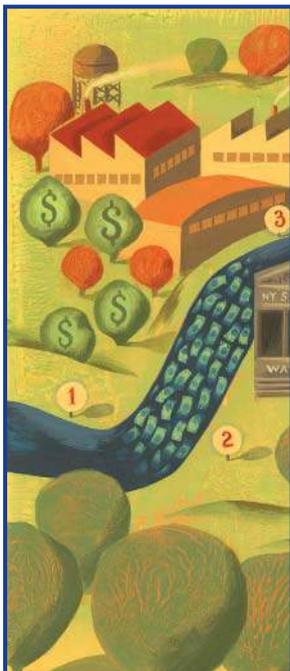


## CHAPTER OUTLINE

**Why Study Risk and Return?**

- The General Relationship Between Risk and Return
- The Return on an Investment
- Risk—A Preliminary Definition

**Portfolio Theory**

- Review of the Concept of a Random Variable
- The Return on a Stock Investment as a Random Variable
- Risk Redefined as Variability
- Risk Aversion

- Decomposing Risk—Systematic (Market) and Unsystematic (Business-Specific) Risk

## Portfolios

- Diversification—How Portfolio Risk Is Affected When Stocks Are Added

- Measuring Market Risk—The Concept of Beta

- Using Beta—The Capital Asset Pricing Model (CAPM)

- The Validity and Acceptance of the CAPM and Its SML

This chapter explores the relationship between risk and return inherent in investing in securities, especially stocks. In what follows we'll define risk and return precisely, investigate the nature of their relationship, and find that there are ways to limit exposure to investment risk.

The body of thought we'll be working with is known as *portfolio theory*. The ideas behind the theory were motivated by observations of the returns on various investments over many years. We'll begin by reviewing those observations.

## WHY STUDY RISK AND RETURN?

As we've said before, there are fundamentally two ways to invest: debt and equity. Debt involves lending by buying bonds or putting money into savings accounts. Equity means buying stock.

People are constantly looking at the relative returns on these two investment vehicles. It has always been apparent that long-run average returns on equity investments are much higher than those available on debt. Indeed, over most of the twentieth century, equity returns averaged more than 10% while debt returns averaged between 3% and 4%. At the same time, inflation averaged about 3%, so debt investors didn't get ahead by much!

But average returns aren't the whole story. Although equity returns tend to be much higher than debt returns in the long run, they are subject to huge swings during shorter periods. In a given one- or two-year period, for example, the annual return on stock investments can be as high as 30% or as low as  $-30\%$ . The high side of this range is great news, but the low side is a disaster to most investors.

The **return on equity (stock)** investments has historically been **much higher** than the **return on debt** investments.

**Equity** is historically much **riskier** than debt.

**Portfolios** are collections of financial assets held by investors.

The short-term variability of equity returns is a very important observation, because few people invest for really long periods, say 75 years. Most everyone has a much shorter time horizon of 2, 10, or perhaps 20 years. The variability of equity returns means that if you invest in stock today with a goal of putting a child through college in 5 years, there's a good chance that you'll lose money instead of making it. That's a frightening possibility to most people.

As a result of these observations, people began to wonder if there wasn't some way to invest in equities (stocks) that would take advantage of their high average rate of return but minimize their risk at the same time.

Thinking about that question resulted in the development of some techniques that enable investors to control and manage the risk to which they subject themselves while searching for high returns. These techniques involve investing in combinations of stocks called *portfolios*.

In the rest of this chapter we'll gain a better understanding of the concept of risk and see how it fits into the portfolio idea. Keep in mind throughout that the reason we do this is to *capture the high average returns of equity investing while limiting the associated risk as much as possible*.

## THE GENERAL RELATIONSHIP BETWEEN RISK AND RETURN

People usually use the word “risk” when referring to the probability that something bad will happen. For example, we often talk about the risk of having an accident or of losing a job.

In financial dealings, risk tends to be thought of as the probability of losing some or all of the money we put into a deal. For example, we talked about the risk of default on a loan in Chapter 5, meaning the probability that the loan wouldn't be paid back and the lender would lose his or her investment. Similarly, an investment in a share of stock results in a loss if the price drops before an investor sells. The probability of that happening is what most people think of as risk in stock investments.

In general, investment opportunities that offer higher returns also entail higher risks. Let's consider a hypothetical example to illustrate this central idea.

Suppose you could invest in a stock that will do one of two things. It will either return 15% on your investment or become valueless, resulting in a total loss of your money. Imagine for the sake of illustration that there's no middle ground; you either make 15% or lose everything. Suppose the chance of total loss is 1% and the chance of a 15% return is 99%. The *risk* associated with investing in this stock can be thought of as a 1% chance of total loss.

Let's further assume that all stocks behave in this peculiar way and offer only two possible outcomes, some positive return or a total loss. However, the level of positive return and the probability of total loss can be different for each stock.

It's important to visualize this hypothetical world. Every stock has a positive level of return that's quite likely to occur. *Investors more or less expect to receive that return*, yet they realize that every stock investment also carries some risk, the probability that they'll lose their entire investment instead.

Now, suppose you're not happy with the 15% return offered by the stock we started with, so you look around for an issue that offers a higher rate. *As a general rule, you'd find that stocks offering higher likely returns also come with higher probabilities of total loss*. For example, an issue offering a 20% return might entail a 3% chance of total loss, while something offering a 25% return might have a 10% chance of loss, and so on.

Stocks with **higher likely returns** generally also have **higher risks of loss**.

This relationship is the financial expression of a simple fact of business life. Higher profit business opportunities are generally untried ventures that have a good chance of doing poorly or failing altogether. As a result, higher likely return goes hand in hand with higher risk.

Of course, in the real world there aren't just two possible outcomes associated with each investment opportunity. The actual return on a stock investment can be more or less than the most likely value by any amount. The illustration's total loss is in fact a worst-case situation. The real definition of risk therefore has to be more complex than the one in the illustration. Nevertheless, the general rule remains the same: Higher financial rewards (returns) come with higher risks.

Unfortunately, it isn't easy to understand how the real risk-return relationship works—that is, to predict just how much risk is associated with a given level of return. Understanding the real risk-return relationship involves two things. First we have to define risk in a measurable way, and then we have to relate that measurement to return according to some formula that can be written down.

It's important to realize that the true definition of risk isn't simple and easily measurable the way it was in the illustration. There we had only one bad outcome, total loss, so risk was just the probability of that outcome. In reality there are any number of outcomes that are less favorable than we'd like, and each has a probability of happening. Some outcomes are very bad, like losing everything, while others are just mildly unpleasant, like earning a return that's a little less than we expected. Somehow we have to define risk to include all of these possibilities.

## Portfolio Theory—Modern Thinking about Risk and Return

Recent thinking in theoretical finance, known as **portfolio theory**, grapples with this issue. The theory defines investment risk in a way that can be measured, and then relates the measurable risk in any investment to the level of return that can be expected from that investment in a predictable way.

Portfolio theory has had a major impact on the practical activities of the real world. The theory has important implications for how the securities industry functions every day, and its terminology is in use by practitioners all the time. Because of the central role played by this piece of thinking, it's important that students of finance develop a working familiarity with its principles and terminology. We'll develop that knowledge in this chapter.

**http://**

*Two Internet sources of up-to-date rates of return are BanxQuote at*

**<http://www.banx.com/>**

*and Bank Rate Monitor at*

**<http://www.bankrate.com/>**

## THE RETURN ON AN INVESTMENT

We developed the idea of a return on an investment rather carefully in the last two chapters. Recall that investments could be made in securities that represent either debt or equity, and that the return was the discount (interest) rate that equated the present value of the future cash flows coming from an investment to its current price.

In simpler terms you can think about the return associated with an investment as a rate of interest that the present valuing process makes a lot like the interest rate on a bank account. In effect, the rate of return ties all of an investment's future cash flows into a neat bundle, which can then be compared with the return on other investments.

### One-Year Investments

In what follows we'll use the idea of returns on investments held for just one year to illustrate points, so it's a good idea to keep those definitions in mind in formula form. We developed the expressions in Chapters 7 and 8, but will repeat them here for convenience.

A debt investment is a loan, and the return is just the loan's interest rate. This is simply the ratio of the interest paid to the loan principal.

$$(9.1) \quad k = \frac{\text{interest paid}}{\text{loan amount}}$$

This formulation leads to the convenient idea that a return is what the investor receives divided by what he or she invests. A stock investment involves the receipt of dividends and a capital gain (loss). If a stock investment is held for one year, the return can be written as

$$(9.2) \quad k = \frac{D_1 + (P_1 - P_0)}{P_0}$$

Here  $P_0$  is the price today, while  $P_1$  and  $D_1$  are respectively the price and dividend at the end of the year. This is equation 8.1, which we developed on page 329.

### Returns, Expected and Required

Whenever people make an investment, we'll assume they have some expectation of what the rate of return will be. In the case of a bank account, that's simply the interest rate quoted by the bank. In the case of a stock investment, the return we expect depends on the dividends we think the company is going to pay and what we think the future price of the stock will be. This anticipated return is simply called the **expected return**. It's based on whatever information the investor has available about the nature of the security at the time he or she buys it. In other words, the expected return is based on equation 9.2 with *projected* values inserted for  $P_1$  and  $D_1$ .

It's important to realize that *no rational person makes any investment without some expectation of return*. People understand that in stock investments the actual return probably won't turn out to be exactly what they expected when they made the investment, because future prices and dividends are uncertain. Nevertheless, they have some expectation of what the return is most likely to be.

At the same time, investors have a notion about what return they must receive in order to make particular investments. We call this concept the **required return** on the stock.

The required return is related to the perceived risk of the investment. People have different ideas about the safety of investments in different stocks. If there's a good chance that a company will get into trouble, causing a low return or a loss on an investment in its stock, people will require a higher expected return to make the investment.

A person might say, "I won't put money into IBM stock unless the expected return is at least 9%." That percentage is the person's *required return* for an investment in IBM. Each individual will have a different required return for every stock offered. Exactly how people form required returns is a central subject of this chapter. The important point is that *substantial investment will take place in a particular stock only if the generally expected return exceeds most people's required return for that stock*. In other words, people won't buy an issue unless they think it will return at least as much as they require.

### RISK—A PRELIMINARY DEFINITION

We talked about risk earlier, and alluded to the fact that its definition in finance is somewhat complicated. The definition we'll eventually work with is a little different

The **expected return** on a stock is the return investors feel is most likely to occur based on currently available information.

The **required return** on a stock is the minimum rate at which investors will purchase or hold a stock based on their perceptions of its risk.

Significant investment in a stock occurs only if the **expected return exceeds the required return** for a substantial number of investors.

A preliminary definition of investment **risk** is the **probability that return will be less than expected**.

from the way we normally use the word. We'll need to develop the idea slowly, so we'll begin with a simple definition that we'll modify and add to as we progress. The simple definition is consistent with our everyday notion of risk as the chance that something bad will happen to us.

For now, **risk** for an investor is the chance (probability) that the return on an investment will turn out to be less than he or she expected when the investment was made. Notice that this definition includes more than just losing money. If someone makes an investment expecting a return of 10%, risk includes the probability that the return will turn out to be 9%, even though that's a positive return. Let's look at this definition of risk in the context of two different kinds of investment.

First consider investing in a bank account. What's the chance that a depositor will receive less interest than the bank promised when the account was opened? Today that chance is very small, because most bank accounts are insured by the federal government. Even if the bank goes out of business, depositors get their money, so we're virtually guaranteed the promised return. A bank account has virtually zero risk because there's little or no chance that the investor won't get the expected return.

Now consider an investment in stock. Looking at equation 9.2, we can see that the return is determined by the future price of the stock and its future dividend. Because there are no guarantees about what those future amounts will be, the return on a stock investment may turn out to be different from what was expected at the time the stock was purchased. It may be more than what was anticipated or it may be less. Risk is just the probability that it's anything less.

### Feelings about Risk

Most people have negative feelings about bearing risk in their investment activities. For example, if investors are offered a choice between a bank account that pays 8% and a stock investment with an expected return of 8%, almost everyone would choose the bank account because it has less risk. People prefer lower risk if the expected return is the same. We call this characteristic **risk aversion**, meaning that most of us don't like bearing risk.

At the same time, most people see a trade-off between risk and return. If offered a choice between the 8% bank account and a stock whose expected return is 10%, some will still choose the bank account, but many will now choose the stock.

It's important to understand that risk aversion doesn't mean that risk is to be avoided at all costs. It is simply a negative that can be offset with more anticipated money—in other words, with a higher expected return.

We're now armed with sufficient background material to attempt an excursion into portfolio theory.

## PORTFOLIO THEORY

Portfolio theory is a statistical model of the investment world. We'll develop the ideas using some statistical terms and concepts, but will avoid most of the advanced mathematics. We'll begin with a brief review of a few statistical concepts.

### REVIEW OF THE CONCEPT OF A RANDOM VARIABLE

In statistics, a random variable is the outcome of a chance process. Such variables can be either *discrete* or *continuous*. Discrete variables can take only specific values whereas continuous variables can take any value within a specified range.

**Risk averse** investors prefer lower risk when expected returns are equal.

A **random variable** is the outcome of a chance process and has a probability distribution.

Suppose you toss a coin four times, count the number of heads, and call the result  $X$ . Then  $X$ , the number of heads, is a random variable that can take any of five values: 0, 1, 2, 3, or 4. For any series of four tosses, there's a probability of getting each value of  $X$  [written  $P(X)$ ] as follows.<sup>1</sup>

$X$	$P(X)$
0	.0625
1	.2500
2	.3750
3	.2500
4	.0625
	<u>1.0000</u>

Such a representation of all the possible outcomes along with the probability of each is called the *probability distribution for the random variable  $X$* . Notice that the probabilities of all the possible outcomes have to sum to 1.0. The probability distribution can be shown in tabular form like this or graphically, as in Figure 9.1.

The number of heads in a series of coin tosses is a *discrete* random variable because it can take on only a limited number of discrete values, each of which has a distinct probability. In our example, the only outcomes possible are 0, 1, 2, 3, and 4. There can't be more than four heads or fewer than zero, nor can there be a fractional number of heads.

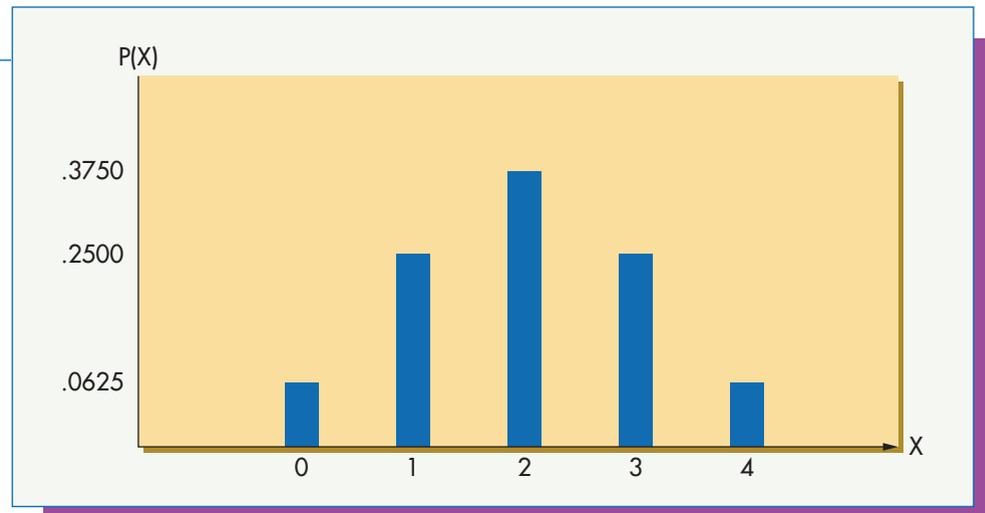
The **mean** or **expected value** of a distribution is the most likely outcome for the random variable.

