk premium for use in the CAPM.

Sources: Stocks, Bonds, Bills, and Inflation: (Valuation Edition) 2005 Yearbook (Chicago: Ibbotson Associates, 2005); Stephen J. Brown, William N. Goetzmann, and Stephen A. Ross, "Survival," *Journal of Finance*, Vol. 50, no. 3 (July 1995), pp. 853–873; and Tim Koller, Marc Goedhart, and David Wessels, *Valuation: Measuring and Managing the Value of Companies,* 4th edition (New York: McKinsey & Company, 2005).

It should be noted that the risk premium of an average stock, $r_M - r_{RF}$, is actually hard to measure because it is impossible to obtain a precise estimate of the expected future return of the market, r_M.[12] Given the difficulty of estimating future market returns, analysts often look to historical data to estimate the market risk premium. Historical data suggest that the market risk premium varies somewhat from year to year due to changes in investors' risk aversion, but that it has generally ranged from 4 to 8 percent.

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[12] This concept, as well as other aspects of the CAPM, is discussed in more detail in Chapter 3 of Eugene F. Brigham and Philip R. Daves, *Intermediate Financial Management*, 8th ed. (Mason, OH: Thomson/South-Western, 2004). That chapter also discusses the assumptions embodied in the CAPM framework. Some of those assumptions are unrealistic, and because of this the theory does not hold exactly.

While historical estimates might be a good starting point for estimating the market risk premium, those estimates would be misleading if investors' attitudes toward risk change considerably over time. (See the box entitled "Estimating the Market Risk Premium.") Indeed, many analysts have argued that the market risk premium has fallen in recent years. If this claim is correct, the market risk premium is considerably lower than one based on historical data.

The risk premium on individual stocks varies in a systematic manner from the market risk premium. For example, if one stock were twice as risky as another, its risk premium would be twice as high, while if its risk were only half as much, its risk premium would be half as large. Further, we can measure a stock's relative riskiness by its beta coefficient. If we know the market risk premium, RP_M, and the stock's risk as measured by its beta coefficient, b_i, we can find the stock's risk premium as the product $(RP_M)b_i$. For example, if $b_i = 0.5$ and $RP_M = 5\%$, then RP_i is 2.5 percent:

$$\text{Risk premium for Stock i} = RP_i = (RP_M)b_i \qquad \textbf{(8-7)}$$

$$= (5\%)(0.5)$$

$$= 2.5\%$$

As the discussion in Chapter 6 implied, the required return for any stock can be expressed in general terms as follows:

$$\begin{array}{c}\text{Required return} \\ \text{on a stock}\end{array} = \text{Risk-free return} + \begin{array}{c}\text{Premium} \\ \text{for the stock's} \\ \text{risk}\end{array}$$

Here the risk-free return includes a premium for expected inflation, and if we assume that the stocks under consideration have similar maturities and liquidity, then the required return on Stock i can be expressed by the **Security Market Line (SML) equation:**

SML Equation:

$$\begin{array}{c}\text{Required return} \\ \text{on Stock i}\end{array} = \begin{array}{c}\text{Risk-free} \\ \text{rate}\end{array} + \left(\begin{array}{c}\text{Market risk} \\ \text{premium}\end{array}\right)\left(\begin{array}{c}\text{Stock i's} \\ \text{beta}\end{array}\right)$$

$$r_i = r_{RF} + (r_M - r_{RF})b_i \qquad \textbf{(8-8)}$$

$$= r_{RF} + (RP_M)b_i$$

$$= 6\% + (11\% - 6\%)(0.5)$$

$$= 6\% + 5\%(0.5)$$

$$= 8.5\%$$

If some other Stock j had $b_j = 2.0$ and thus was riskier than Stock i, then its required rate of return would be 16 percent:

$$r_j = 6\% + (5\%)2.0 = 16\%$$

An average stock, with $b = 1.0$, would have a required return of 11 percent, the same as the market return:

$$r_A = 6\% + (5\%)1.0 = 11\% = r_M$$

Security Market Line (SML) Equation
An equation that shows the relationship between risk as measured by beta and the required rates of return on individual securities.

When the SML equation is plotted on a graph, the resulting line is called the **Security Market Line (SML).** Figure 8-10 shows the SML situation when $r_{RF} = 6\%$ and $r_M = 11\%$. Note the following points:

1. Required rates of return are shown on the vertical axis, while risk as measured by beta is shown on the horizontal axis. This graph is quite different from the one shown in Figure 8-9, where the returns on individual stocks were plotted on the vertical axis and returns on the market index were shown on the horizontal axis. The slopes of the three lines in Figure 8–9 were used to calculate the three stocks' betas, and those betas were then plotted as points on the horizontal axis of Figure 8-10.

2. Riskless securities have $b_i = 0$; therefore, r_{RF} appears as the vertical axis intercept in Figure 8-10. If we could construct a portfolio that had a beta of zero, it would have an expected return equal to the risk-free rate.

3. The slope of the SML (5 percent in Figure 8-10) reflects the degree of risk aversion in the economy—the greater the average investor's risk aversion, then (a) the steeper the slope of the line, (b) the greater the risk premium for all stocks, and (c) the higher the required rate of return on all stocks.[13] These points are discussed further in a later section.

4. The values we worked out for stocks with $b_i = 0.5$, $b_i = 1.0$, and $b_i = 2.0$ agree with the values shown on the graph for r_{Low}, r_A, and r_{High}.

