CHAPTER 18

Return, Risk, and the Security Market Line

An important insight of modern financial theory is that some investment risks yield an expected reward, while other risks do not. Essentially, risks that can be eliminated by diversification do not yield an expected reward, and risks that cannot be eliminated by diversification do yield an expected reward. Thus, financial markets are somewhat fussy regarding what risks are rewarded and what risks are not.

Chapter 1 presented some important lessons from capital market history. The most noteworthy, perhaps, is that there is a reward, on average, for bearing risk. We called this reward a *risk premium*. The second lesson is that this risk premium is positively correlated with an investment's risk.

In this chapter, we return to an examination of the reward for bearing risk. Specifically, we have two tasks to accomplish. First, we have to define risk more precisely and then discuss how to measure it. Once we have a better understanding of just what we mean by "risk," we will go on to quantify the relation between risk and return in financial markets.

When we examine the risks associated with individual assets, we find there are two types of risk: systematic and unsystematic. This distinction is crucial because, as we will see, systematic risk affects almost all assets in the economy, at least to some degree, whereas unsystematic risk affects at most only a small number of assets. This observation allows us to say a great deal about the risks and returns on individual assets. In particular, it is the basis for a famous relationship between risk and return called the *security market line,* or SML. To develop the SML, we introduce the equally famous beta coefficient, one of the centerpieces of modern finance. Beta and the SML are key concepts because they supply us with at least part of the answer to the question of how to go about determining the expected return on a risky investment.

18.1 Announcements, Surprises, and Expected Returns

In our previous chapter, we discussed how to construct portfolios and evaluate their returns. We now begin to describe more carefully the risks and returns associated with individual securities. Thus far, we have measured volatility by looking at the difference between the actual return on an asset or portfolio, R, and the expected return, $E(R)$. We now look at why those deviations exist.

Expected and Unexpected Returns

To begin, consider the return on the stock of a hypothetical company called Flyers. What will determine this stock's return in, say, the coming year?

The return on any stock traded in a financial market is composed of two parts. First, the normal, or expected, return from the stock is the part of the return that investors predict or expect. This return depends on the information investors have about the stock, and it is based on the market's understanding today of the important factors that will influence the stock in the coming year.

The second part of the return on the stock is the uncertain, or risky, part. This is the portion that comes from unexpected information revealed during the year. A list of all possible sources of such information would be endless, but here are a few basic examples:

News about Flyers' product research.

Government figures released on gross domestic product.

The results from the latest arms control talks.

The news that Flyers' sales figures are higher than expected.

A sudden, unexpected drop in interest rates.

Based on this discussion, one way to express the return on Flyers stock in the coming year would be

$$\text{Total return} - \text{Expected return} = \text{Unexpected return} \qquad [18.1]$$

$$\text{or} \qquad R - E(R) = U$$

where R stands for the actual total return in the year, $E(R)$ stands for the expected part of the return, and U stands for the unexpected part of the return. What this says is that the actual return, R, differs from the expected return, $E(R)$, because of surprises that occur during the year. In any given year, the unexpected return will be positive or negative, but, through time, the average value of U will be zero. This simply means that, on average, the actual return equals the expected return.

Announcements and News

We need to be careful when we talk about the effect of news items on stock returns. For example, suppose Flyers' business is such that the company prospers when gross domestic product (GDP) grows at a relatively high rate and suffers when GDP is relatively stagnant. In this case, in deciding what return to expect this year from owning stock in Flyers, investors either implicitly or explicitly must think about what GDP is likely to be for the coming year.

When the government actually announces GDP figures for the year, what will happen to the value of Flyers stock? Obviously, the answer depends on what figure is released. More to the point, however, the impact depends on how much of that figure actually represents new information

At the beginning of the year, market participants will have some idea or forecast of what the yearly GDP figure will be. To the extent that shareholders have predicted GDP, that prediction will already be factored into the expected part of the return on the stock, $E(R)$. On the other hand, if the announced GDP is a surprise, then the effect will be part of U, the unanticipated portion of the return.

As an example, suppose shareholders in the market had forecast that the GDP increase this year would be .5 percent. If the actual announcement this year is exactly .5 percent, the same as the forecast, then the shareholders don't really learn anything, and the announcement isn't news. There will be no impact on the stock price as a result. This is like receiving redundant confirmation about something that you suspected all along; it reveals nothing new.