### The Mean or Expected Value

The value that the random variable is most likely to take is an important statistical concept. In symmetrical probability distributions with only one peak like the one

**Figure 9.1**

#### Discrete Probability Distribution



1. The probabilities can be calculated by enumerating all of the 16 possible head-tail sequences in four coin tosses and counting the number of heads in each. Each sequence has an equal one-sixteenth probability (.0625) of happening. The probability of any number of heads is one-sixteenth times the number of sequences containing that number of heads.

The **mean** or **expected value** of a distribution is the most likely outcome for the random variable.

in Figure 9.1, it's at the center of the distribution under its highest point. We call this most likely outcome the *mean* or the *expected value* of the distribution, and write it by placing a bar over the variable. In the coin toss illustration, the mean is written as

$$\bar{X} = 2$$

Thinking of the mean as the value of the random variable at the highest point of the distribution makes intuitive sense, but the statistical definition is more precise. The mean is actually the weighted average of all possible outcomes where each outcome is weighted by its probability. This is written as

$$\bar{X} = \sum_{i=1}^n X_i P(X_i)$$

where  $X_i$  is the value of each outcome and  $P(X_i)$  is its probability. The summation sign means that we add this figure for each of the  $n$  possible outcomes.

Calculating the mean for discrete distributions is relatively easy. For the coin toss illustration, we just list each possible outcome along with its probability, multiply, and sum.

X	P(X)	X * P(X)
0	.0625	.00
1	.2500	.25
2	.3750	.75
3	.2500	.75
4	.0625	.25
	1.0000	$\bar{X} = 2.00$

The mean is simply the mathematical expression of the everyday idea of an average. That is, if we repeat the *series* of coin tosses a number of times, the average outcome will be 2. Notice that the process of multiplying something related to an outcome (in this case the outcome itself) by the probability of the outcome and summing gives an average value. We'll use the technique again shortly.

## The Variance and Standard Deviation

A second important characteristic of a random variable is its variability. The idea gets at how far a typical observation of the variable is likely to deviate from the mean. Here's an example.

Suppose we define a random variable by estimating the heights of randomly selected buildings in a city. Allow 12 feet per story. The results might range from 12 feet for one-story structures to more than 1,000 feet for skyscrapers. Suppose the average height turned out to be 30 stories or 360 feet. It's easy to see that a typical building would have a height that's very different from that average. Some office buildings would be hundreds of feet higher, while all private homes would be hundreds shorter.

Now, suppose we did the same thing for telephone poles, measuring to the nearest foot, and got an average height of 30 feet. Unlike buildings, we'd find that telephone poles don't vary much around 30 feet. Some might be 31 feet and some 29, but not very many of them would be far out of that range.

The point is that there's a great deal of difference in *variability around the mean* in different distributions. Telephone pole heights are closely clustered around their average, while building heights are widely dispersed around theirs.

The **standard deviation** gives an indication of how far from the mean a typical observation is likely to fall.

In statistics, this notion of how far a typical observation is likely to be from the mean is described by the *standard deviation* of the distribution, usually written as the Greek letter sigma,  $\sigma$ . You can think of the standard deviation as the average (standard) distance (deviation) between an outcome and the mean. For example, in our building illustration the "average" (typical) building might be 20 stories different in height than the mean height of all buildings. As we'll explain shortly, that interpretation isn't quite right because of the way standard deviations are calculated, but it's a good way to visualize the concept.

The standard deviation idea intuitively begins as an average distance from the mean. One would think that could be calculated in the same way as the mean itself. That is, by taking the distance of each possible outcome from the mean, multiplying it by the probability of the outcome, and summing over all outcomes. Mathematically that would look like this:

$$\sum_{i=1}^n (X_i - \bar{X}) P(X_i)$$

The problem with this formulation is that the deviations [the  $(X_i - \bar{X})$ 's] are of different signs depending on the side of the mean on which each outcome ( $X_i$ ) is located. Hence, they cancel each other when summed. Statisticians avoid the problem by squaring the deviations before multiplying by the probabilities and summing. This leads to a statistic called the *variance* written as

$$\text{Var } X = \sigma_x^2 = \sum_{i=1}^n [(X_i - \bar{X})^2] P(X_i)$$

In words, the variance is the average *squared* deviation from the mean. The *standard deviation* is the square root of the variance.

Intuitively, taking the square root of the variance reverses the effect of the earlier squaring to get rid of the sign differences. Unfortunately, it doesn't quite work. The square root of the sum of squares isn't equal to the sum of the original amounts. Hence, the standard deviation isn't an average distance from the mean, but it's *conceptually* close. This is why we use the term *standard deviation* instead of average deviation. In any event, standard deviation and variance are the traditional measures of variability in probability distributions and are used extensively in financial theory.

For a discrete distribution like our coin toss, we calculate the variance and then the standard deviation by (1) measuring each possible outcome's distance from the mean, (2) squaring it, (3) multiplying by the probability of the outcome, (4) summing the result over all possible outcomes for the variance, and then (5) taking the square root for the standard deviation. Of course, the mean has to be calculated first. The computations are laid out in the following table.

$X_i$	$(X_i - \bar{X})$	$(X_i - \bar{X})^2$	$P(X_i)$	$(X_i - \bar{X})^2 * P(X_i)$
0	-2	4	.0625	0.25
1	-1	1	.2500	0.25
2	0	0	.3750	0.00
3	1	1	.2500	0.25
4	2	4	.0625	0.25
				$\text{Var } X = \sigma_X^2 = 1.00$
				$\text{Std Dev} = \sqrt{\text{Var } X} = \sigma_X = 1.00$

This example is unusual in that the variance is exactly 1, so the standard deviation turns out to be the same number.

Keep in mind that the terms “variance” and “standard deviation” are both used to characterize variability around the mean.

### The Coefficient of Variation

The *coefficient of variation*, CV, is a *relative* measure of variation. It is the ratio of the standard deviation of a distribution to its mean.

$$CV = \frac{\sigma_X}{\bar{X}}$$

It is essentially variability as a fraction of the average value of the variable. In our coin toss example, the mean outcome is two heads in a series of four tosses. The standard deviation is one head, meaning a typical series will vary by one from the mean of two. The coefficient of variation is then ( $1/2 =$ ) .5, meaning the typical variation is one half the size of the mean.

### Continuous Random Variables

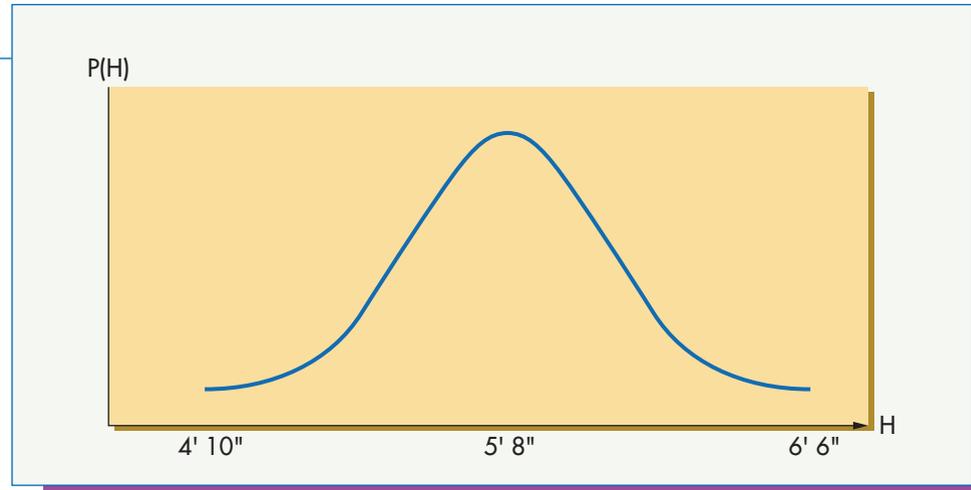
Other random variables are continuous, meaning they can take any numerical value within some range. For example, if we choose people at random and measure their height, that measurement could be considered a random variable called H. A graphic representation of the probability distribution of H is shown in Figure 9.2. In this graph, probability is represented by the area under the curve and above the horizontal axis. That entire area is taken to be 1.0.

When the random variable is continuous, we talk about the probability of an actual outcome being *within a range* of values rather than turning out to be an exact amount. For example, it isn't meaningful to state the probability of finding a person whose height is *exactly* 5'2", because the chance of doing that is virtually zero. However, it is meaningful to state a probability of finding a person whose height is between 5'1<sup>7</sup>/<sub>8</sub>" and 5'2<sup>1</sup>/<sub>8</sub>". In the distribution, that probability is represented by the area under the curve directly above and between those values on the horizontal axis.

Calculating the mean and variance of a continuous distribution is mathematically more complex than in the discrete case, but the idea is the same. The mean is the average of all possible outcomes, each weighted by its probability. When the distribution is symmetrical and has only one peak, the mean is found under that peak.

**Figure 9.2**

**Probability Distribution for a Continuous Random Variable**



## THE RETURN ON A STOCK INVESTMENT AS A RANDOM VARIABLE

In financial theory, the **return on a stock investment** is considered a **random variable**.

In portfolio theory, the return on an investment in stock is considered a random variable. This makes sense because return is influenced by a significant number of uncertainties. Consider equation 9.2. In that expression, the value of the return depends on the future market price of the stock,  $P_1$ , and a future dividend,  $D_1$ . Both of these amounts are influenced by the multitude of events that make up the business environment in which the company that issued the stock operates. The price is further affected by all the forces that influence financial markets. In other words, there's an element of uncertainty or randomness in both the future price and the future dividend. It follows that there's an uncertainty or randomness to the value of  $k$ , and we can consider it a random variable.

Return is a continuous random variable whose values are generally expressed as percentages. Equation 9.2 calculates the decimal form of those percentages (e.g., .10 for 10%). In straightforward stock investments, the lowest return possible is  $-100\%$ , a total loss of invested money, but there's technically no limit to the amount of positive return that's possible.

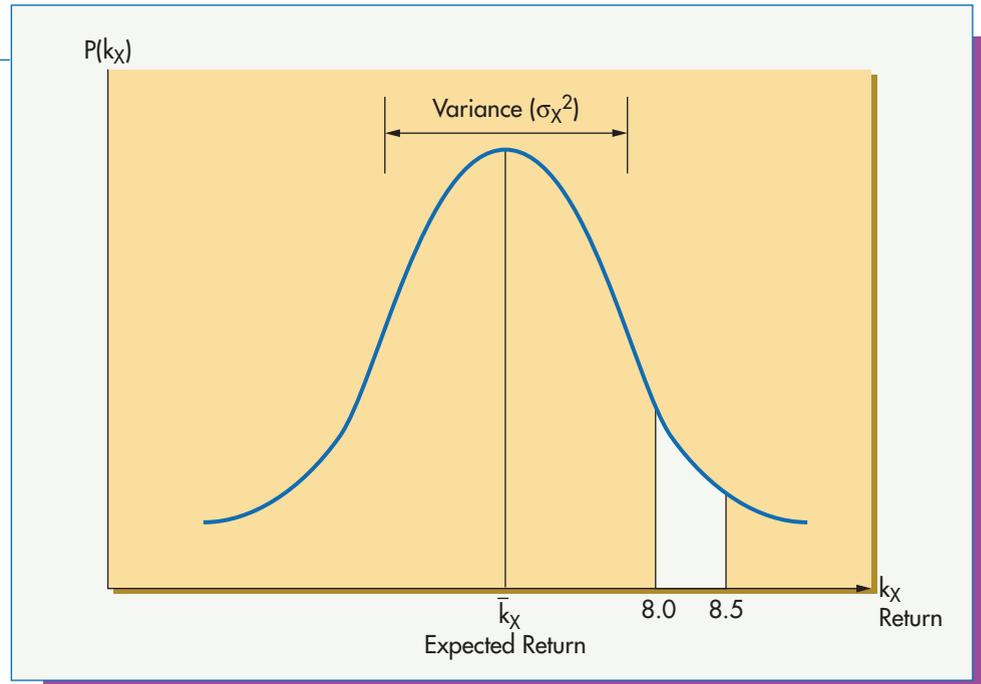
Like any random variable, the return on a stock investment has an associated probability distribution. Figure 9.3 is a graphic depiction of a probability distribution for the return on a stock we'll call X. The return on X is called  $k_X$ . The values the return can take appear along the horizontal axis, and the probabilities of those values appear on the vertical axis. The shape of the distribution depicts the likelihood of all possible actual values of  $k_X$  according to areas under the curve.

The total area under the curve is 1.0, and the proportionate area under any section represents the probability that an actual return will fall along the horizontal axis in that area. For example, the shaded area in the diagram represents the probability that in any particular year the actual return on an investment in stock X will turn out to be between 8.0% and 8.5%. If that area is .1 or 10% of the total area under the curve, the probability of the actual return being between 8.0% and 8.5% in any year would be 10%.

The mean or expected value (the most likely outcome) is usually found under the highest point of the curve. It's indicated as  $\bar{k}_X$  in the diagram.

Figure 9.3

**The Probability Distribution of the Return on an Investment in Stock X**



The mean of the distribution of returns is the stock's **expected return**.

The mean is the statistical representation of the average investor's expected return that we talked about earlier. This is an important point. Portfolio theory assumes that all of the knowledge the investment community has about the future performance of a stock is reflected in the probability distribution of returns perceived by the investors. In particular, the mean of that perceived distribution is the expected return investors plan on receiving when they buy.

The variance and standard deviation of the distribution show how likely it is that an actual return will be some distance away from the expected value. A distribution with a large variance is more likely to produce actual outcomes that are substantially away from the expected value than one with a small variance.

Figure 9.3 shows the variance conceptually as the width of the distribution. We'll use  $\sigma_X^2$  to indicate that we're talking about the distribution of returns for stock X. Similarly,  $\sigma_X$  will be the standard deviation for stock X. A large variance implies a wide distribution with gently sloping sides and a low peak. A narrow distribution with steeply sloping sides and a high peak has a small variance and standard deviation. Figure 9.4 shows distributions with large and small variances.

Notice that the large variance distribution has more area under the curve farther away from the mean than the small variance distribution. This pattern means that more actual observations of the return are likely to be far away from the mean when the distribution's variance is large. Stated another way, returns will tend to be more different, or more variable, from year to year when the variance is large. When the variance is small, actual returns in successive years are more likely to cluster closely around the mean or expected value.

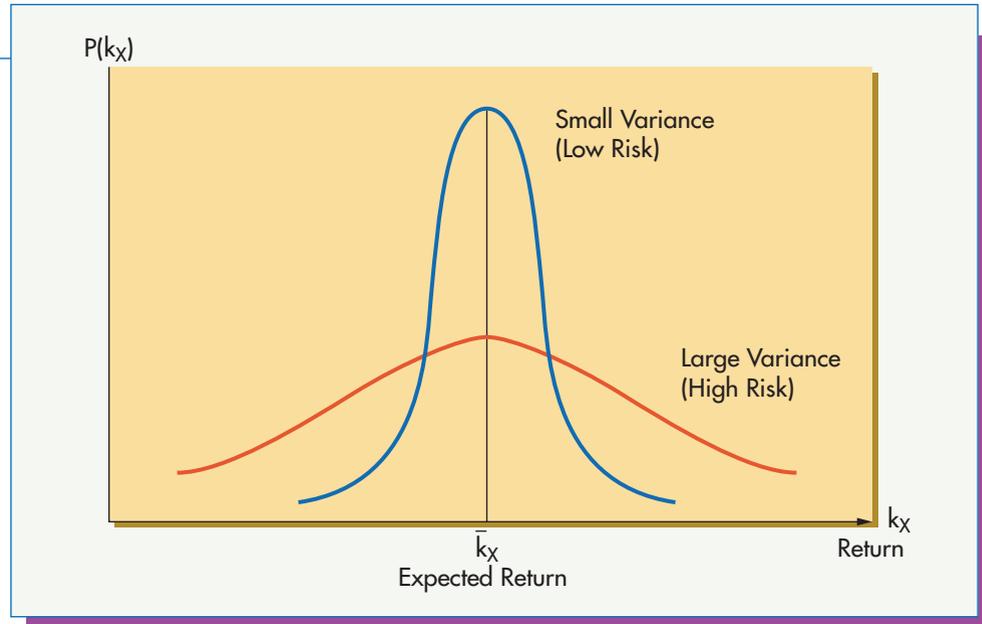
## RISK REDEFINED AS VARIABILITY

The meaning of risk in portfolio theory differs from the definition we gave earlier. Before we said that risk is the probability that return will be less than expected. In portfolio theory, risk is variability. That is, a stock whose return is likely to be

In financial theory **risk** is defined as **variability** in return.