FIGURE 8-10 *The Security Market Line (SML)*

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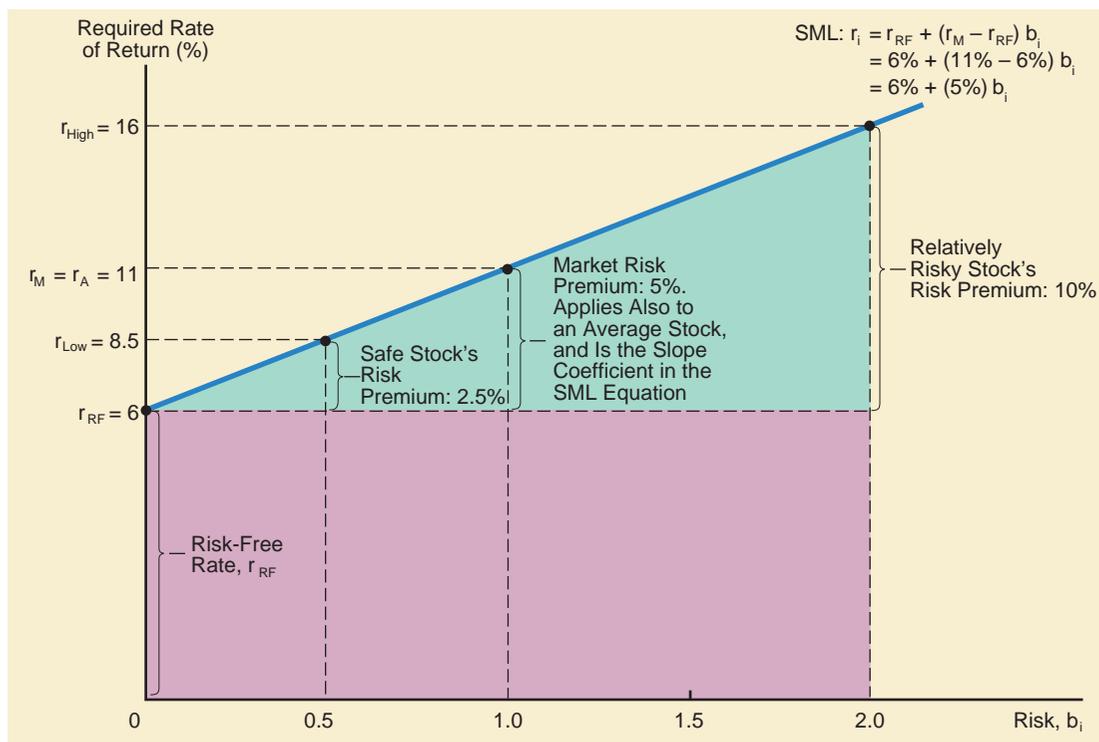
[13] Students sometimes confuse beta with the slope of the SML. This is a mistake. Consider Figure 8-10. The slope of any straight line is equal to the "rise" divided by the "run," or $(Y_1 - Y_0)/(X_1 - X_0)$. If we let $Y = r$ and $X =$ beta, and we go from the origin to $b = 1.0$, we see that the slope is $(r_M - r_{RF})/(b_M - b_{RF}) = (11\% - 6\%)/(1 - 0) = 5\%$. Thus, the slope of the SML is equal to $(r_M - r_{RF})$, the market risk premium. In Figure 8-10, $r_i = 6\% + 5\%b_i$, so a doubling of beta from 1.0 to 2.0 would produce a 5 percentage point increase in r_i.

Both the Security Market Line and a company's position on it change over time due to changes in interest rates, investors' risk aversion, and individual companies' betas. Such changes are discussed in the following sections.

The Impact of Inflation

As we discussed in Chapter 6, interest amounts to "rent" on borrowed money, or the price of money. Thus, r_{RF} is the price of money to a riskless borrower. We also saw that the risk-free rate as measured by the rate on U.S. Treasury securities is called the *nominal*, or *quoted*, *rate*, and it consists of two elements: (1) a *real, inflation-free rate of return, r**, and (2) an *inflation premium*, IP, equal to the anticipated rate of inflation.[14] Thus, $r_{RF} = r^* + IP$. The real rate on long-term Treasury bonds has historically ranged from 2 to 4 percent, with a mean of about 3 percent. Therefore, if no inflation were expected, long-term Treasury bonds would yield about 3 percent. However, as the expected rate of inflation increases, a premium must be added to the real risk-free rate of return to compensate investors for the loss of purchasing power that results from inflation. Therefore, the 6 percent r_{RF} shown in Figure 8-10 might be thought of as consisting of a 3 percent real risk-free rate of return plus a 3 percent inflation premium: $r_{RF} = r^* + IP = 3\% + 3\% = 6\%$.

If the expected inflation rate rose by 2 percent, to $3\% + 2\% = 5\%$, this would cause r_{RF} to rise to 8 percent. Such a change is shown in Figure 8-11. Notice that under the CAPM, an increase in r_{RF} leads to an *equal* increase in the rate of return on all risky assets, because the same inflation premium is built into required rates of return on both riskless and risky assets.[15] Therefore, the rate of return on our illustrative average stock, r_M, increases from 11 to 13 percent. Other risky securities' returns also rise by two percentage points.

Changes in Risk Aversion

The slope of the Security Market Line reflects the extent to which investors are averse to risk—the steeper the slope of the line, the more the average investor requires as compensation for bearing risk, which denotes increased risk aversion. Suppose investors were indifferent to risk; that is, they were not at all risk averse. If r_{RF} were 6 percent, then risky assets would also have a required return of 6 percent, because if there were no risk aversion, there would be no risk premium. In that case, the SML would plot as a horizontal line. However, investors are risk averse, so there is a risk premium, and the greater the risk aversion, the steeper the slope of the SML.

Figure 8-12 illustrates an increase in risk aversion. The market risk premium rises from 5 to 7.5 percent, causing r_M to rise from $r_{M1} = 11\%$ to $r_{M2} = 13.5\%$. The returns on other risky assets also rise, and the effect of this shift in risk aversion is more pronounced on riskier securities. For example, the required return on a stock with $b_i = 0.5$ increases by only 1.25 percentage points, from 8.5 to 9.75 percent, whereas that on a stock with $b_i = 1.5$ increases by 3.75 percentage points, from 13.5 to 17.25 percent.

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[14] Long-term Treasury bonds also contain a maturity risk premium, MRP. We include the MRP in r* to simplify the discussion.

[15] Recall that the inflation premium for any asset is the average expected rate of inflation over the asset's life. Thus, in this analysis we must assume either that all securities plotted on the SML graph have the same life or else that the expected rate of future inflation is constant.

It should also be noted that r_{RF} in a CAPM analysis can be proxied by either a long-term rate (the T-bond rate) or a short-term rate (the T-bill rate). Traditionally, the T-bill rate was used, but in recent years there has been a movement toward use of the T-bond rate because there is a closer relationship between T-bond yields and stocks than between T-bill yields and stocks. See *Stocks, Bonds, Bills, and Inflation: (Valuation Edition) 2005 Yearbook* (Chicago: Ibbotson Associates, 2005) for a discussion.