To give a more concrete example, on June 24, 1996, Nabisco announced it was taking a massive $300 million charge against earnings for the second quarter in a sweeping restructuring plan. The company also announced plans to cut its workforce sharply by 7.8 percent, eliminate some package sizes and small brands, and relocate some of its operations. This all seems like bad news, but the stock price didn't even budge. Why? Because it was already fully expected that Nabisco would take such actions and the stock price already reflected the bad news.

A common way of saying that an announcement isn't news is to say that the market has already discounted the announcement. The use of the word "*discount*" here is different from the use of the term in computing present values, but the spirit is the same. When we discount a dollar to be received in the future, we say it is worth less to us today because of the time value of money. When an announcement or a news item is discounted into a stock price, we say that its impact is already a part of the stock price because the market already knew about it.

Going back to Flyers, suppose the government announces that the actual GDP increase during the year has been 1.5 percent. Now shareholders have learned something, namely, that the increase is 1 percentage point higher than they had forecast. This difference between the actual result and the forecast, 1 percentage point in this example, is sometimes called the *innovation* or the *surprise*.

This distinction explains why what seems to be bad news can actually be good news. For example, Gymboree, a retailer of children's apparel, had a 3 percent decline in same-store sales for the month of July 1996, yet its stock price shot up 13 percent on the news. In the retail business, same-store sales, which are sales by existing stores in operation at least a year, are a crucial barometer, so why was this decline good news? The reason was that analysts had been expecting significantly sharper declines, so the situation was not as bad as previously thought.

A key fact to keep in mind about news and price changes is that news about the future is what matters. For example, on May 8, 1996, America Online (AOL) announced third-quarter earnings that exceeded Wall Street's expectations. That seems like good news, but America Online’s stock price promptly dropped 10 percent. The reason was that America Online also announced a new discount subscriber plan, which analysts took as an indication that future revenues would be growing more slowly. Similarly, shortly thereafter, Microsoft reported a 50 percent jump in profits, exceeding projections. That seems like *really* good news, but Microsoft’s stock price proceeded to decline sharply. Why? Because Microsoft warned that its phenomenal growth could not be sustained indefinitely, so its 50 percent increase in current earnings was not such a good predictor of future earnings growth.

To summarize, an announcement can be broken into two parts, the anticipated, or expected part plus the surprise, or innovation:

$$\text{Announcement} = \text{Expected part} + \text{Surprise} \qquad [18.2]$$

The expected part of any announcement is the part of the information that the market uses to form the expectation, $E(R)$, of the return on the stock. The surprise is the news that influences the unanticipated return on the stock, U.

Our discussion of market efficiency in Chapter 8 bears on this discussion. We are assuming that relevant information known today is already reflected in the expected return. This is identical to saying that the current price reflects relevant publicly available information. We are thus implicitly assuming that markets are at least reasonably efficient in the semi-strong form sense. Henceforth, when we speak of news, we will mean the surprise part of an announcement and not the portion that the market had expected and therefore already discounted.

Example 18.1 In the News. Suppose Intel were to announce that earnings for the quarter just ending were up by 40 percent relative to a year ago. Do you expect that the stock price would rise or fall on the announcement?

The answer is you can’t really tell. Suppose the market was expecting a 60 percent increase. In this case, the 40 percent increase would be a negative surprise, and we would expect the stock price to fall. On the other hand, if the market was expecting only a 20 percent increase, there would be a positive surprise, and we would expect the stock to rise on the news.

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18.1a What are the two basic parts of a return on common stock?

18.1b Under what conditions will an announcement have no effect on common stock prices?

18.2 Risk: Systematic and Unsystematic

It is important to distinguish between expected and unexpected returns because the unanticipated part of the return, that portion resulting from surprises, is the significant risk of any investment. After all, if we always receive exactly what we expect, then the investment is perfectly predictable and, by definition, risk-free. In other words, the risk of owning an asset comes from surprises—unanticipated events.

There are important differences, though, among various sources of risk. Look back at our previous list of news stories. Some of these stories are directed specifically at Flyers, and some are more general. Which of the news items are of specific importance to Flyers?