Figure 9.4

### Probability Distributions with Large and Small Variances



significantly different from one year to the next is risky, while one whose returns are likely to cluster tightly is less risky. Stated another way, a risky stock has a high probability of producing a return that's substantially away from the mean of the distribution of returns, while a low-risk stock is unlikely to produce a return that differs from the expected return by very much.

But this is exactly the idea of variance and standard deviation that we've been talking about, so in portfolio theory, *a stock investment's risk is defined as the standard deviation of the probability distribution of its return*. A large standard deviation implies high risk and a small one means low risk. In practical terms, high risk implies *variability* in return, meaning that returns in successive years are likely to be considerably different from one another.

Figure 9.4 can be interpreted as showing a risky stock and a low-risk stock with the same expected return. The difference is in the variances, which can be visually observed as the widths of the distributions.

This definition is somewhat inconsistent with the earlier version in which we said risk was the probability that return would be *less than* what was expected. One would think that a more appropriate definition in statistical terms would equate risk with only the left side of the probability distribution, because in that area return is less than expected. Defining risk as the entire standard deviation includes the probability that the return turns out to be more than expected, and we're certainly not concerned if that happens.

Indeed, a left-side-only definition would make more intuitive sense. However, it would be very difficult to work with mathematically. Theorists solved the problem by noticing that return distributions are usually relatively symmetrical. This means that a large left side always implies a large right side as well. Why not therefore define risk for mathematical convenience as total variability, understanding that we're really only concerned with the probability of lower than expected returns (those on the left)? Indeed, this is what was done. The resulting technical definition of risk is a little

strange in that it includes good news as well as bad news, but that doesn't bother us if we keep the reason in mind.

So we actually have two definitions of risk that are both correct. In practical terms, risk is the probability that return will be less than expected. In financial theory, risk is the variability of the probability distribution of returns.

Terminology isn't entirely consistent. When talking conceptually about risk, people are likely to use the terms "variance" or "variability." But when a precise value is needed to represent risk in a mathematical equation, it's more common to use  $\sigma$ , the standard deviation.

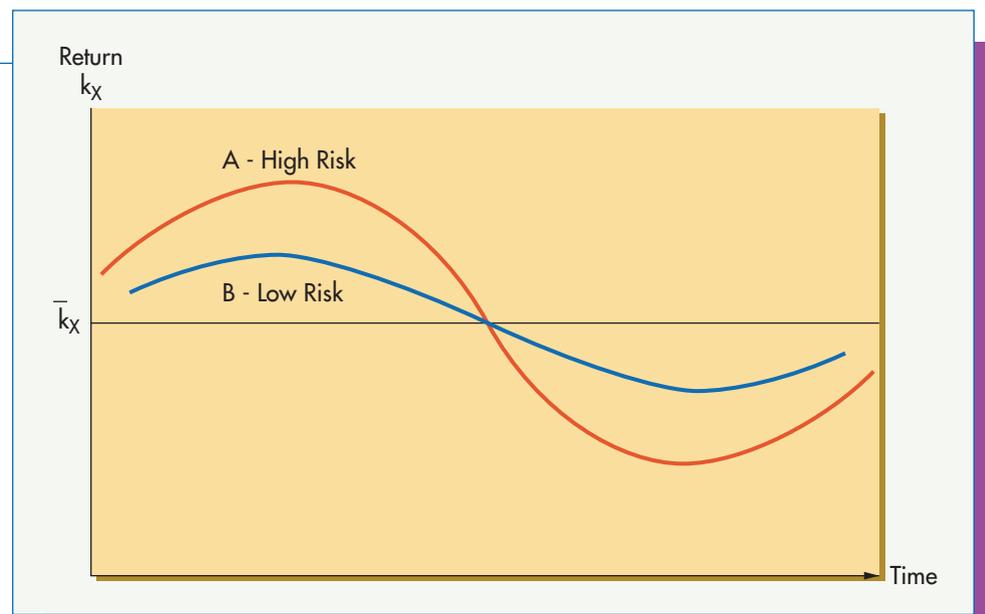
Notice also that defining risk as the probability that return will be less than expected doesn't tell us much. For more or less symmetrical distributions of returns, that probability will always be about 50%. But for some investments the return is never below the expected value by very much, while for others it can be below by a lot. The variance definition gets right at this distinction. If the distribution has a large variance, the return can be below the expected value by a substantial amount, and an investor can be hurt badly.

### An Alternate View

There's another way to visualize risk that many students find helpful. Imagine plotting the historical values of return on a particular stock over time. When we do that, we get an up-and-down graph like one of those shown in Figure 9.5. Over time the stock's return is seen to oscillate around its average value,  $\bar{k}_x$ . The more the stock's return moves up and down over time, the more risky we say it is as an investment. That is, the greater the amplitude of the swings, the riskier the stock. This view is simply a graphic result of the variance of the distribution. In the diagram, stock A is relatively high risk and stock B is relatively low risk. We will use this representation again shortly.

**Figure 9.5**

**Investment Risk  
Viewed as  
Variability of  
Return over Time**



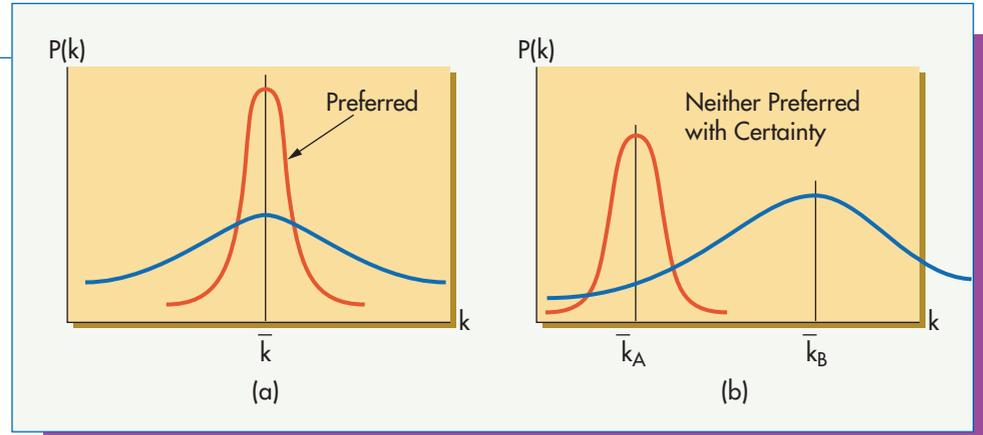
**Risk aversion** means investors prefer lower risk when **expected returns are equal**.

## RISK AVERSION

Now we're in a position to define **risk aversion** more precisely. The axiom simply states that people prefer investments with less risk to those with more risk if the expected returns are equal. Figure 9.6a illustrates the idea with probability distributions. The narrower distribution has less risk and will be preferred to the wider, riskier distribution.

**Figure 9.6**

### Risk Aversion



It's important to understand that this preference is assumed to hold universally only in cases where the expected returns are exactly equal. When the choice is as illustrated in Figure 9.6b, the principle of risk aversion tells us nothing. There, investment A is preferred on the basis of risk, while investment B is preferred on the basis of expected return. Which will be chosen depends on the individual investor's tolerance for risk.



### Example 9.1

#### Evaluating Stand-Alone Risk

The notions of risk we've just developed are associated with owning shares of a single stock by itself. That can be characterized as **stand-alone risk**, because the stock's variability stands alone independent of anything happening in the owner's portfolio.

Harold MacGregor is considering buying stocks for the first time and is looking for a single company in which he'll make a substantial investment. He has narrowed his search to two firms, Evanston Water Inc. and Astro Tech Corp. Evanston is a public utility supplying water to the county, and Astro is a relatively new high-tech company in the computer field.

Public utilities are classic examples of low-risk stocks because they're *regulated monopolies*. That means the government gives them the exclusive right to sell their products in an area but also controls pricing so they can't take advantage of the public by charging excessively. The *utility commission* usually sets prices aimed at achieving a reasonable return for the company's stockholders.

On the other hand, young high-tech firms are classic examples of high-risk companies. That's because new technical ideas can be enormously profitable, complete failures, or anything in between.

Harold has studied the history and prospects of both firms and their industries, and with the help of his broker has made a discrete estimate of the probability distribution of returns for each stock as follows.

Evanston Water		Astro Tech	
$k_E$	$P(k_E)$	$k_A$	$P(k_A)$
6%	.05	-100%	.15
8	.15	0	.20
10	.60	15	.30
12	.15	30	.20
14	.05	130	.15

Evaluate Harold's options in terms of statistical concepts of risk and return.

**SOLUTION:** First calculate the expected return for each stock. That's the mean of each distribution.

Evanston Water			Astro Tech		
$k_E$	$P(k_E)$	$k_E * P(k_E)$	$k_A$	$P(k_A)$	$k_A * P(k_A)$
6%	.05	0.3%	-100%	.15	-15.0%
8	.15	1.2	0	.20	0.0
10	.60	6.0	15	.30	4.5
12	.15	1.8	30	.20	6.0
14	.05	0.7	130	.15	19.5
$\bar{k}_E = 10.0\%$			$\bar{k}_A = 15.0\%$		

Next calculate the variance and standard deviation of the return on each stock.

Evanston Water				
$k_E$	$k_E - \bar{k}_E$	$(k_E - \bar{k}_E)^2$	$P(k_E)$	$(k_E - \bar{k}_E)^2 * P(k_E)$
6%	-4%	16	.05	0.8
8	-2	4	.15	0.6
10	0	0	.60	0.0
12	2	4	.15	0.6
14	4	16	.05	0.8

Variance  $\sigma_E^2 = 2.8$

Standard Deviation:  $\sigma_E = 1.7\%$

Astro Tech				
$k_A$	$k_A - \bar{k}_A$	$(k_A - \bar{k}_A)^2$	$P(k_A)$	$(k_A - \bar{k}_A)^2 * P(k_A)$
-100%	-115%	13,225	.15	1,984
0	-15	225	.20	45
15	0	0	.30	0
30	15	225	.20	45
130	115	13,225	.15	1,984
				Variance: $\sigma_A^2 = 4,058$
				Standard Deviation: $\sigma_A = 63.7\%$

Finally, calculate the coefficient of variation for each stock's return.

$$CV_E = \frac{\sigma_E}{\bar{k}_E} = \frac{1.7}{10.0} = .17 \quad CV_A = \frac{\sigma_A}{\bar{k}_A} = \frac{63.7\%}{15\%} = 4.25$$

**Discussion:** If Harold considers only the expected returns on his investment options, he'll certainly choose Astro. It's most likely return is half again as high as Evanston's. But a glance at the distributions reveals that's not the whole story. With Evanston, Harold's investment is relatively safe, because the worst he's likely to do is a return of 6% rather than the expected 10%.

Investing in Astro is a completely different story. While Harold's most likely return there is 15%, a substantial chance (15%) exists that he'll lose everything. There's also a 20% chance he'll earn a zero return. Possibilities like these give people concerns about investing in this kind of stock.

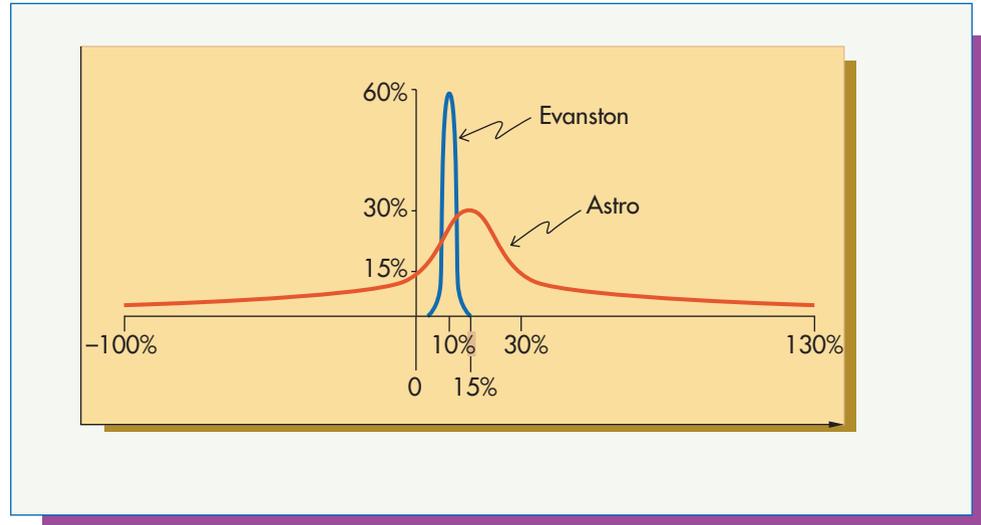
It's also important to appreciate the high side of the two distributions. With Evanston, Harold isn't likely to do much better than the expected return, because the highest yield available is only 14%. The utility commission's pricing regulations guarantee that. But with Astro there's a chance of more than doubling invested money in a relatively short time. That's reflected in the 15% chance of a 130% return. That tends to offset the depressing loss possibilities in the minds of some investors.

It should be clear that on a stand-alone basis, Astro is a relatively risky stock, while Evanston is relatively safe. Astro's risk and Evanston's lack of it come from the *variation* in the distributions of their returns, which we just observed by examining the distributions in detail. But the idea is also available in summarized form from the standard deviations and coefficients of variation.

First notice that Astro's standard deviation is 63.7%. That means a "typical" return has a good chance of being about 64% above or below the expected return of 15%. That's an enormous range for return, from -49% to 79%. On the other hand, Evanston's standard deviation is only 1.7%, meaning a typical return will probably be less than two percentage points off the expected return.

It's tempting to compare the two companies by saying Astro's risk is  $(63.7/1.7=)$  37 times that of Evanston. But that's not quite fair because Astro has a higher expected return. It makes more sense to compare the coefficients of variation, which state the standard deviations in units of their respective means. Evanston's CV is .17 while Astro's is 4.25, so it's more reasonable to say that Astro is  $(4.25/.17=)$  25 times as risky as Evanston.

A picture is even more telling. Continuous approximations of the two distributions are plotted as follows.



So, after having said all that, which stock should Harold choose?

Although our analysis has laid out the solution clearly, no one but Harold can answer that question. That's because his choice depends on his degree of *risk aversion*. Evanston is the better choice with respect to risk, but Astro is better with respect to expected return. Which dominates is a personal choice that only the investor can make.

The **returns** on securities tend to **move** up and down **together**.

## DECOMPOSING RISK—SYSTEMATIC (MARKET) AND UNSYSTEMATIC (BUSINESS-SPECIFIC) RISK

A fundamental truth of the investment world is that the returns offered on various securities tend to move up and down together. They don't move exactly together, or even proportionately, but for the most part, stocks tend to go up and down at the same times.

### Events and Conditions Causing Movement in Returns

Returns on stock investments move up and down in response to various events and conditions that affect the environment. Some things influence all stocks, while others affect only specific companies. News of politics, inflation, interest rates, war, and economic events tend to move most stocks in the same direction at the same time. A labor dispute in a particular industry, on the other hand, tends to affect only the stocks of firms in that industry.

Although certain events affect the returns of all stocks, some returns tend to respond more than others to particular things. Suppose news of an impending recession hits the market. The return on most stocks can be expected to decline, but not by the same amount. The return on a public utility like a water company isn't likely to change much. That's because people's demand for water doesn't change much in hard times, and the utility is a regulated monopoly whose profitability is more or less guaranteed by the government. On the other hand, the return on the stock of a

luxury goods manufacturer may drop sharply, because recession signals a drying up of demand for the company's product.

In short, there's a general but disproportionate movement together upon which is superimposed a fair amount of individual movement.

### Movement in Return as Risk

Remember that one way to look at a stock's risk is to consider the up-and-down movement of its return over time as equivalent to that risk (Figure 9.5). Think of that total movement as the total risk inherent in the stock.