FIGURE 8-11 *Shift in the SML Caused by an Increase in Inflation*

Required Rate
of Return (%)

$SML_2 = 8\% + 5\%(b_i)$

$SML_1 = 6\% + 5\%(b_i)$

$r_{M2} = 13$

$r_{M1} = 11$

$r_{RF2} = 8$

Increase in Anticipated Inflation, $\Delta IP = 2\%$

$r_{RF1} = 6$

Original IP = 3%

$r^* = 3$

Real Risk-Free Rate of Return, r^*

0   0.5   1.0   1.5   2.0   Risk, b_i

FIGURE 8-12 *Shift in the SML Caused by Increased Risk Aversion*

$SML_2 = 6\% + 7.5\%(b_i)$

Required Rate
of Return (%)

17.25

$SML_1 = 6\% + 5\%(b_i)$

$r_{M2} = 13.5$

$r_{M1} = 11$

New Market Risk
Premium, $r_{M2} - r_{RF} = 7.5\%$

9.75

8.5

$r_{RF} = 6$

Original Market Risk
Premium, $r_{M1} - r_{RF} = 5\%$

0   0.5   1.0   1.5   2.0   Risk, b_i

Changes in a Stock's Beta Coefficient

As we shall see later in the book, a firm can influence its market risk, hence its beta, through (1) changes in the composition of its assets and (2) changes in the amount of debt it uses. A company's beta can also change as a result of external factors such as increased competition in its industry, the expiration of basic patents, and the like. When such changes occur, the firm's required rate of return also changes, and, as we shall see in Chapter 9, this will affect the firm's stock price. For example, consider Allied Food Products, with a beta of 1.48. Now suppose some action occurred that caused Allied's beta to increase from 1.48 to 2.0. If the conditions depicted in Figure 8-10 held, Allied's required rate of return would increase from 13.4 to 16 percent:

$$r_1 = r_{RF} + (r_M - r_{RF})b_i$$
$$= 6\% + (11\% - 6\%)1.48$$
$$= 13.4\%$$

to

$$r_2 = 6\% + (11\% - 6\%)2.0$$
$$= 16\%$$

As we shall see in Chapter 9, this change would have a negative effect on Allied's stock price.

SELF TEST

Differentiate among a stock's expected rate of return ($\hat{r}$), required rate of return (r), and realized, after-the-fact, historical return ($\bar{r}$). Which would have to be larger to induce you to buy the stock, $\hat{r}$ or r? At a given point in time, would $\hat{r}$, r, and $\bar{r}$ typically be the same or different? Explain.

What are the differences between the relative volatility graph (Figure 8-9), where "betas are made," and the SML graph (Figure 8-10), where "betas are used"? Explain how both graphs are constructed and the information they convey.

What would happen to the SML graph in Figure 8-10 if inflation increased or decreased?

What happens to the SML graph when risk aversion increases or decreases?

What would the SML look like if investors were indifferent to risk, that is, if they had zero risk aversion?

How can a firm influence the size of its beta?

A stock has a beta of 1.2. Assume that the risk-free rate is 4.5 percent and the market risk premium is 5 percent. What is the stock's required rate of return? (10.5%)

8.4 SOME CONCERNS ABOUT BETA AND THE CAPM

The Capital Asset Pricing Model (CAPM) is more than just an abstract theory described in textbooks—it has great intuitive appeal, and it is widely used by analysts, investors, and corporations. However, a number of recent studies have

*Kenneth French's Web site, **http://mba.tuck .dartmouth.edu/pages/ faculty/ken.french/index .html** is an excellent resource for data and information regarding factors related to stock returns.*

raised concerns about its validity. For example, a study by Eugene Fama of the University of Chicago and Kenneth French of Dartmouth found no historical relationship between stocks' returns and their market betas, confirming a position long held by some professors and stock market analysts.[16]

As an alternative to the traditional CAPM, researchers and practitioners are developing models with more explanatory variables than just beta. These multi-variable models represent an attractive generalization of the traditional CAPM model's insight that market risk—risk that cannot be diversified away—underlies the pricing of assets. In the multi-variable models, risk is assumed to be caused by a number of different factors, whereas the CAPM gauges risk only relative to returns on the market portfolio. These multi-variable models represent a potentially important step forward in finance theory; they also have some deficiencies when applied in practice. As a result, the basic CAPM is still the most widely used method for estimating required rates of return on stocks.

SELF TEST

Have there been any studies that question the validity of the CAPM? Explain.

8.5 SOME CONCLUDING THOUGHTS: IMPLICATIONS FOR CORPORATE MANAGERS AND INVESTORS

The connection between risk and return is an important concept, and it has numerous implications for both corporate managers and investors. As we will see in later chapters, corporate managers spend a great deal of time assessing the risk and returns on individual projects. Indeed, given their concerns about the risk of individual projects, it might be fair to ask why we spend so much time discussing the riskiness of stocks. Why not begin by looking at the riskiness of such business assets as plant and equipment? *The reason is that for a management whose primary goal is stock price maximization, the overriding consideration is the riskiness of the firm's stock, and the relevant risk of any physical asset must be measured in terms of its effect on the stock's risk as seen by investors.* For example, suppose Goodyear, the tire company, is considering a major investment in a new product, recapped tires. Sales of recaps, hence earnings on the new operation, are highly uncertain, so on a stand-alone basis the new venture appears to be quite risky. However, suppose returns in the recap business are negatively correlated with Goodyear's other operations—when times are good and people have plenty of money, they buy new cars with new tires, but when times are bad, they tend to keep their old cars and buy recaps for them. Therefore, returns would be high on regular operations and low on the recap division during good times, but the opposite would be true during recessions. The result might be a pattern like that shown earlier in Figure 8-5 for Stocks W and M. Thus, what appears to be a risky investment when viewed on a stand-alone basis might not be very risky when viewed within the context of the company as a whole.

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[16] See Eugene F. Fama and Kenneth R. French, "The Cross-Section of Expected Stock Returns," *Journal of Finance*, Vol. 47 (1992), pp. 427–465; and Eugene F. Fama and Kenneth R. French, "Common Risk Factors in the Returns on Stocks and Bonds," *Journal of Financial Economics*, Vol. 33 (1993), pp. 3–56. They found that stock returns are related to firm size and market/book ratios—small firms, and those with low market/book ratios, had higher returns, but they found no relationship between returns and beta.