Announcements about interest rates or GDP are clearly important for nearly all companies, whereas the news about Flyers's president, its research, or its sales is of specific interest to Flyers investors only. We distinguish between these two types of events, because, as we shall see, they have very different implications.

Systematic and Unsystematic Risk

The first type of surprise, the one that affects most assets, we will label **systematic risk**. A systematic risk is one that influences a large number of assets, each to a greater or lesser extent. Because systematic risks have market-wide effects, they are sometimes called *market risks*.

(*marg. def.* **systematic risk**. Risk that influences a large number of assets. Also called *market* risk.)

The second type of surprise we will call **unsystematic risk**. An unsystematic risk is one that affects a single asset, or possibly a small group of assets. Because these risks are unique to individual companies or assets, they are sometimes called *unique* or *asset-specific risks*. We use these terms interchangeably.

(*marg. def.* **unsystematic risk.** Risk that influences a single company or a small group of companies. Also called *unique* or *asset-specific* risk.)

As we have seen, uncertainties about general economic conditions, such as GDP, interest rates, or inflation, are examples of systematic risks. These conditions affect nearly all companies to some degree. An unanticipated increase, or surprise, in inflation, for example, affects wages and the costs of supplies that companies buy; it affects the value of the assets that companies own; and it affects the prices at which companies sell their products. Forces such as these, to which all companies are susceptible, are the essence of systematic risk.

In contrast, the announcement of an oil strike by a particular company will primarily affect that company and, perhaps, a few others (such as primary competitors and suppliers). It is unlikely to have much of an effect on the world oil market, however, or on the affairs of companies not in the oil business, so this is an unsystematic event.

Systematic and Unsystematic Components of Return

The distinction between a systematic risk and an unsystematic risk is never really as exact as we would like it to be. Even the most narrow and peculiar bit of news about a company ripples through the economy. This is true because every enterprise, no matter how tiny, is a part of the economy. It's like the tale of a kingdom that was lost because one horse lost a shoe. This is mostly hairsplitting, however. Some risks are clearly much more general than others.

The distinction between the two types of risk allows us to break down the surprise portion, *U*, of the return on the Flyers stock into two parts. Earlier, we had the actual return broken down into its expected and surprise components: $R - E(R) = U$. We now recognize that the total surprise component for Flyers, *U*, has a systematic and an unsystematic component, so

$$R - E(R) = \text{Systematic portion} + \text{Unsystematic portion} \qquad [18.3]$$

Because it is traditional, we use the Greek letter epsilon, ϵ, to stand for the unsystematic portion. Because systematic risks are often called "market" risks, we use the letter *m* to stand for the systematic part of the surprise. With these symbols, we can rewrite the formula for the total return:

$$R - E(R) = U = m + \epsilon \qquad [18.4]$$

The important thing about the way we have broken down the total surprise, *U*, is that the unsystematic portion, ϵ, is more or less unique to Flyers. For this reason, it is unrelated to the unsystematic portion of return on most other assets. To see why this is important, we need to return to the subject of portfolio risk.

Example 18.2 Systematic versus Unsystematic Events. Suppose Intel were to unexpectedly announce that its latest computer chip contains a significant flaw in its floating point unit that left it unable to handle numbers bigger than a couple of gigatrillion (meaning that, among other things, the chip cannot calculate Intel's quarterly profits). Is this a systematic or unsystematic event?

Obviously, this event is for the most part unsystematic. However, it would also benefit Intel's competitors to some degree and, at least potentially, harm some users of Intel products such as personal computer makers. Thus, as with most unsystematic events, there is some spillover, but the effect is mostly confined to a relatively small number of companies.

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18.2a What are the two basic types of risk?

18.2b What is the distinction between the two types of risk?

18.3 Diversification, Systematic Risk, and Unsystematic Risk

In the previous chapter, we introduced the principle of diversification. What we saw was that some of the risk associated with individual assets can be diversified away and some cannot. We are left with an obvious question: Why is this so? It turns out that the answer hinges on the distinction between systematic and unsystematic risk.