### Separating Movement/Risk into Two Parts

It's conceptually possible to separate the total up-and-down movement of a stock's return into two parts. The first part is the movement that occurs along with that of all other stocks in response to events affecting them all. That movement is known as *systematic risk*. It systematically affects everyone.

The second part is whatever movement is left over after the first part has been removed. This movement is a result of events that are specific to particular companies and industries. Strikes, good or bad weather, good or bad management, and demand conditions are examples of things that affect particular firms. This remaining movement is called *unsystematic risk*. It affects specific companies.

Systematic and unsystematic risk can also be called **market risk** and **business-specific risk**, respectively.

## PORTFOLIOS

Most equity investors hold stock in a number of companies rather than putting all of their funds in one firm's securities. We refer to an investor's total stock holding as his or her *portfolio*.

### Risk and Return for a Portfolio

Each stock in a portfolio has its own expected return and its own risk. These are the mean and standard deviation of the probability distribution of the stock's return. As might be expected, the total portfolio also has its own risk and return.

The return (actual or expected) on a portfolio is simply the average of the returns of the stocks in it, where the average is weighted by the proportionate dollars invested in each stock. For example, suppose we have the following three-stock portfolio.

Stock	\$ Invested	Return
A	\$ 6,000	5%
B	9,000	9
C	15,000	11
	<u>\$30,000</u>	

The return on the portfolio, expected or actual, is

$$k_p = w_A k_A + w_B k_B + w_C k_C$$

where  $k_p$  is the portfolio's return and the  $w$ 's are the fractions of its total value invested in each asset. The weighted average calculation is as follows.

A stock's risk can be separated into **systematic or market risk** and **unsystematic or business-specific risk**.

Portfolios have **their own** risks and returns.

$$\begin{aligned}
 k_p &= \frac{\$6K}{\$30K} (5\%) + \frac{\$9K}{\$30K} (9\%) + \frac{\$15K}{\$30K} (11\%) \\
 &= (.2)(.05) + (.3)(.09) + (.5)(.11) \\
 &= 9.2\%
 \end{aligned}$$

The risk of a portfolio is the variance or standard deviation of the probability distribution of the portfolio's return. That depends on the variances (risks) of the returns on the stocks in the portfolio, but not in a simple way. We'll understand more about this relationship of portfolio risk to stock risk as we move on.

### The Goal of the Investor/Portfolio Owner

As we said earlier, the goal of investors is to capture the high average returns of equities while avoiding as much of their risk as possible. *That's generally done by constructing diversified portfolios to minimize portfolio risk for a given return.*

Investment theory is based on the premise that portfolio owners care only about the financial performance of their whole portfolios and not about the stand-alone characteristics of the individual stocks in the portfolios.

In other words, an investor evaluates the risk and return characteristics of a new stock only in terms of how that stock will affect the performance of his or her portfolio and not on the stand-alone merits of the stock. How a stock's characteristics can be different in and out of a portfolio will become clear shortly.

## DIVERSIFICATION — HOW PORTFOLIO RISK IS AFFECTED WHEN STOCKS ARE ADDED

Our basic goal in investing, to capture a high portfolio return while avoiding as much risk as possible, is accomplished through diversification. **Diversification** means adding different, or diverse, stocks to a portfolio. It's the investor's most basic tool for managing risk. Properly employed, diversification can reduce but not eliminate risk (variation in return) in a portfolio. To achieve the goal, however, we have to be careful about how we go about diversifying. We'll need to address unsystematic (business-specific) risk and systematic (market) risk separately.

### Business-Specific Risk and Diversification

If we diversify by forming a portfolio of the stocks of a fairly large number of different companies, we can imagine business-specific risk as a series of essentially random events that push the returns on individual stocks up or down. The stimuli that affect individual companies are separate events that occur across the country. Some are good and some are bad.

Because events causing business-specific risk are random from the investor's point of view, their effects simply cancel when added together over a substantial number of stocks. Therefore, we say that business-specific risk can be "diversified away" in a portfolio of any size. In other words, the good events offset the bad ones, and if there are enough events the net result tends to be about zero.

However, a word of caution is in order. For this idea to work, the stocks in the portfolio have to be from companies in fundamentally different industries. For example, if all the companies in a portfolio were agricultural, the effect of a drought wouldn't be random. It would hit all of the stocks. Therefore, the business-specific risk wouldn't be diversified away.

Investors are concerned with how stocks **impact portfolio performance** and not with their stand-alone characteristics.

**Business-specific risk** is essentially random and can be **diversified away**.

This is an easy but powerful concept. For investors who hold numerous stocks, business-specific risk simply doesn't exist at the aggregate level because it's "washed out" statistically. Individual stocks still have it, but portfolios do not, and the portfolio is all the investor cares about.

### Systematic (Market) Risk and Diversification

Reducing market risk in a portfolio calls for more complicated thinking than does handling business-specific risk. It should be intuitively clear that if the returns of all stocks move up and down more or less together, we're unlikely to be able to eliminate all of the movement in a portfolio's return by adding more stocks. In fact, systematic or market risk in a portfolio can be reduced but never entirely eliminated through diversification. However, even the reduction of market risk requires careful attention to the risk characteristics of the stocks added to the portfolio.

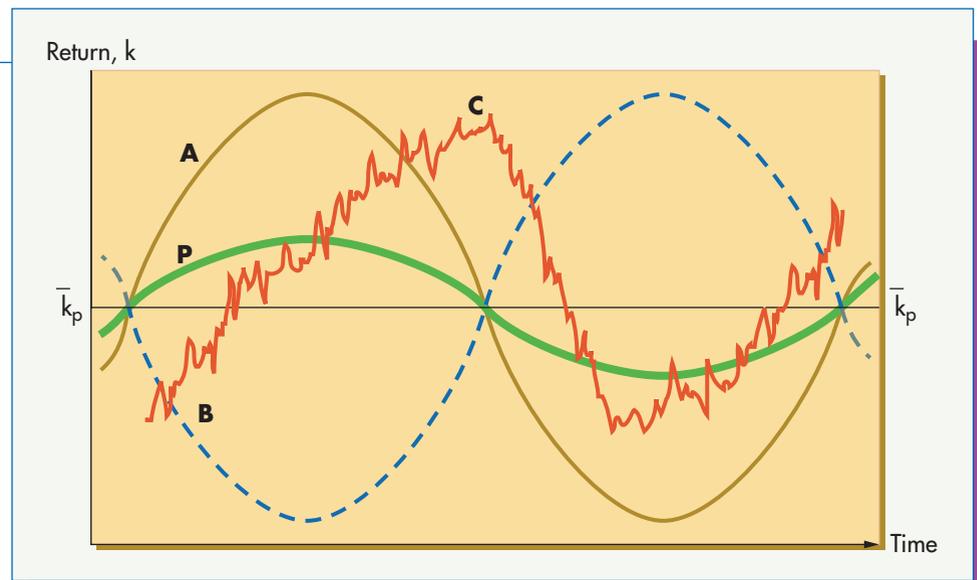
### The Portfolio

To appreciate the issue, imagine we have a portfolio of stocks that has an expected return  $\bar{k}_p$ . In what follows, we'll assume for simplicity that all the stocks have the same expected return. It's all right to make this unrealistic assumption for illustrative purposes, because the points we're getting at involve the interplay of risk among stocks and not of returns.

Our portfolio will have its own risk or variation in return, which is determined by the stocks in it. We'll assume the portfolio has been put together to mirror exactly the makeup of the overall stock market. That is, if the prices of the stocks in the overall market are such that General Motors makes up 2% of the market's value, we'll spend 2% of our money on General Motors stock, and so on through all the stocks listed on the market. If the portfolio is constituted in this way, its return will move up and down just as the market's return does. In other words, the portfolio's risk will just equal the market's risk. The behavior of the portfolio's return over time is illustrated in Figure 9.7 by the heavy line labeled P.

**Figure 9.7**

**Risk in and out of a Portfolio**



### The Impact on Portfolio Risk of Adding New Stocks

We now want to consider the impact on the portfolio's risk of adding a little of *either* of two new stocks to it. We'll call these stocks A and B. The special behavior of the return on each is shown in Figure 9.7. Notice that we're not talking about adding both stocks A and B at the same time. Rather the idea is to assess the impact on the risk of the resulting portfolio of adding a little of A *or* a little of B to the original portfolio.

First consider stock A. What happens to the risk of the portfolio if we add a few shares of A? Notice that A's return achieves its highs and lows at exactly the same times as does the portfolio's, and that its peaks and troughs are higher and lower, respectively, than the portfolio's. It should be clear that the inclusion of a little A will tend to heighten the portfolio's peak returns and depress its lowest returns. In other words, it will make the swings in the portfolio's return larger. That means it will add risk to the portfolio.

In statistical terms, A's return is said to be perfectly positively correlated with the portfolio's return. That means the two returns move up and down at exactly the same times. Such stocks will generally add risk to a diversified portfolio.

Now consider the pattern of returns on stock B over time. Its peaks occur with the portfolio's valleys, and its valleys coincide with the portfolio's peaks. The return on stock B is always moving up or down in a direction opposite the movement of the return on the portfolio.

What will happen to the pattern of returns of the portfolio if we add a few shares of B? Clearly, the peaks will be lower and the valleys will be higher—that is, the swings won't be as wide. According to our definitions, that means the risk will be lowered by adding some B. In statistical terms, B's return is said to be perfectly negatively correlated with the portfolio's return. Such stocks will always lower the portfolio's risk.

In short, A adds risk to a portfolio while B reduces the portfolio's risk.

### The Risk of the New Additions by Themselves and in Portfolios

Now consider the relative riskiness of stocks A and B without reference to a portfolio. That is, how risky is each one standing alone? Figure 9.7 shows that A's and B's returns have about the same level of variation. That is, their peaks and troughs are about the same height. Therefore, their stand-alone risks as individual stocks are about the same.

However, in a portfolio sense, A is risky and B is safe in that A adds and B subtracts risk. This is a central and critically important concept. *Although A and B are equally risky on a stand-alone basis, they have completely opposite risk impacts on a portfolio.*

The portfolio definition of a stock's risk is related to the timing of the variability of the stock's return rather than to the magnitude of the variation. It has to do with the way the new stock's return changes when the portfolio's return changes. Or, if the portfolio is constituted like the market as we've assumed, it has to do with the way the stock's return changes with the return on the market.

However, the degree to which a stock's return moves with the market is what we've called market risk. Hence, we can say that *a stock's risk in a portfolio sense is its market risk.*

### Choosing Stocks to Diversify for Market Risk

How do we diversify to reduce market risk in a portfolio? Figure 9.7 might imply that it's easy: Just add stocks like B until the movement of the portfolio is virtually dampened out. Unfortunately, stocks like B that move countercyclically with the market are few and far between.

Stocks with **equal stand-alone risk** can have **opposite risk impacts on a portfolio** because of the timing of the variations in their returns.

The classic example of such a stock involves shares in a gold mine. When returns on most stocks are down, people flee from paper investments and put money in tangible assets, notably gold. That drives the price of gold up. A higher price for gold means a gold mine becomes more profitable, which elevates the return on its stock. Hence, when the return on most stocks is down, the return on gold mine stocks tends to be up. The reverse happens when stock returns are generally high.

Although people do diversify with gold mine stocks to stabilize portfolios, there aren't enough of them to do the job thoroughly. There simply aren't many stocks around that are negatively correlated with the market.

However, a great number of stocks are available whose returns behave in a manner somewhere between those of A and B in the diagram. In terms of the behavior of return, that kind of stock can be thought of as a combination of A and B. Such a stock is illustrated by line C in Figure 9.7. Stocks like C are said to be *not* perfectly positively correlated with the portfolio.

Adding some C to the portfolio will generally reduce its risk somewhat. If we think of C as a hybrid or cross between A and B, its addition is a way to get a little B into the portfolio indirectly. An intuitive way to put it is to say that C contains a little of the "personality" of B.

In summary, market risk generally can be reduced but not eliminated by diversifying with stocks like C that are not perfectly positively correlated with the portfolio.

Market risk in a portfolio can be reduced but not eliminated by diversifying with stocks that are **not perfectly positively correlated** with the portfolio.

### The Importance of Market Risk

Let's return to stocks A and B in Figure 9.7 for a moment. The illustration is constructed to point out two different concepts of risk. Considered individually, the stocks are equally risky, yet in a portfolio one is risky and the other is not. Which interpretation is appropriate and when?

The relative risk attributes of the two stocks are entirely changed if we assume investors focus on portfolios rather than on individual stocks. Modern portfolio theory is based on that assumption. *What matters is how stocks affect portfolios rather than how they behave when considered alone. And how they affect portfolios depends only on market risk.*

This is a fundamental result of portfolio theory. According to the theory, what matters in the investment world is market risk alone. *It is also a dangerous result.* Business-specific risk is truly diversified away only in the context of large portfolios. For the small investor with a limited portfolio, that effect simply doesn't occur. An individual business reversal can devastate an investment program if the stock represents a significant portion of a small portfolio. Hence, while the thinking behind portfolio theory may be appropriate for running a mutual fund, it should not be applied blindly to managing one's personal assets.

**Caution:** The concepts of risk associated with portfolio theory **may not be appropriate for individual** investors.

## MEASURING MARKET RISK—THE CONCEPT OF BETA

Because market risk is of such central importance to investing, it's appropriate to look for a way to measure it for individual stocks.

A statistic known as a stock's **beta** coefficient has been developed that is commonly considered to be the measure of a stock's market risk. Essentially, beta captures the variation in a stock's return which *accompanies* variation in the return on the market.

A stock's **beta** measures its **market risk**.

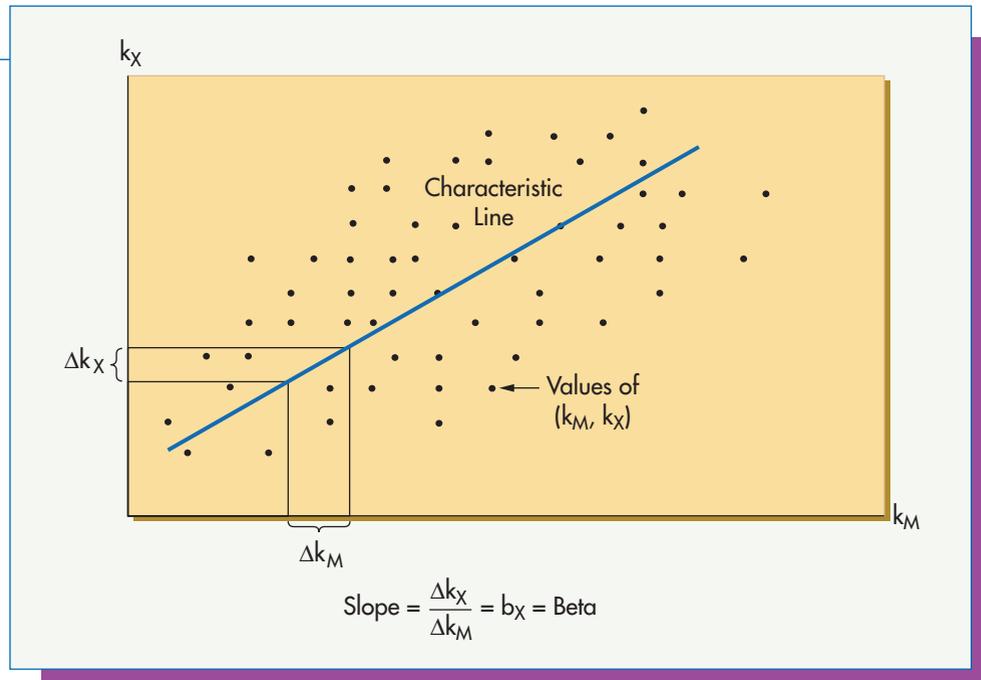
## Developing Beta

A stock's beta coefficient is developed by plotting the historical relationship between the return on the stock and the return on the market.<sup>2</sup> Figure 9.8 shows such a plot. Each point represents a past time period for which we plot the stock's return,  $k_X$ , on the vertical axis and the market's return,  $k_M$ , on the horizontal axis. Doing this for a number of past periods results in a "scatter diagram" of historical observations. A regression line fitted to these data points is known as the *characteristic line* for the stock.