This analysis can be extended to the corporation's stockholders. Because Goodyear's stock is owned by diversified stockholders, the real issue each time management makes an investment decision is this: How will this investment affect the risk of our stockholders? Again, the stand-alone risk of an individual project may look quite high, but viewed in the context of the project's effect on stockholder risk, it may not be very large. We will address this issue again in Chapter 12, where we examine the effects of capital budgeting on companies' beta coefficients and thus on stockholders' risks.

While these concepts are obviously important for individual investors, they are also important for corporate managers. We summarize below some key ideas that all investors should consider.

1. There is a trade-off between risk and return. The average investor likes higher returns but dislikes risk. It follows that higher-risk investments need to offer investors higher expected returns. Put another way—if you are seeking higher returns, you must be willing to assume higher risks.

2. Diversification is crucial. By diversifying wisely, investors can dramatically reduce risk without reducing their expected returns. Don't put all of your money in one or two stocks, or one or two industries. A huge mistake many people make is to invest a high percentage of their funds in their employer's stock. If the company goes bankrupt, they not only lose their job but also their invested capital. While no stock is completely riskless, you can smooth out the bumps by holding a well-diversified portfolio.

3. Real returns are what matters. All investors should understand the difference between nominal and real returns. When assessing performance, the real return (what you have left over after inflation) is what really matters. It follows that as expected inflation increases, investors need to receive higher nominal returns.

4. The risk of an investment often depends on how long you plan to hold the investment. Common stocks, for example, can be extremely risky for short-term investors. However, over the long haul the bumps tend to even out, and thus, stocks are less risky when held as part of a long-term portfolio. Indeed, in his best-selling book *Stocks for the Long Run*, Jeremy Siegel of the University of Pennsylvania concludes that "The safest long-term investment for the preservation of purchasing power has clearly been stocks, not bonds."

5. While the past gives us insights into the risk and returns on various investments, there is no guarantee that the future will repeat the past. Stocks that have performed well in recent years might tumble, while stocks that have struggled may rebound. The same thing can hold true for the stock market as a whole. Even Jeremy Siegel, who has preached that stocks have historically been good long-term investments, has also argued that there is no assurance that returns in the future will be as strong as they have been in the past. More importantly, when purchasing a stock you always need to ask, "Is this stock fairly valued, or is it currently priced too high?" We discuss this issue more completely in the next chapter.

SELF TEST

Explain the following statement: "The stand-alone risk of an individual corporate project may be quite high, but viewed in the context of its effect on stockholders' risk, the project's true risk may not be very large."

How does the correlation between returns on a project and returns on the firm's other assets affect the project's risk?

What are some important concepts for individual investors to consider when evaluating the risk and returns of various investments?

Tying It All Together

In this chapter, we described the relationship between risk and return. We discussed how to calculate risk and return for both individual assets and portfolios. In particular, we differentiated between stand-alone risk and risk in a portfolio context, and we explained the benefits of diversification. We also explained the CAPM, which describes how risk should be measured and how it affects rates of return. In the chapters that follow, we will give you the tools to estimate the required rates of return on a firm's common stock, and we will explain how that return and the yield on its bonds are used to develop the firm's cost of capital. As you will see, the cost of capital is a key element in the capital budgeting process.

SELF-TEST QUESTIONS AND PROBLEMS (Solutions Appear in Appendix A)

ST-1 **Key terms** Define the following terms, using graphs or equations to illustrate your answers wherever feasible:

a. Risk; stand-alone risk; probability distribution
b. Expected rate of return, $\hat{r}$
c. Continuous probability distribution
d. Standard deviation, σ; variance, σ^2; coefficient of variation, CV
e. Risk aversion; realized rate of return, $\bar{r}$
f. Risk premium for Stock i, RP_i; market risk premium, RP_M
g. Expected return on a portfolio, $\hat{r}_p$; market portfolio
h. Correlation; correlation coefficient, ρ
i. Market risk; diversifiable risk; relevant risk
j. Capital Asset Pricing Model (CAPM)
k. Beta coefficient, b; average stock's beta, b_A
l. SML equation; Security Market Line (SML)

ST-2 **Realized rates of return** Stocks A and B have the following historical returns:

Year	Stock A's Returns, r_A	Stock B's Returns, r_B
2001	(24.25%)	5.50%
2002	18.50	26.73
2003	38.67	48.25
2004	14.33	(4.50)
2005	39.13	43.86

a. Calculate the average rate of return for each stock during the period 2001 through 2005. Assume that someone held a portfolio consisting of 50 percent of Stock A and 50 percent of Stock B. What would the realized rate of return on the portfolio have been in each year from 2001 through 2005? What would the average return on the portfolio have been during that period?
b. Now calculate the standard deviation of returns for each stock and for the portfolio. Use Equation 8-3a.
c. Looking at the annual returns on the two stocks, would you guess that the correlation coefficient between the two stocks is closer to +0.8 or to −0.8?
d. If more randomly selected stocks had been included in the portfolio, which of the following is the most accurate statement of what would have happened to σ_p?
   (1) σ_p would have remained constant.
   (2) σ_p would have been in the vicinity of 20 percent.
   (3) σ_p would have declined to zero if enough stocks had been included.

ST-3 **Beta and the required rate of return** ECRI Corporation is a holding company with four main subsidiaries. The percentage of its capital invested in each of the subsidiaries, and their respective betas, are as follows:

Subsidiary	Percentage of Capital	Beta
Electric utility	60%	0.70
Cable company	25	0.90
Real estate development	10	1.30
International/special projects	5	1.50

a. What is the holding company's beta?
b. If the risk-free rate is 6 percent and the market risk premium is 5 percent, what is the holding company's required rate of return?
c. ECRI is considering a change in its strategic focus; it will reduce its reliance on the electric utility subsidiary, so the percentage of its capital in this subsidiary will be reduced to 50 percent. At the same time, it will increase its reliance on the international/special projects division, so the percentage of its capital in that subsidiary will rise to 15 percent. What will the company's required rate of return be after these changes?