**Figure 9.8**

### The Determination of Beta

A stock's **characteristic line** reflects the average relationship between its return and the market's. **Beta is the slope of the characteristic line.**



The characteristic line represents the average relationship between the stock's return and the market's return. Its slope is particularly rich in information. The slope tells us *on the average* how much of a change in  $k_X$  has come about with a given change in  $k_M$ . This is exactly what we're looking for in terms of measuring market risk. The slope is an indication of how much variation in the return on the stock goes along with variation in the return on the market.

To see this, notice that as we move along the characteristic line, a change in  $k_M$ ,  $\Delta k_M$ , comes with a change in  $k_X$ ,  $\Delta k_X$ . The relationship between these changes is reflected in the slope of the line.

$$(9.3) \quad \text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta k_X}{\Delta k_M} = b_X = \text{beta}$$

Market risk is defined as the degree to which the return on the stock moves with the return on the market. That idea is summarized perfectly by the slope of the characteristic line. The slope can therefore be *defined* as the measure of market risk for the stock. This measure is called the beta coefficient, or simply *beta*, for the stock.

<sup>2</sup> The return on the market is estimated by calculating the return on a market index such as the Standard & Poor's 500.



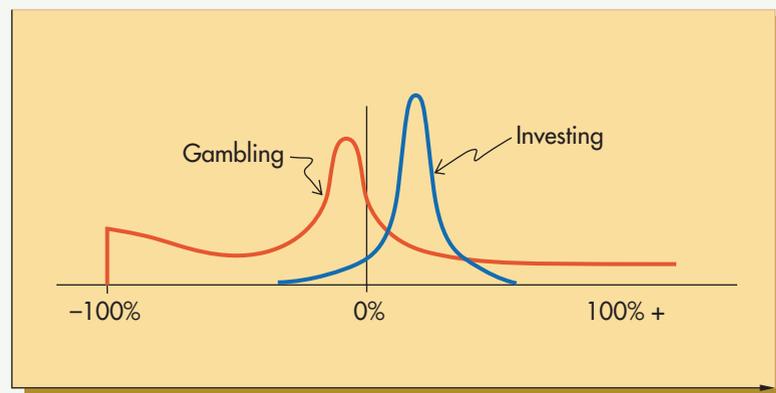
## PRACTICAL FINANCE

### Is It Investing or Gambling?

Investing is putting money at risk in the hope of earning more money—a return. But isn't that also a definition of gambling? Certainly it is, so what's the difference between investing and gambling, and why do we have such different moral and ethical attitudes about them?

Investing has economic value to the society that gambling doesn't. But, aside from that, from an individual's perspective it's fair to ask about the distinction between playing the stock market and taking a trip to Las Vegas.

Viewing both processes in terms of the probability distributions of their returns provides some insight. Investing tends to be characterized by probability distributions with positive expected values (means) and relatively small probabilities of very large gains or losses. Gambling on the other hand generally has a zero or negative expected value and offers a good chance of losing everything placed at risk. The attraction of gambling is that there's also a visible chance of winning many times the amount risked along with its entertainment value. Think of playing roulette in a Las Vegas casino. It's no secret that the odds are stacked slightly in favor of the house, and that many visitors leave town with empty pockets. But there are also a few well-publicized examples of people who hit the jackpot. Graphically, the distributions might look something like this.



This view leads to another logical question. Are there activities that people normally call investing that are more like gambling? The answer is a resounding yes. Buying the stock of a high-risk new venture might be an example. There are also some financial markets that are risky to the point of bordering on gambling (e.g., commodities and futures markets, which are beyond the scope of this book).

In fact, the whole idea of portfolio theory is to move the investor's exposure toward the investment profile we've just described and away from the gambling profile.

The important thing to take away from this discussion is that something isn't "investing" just because it happens through the financial industry. Brokers like to characterize all their offerings as investing because it has a nobler image. But, in fact, some financial "investments" are really more like gambles.

## Projecting Returns with Beta

Knowing a stock's beta enables us to estimate changes in its return given changes in the market's return.

### Example 9.2

Conroy Corp. has a beta of 1.8 and is currently earning its owners a return of 14%. The stock market in general is reacting negatively to a new crisis in the Middle East that threatens world oil supplies. Experts estimate that the return on an average stock will drop from 12% to 8% because of investor concerns over the economic impact of a potential oil shortage as well as the threat of war. Estimate the change in the return on Conroy shares and its new return.

**SOLUTION:** Beta represents the past average change in Conroy's return relative to changes in the market's return.

$$b_{\text{Conroy}} = \frac{\Delta k_{\text{Conroy}}}{\Delta k_{\text{M}}}$$

Substituting,

$$1.8 = \frac{\Delta k_{\text{Conroy}}}{4\%}$$

$$\Delta k_{\text{Conroy}} = 7.2\%$$

The new return can be estimated as

$$k_{\text{Conroy}} = 14\% - 7.2\% = 6.8\%$$

## Understanding Beta

It's important to understand that beta represents an average relationship based on past history. To appreciate this, consider the movement from one data point to the next in Figure 9.8.

The change between any two successive values of  $k_X$  represents movement caused by the combination of market risk forces and business-specific risk forces. In other words, such a change is part of the stock's total risk. By regressing  $k_X$  versus  $k_M$ , we're making the assumption that movement along the line representing an average relationship between the variables reflects only market-related changes. In this view, movement from one data point to the next has two components, movement to and from the line and movement along the line. Movement to and from the line represents business-specific risk, while movement along the line represents market risk.

Forecasting with beta, as in the last example, uses only the average relationship between the returns, which is assumed to be market related. It says nothing about business-specific risk factors.

### Example 9.3

Suppose Conroy Corp. in Example 9.2 is a defense contractor that makes sophisticated antimissile systems. Would the estimate of return done in that example be valid? What if Conroy were in the orange juice business?

**SOLUTION:** It's unlikely that the estimate would be much good if Conroy were a defense contractor. The threat of war could be expected to have a positive impact on the company because of its defense-related line of business. In other words, such a threat is likely to have a major business-specific risk impact on the firm's return that would act in a direction opposite the market-related decline.

If Conroy made orange juice, we wouldn't expect a business-specific risk change due to the Middle East crisis, so the market-related estimate would be more realistic.

Betas are developed from **historical data** and **may not be accurate** if a **fundamental change** in the business environment occurs.

### Beta over Time

Any firm's beta is derived from observation of the behavior of its return in the past relative to the return on the market. Use of the statistic implicitly assumes that the relationship between the two returns is going to remain constant over time. In other words, using beta assumes the stock's return will behave in the same way in the future that it did in the past relative to the market's return. This assumption is usually reasonable, but at times it may not be.

### Example 9.4

Let's consider the Conroy Corp. of the last two examples once more. Think of the early 1990s when the Cold War was ending and military budgets were being reduced dramatically. Would a projection using beta have been valid at that time?

**SOLUTION:** In this situation the value of Conroy's beta is uncertain. The data from which the firm's characteristic line was developed would have been from earlier periods during the Cold War when military spending and lucrative defense contracts were considered a way of life that was likely to continue forever. The early 1990s were characterized by a climate of reduced defense budgets which made high-technology defense production look a lot more risky. Therefore, the future beta is likely to have been different from the past value at that time.

Small investors should remember that **beta doesn't measure total risk**.

### Volatility

Beta measures volatility in relation to market changes. In other words, it tells us whether the stock's return moves around more or less than the return of an average stock.

A beta of 1.0 means the stock's return moves on average just as much as the market's return. Beta  $>$  1.0 implies the stock moves more than the market. Beta  $<$  1.0 means the stock tends to move with the market but less. Beta  $<$  0 (negative) means the stock tends to move against the market, that is, in the opposite direction. Such stocks are rare. Stock B of Figure 9.7 is a negative beta stock. Gold mines are the primary real-world example of such stocks.

The idea of beta immediately suggests an investment strategy. When the market is moving up, hold high-beta stocks because they move up more. When the market is moving down, switch to low-beta stocks because they move down less!



## REAL APPLICATIONS

### Just How Risky Is AT&T—Really? A Problem with Betas

Calculating beta is a pretty simple procedure. It's just a straightforward linear regression of a stock's return versus the market's. Unfortunately, in some cases several problems can make calculated betas unreliable. One of the biggest involves the evolution of the company whose risk is being assessed. If the firm has changed significantly during the period from which the historical return data comes, beta may be virtually meaningless. That's because the company as it stands today isn't the same business that generated the returns used in the regression analysis. AT&T provides an excellent example.

Before 1983, AT&T was “the” phone company in the United States. It supplied all long distance service and local service in most metropolitan areas, and operated Bell Laboratories, which handled communications technology and manufacturing. But AT&T was sued by the Justice Department for violation of antitrust laws that prohibit monopolies. As a result, the firm agreed to break into eight separate companies. Long distance service and Bell Labs continued to operate under the AT&T name, while local service was divided among seven regional firms collectively referred to as “Baby Bells.”

AT&T continued to provide long distance service and technology through the late 1980s and early 90s, but acquired NCR, a major computer manufacturer, in 1991. It operated these three businesses for five years until 1996, when it again split, this time along the lines of those businesses. The AT&T name stayed with long distance operations, while technology and computers were split off as Lucent Technologies and NCR, respectively.

In 2001, AT&T split into four pieces: AT&T Business, AT&T Wireless, AT&T Broadband, and AT&T Consumer. These represent several new lines AT&T developed after the 1996 split, including cable television, Internet service, cell phone service, and local phone service. The broadband unit was sold in 2002.

In 2005 AT&T was acquired by SBC, one of the baby bells spun off in 1983 (SBC owns BellSouth, the original baby bell). The combined company renamed itself AT&T Inc. in a move that seems to take the firm a step back toward its pre-1983 composition.

Making all this even more complicated is the fact that the nature of the telephone business was changing dramatically during much of this time. Before 1983 phone companies were regulated monopolies and cell phones didn't exist. But since the early eighties the business has been a competitive free-for-all, and wireless phones have permanently altered the way people communicate. These changes are significant because the risk characteristics of regulated and competitive industries are different, as are those of the fast-moving cellular phone business.

So how meaningful is AT&T's beta today? Probably not very meaningful, because the company hasn't been a consistently defined enterprise over any period from which data on returns can be collected.

**Sources:** Margaret Johnston, “Searching for Value, AT&T Splits Four Ways,” *Infoworld* (October 30, 2000): 10; “AT&T's Three-Way Split,” *The Economist* (September 23, 1995): 51; <http://www.sbc.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=21906> (4/17/2006)

### Beta for a Portfolio

Because beta measures market risk, the degree to which a stock moves with the market, it makes sense to think about market risk and beta for an entire portfolio. In fact, the concept is rather simple. Beta for a portfolio of stocks is just the weighted

average of the betas of the individual stocks where the weights are the dollar amounts invested in each stock.

For example, suppose a two-stock portfolio is made up like this.

Stock	Beta	Current Dollar Value	Portion of Value
A	.7	800	.8
B	1.1	<u>200</u>	<u>.2</u>
		1,000	1.0

Then the portfolio's beta, written  $b_P$ , is calculated as follows.

$$b_P = .8b_A + .2b_B = .8(.7) + .2(1.1) = .78$$

### A Note on Decimal Accuracy

Notice that the portfolio beta we just calculated is expressed to two decimal places. You'll sometimes see betas calculated to three decimal places. However, if you think about the nature of beta and the way it's derived for individual stocks, it's apparent that such accuracy is meaningless. Rounding off to one decimal place is generally sufficient.

## USING BETA—THE CAPITAL ASSET PRICING MODEL (CAPM)

The CAPM attempts to explain **stock prices** by explaining how investors' **required returns** are determined.

The things we've been discussing in this chapter are inputs to a sophisticated mathematical model of the financial world called the **capital asset pricing model**, abbreviated as **CAPM**. The terminology can be a little confusing. A "capital asset" is a share of stock, and "pricing model" implies an attempt to explain how stock prices are set in the market.

The CAPM has been around for some time. It was developed during the 1950s and 1960s by economists Harry Markowitz and William F. Sharpe, who shared the 1990 Nobel Prize in economics for their work.

### The CAPM's Approach

The model's approach to determining how prices are set is to explain how the required rate of return on a stock comes about. Recall that the required rate of return is the return that just holds investors in the stock. It's the amount an individual has to expect to get in order to be willing to put his or her money in a particular issue. It's related to the riskiness of the issue as perceived by the investor. (Review page 372 if necessary.) People won't invest unless the expected return is at least equal to their required return.

### Price Depends on Return

In general, once a required rate of return is specified, price follows. For example, consider equation 9.2, our definition of the return on a stock investment (page 372). If we solve that equation for the current price,  $P_0$ , we get

$$P_0 = \frac{D_1 + P_1}{(1 + k)}$$

where we can think of  $k$  as the required rate of return.

If we make assumptions about the future price and dividend,  $P_1$  and  $D_1$ , the current price of the stock,  $P_0$ , depends on knowing  $k$ .

Another approach involves the Gordon model, equation 8.10 from Chapter 8, on stock valuation. We'll repeat that expression here for convenience, considering  $k$  a required rate of return.

$$(8.10) \quad P_0 = \frac{D_0 (1 + g)}{k - g}$$

Notice that if the last dividend,  $D_0$ , is known and an assumption is made about the growth rate,  $g$ , the current price again depends on knowing  $k$ . We'll use this relationship in some problems shortly.

All this says that if we understand how required returns are set, we'll understand a great deal about how prices are established.

### Rates of Return, the Risk-Free Rate, and Risk Premiums

At this time, we have to make a few points about rates of return in general. First, interest is the rate of return on debt and is conceptually identical to the rate of return on an equity investment. Therefore, we can mix the two ideas as we like. Specifically, we can have both interest rates and rates of return on stock investments within the same equation.

Next we need to recall the concept of a risk-free rate of return from Chapter 5. (Review page 203 if necessary.) A risk-free investment is one in which there is no possibility of receiving less than the expected return. Federally insured bank accounts are essentially risk free, as are investments in short-term treasury debt. The current rate of interest paid on three-month treasury bills is generally taken to be the prevailing risk-free rate, written as  $k_{RF}$ .

The rate of return on any other investment involves some allowance for bearing risk added to the risk-free rate. The allowance is known as the *risk premium* for the investment. If we call some investment  $Y$ , we can write the return on  $Y$  as

$$k_Y = k_{RF} + k_{RPY}$$

where  $k_{RPY}$  is the risk premium on investment  $Y$ . Solving for the risk premium, we have

$$k_{RPY} = k_Y - k_{RF}$$

That is,  $Y$ 's risk premium is the difference between the return on  $Y$  and the risk-free rate. Hold onto that idea for a moment along with the idea that the required rate of return on an investment in a stock is the risk-free rate plus some *premium* for bearing the risk associated with that stock.

The mystery is to try to explain just what that risk premium depends on. This is what the capital asset pricing model purports to do.

### Putting the Pieces Together

Each of the concepts we've talked about so far, including return as a random variable, risk defined as variance, risk aversion, all the portfolio ideas, and beta, is a necessary assumption undergirding the CAPM.

All of these ideas can be stated in mathematical terms. When they are, some advanced math can be used to derive a single, simple equation that defines the required return on a stock in terms of its risk. That equation, called the **security market line, SML**, is the heart of the CAPM.

The beauty of the model and probably the reason for its wide acceptance is the simplicity of this result.

The **CAPM** purports to explain how the **risk premiums** in required rates of return are formed.

## The Security Market Line (SML)

The security market line proposes that required rates of return are determined by the following equation.

$$(9.4) \quad k_X = k_{RF} + \underbrace{(k_M - k_{RF})}_{\text{Market Risk Premium}} b_X$$

Stock X's Risk Premium

The **SML** is the heart of the **CAPM**.

where:

- $k_X$  is the required return on stock X
- $k_{RF}$  is the risk-free rate
- $k_M$  is the return on the market
- $b_X$  is stock X's beta coefficient

First notice that the right side of the equation is in two parts: the risk-free rate and a risk premium for stock X. This is consistent with the ideas we expressed earlier about rates of return in general.