QUESTIONS

8-1 Suppose you owned a portfolio consisting of $250,000 of long-term U.S. government bonds.

a. Would your portfolio be riskless? Explain.
b. Now suppose the portfolio consists of $250,000 of 30-day Treasury bills. Every 30 days your bills mature, and you will reinvest the principal ($250,000) in a new batch of bills. You plan to live on the investment income from your portfolio, and you want to maintain a constant standard of living. Is the T-bill portfolio truly riskless? Explain.
c. What is the least risky security you can think of? Explain.

8-2 The probability distribution of a less risky expected return is more peaked than that of a riskier return. What shape would the probability distribution have for (a) completely certain returns and (b) completely uncertain returns?

8-3 A life insurance policy is a financial asset, with the premiums paid representing the investment's cost.

a. How would you calculate the expected return on a 1-year life insurance policy?
b. Suppose the owner of a life insurance policy has no other financial assets—the person's only other asset is "human capital," or earnings capacity. What is the correlation coefficient between the return on the insurance policy and that on the human capital?
c. Life insurance companies must pay administrative costs and sales representatives' commissions, hence the expected rate of return on insurance premiums is generally low or even negative. Use portfolio concepts to explain why people buy life insurance in spite of low expected returns.

8-4 Is it possible to construct a portfolio of real-world stocks that has an expected return equal to the risk-free rate?

8-5 Stock A has an expected return of 7 percent, a standard deviation of expected returns of 35 percent, a correlation coefficient with the market of −0.3, and a beta coefficient of −0.5. Stock B has an expected return of 12 percent, a standard deviation of returns of 10 percent, a 0.7 correlation with the market, and a beta coefficient of 1.0. Which security is riskier? Why?

8-6 A stock had a 12 percent return last year, a year when the overall stock market declined. Does this mean that the stock has a negative beta and thus very little risk if held in a portfolio? Explain.

8-7 If investors' aversion to risk increased, would the risk premium on a high-beta stock increase by more or less than that on a low-beta stock? Explain.

8-8 If a company's beta were to double, would its required return also double?

8-9 In Chapter 7 we saw that if the market interest rate, r_d, for a given bond increased, then the price of the bond would decline. Applying this same logic to stocks, explain (a) how a decrease in risk aversion would affect stocks' prices and earned rates of return, (b) how this would affect risk premiums as measured by the historical difference between returns on stocks and returns on bonds, and (c) the implications of this for the use of historical risk premiums when applying the SML equation.

PROBLEMS

8-1 **Expected return** A stock's returns have the following distribution:

Demand for the Company's Products	Probability of This Demand Occurring	Rate of Return If This Demand Occurs
Weak	0.1	(50%)
Below average	0.2	(5)
Average	0.4	16
Above average	0.2	25
Strong	0.1	60
	1.0	

Calculate the stock's expected return, standard deviation, and coefficient of variation.

8-2 **Portfolio beta** An individual has $35,000 invested in a stock with a beta of 0.8 and another $40,000 invested in a stock with a beta of 1.4. If these are the only two investments in her portfolio, what is her portfolio's beta?

8-3 **Required rate of return** Assume that the risk-free rate is 6 percent and the expected return on the market is 13 percent. What is the required rate of return on a stock with a beta of 0.7?

8-4 **Expected and required rates of return** Assume that the risk-free rate is 5 percent and the market risk premium is 6 percent. What is the expected return for the overall stock market? What is the required rate of return on a stock with a beta of 1.2?

8-5 **Beta and required rate of return** A stock has a required return of 11 percent; the risk-free rate is 7 percent; and the market risk premium is 4 percent.

a. What is the stock's beta?
b. If the market risk premium increased to 6 percent, what would happen to the stock's required rate of return? Assume the risk-free rate and the beta remain unchanged.

8-6 **Expected returns** Stocks X and Y have the following probability distributions of expected future returns:

Probability	X	Y
0.1	(10%)	(35%)
0.2	2	0
0.4	12	20
0.2	20	25
0.1	38	45

a. Calculate the expected rate of return, $\hat{r}_Y$, for Stock Y. ($\hat{r}_X = 12\%$.)
b. Calculate the standard deviation of expected returns, σ_X, for Stock X. ($\sigma_Y = 20.35\%$.) Now calculate the coefficient of variation for Stock Y. Is it possible that most investors might regard Stock Y as being *less* risky than Stock X? Explain.

8-7 **Portfolio required return** Suppose you are the money manager of a $4 million investment fund. The fund consists of 4 stocks with the following investments and betas:

Stock	Investment	Beta
A	$ 400,000	1.50
B	600,000	(0.50)
C	1,000,000	1.25
D	2,000,000	0.75

If the market's required rate of return is 14 percent and the risk-free rate is 6 percent, what is the fund's required rate of return?

8-8 **Beta coefficient** Given the following information, determine the beta coefficient for Stock J that is consistent with equilibrium: $\hat{r}_J = 12.5\%$; $r_{RF} = 4.5\%$; $r_M = 10.5\%$.

8-9   **Required rate of return** Stock R has a beta of 1.5, Stock S has a beta of 0.75, the expected rate of return on an average stock is 13 percent, and the risk-free rate of return is 7 percent. By how much does the required return on the riskier stock exceed the required return on the less risky stock?

8-10   **CAPM and required return** Bradford Manufacturing Company has a beta of 1.45, while Farley Industries has a beta of 0.85. The required return on an index fund that holds the entire stock market is 12.0 percent. The risk-free rate of interest is 5 percent. By how much does Bradford's required return exceed Farley's required return?

8-11   **CAPM and required return** Calculate the required rate of return for Manning Enterprises, assuming that investors expect a 3.5 percent rate of inflation in the future. The real risk-free rate is 2.5 percent and the market risk premium is 6.5 percent. Manning has a beta of 1.7, and its realized rate of return has averaged 13.5 percent over the past 5 years.

8-12   **CAPM and market risk premium** Consider the following information for three stocks, Stocks X, Y, and Z. The returns on the three stocks are positively correlated, but they are not perfectly correlated. (That is, each of the correlation coefficients is between 0 and 1.)