Next we'll consider the risk premium in detail. It's made up of two parts, the expression in parentheses and beta. Beta, of course, is our measure of market risk for stock X. The expression in parentheses is the difference between the return on the market and the risk-free rate.

### The Market Risk Premium

In the section before last we said that the difference between the return on an investment and the risk-free rate is the risk premium for that investment. Therefore, the term in parentheses in equation 9.4 is the risk premium for an investment in the market as a whole. That can be interpreted as an investment in an "average" stock or in a portfolio constituted to mirror the market.

The **market risk premium** reflects the average tolerance for risk of all investors at a point in time. In other words, it's indicative of the degree of *risk aversion* felt by the investing community.

### The Risk Premium for Stock X

The risk premium for stock X is just the market, or "average," risk premium multiplied by stock X's own beta, the measure of its market risk.

What the SML is saying is simple and yet profound. It alleges that a stock's risk premium is determined only by the market risk premium factored by the stock's beta.

Notice that the only thing in the equation that relates specifically to company X is  $b_X$ , the measure of X's *market risk*! So if management wants to influence stock price, an important way to try to do so is by changing the volatility of the firm's return and thereby its beta.

The important implication of the SML is that *only market risk counts*. Business-specific risk doesn't enter the equation; market risk does through beta. Put another way, investors are rewarded with extra return only for bearing market risk, not for bearing business-specific risk. This makes sense because we've assumed that business-specific risk is diversified away for portfolio investors.

The SML holds for the stock of any company. That's why we've used the generic "X" to represent the company's name. The model says that any firm's required rate of

The **market risk premium**,  $(k_M - k_{RF})$ , is a reflection of the investment community's level of **risk aversion**.

The **CAPM** asserts that the only **company-specific** thing affecting required return is **market risk**.

return, as generally perceived by most investors, can be found by just putting that company’s beta into equation 9.4.

### The SML as a Portrayal of the Securities Market

The SML can be thought of as representing the entire securities market, most notably the stock market. To show this we’ll plot the line in *risk return space*. That simply means the graph will have return on the vertical axis and risk along the horizontal axis. The variable representing risk will be beta. The SML is portrayed graphically in Figure 9.9, where it’s seen as a straight line.

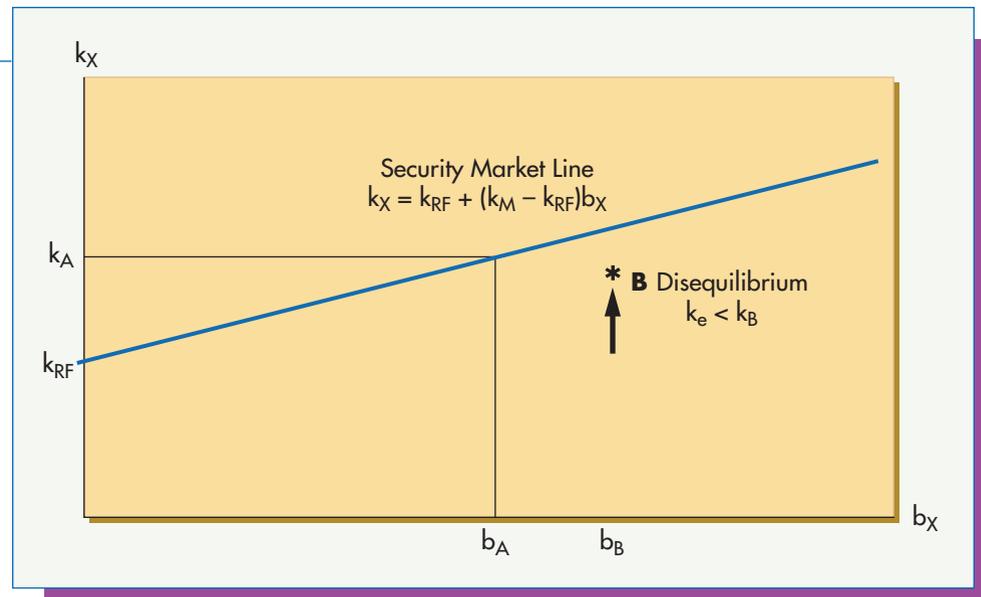
Recall the standard formulation for plotting a straight line from algebra.

$$(9.5) \quad y = mx + b$$

Here  $y$  is traditionally the vertical axis variable and  $x$  is the horizontal axis variable. When the equation of a straight line is in this form,  $m$  is the slope of the line and  $b$  is its  $y$ -intercept.

Figure 9.9

The Security Market Line



In our graph of the SML, the variable on the vertical axis is  $k_X$  and the variable on the horizontal axis is  $b_X$ . We can write equation 9.4 in the same form as equation 9.5 and compare the two.

$$k_X = \underbrace{(k_M + k_{RF})}_{m} \underbrace{b_X}_x + \underbrace{k_{RF}}_b$$

$$y = mx + b$$

The slope of the SML plotted in risk-return space reflects the general level of risk aversion.

(Don’t confuse the X’s in the two equations. In the first, X represents the generic name of any company. In the second, x just refers to the variable on the horizontal axis which is  $b_X$  in the first equation.)

The comparison shows that the slope of the SML is the market risk premium  $(k_M - k_{RF})$ . Thus, the slope of the SML is a reflection of the risk tolerance or level

of risk aversion felt by investors in general. If investors become more risk averse, the spread between  $k_M$  and  $k_{RF}$  will increase because people will demand a larger premium for bearing any level of risk. When that happens, the SML will get steeper. Conversely, if people become less concerned about risk, the market risk premium will shrink and the SML will become flatter.

It's important to understand that attitudes about risk do change over time, and that the changes are indeed reflected in real differences between  $k_M$  and  $k_{RF}$ .

Next consider the intercept of the SML with the vertical axis. This is the y-intercept in the traditional equation. The value of  $k_X$  at the intercept point is clearly  $k_{RF}$ . This makes sense because risk, represented by beta, is zero at the left side of the graph. The intercept point is simply saying that an investor always has the option of putting his or her money into government securities earning  $k_{RF}$  with no risk.

The SML portrays the market in terms of risk and return in that any stock can be thought of as occupying a point along the line determined by its level of risk. For instance, stock A is shown on the diagram. If we enter the graph at A's beta,  $b_A$ , we can find A's required return by moving up to the line and then over to the vertical axis at  $k_A$ .

The **vertical intercept** of the SML represents investment in short-term government securities.

### The SML as a Line of Market Equilibrium

A system is said to be in *equilibrium* if it tends to remain in a constant state over time. The equilibrium condition is said to be *stable* if when the system is displaced, forces are created that tend to push it back into the equilibrium position.

The SML represents an equilibrium situation if for every stock along the line, the expected rate of return is equal to the required rate of return. In that case, investors holding stocks are happy because their expected and required rates of return are at least equal. There is no excess of either buyers or sellers, and in theory the market remains where it is.

Now suppose conditions change in such a way that the expected return on some stock becomes less than its required return. This situation is represented by point B in the diagram where the expected return, shown as  $k_e$ , is less than the required return for stock B, which is on the SML above  $b_B$ .

In this case, people who own the stock will be inclined to sell because the anticipated return no longer meets their needs. That is, it is below their required return, which is on the SML. However, potential buyers will not be interested in purchasing the stock because the expected return is also lower than their required returns. In other words, we have would-be sellers but no interested buyers. When that happens in the market for anything, there's only one solution if trading is to take place—sellers must lower their asking prices. In other words, the market price falls.

Now examine equation 9.2 once again which we'll repeat here for convenience.

$$(9.2) \quad k = \frac{D_1 + (P_1 - P_0)}{P_0}$$

Notice that the current market price is represented as  $P_0$ . If  $P_0$  falls while  $D_1$  and  $P_1$  remain unchanged, the value of  $k$  on the left side of the equation *increases*. That means the expected return becomes higher as new investors have to spend less for the same future cash flows.

In Figure 9.9, this means market forces drive the expected return back up toward the equilibrium line of the SML. Hence, the stock market equilibrium is stable, because when some external occurrence displaces a return away from the equilibrium line, forces are created to push it back.

The SML represents a condition of **stable equilibrium**.

In reality the market is never quietly in equilibrium, because things are always happening that move stock prices and returns around. The important point of the theory is that market forces are constantly being created that tend to push things back *toward* an equilibrium position with respect to risk and return.

### Valuation Using Risk-Return Concepts

We can use the ideas of the capital asset pricing model in another approach to stock valuation. The method assumes that the marginal investor buys and sells the stock at the return determined by the SML, and that those sales determine market price.

Given that assumption, we can calculate the price in two steps. First we use the SML to calculate a required rate of return. Then we use that return in the Gordon model to arrive at a price.

The SML and the Gordon model provide a two-step approach to valuation.

### Example 9.5

The Kelvin Company paid an annual dividend of \$1.50 recently, and is expected to grow at 7% into the indefinite future. Short-term treasury bills are currently yielding 6%, and an average stock yields its owner 10%. Kelvin stock is relatively volatile. Its return tends to move in response to political and economic changes about twice as much as does the return on the average stock. What should Kelvin sell for today?

**SOLUTION:** First write the SML for Kelvin from equation 9.4.

$$k_{\text{Kelvin}} = k_{\text{RF}} + (k_{\text{M}} - k_{\text{RF}})b_{\text{Kelvin}}$$

Next notice that the inputs to the SML have been specified in the problem description without being named. The return on short-term treasury bills reflects the current risk-free rate,  $k_{\text{RF}}$ , and the return on the “average stock” is equivalent to the return on the market,  $k_{\text{M}}$ . Finally, recognize that we’ve been given beta in rather cryptic terms. Political and economic changes are things that tend to affect all stocks and the response to them relates to market risk. Therefore, saying Kelvin’s return responds twice as much as the average to those things implies that Kelvin’s beta is 2.0.

Substituting for Kelvin’s required return we have

$$k_{\text{Kelvin}} = 6 + (10 - 6)2.0 = 14\%$$

Next write the Gordon model and substitute using  $k_{\text{Kelvin}}$  for  $k$  in the denominator.

$$\begin{aligned} P_0 &= \frac{D_0(1+g)}{k-g} \\ &= \frac{\$1.50(1.07)}{.14 - .07} \\ &= \$22.93 \end{aligned}$$

### The Impact of Management Decisions on Stock Prices

The fact that management decisions can affect both beta and likely future growth rates makes the SML approach to valuation relevant for policy decisions.

## Example 9.6

The Kelvin Company described in the last example has an exciting new opportunity. The firm has identified a new field into which it can expand using technology it already possesses. The venture promises to increase the firm's growth rate to 9% from the current 7%. However, the project is new and unproven, so there's a chance it will fail and cause a considerable loss. As a result, there's some concern that the stock market won't react favorably to the additional risk. Management estimates that undertaking the venture will raise the firm's beta to 2.3 from its current level of 2.0. Should Kelvin undertake the new project?

**SOLUTION:** A strategic decision such as this should be based on the primary objective of the firm's management, maximizing shareholder wealth. That's equivalent to maximizing the price of the company's stock.

An increased growth rate will have a positive effect on stock price. Convince yourself of this by examining how the growth rate,  $g$ , influences the value of  $P_0$  in the Gordon model in the last example. A bigger  $g$  makes the numerator larger and the denominator smaller, both of which contribute to an increase in  $P_0$ . (Remember that  $g$  must remain less than  $k$ .)

On the other hand, examining the SML of equation 9.4, we see that a larger beta results in a larger risk premium and therefore a larger required rate of return. That in turn goes into the denominator of the Gordon model as  $k$ , and a larger  $k$  in the Gordon denominator results in a smaller price.

Hence, taking on the new project involves two things that tend to move the stock's price in opposite directions. Faster growth will increase stock price, while higher risk will decrease it. The question is which effect will dominate. We can find out by calculating an estimated price assuming the project is undertaken.

First recalculate the required rate of return.

$$k_{\text{Kelvin}} = 6 + (10 - 6)2.3 = 15.2\%$$

Then recalculate the price using the Gordon model with the new return and the new estimated growth rate.

$$P_0 = \frac{D_0(1 + g)}{k - g} = \frac{\$1.50(1.09)}{.152 - .09} = \$26.37$$

The resulting price of \$26.37 is higher than the \$22.93 price before the project, indicating that the positive effect of the increased growth rate outweighs the negative effect of increased risk. Therefore, the venture looks like a good idea.

*In actual practice it would be difficult to make accurate estimates of the effect of a project like this on a firm's growth rate and beta.* Such estimates would be subjective guesses at best. The impact on beta would be particularly vague. Nevertheless an exercise like this would give management a valuable insight into the potential effects of their actions on stock price.

from the **CFO**

## Adjustments to Changing Market Conditions

As the securities market changes over time, the equilibrium of the SML accommodates to the altered conditions by shifting its position. We'll consider two such movements.

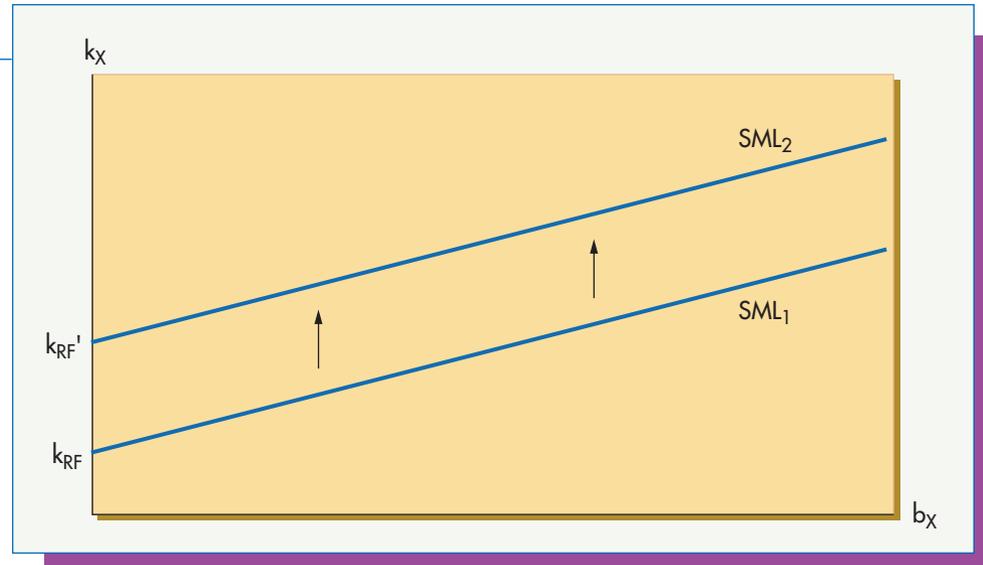
The SML shifts **parallel** to itself in response to changes in the **risk-free rate**.

### The Response to a Change in the Risk-Free Rate

When the risk-free rate changes, all other things held equal, the SML simply shifts up or down parallel to itself. The new equilibrium position is determined by the new rate at the vertical axis intercept. The idea is illustrated in Figure 9.10 for an increase in the risk-free rate from  $k_{RF}$  to  $k_{RF}'$ .

**Figure 9.10**

**A Shift in the Security Market Line to Accommodate an Increase in the Risk-Free Rate**



The shift illustrated in Figure 9.10 contains a subtlety. The parallel shift of the SML implies that its slope remains the same. Recall that the slope of the SML is the market risk premium ( $k_M - k_{RF}$ ), which reflects the general degree of investors' risk aversion.

If the slope of the SML doesn't change when  $k_{RF}$  changes,  $k_M$  must also increase or decrease by the amount of the change in  $k_{RF}$ . This makes sense because the market rate, like any other rate, consists of the risk-free rate plus a risk premium.

### The Response to a Change in Risk Aversion

A change in the general sensitivity of investors to risk will be reflected in a change in the market risk premium, represented as  $(k_M - k_{RF})$  and as the *slope* of the SML in the diagram. We'll assume that  $k_M$  changes with no accompanying change in  $k_{RF}$ .

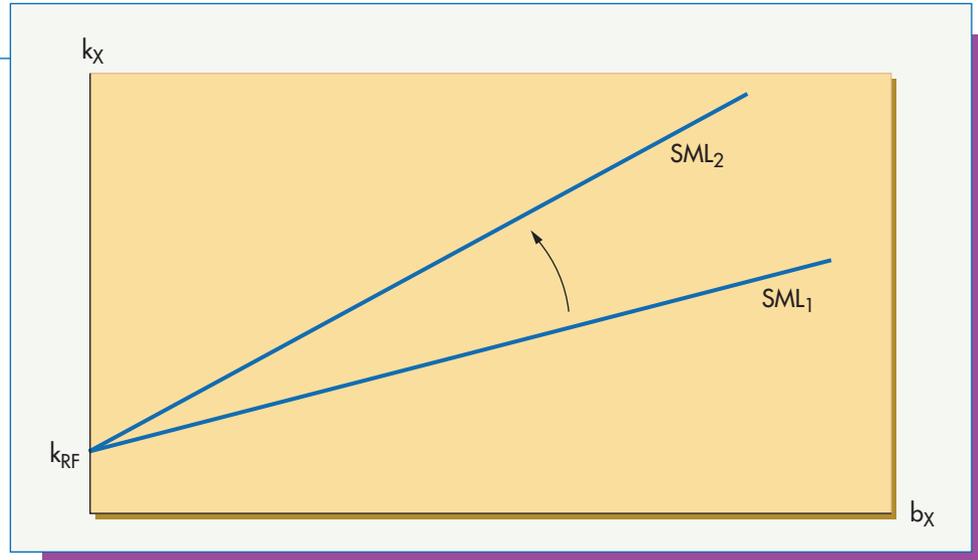
A change in slope alone is reflected by a rotation of the SML around the constant vertical intercept point at  $k_{RF}$ . The idea is illustrated in Figure 9.11.

In the illustration  $SML_1$  rotates to  $SML_2$  in response to an *increase* in risk aversion. In other words, the average investor demands a higher risk premium on any investment to compensate for his or her increased aversion to risk. The higher premium is reflected in a steeper slope for the resulting SML.

Changes in **attitudes toward risk** are reflected by **rotations of the SML** around its vertical intercept.

**Figure 9.11**

**A Rotation of the Security Market Line to Accommodate an Increase in Risk Aversion**

**Example 9.7**

The Sidel Company has a beta of 1.25. The risk-free rate is currently 6%, and the market is returning 10%. According to the SML, Sidel's required rate of return is

$$k_S = k_{RF} + (k_M - k_{RF})b_S = 6 + (10 - 6)1.25 = 11.0$$

- A Change in the Risk Free Rate:** Calculate Sidel's new required rate of return if the risk-free rate increases to 8% and investors' risk aversion remains unchanged.
- A Change in Risk Aversion:** Calculate the new required rate if the return on the market increases to 11% with the risk-free rate remaining at the original 6%.

**SOLUTION:**

- If the risk-free rate changes with no change in risk aversion, the market return has to change with it, so the difference between the two remains constant. Substituting into the SML, we have

$$k_S = k_{RF} + (k_M - k_{RF})b_S = 8 + (12 - 8)1.25 = 13.0\%$$

In this case, interest rates in general will rise by the increase in the risk-free rate.

- If the market return changes by itself, simply substitute the new value into the SML as follows.

$$k_S = k_{RF} + (k_M - k_{RF})b_S = 6 + (11 - 6)1.25 = 12.25\%$$

Here the increase in the market return reflects a higher risk premium, meaning people are more concerned about bearing risk. As a result, the rate on all risky investments will rise.

In both cases, the price of Sidel stock will fall.



## PRACTICAL FINANCE

### Beta in Practice

The concept of beta as a measurement of risk is probably the most widely used piece of stock market theory today. Investment advisory services publish betas for all heavily traded stocks, and people in the securities industry talk about beta all the time.

However, it's quite likely that many of the people who use the term aren't aware of exactly what it means. Beta measures risk, and risk means volatility of return, both up and down. Most people are aware of that much. But beta measures market-related volatility, not total volatility. That's what the average person forgets.

Beta means market risk only, and that's the relevant measure only if you're dealing with a large, well-diversified portfolio. If you're a moderate or small investor, beta tells only part of the story, and you can get hurt pretty badly by the part it doesn't tell.

## THE VALIDITY AND ACCEPTANCE OF THE CAPM AND ITS SML

The capital asset pricing model is like the other models we've discussed in that it is an abstraction of reality. It's a simplification of the complex securities world, designed to help in making predictions about what stock prices and returns will do. Such predictions can then be used to make various investment decisions.

The main reason for CAPM's popularity is probably its simplicity. The model's operative equation, the SML, is short and easy to understand. This is unusual among mathematical and statistical models, which are typically very difficult.

In addition, CAPM provides something that's very relevant in finance, a tangible statement of the relationship between risk and return. Everyone intuitively feels there's a relation between the two, and that higher risk goes along with higher return. But until CAPM came along, no one had a usable handle on the idea. In other words, there wasn't anything that said *this* much risk is appropriate for *that* much return, and therefore I'll invest, but otherwise I won't.

Unfortunately, because models that simplify the real world have to leave a lot out, they don't always work. CAPM is no exception to that general rule. Scholars are deeply divided on its validity and usefulness. Many question whether there is any real predictive value in the SML at all, while others feel the equation is sound but that people tend to apply it incorrectly. Staunch proponents maintain that the model is entirely valid and works under most conditions.

The most important attack on the CAPM has come from the work of two well-known scholars, Eugene Fama and Kenneth French. They found no historical relationship between the returns on stocks and their betas.<sup>3</sup> The CAPM, of course, assumes that a relationship does exist as expressed by the SML. If Fama and French are right, the CAPM isn't worth much. Other researchers, however, have challenged

The CAPM is **not universally accepted**, and a continuing debate exists as to its relevance and usefulness.

3. Eugene Fama and Kenneth French, "The Cross-Section of Expected Stock Returns," *Journal of Finance* 47, No. 2 (June 1992): 427–65.

their work on both empirical and theoretical grounds. A lively controversy continues in the scholarly literature that is as yet inconclusive.

It's unlikely that the leading scholars in this area will come to an agreement any time soon. CAPM and beta, the associated measure of risk, are part of the framework of theoretical finance and will probably remain so for the foreseeable future.

For our purposes, you should understand the ideas and assumptions leading up to the SML and appreciate what the equation is saying in terms of the relation between risk and return. We'll assume that it's a pretty good representation of reality most of the time.

It is important, however, to keep one important limitation in mind. The model's risk as measured by beta is market risk only, and not a stock's total risk. As we said earlier, that limits the concept substantially.

## QUESTIONS

1. What is the fundamental motivation behind portfolio theory? That is, what are people trying to achieve by investing in portfolios of stocks rather than in a few individual stocks or in debt? What observations prompted this view?
2. What is the general (in words) relationship between risk and return?
3. Define and discuss (words only, no equations) the concepts of expected return and required return.
4. Give a verbal definition of "risk" that's consistent with the way we use the word in everyday life. Discuss the weaknesses of that definition for financial theory.
5. Define risk aversion in words without reference to probability distributions. If people are risk averse, why are lotteries so popular? Why are trips to Las Vegas popular? (*Hint*: Think in terms of the size of the amount risked and entertainment value.)
6. The following definition applies to both investing and gambling: putting money at risk in the hope of earning more money. In spite of this similarity, society has very different moral views of the two activities.
  - a. Develop an argument reconciling the differences and similarities between the two concepts. That is, why do people generally feel good about investing and bad about gambling? (*Hint*: Think of where the money goes and what part of a person's income is used.)
  - b. Discuss the difference between investing and gambling by referring to the probability distributions shown on page 392. Identify the representations of a total loss, a big win, and likely outcomes.
7. Why does it make sense to think of the return on a stock investment as a random variable? Does it make sense to think of the return on a bond investment that way? How about an investment in a savings account?
8. In everyday language, "risk" means the probability of something bad happening. "Risk" in finance, however, is defined as the standard deviation of the probability distribution of returns.
  - a. Why do these definitions seem contradictory?
  - b. Reconcile the two ideas.

9. Analyze the shape of the probability distribution for a high-risk stock versus that of a low-risk stock. (*Hint: Think in terms of where the area under the curve lies.*)
10. Describe risk in finance as up-and-down movement of return. Does this idea make sense in terms of the variance definition?
11. Define and discuss the idea of separating risk into two parts. Describe each part carefully.
12. Describe the goal of a portfolio owner in terms of risk and return. How does he or she evaluate the risk characteristics of stocks being considered for addition to the portfolio?
13. Discuss lowering portfolio risk through diversification. Consider
  - a. Unsystematic (business-specific) risk.
  - b. Systematic (market) risk.
14. Describe the concept of beta. Include what it measures and how it's developed.
15. Describe the SML in words. What is it saying about how investors form required rates of return? Thoroughly evaluate the implications of the SML's message.
16. How does the SML determine the price of a security?
17. How is risk aversion reflected in the SML?
18. The CAPM purports to explain how management decisions about risk can influence the well-being of stockholders. Describe in words the mechanism through which this works.
19. Is the CAPM a true and accurate representation of the securities world?

### BUSINESS ANALYSIS

1. You've just begun work at the brokerage firm of Dewey, Cheatam, and Howe as a stock analyst. This morning you read an article in the paper that said a large-scale reduction in defense spending is imminent. Fred Fastbuck, a broker at the firm, has several clients who are elderly retirees. You recently learned that he's actively putting those clients into several defense industry stocks he describes as low risk. Fred has told you that he feels the stocks are low risk because they have betas of 1.0 or less. How would you advise Fred? Consider the real meaning of beta and its constancy over time.

### PROBLEMS

1. The Duncan Company's stock is currently selling for \$15. People generally expect its price to rise to \$18 by the end of next year. They also expect that it will pay a dividend of \$.50 per share during the year.
  - a. What is the expected return on an investment in Duncan's stock?
  - b. Recalculate the expected return if next year's price is forecast to be only \$17 and the dividend \$.25.
  - c. Calculate the actual return on Duncan if at the end of the year the price turns out to be \$13 and the dividend actually paid was just \$.10.

2. The Rapscallion Company's stock is selling for \$43.75. Dave Jones has done some research on the firm and its industry, and he thinks it will pay dividends of \$5 next year and \$7 the following year. After those two years Dave thinks its market price will peak at \$50. His strategy is to buy now, hold for the two years, and then sell at the peak price. If Dave is confident about his financial projections but requires a return of 25% before investing in stocks like Rapscallion, should he invest in this opportunity? (*Hint:* The return on a multiyear investment is the discount (interest) rate that makes the present value of the future cash flows equal to the price. See pages 271–272 at the beginning of Chapter 7.)
3. Wayne Merritt drives from Cleveland to Chicago frequently and has noticed that traffic and weather make a big difference in the time it takes to make the trip. As a result, he has a hard time planning activities around his arrival time. To better plan his business, Wayne wants to calculate his average driving time as well as a measure of how much an actual trip is likely to vary from that average. To do that, he clocked 10 trips with the following results:

Driving Time	Number of trips
6 hrs, 0 min	1
6 hrs, 15 min	1
6 hrs, 30 min	2
6 hrs, 45 min	3
7 hrs, 0 min	1
7 hrs, 30 min	1
9 hrs, 20 min	1

- a. Calculate the mean, standard deviation, and coefficient of variation of Wayne's driving time to Chicago.
- b. Calculate the average variation in driving time. Compare the standard and average variations. Is the difference significant? Which is more meaningful to Wayne?
4. Suppose dice had four sides instead of six, so rolling a single die would produce equally likely numbers from 1 to 4, and rolling two dice would produce numbers from 2 to 8.
  - a. Compute the probability distribution of outcomes from rolling two dice.
  - b. Calculate the mean, standard deviation, and coefficient of variation of the distribution.
5. Conestoga Ltd. has the following estimated probability distribution of returns.

Return	Probability
4%	.20
12	.50
14	.30

Calculate Conestoga's expected return, the variance and standard deviation of its expected return, and the return's coefficient of variation.

6. The probability distribution of the return on an investment in Omega Inc.'s common stock follows.

Return	Probability
5%	.05
8	.25
10	.40
12	.25
15	.05

Graph the probability distribution. Calculate the expected return, the standard deviation of the return, and the coefficient of variation. (Notice that to make the calculations manageable, we've made the unrealistic assumption that the probability distribution of returns is discrete.)

7. Calculate the expected return on an investment in Delta Inc.'s stock if the probability distribution of returns is as follows.

Return	Probability
-5%	.10
5	.25
10	.30
15	.25
25	.10

Plot the distribution on the axes with Omega Inc. in the previous problem. Looking at the graph, which company has the lower risk/variance? If offered the choice between making an investment in Delta and in Omega Inc., which would most investors choose? Why?

8. The Manning Company's stock is currently selling for \$23. It has the following prospects for next year.

Next Year's		
Stock Price	Dividend	Probability
\$25	\$1.00	.25
30	1.50	.50
35	2.00	.25

Calculate Manning's expected return for a one-year holding period.

9. Imagine making choices in the following situation to test your degree of risk aversion. Someone offers you the choice between the following game and a sure thing.

*The game:* A coin is tossed. If it turns up heads, you get a million dollars. If tails, you get nothing.

*The sure thing:* You're given \$500,000.

- What is the expected value of each option?
- Which option would you choose?

- c. Viewing the options as probability distributions, which has the larger variance? What is the variance of the sure thing? (No calculations.)
- d. Suppose the game is changed to offer a payoff of \$1.2 million for a head but still offers nothing for a tail. The sure thing remains \$500,000. What is the expected value of each option now? Which option would you choose now?
- e. Most people will have chosen the sure thing in part (d). Assuming you did too, how much would the game's payoff have to increase before you would choose it over the sure thing?
- f. Relate this exercise to Figure 9.6 on page 382.
10. A portfolio consists of the following four stocks.

<b>Stock</b>	<b>Current Market Value</b>	<b>Expected Return</b>
A	\$ 180,000	8%
B	145,000	10
C	452,000	12
D	223,000	5
	<b>\$1,000,000</b>	

What is the expected return of the portfolio?

11. Laurel Wilson has a portfolio of five stocks. The stocks' actual investment performance last year is given below along with an estimate of this year's performance.

<b>Stock</b>	<b>Last Year</b>		<b>This Year</b>	
	<b>Investment</b>	<b>Return</b>	<b>Investment</b>	<b>Return</b>
A	\$50,000	8.0%	\$55,000	8.5%
B	40,000	6.0	40,000	7.0
C	80,000	4.0	60,000	4.5
D	20,000	12.0	45,000	9.0
E	60,000	3.0	50,000	5.0

Compute the actual return on Laurel's overall portfolio last year and its expected return this year.

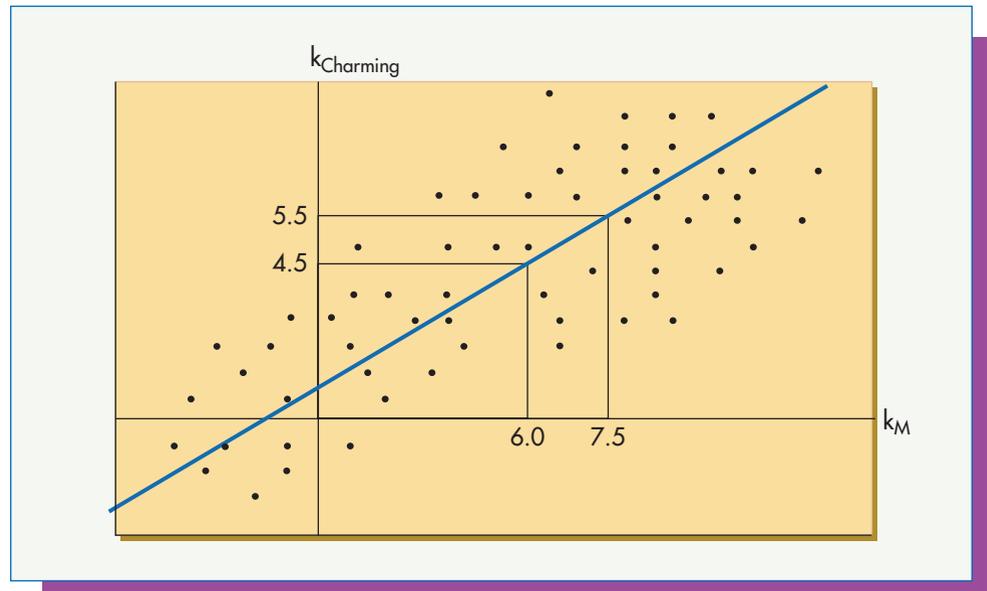
12. The stocks in the previous problem have the following betas.