Stock	Expected Return	Standard Deviation	Beta
X	9.00%	15%	0.8
Y	10.75	15	1.2
Z	12.50	15	1.6

Fund P has half of its funds invested in Stock X and half invested in Stock Y. Fund Q has one-third of its funds invested in each of the three stocks. The risk-free rate is 5.5 percent, and the market is in equilibrium. (That is, required returns equal expected returns.) What is the market risk premium ($r_M - r_{RF}$)?

8-13   **Required rate of return** Suppose r_{RF} = 9%, r_M = 14%, and b_i = 1.3.

a.   What is r_i, the required rate of return on Stock i?
b.   Now suppose r_{RF} (1) increases to 10 percent or (2) decreases to 8 percent. The slope of the SML remains constant. How would this affect r_M and r_i?
c.   Now assume r_{RF} remains at 9 percent but r_M (1) increases to 16 percent or (2) falls to 13 percent. The slope of the SML does not remain constant. How would these changes affect r_i?

Challenging
Problems 14–21

8-14   **Portfolio beta** Suppose you held a diversified portfolio consisting of a $7,500 investment in each of 20 different common stocks. The portfolio's beta is 1.12. Now suppose you decided to sell one of the stocks in your portfolio with a beta of 1.0 for $7,500 and to use these proceeds to buy another stock with a beta of 1.75. What would your portfolio's new beta be?

8-15   **CAPM and required return** HR Industries (HRI) has a beta of 1.8, while LR Industries' (LRI) beta is 0.6. The risk-free rate is 6 percent, and the required rate of return on an average stock is 13 percent. Now the expected rate of inflation built into r_{RF} falls by 1.5 percentage points, the real risk-free rate remains constant, the required return on the market falls to 10.5 percent, and all betas remain constant. After all of these changes, what will be the difference in the required returns for HRI and LRI?

8-16   **CAPM and portfolio return** You have been managing a $5 million portfolio that has a beta of 1.25 and a required rate of return of 12 percent. The current risk-free rate is 5.25 percent. Assume that you receive another $500,000. If you invest the money in a stock with a beta of 0.75, what will be the required return on your $5.5 million portfolio?

8-17   **Portfolio beta** A mutual fund manager has a $20,000,000 portfolio with a beta of 1.5. The risk-free rate is 4.5 percent and the market risk premium is 5.5 percent. The manager expects to receive an additional $5,000,000, which she plans to invest in a number of stocks. After investing the additional funds, she wants the fund's required return to be 13 percent. What should be the average beta of the new stocks added to the portfolio?

8-18   **Expected returns** Suppose you won the lottery and had two options: (1) receiving $0.5 million or (2) a gamble in which you would receive $1 million if a head were flipped but zero if a tail came up.

a.   What is the expected value of the gamble?
b.   Would you take the sure $0.5 million or the gamble?
c.   If you chose the sure $0.5 million, would that indicate that you are a risk averter or a risk seeker?
d.   Suppose the payoff was actually $0.5 million—that was the only choice. You now face the choice of investing it in either a U.S. Treasury bond that will return $537,500

at the end of a year or a common stock that has a 50–50 chance of being either worthless or worth $1,150,000 at the end of the year.

(1) The expected profit on the T-bond investment is $37,500. What is the expected dollar profit on the stock investment?
(2) The expected rate of return on the T-bond investment is 7.5 percent. What is the expected rate of return on the stock investment?
(3) Would you invest in the bond or the stock?
(4) Exactly how large would the expected profit (or the expected rate of return) have to be on the stock investment to make *you* invest in the stock, given the 7.5 percent return on the bond?
(5) How might your decision be affected if, rather than buying one stock for $0.5 million, you could construct a portfolio consisting of 100 stocks with $5,000 invested in each? Each of these stocks has the same return characteristics as the one stock—that is, a 50–50 chance of being worth either zero or $11,500 at year-end. Would the correlation between returns on these stocks matter?

8-19 **Evaluating risk and return** Stock X has a 10 percent expected return, a beta coefficient of 0.9, and a 35 percent standard deviation of expected returns. Stock Y has a 12.5 percent expected return, a beta coefficient of 1.2, and a 25 percent standard deviation. The risk-free rate is 6 percent, and the market risk premium is 5 percent.

a. Calculate each stock's coefficient of variation.
b. Which stock is riskier for a diversified investor?
c. Calculate each stock's required rate of return.
d. On the basis of the two stocks' expected and required returns, which stock would be more attractive to a diversified investor?
e. Calculate the required return of a portfolio that has $7,500 invested in Stock X and $2,500 invested in Stock Y.
f. If the market risk premium increased to 6 percent, which of the two stocks would have the larger increase in its required return?

8-20 **Realized rates of return** Stocks A and B have the following historical returns:

Year	Stock A's Returns, r_A	Stock B's Returns, r_B
2001	(18.00%)	(14.50%)
2002	33.00	21.80
2003	15.00	30.50
2004	(0.50)	(7.60)
2005	27.00	26.30

a. Calculate the average rate of return for each stock during the period 2001 through 2005.
b. Assume that someone held a portfolio consisting of 50 percent of Stock A and 50 percent of Stock B. What would the realized rate of return on the portfolio have been in each year? What would the average return on the portfolio have been during this period?
c. Calculate the standard deviation of returns for each stock and for the portfolio.
d. Calculate the coefficient of variation for each stock and for the portfolio.
e. Assuming you are a risk-averse investor, would you prefer to hold Stock A, Stock B, or the portfolio? Why?

8-21 **Security Market Line** You plan to invest in the Kish Hedge Fund, which has total capital of $500 million invested in five stocks:

Stock	Investment	Stock's Beta Coefficient
A	$160 million	0.5
B	120 million	2.0
C	80 million	4.0
D	80 million	1.0
E	60 million	3.0

Kish's beta coefficient can be found as a weighted average of its stocks' betas. The risk-free rate is 6 percent, and you believe the following probability distribution for future market returns is realistic:

Probability	Market Return
0.1	7%
0.2	9
0.4	11
0.2	13
0.1	15

a. What is the equation for the Security Market Line (SML)? (Hint: First determine the expected market return.)
b. Calculate Kish's required rate of return.
c. Suppose Rick Kish, the president, receives a proposal from a company seeking new capital. The amount needed to take a position in the stock is $50 million, it has an expected return of 15 percent, and its estimated beta is 2.0. Should Kish invest in the new company? At what expected rate of return should Kish be indifferent to purchasing the stock?