<b>Stock</b>	<b>Beta</b>
A	1.1
B	0.6
C	1.0
D	1.6
E	0.8

Calculate Laurel's portfolio beta for last year and for this year. Assume that the changes in investment (value) come from changing stock prices rather than

buying and selling shares. What has happened to the riskiness of Laurel’s portfolio? Should she be concerned?

13. Charming Co. manufactures decorating products. Treasury bills currently yield 5.4% and the market is returning 8.1%.
- a. Calculate Charming Co.’s beta from its characteristic line as depicted below.



- b. What expected return would an average investor require to buy shares of Charming?
- c. Would the answer to part (b) be a “fair” return? Why?
14. A four-stock portfolio is made up as follows.

Stock	Current Value	Beta
A	\$4,500	.8
B	2,900	.6
C	6,800	1.3
D	1,200	1.8

Calculate the portfolio’s beta.

15. The return on Holland-Wilson Inc. (HWI) stock over the last three years is shown below along with the market’s return for the same period.

Year	HWI	Market
1	4.0%	3.0%
2	9.0	6.0
3	12.0	10.0

- Plot HWI's return against that of the market in each of the three years. Make three estimates of HWI's beta by drawing characteristic lines between pairs of data points (1 and 2; 1 and 3; 2 and 3). What does this range of betas imply about the stock's risk relative to an average stock?
16. You have recently purchased stock in Topical Inc. which has returned between 7% and 9% over the last three years. Your friend, Bob, has criticized your purchase and insists that you should have invested in Combs Inc., as he did, because it's been returning between 10% and 12% in the last three years. Bob knows nothing about financial theory. Topical's beta is 0.7 and Combs's is 1.2. Treasury bills are currently yielding the risk free rate of 4.2%, while the stock market is returning an average rate of 9.4%.
    - a. What return should you expect from Topical? What return should Bob expect from Combs?
    - b. Write a few words explaining to Bob why these expected returns aren't the whole story.
  17. Erin Behlen has a three stock portfolio and is interested in estimating its overall return next year. She has \$25,000 invested in Forms Corp., which has a beta of 1.3, \$75,000 in Crete Corp. with a beta of .8 and \$20,000 in Stalls Corp, which has a beta of 1.45. The stock market is currently returning 10.2% and Treasury securities are yielding the risk free rate of 4.6%. What return should Erin anticipate on her portfolio?
  18. The CFO of Ramekin Pottery Inc. is concerned about holding up the price of the company's stock. He's asked you to do an analysis starting with an estimate of the return investors are likely to require before they will invest in the firm. The overall stock market is currently returning 16%, 90-day treasury bills yield 6%, and the return on Ramekin's stock typically responds to changes in the political and economic environment only about 60% as vigorously as does that of the average stock.
    - a. Prepare an estimate of the firm's required return using the CAPM.
    - b. Is a higher or lower required return good for the company? Why?
    - c. Suppose the CFO asks you what management can do to improve the required return. How will you respond?
    - d. What will you tell him if he wants it done within the next three months?
  19. You are a junior treasury analyst at the Palantine Corporation. The treasurer believes the CAPM gives a good estimate of the company's return to equity investors at any time, and has asked you to prepare an estimate of that return using the SML. Treasury bills currently yield 6%, but may go up or down by 1%. The S&P 500 shows a return of 10% but may vary from that figure up to 12%. Palantine's beta is .8. Construct a table showing all possible values of  $k_{\text{Palantine}}$  for 1% increments of  $k_{\text{RF}}$  and  $k_{\text{M}}$  (nine entries). For this problem treat  $k_{\text{M}}$  and  $k_{\text{RF}}$  separately. That is, do not assume an increase in  $k_{\text{M}}$  when  $k_{\text{RF}}$  changes.
  20. The Framingham Company expects to grow at 4% indefinitely. Economists are currently asserting that investment opportunities in short-term government securities (Treasury bills) are readily available at a risk-free rate of 5%. The stock market is returning an average rate of 9%. Framingham's beta has recently been calculated at 1.4. The firm recently paid an annual dividend of \$ 1.68 per share. At what price should shares of Framingham stock be selling?

21. Whole Foods Inc. paid a quarterly dividend of \$0.47 recently. Treasury bills are yielding 4%, and the average stock is returning about 11%. Whole Foods is a stable company. The return on its stock responds to changes in the political and economic environment only about 70% as vigorously as that of the average stock. Analysts expect the firm to grow at an annual rate of 3.5% into the indefinite future. Calculate a reasonable price that investors should be willing to pay for Whole Foods stock.
22. Seattle Software Inc. recently paid an annual dividend of \$1.95 per share and is expected to grow at a 15% rate indefinitely. Short-term federal government securities are paying 4%, while an average stock is earning its owner 11%. Seattle is a very volatile stock, responding to the economic climate two and a half times as violently as an average stock. This is, however, typical of the software industry.
  - a. How much should a share of Seattle be worth?
  - b. Do you see any problems with this estimate? Change one assumption to something more reasonable and compare the results.
23. The Aldridge Co. is expected to grow at 6% into the indefinite future. Its latest annual dividend was \$2.50. Treasury bills currently earn 7% and the S&P 500 yields 11%.
  - a. What price should Aldridge shares command in the market if its beta is 1.3?
  - b. Evaluate the sensitivity of Aldridge's price to changes in expected growth and risk by recalculating the price while varying the growth rate between 5% and 7% (increments of 1%) and varying beta between 1.2 and 1.4 (increments of .1).
24. Bergman Corp. has experienced zero growth over the last seven years paying an annual dividend of \$2.00 per share. Investors generally expect this performance to continue. Bergman stock is currently selling for \$24.39. The risk-free rate is 3.0%, and Bergman's beta is 1.3.
  - a. Calculate the return investors require on Bergman's stock.
  - b. Calculate the market return.
  - c. Suppose you think Bergman is about to announce plans to grow at 3.0% into the foreseeable future. You also believe investors will accept that prediction and continue to require the same return on its stock. How much should you be willing to pay for a share of Bergman's stock?
25. Weisman Electronics just paid a \$1.00 dividend, the market yield is yielding 10%, the risk-free rate is 4%, and Weisman's beta is 1.5. How fast do investors expect the company to grow in the future if its stock is selling for \$27.25?
26. Weisman Electronics from the previous problem is considering acquiring an unrelated business. Management thinks the move could change the firm's stock price by moving its beta up or down and decreasing its growth rate. A consultant has estimated that Weisman's beta after the acquisition could be anywhere between 1.3 and 1.7 while the growth rate could remain at 4% or decline to as little as 3%. Calculate a range of intrinsic values for Weisman's stock based on best-and-worst case scenarios. (*Hint: Consider combinations of the highest and lowest beta and growth rate, but don't make four sets of calculations. Think through which way a change in each variable moves stock price and evaluate only two scenarios.*)
27. Broken Wing Airlines just paid a \$2 dividend and has a beta of 1.3 and a growth rate of 6% for the foreseeable future. The current return on the market is 10%, and Treasury bills earn 4%. If the rate on Treasury bills drops by 0.5% and the

- market risk premium  $[(k_M - k_{RF})]$  increases by 1.0%, what growth rate would keep Broken Wing's stock price constant?
28. Lipson Ltd. expects a constant growth rate of 5% in the future. Treasury bills yield 8% and the market is returning 13% on an average issue. Lipson's last annual dividend was \$1.35. The company's beta has historically been .9. The introduction of a new line of business would increase the expected growth rate to 7% while increasing its risk substantially. Management estimates the firm's beta would increase to 1.2 if the new line were undertaken. Should Lipson undertake the new line of business?
29. The Picante Corp.'s beta is .7. Treasury bills yield 5% and an average stock yields 10%.
- Write and sketch the SML and locate Picante on it. Calculate Picante's required rate of return and show it on the graph.
  - Assume the yield on treasury bills suddenly increases to 7% with no other changes in the financial environment. Write and sketch the new SML, calculate Picante's new required rate, and show it on the new line.
  - Now assume that besides the change in part (b), investors' risk aversion increases so that the market risk premium is 7%. Write and sketch the resulting SML, calculate Picante's required return, and show it on the last line.

### INTERNET PROBLEM

30. Learn a little about investing in general and mutual funds in particular from the website of Vanguard, one of the largest fund companies in the world. Go to <http://www.vanguard.com>. Click on personal investors and then click on the planning and education tab. Notice the six education options along the left side of the page. Click on each and write a short paragraph summarizing the information on each page. Answer the following questions as you summarize.

What's the difference between saving and investing?

What's the most important economic question to consider when investing?

How and when was the NYSE founded?

What does asset allocation mean?

What are the advantages of mutual funds?

What's the most common mistake fund investors make?

### COMPUTER PROBLEMS

31. Problem 23 in Chapter 8 concerned the Rollins Metal Company, which is engaged in long-term planning. The firm is trying to choose among several strategic options that imply different future growth rates and risk levels. Reread that problem on pages 366–367 now.

The CAPM gives some additional insight into the relation between risk and required return. We can now define risk as beta, and evaluate its effect on stock price by constructing a chart similar to the one called for in Problem 23 of Chapter 8, replacing  $k$  on the left side with beta ( $\beta$ ).

Rollins's beta calculated from historical data is .8. However, the risky strategies being considered could influence that figure significantly. Management feels beta

could rise to as much as 2.0 under certain strategic options. Treasury bills currently yield 3%, while the S&P index is showing a return of 8%. Recall that Rollins's last dividend was \$2.35.

a. Use the CAPMVAL program to construct the following chart.

**The Price of Rollins Stock as a Function of Growth Rate and Beta**

		Growth Rates (g)			
		6%	8%	10%	12%
Beta (b)	.8				
	1.2				
	1.6				
	2.0				

- b. The effect of beta on required return and price is influenced by the general level of risk aversion, which in the CAPM is represented by  $(k_M - k_{RF})$ , which is also the market risk premium and the slope of the SML. In part (a) of this problem the market risk premium is  $(8\% - 3\%) = 5\%$ . Economists, however, predict a recession that could sharply increase risk aversion. Reconstruct the chart above assuming the market risk premium increases to 7% ( $k_M$  rises to 10% with no change in  $k_{RF}$ ).
- c. Do your charts give any new insights into the risk-return-growth relationship? (i.e., how does the reward for bearing more risk in terms of stock price change in recessionary times?) Write the implied required return on your charts next to the values of beta. Then compare the charts with the one from Problem 23 of Chapter 8.
- d. Does the inclusion of beta and the CAPM really make management's planning job any less intuitive? In other words, is it any easier to associate a strategy's risk level with a beta than directly with a required return?

**DEVELOPING SOFTWARE**

32. Write a spreadsheet program to calculate the expected return and beta for a portfolio of 10 stocks given the expected returns and betas of the stocks in the portfolio and their dollar values.

The calculation involves taking a weighted average of the individual stocks' expected returns and betas where the weights are based on the dollar values invested in each stock.

Set up your spreadsheet like this:

Stock	Value	Weight	Beta	Factor	$k_e$	Factor
1. ABC	\$ 5,530	.0645	.93	.0600	8.0%	.5160
2. EFG	2,745	.0320	1.25	.0400	12.2%	.3904
⋮	⋮	⋮	⋮	⋮	⋮	⋮
10. XYZ	9,046	.1055	1.12	.1182	11.5%	1.2133
	<u>\$85,715</u>	<u>1.0000</u>		<u>XXX</u>		<u>XXX</u>

Sum columns for: Portfolio beta      ←

Portfolio  $k_e$                       ←

The computational procedure is as follows.

1. Input the names of the stocks, their dollar values, their betas, and their  $k_e$ 's.
2. Sum the value column.
3. Calculate the weight column by dividing each row's value cell by the cell carrying the sum of the values.
4. Calculate the beta and  $k_e$  factors by multiplying the individual beta and  $k_e$  cells by the cells in the weight column on the same row.
5. Sum the two factor columns for the results indicated.

Is your program general in that it will handle a portfolio of up to 10 stocks, or will it only work for exactly 10? If it is general, what do you have to be careful about with respect to inputs?

**Extra:** Assume you have \$1 million to invest in stocks. Look up several stocks' betas in Value Line and estimate  $k_e$  for each. Look up the current price of each stock in *The Wall Street Journal*, and form a hypothetical portfolio by allocating your money among the stocks. Find your portfolio's expected return and beta using your program.

## THOMSON ONE Business School Edition

Go to the text Web site at <http://lasher.swlearning.com>, select your book and click on the Thomson ONE button. Enter Thomson ONE—Business School Edition by using the username and password you created when you registered the serial number on your access card. Select a problem for this chapter, and you'll see an expanded version that includes instructions on how to navigate within the Thomson ONE system, as well as some additional explanation of the presentation format.

33. In this exercise we'll explore beta, portfolio theory's measure of risk, and its theoretical impact on stock prices.

Enter Thomson ONE for each of the five companies we've been working with, Sherwin Williams (SHW), General Motors (GM), Harley-Davidson (HOG), Starbucks (SBUX), and Microsoft (MSFT). Find and record the company's beta. Also look up and record the betas of General Mills (GIS), a large food processing company with a low beta, and Yahoo (YHOO), a provider of internet services with a high beta.

### Computations with Beta

Evaluate the impact of different betas by calculating the required return on each company using the SML (equation 9.4 on page 398). Assume  $k_M$  is 12% and  $k_{RF}$  is 5%. How large is the variation between the smallest and largest required return?

Now make a hypothetical price calculation using the Gordon model (see page 401) and the returns you've just calculated. In each case assume the last dividend paid was \$1, and the expected growth rate is 4%. You should see that the price difference generated by real betas under the assumption that dividends and growth rates are equal is very large.

But these things generally are not equal. Companies that issue high-risk stocks are often expected to grow rapidly and pay small or no dividends. Using your Gordon Model results, find the growth rate assumption about the highest beta stock that will equate its price with that of the lowest beta stock. (*Write the Gordon Model still assuming a \$1 dividend, substitute the high beta return for  $k$ , and set the resulting expression equal to the low beta price. Then solve for  $g$ .*)

What growth rate assumption would result in the same price for the highest beta stock if it paid a dividend of \$.50 instead of \$1?

### Beta as Volatility Relative to the Market

Beta is not a precise measure of risk. Indeed, some authorities don't feel it has much validity at all. Recall that beta measures only market risk, which is the degree to which a stock's return moves with the market's. The market is generally represented by the S&P 500 index, which is based on the average price of 500 selected stocks. In the following exercise we'll use a graphic representation of price performance as an approximation of return to help you develop your own sense of the beta technique.

Enter Thomson ONE and examine the three-year stock price history compared with the S&P 500 graph for each company.

Notice the degree to which each stock has historically moved with the market. Do this by looking for periods in which the market represented by the red S&P 500 line is trending up or down. Then observe whether the stock is trending in the same direction. Is the stock's movement more or less vigorous in the same direction as the market's? (This is usually easiest to see with high beta stocks.) Work your way down the list of stocks as betas decrease. Are there periods when certain stocks don't seem to move with the market or move against it? Are these periods frequent or unusual? You may want to experiment with five- and ten-year graphs.

From your observations, does beta seem to predict movement relative to the market's? Is that a worthwhile measure of risk if we don't know where the market is going from one week to the next? Why or why not? After these observations, do you feel like an investor really appreciates a stock's risk if she knows its beta? In what context is beta most meaningful?