COMPREHENSIVE/SPREADSHEET PROBLEM

8-22   **Evaluating risk and return** Bartman Industries' and Reynolds Inc.'s stock prices and dividends, along with the Winslow 5000 Index, are shown here for the period 2000–2005. The Winslow 5000 data are adjusted to include dividends.

	BARTMAN INDUSTRIES		REYNOLDS INC.		WINSLOW 5000
Year	Stock Price	Dividend	Stock Price	Dividend	Includes Dividends
2005	$17.250	$1.15	$48.750	$3.00	11,663.98
2004	14.750	1.06	52.300	2.90	8,785.70
2003	16.500	1.00	48.750	2.75	8,679.98
2002	10.750	0.95	57.250	2.50	6,434.03
2001	11.375	0.90	60.000	2.25	5,602.28
2000	7.625	0.85	55.750	2.00	4,705.97

a. Use the data to calculate annual rates of return for Bartman, Reynolds, and the Winslow 5000 Index, and then calculate each entity's average return over the 5-year period. (Hint: Remember, returns are calculated by subtracting the beginning price from the ending price to get the capital gain or loss, adding the dividend to the capital gain or loss, and dividing the result by the beginning price. Assume that dividends are already included in the index. Also, you cannot calculate the rate of return for 2000 because you do not have 1999 data.)
b. Calculate the standard deviations of the returns for Bartman, Reynolds, and the Winslow 5000. (Hint: Use the sample standard deviation formula, 8-3a, to this chapter, which corresponds to the STDEV function in *Excel*.)
c. Now calculate the coefficients of variation for Bartman, Reynolds, and the Winslow 5000.
d. Construct a scatter diagram that shows Bartman's and Reynolds's returns on the vertical axis and the Winslow Index's returns on the horizontal axis.
e. Estimate Bartman's and Reynolds's betas by running regressions of their returns against the index's returns. Are these betas consistent with your graph?
f. Assume that the risk-free rate on long-term Treasury bonds is 6.04 percent. Assume also that the average annual return on the Winslow 5000 is *not* a good estimate of the market's required return—it is too high, so use 11 percent as the expected return on the market. Now use the SML equation to calculate the two companies' required returns.
g. If you formed a portfolio that consisted of 50 percent Bartman and 50 percent Reynolds, what would the beta and the required return be?
h. Suppose an investor wants to include Bartman Industries' stock in his or her portfolio. Stocks A, B, and C are currently in the portfolio, and their betas are 0.769, 0.985, and 1.423, respectively. Calculate the new portfolio's required return if it consists of 25 percent of Bartman, 15 percent of Stock A, 40 percent of Stock B, and 20 percent of Stock C.

Integrated Case

Merrill Finch Inc.

8-23 **Risk and return** Assume that you recently graduated with a major in finance, and you just landed a job as a financial planner with Merrill Finch Inc., a large financial services corporation. Your first assignment is to invest $100,000 for a client. Because the funds are to be invested in a business at the end of 1 year, you have been instructed to plan for a 1-year holding period. Further, your boss has restricted you to the investment alternatives in the following table, shown with their probabilities and associated outcomes. (Disregard for now the items at the bottom of the data; you will fill in the blanks later.)

| | | | | RETURNS ON ALTERNATIVE INVESTMENTS | | | |
| | | | | ESTIMATED RATE OF RETURN | | | |
State of the Economy	Probability	T-Bills	High Tech	Collections	U.S. Rubber	Market Portfolio	2-Stock Portfolio
Recession	0.1	5.5%	(27.0%)	27.0%	6.0%[a]	(17.0%)	0.0%
Below average	0.2	5.5	(7.0)	13.0	(14.0)	(3.0)	
Average	0.4	5.5	15.0	0.0	3.0	10.0	7.5
Above average	0.2	5.5	30.0	(11.0)	41.0	25.0	
Boom	0.1	5.5	45.0	(21.0)	26.0	38.0	12.0
$\hat{r}$				1.0%	9.8%	10.5%	
σ		0.0		13.2	18.8	15.2	3.4
CV				13.2	1.9	1.4	0.5
b				−0.87	0.88		

[a] Note that the estimated returns of U.S. Rubber do not always move in the same direction as the overall economy. For example, when the economy is below average, consumers purchase fewer tires than they would if the economy was stronger. However, if the economy is in a flat-out recession, a large number of consumers who were planning to purchase a new car may choose to wait and instead purchase new tires for the car they currently own. Under these circumstances, we would expect U.S. Rubber's stock price to be higher if there is a recession than if the economy was just below average.

Merrill Finch's economic forecasting staff has developed probability estimates for the state of the economy, and its security analysts have developed a sophisticated computer program, which was used to estimate the rate of return on each alternative under each state of the economy. High Tech Inc. is an electronics firm; Collections Inc. collects past-due debts; and U.S. Rubber manufactures tires and various other rubber and plastics products. Merrill Finch also maintains a "market portfolio" that owns a market-weighted fraction of all publicly traded stocks; you can invest in that portfolio, and thus obtain average stock market results. Given the situation as described, answer the following questions.

a. (1) Why is the T-bill's return independent of the state of the economy? Do T-bills promise a completely risk-free return?
    (2) Why are High Tech's returns expected to move with the economy whereas Collections' are expected to move counter to the economy?
b. Calculate the expected rate of return on each alternative and fill in the blanks on the row for $\hat{r}$ in the table above.
c. You should recognize that basing a decision solely on expected returns is only appropriate for risk-neutral individuals. Because your client, like virtually everyone, is risk averse, the riskiness of each alternative is an important aspect of the decision. One possible measure of risk is the standard deviation of returns.
    (1) Calculate this value for each alternative, and fill in the blank on the row for σ in the table.
    (2) What type of risk is measured by the standard deviation?
    (3) Draw a graph that shows *roughly* the shape of the probability distributions for High Tech, U.S. Rubber, and T-bills.
d. Suppose you suddenly remembered that the coefficient of variation (CV) is generally regarded as being a better measure of stand-alone risk than the standard deviation when the alternatives being considered have widely differing expected returns. Calculate the missing CVs, and fill in the blanks on the row for CV in the table. Does the CV produce the same risk rankings as the standard deviation?
e. Suppose you created a 2-stock portfolio by investing $50,000 in High Tech and $50,000 in Collections.
    (1) Calculate the expected return ($\hat{r}_p$), the standard deviation (σ_p), and the coefficient of variation (CV_p) for this portfolio and fill in the appropriate blanks in the table.
    (2) How does the riskiness of this 2-stock portfolio compare with the riskiness of the individual stocks if they were held in isolation?

f. Suppose an investor starts with a portfolio consisting of one randomly selected stock. What would happen
(1) to the riskiness and
(2) to the expected return of the portfolio as more and more randomly selected stocks were added to the portfolio? What is the implication for investors? Draw a graph of the 2 portfolios to illustrate your answer.

g. (1) Should portfolio effects impact the way investors think about the riskiness of individual stocks?
(2) If you decided to hold a 1-stock portfolio, and consequently were exposed to more risk than diversified investors, could you expect to be compensated for all of your risk; that is, could you earn a risk premium on that part of your risk that you could have eliminated by diversifying?

h. The expected rates of return and the beta coefficients of the alternatives as supplied by Merrill Finch's computer program are as follows:

Security	Return ($\hat{r}$)	Risk (Beta)
High Tech	12.4%	1.32
Market	10.5	1.00
U.S. Rubber	9.8	0.88
T-bills	5.5	0.00
Collections	1.0	(0.87)

(1) What is a beta coefficient, and how are betas used in risk analysis?
(2) Do the expected returns appear to be related to each alternative's market risk?
(3) Is it possible to choose among the alternatives on the basis of the information developed thus far? Use the data given at the start of the problem to construct a graph that shows how the T-bill's, High Tech's, and the market's beta coefficients are calculated. Then discuss what betas measure and how they are used in risk analysis.

i. The yield curve is currently flat, that is, long-term Treasury bonds also have a 5.5 percent yield. Consequently, Merrill Finch assumes that the risk-free rate is 5.5 percent.
(1) Write out the Security Market Line (SML) equation, use it to calculate the required rate of return on each alternative, and then graph the relationship between the expected and required rates of return.
(2) How do the expected rates of return compare with the required rates of return?
(3) Does the fact that Collections has an expected return that is less than the T-bill rate make any sense?
(4) What would be the market risk and the required return of a 50–50 portfolio of High Tech and Collections? Of High Tech and U.S. Rubber?

j. (1) Suppose investors raised their inflation expectations by 3 percentage points over current estimates as reflected in the 5.5 percent risk-free rate. What effect would higher inflation have on the SML and on the returns required on high- and low-risk securities?
(2) Suppose instead that investors' risk aversion increased enough to cause the market risk premium to increase by 3 percentage points. (Inflation remains constant.) What effect would this have on the SML and on returns of high- and low-risk securities?

cyberproblem

Please go to the ThomsonNOW Web site to access the Cyberproblems.

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Access the Thomson ONE problems though the ThomsonNOW Web site. Use the Thomson ONE—Business School Edition online database to work this chapter's questions.

Using Past Information to Estimate Required Returns

Chapter 8 discussed the basic trade-off between risk and return. In the Capital Asset Pricing Model (CAPM) discussion, beta is identified as the correct measure of risk for diversified shareholders. Recall that beta measures the extent to which the returns of a given

stock move with the stock market. When using the CAPM to estimate required returns, we would ideally like to know how the stock will move with the market in the future, but since we don't have a crystal ball we generally use historical data to estimate this relationship with beta.

As mentioned in the Web Appendix for this chapter, beta can be estimated by regressing the individual stock's returns against the returns of the overall market. As an alternative to running our own regressions, we can instead rely on reported betas from a variety of sources. These published sources make it easy for us to readily obtain beta estimates for most large publicly traded corporations. However, a word of caution is in order. Beta estimates can often be quite sensitive to the time period in which the data are estimated, the market index used, and the frequency of the data used. Therefore, it is not uncommon to find a wide range of beta estimates among the various published sources. Indeed, Thomson One reports multiple beta estimates. These multiple estimates reflect the fact that Thomson One puts together data from a variety of different sources.

Discussion Questions

1. Begin by taking a look at the historical performance of the overall stock market. If you want to see, for example, the performance of the S&P 500, select INDICES and enter S&PCOMP. Click on PERFORMANCE and you will immediately see a quick summary of the market's performance in recent months and years. How has the market performed over the past year? The past 3 years? The past 5 years? The past 10 years?
2. Now let's take a closer look at the stocks of four companies: Colgate Palmolive (Ticker = CL), Gillette (G), Merrill Lynch (MER), and Microsoft (MSFT). Before looking at the data, which of these companies would you expect to have a relatively high beta (greater than 1.0), and which of these companies would you expect to have a relatively low beta (less than 1.0)?
3. Select one of the four stocks listed in question 2 by selecting COMPANIES, entering the company's ticker symbol, and clicking on GO. On the overview page, you should see a chart that summarizes how the stock has done relative to the S&P 500 over the past 6 months. Has the stock outperformed or underperformed the overall market during this time period?
4. Return to the overview page for the stock you selected. If you scroll down the page you should see an estimate of the company's beta. What is the company's beta? What was the source of the estimated beta?
5. Click on the tab labeled PRICES. What is the company's current dividend yield? What has been its total return to investors over the past 6 months? Over the past year? Over the past 3 years? (Remember that total return includes the dividend yield plus any capital gains or losses.)
6. What is the estimated beta on this page? What is the source of the estimated beta? Why might different sources produce different estimates of beta? [Note if you want to see even more beta estimates, click OVERVIEWS (on second line of tabs) and then select the SEC DATABASE MARKET DATA. Scroll through the STOCK OVERVIEW SECTION and you will see a range of different beta estimates.]
7. Select a beta estimate that you believe is best. (If you are not sure, you may want to consider an average of the given estimates.) Assume that the risk-free rate is 5 percent and the market risk premium is 6 percent. What is the required return on the company's stock?
8. Repeat the same exercise for each of the 3 remaining companies. Do the reported betas confirm your earlier intuition? In general, do you find that the higher-beta stocks tend to do better in up markets and worse in down markets? Explain.