Diversification and Unsystematic Risk

By definition, an unsystematic risk is one that is particular to a single asset or, at most, a small group of assets. For example, if the asset under consideration is stock in a single company, such things as successful new products and innovative cost savings will tend to increase the value of the stock. Unanticipated lawsuits, industrial accidents, strikes, and similar events will tend to decrease future cash flows and thereby reduce share values.

Here is the important observation: If we hold only a single stock, then the value of our investment will fluctuate because of company-specific events. If we hold a large portfolio, on the other hand, some of the stocks in the portfolio will go up in value because of positive company-specific events and some will go down in value because of negative events. The net effect on the overall value of the portfolio will be relatively small, however, because these effects will tend to cancel each other out.

Now we see why some of the variability associated with individual assets is eliminated by diversification. When we combine assets into portfolios, the unique, or unsystematic, events—both positive and negative—tend to "wash out" once we have more than just a few assets. This is an important point that bears repeating:

Unsystematic risk is essentially eliminated by diversification, so a portfolio with many assets has almost no unsystematic risk.

In fact, the terms *diversifiable risk* and *unsystematic risk* are often used interchangeably.

Diversification and Systematic Risk

We've seen that unsystematic risk can be eliminated by diversification. What about systematic risk? Can it also be eliminated by diversification? The answer is no because, by definition, a systematic risk affects almost all assets. As a result, no matter how many assets we put into a portfolio, systematic risk doesn't go away. Thus, for obvious reasons, the terms *systematic risk* and *nondiversifiable risk* are used interchangeably.

Because we have introduced so many different terms, it is useful to summarize our discussion before moving on. What we have seen is that the total risk of an investment can be written as:

$$\text{Total risk} = \text{Systematic risk} + \text{Unsystematic risk} \qquad [18.5]$$

Systematic risk is also called *nondiversifiable risk* or *market risk*. Unsystematic risk is also called *diversifiable risk, unique risk,* or *asset-specific risk*. Most important, for a well-diversified portfolio, unsystematic risk is negligible. For such a portfolio, essentially all risk is systematic.

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18.3a Why is some risk diversifiable? Why is some risk not diversifiable?

18.3b Why can't systematic risk be diversified away?

18.4 Systematic Risk and Beta

We now begin to address another question: What determines the size of the risk premium on a risky asset? Put another way, why do some assets have a larger risk premium than other assets? The answer, as we discuss next, is also based on the distinction between systematic and unsystematic risk.

The Systematic Risk Principle

Thus far, we've seen that the total risk associated with an asset can be decomposed into two components: systematic and unsystematic risk. We have also seen that unsystematic risk can be essentially eliminated by diversification. The systematic risk present in an asset, on the other hand, cannot be eliminated by diversification.

Based on our study of capital market history in Chapter 1, we know that there is a reward, on average, for bearing risk. However, we now need to be more precise about what we mean by risk. The **systematic risk principle** states that the reward for bearing risk depends only on the systematic risk of an investment.

(*marg. def.* **systematic risk principle**. The reward for bearing risk depends only on the systematic risk of an investment.)

The underlying rationale for this principle is straightforward: Because unsystematic risk can be eliminated at virtually no cost (by diversifying), there is no reward for bearing it. In other words, the market does not reward risks that are borne unnecessarily.

The systematic risk principle has a remarkable and very important implication:

The expected return on an asset depends only on its systematic risk.

There is an obvious corollary to this principle: No matter how much total risk an asset has, only the systematic portion is relevant in determining the expected return (and the risk premium) on that asset.

Measuring Systematic Risk

Because systematic risk is the crucial determinant of an asset's expected return, we need some way of measuring the level of systematic risk for different investments. The specific measure we will use is called the **beta coefficient**, designated by the Greek letter β. A beta coefficient, or just beta for short, tells us how much systematic risk a particular asset has relative to an average asset. By definition, an average asset has a beta of 1.0 relative to itself. An asset with a beta of .50, therefore, has half as much systematic risk as an average asset. Likewise, an asset with a beta of 2.0 has twice as much systematic risk.

(*marg. def.* **beta coefficient**. Measure of the relative systematic risk of an asset. Assets with betas larger (smaller) than 1 have more (less) systematic risk than average.)

Table 18.1 presents the estimated beta coefficients for the stocks of some well-known companies. (This particular source rounds numbers to the nearest .05. The range of betas in Table 18.1 is typical for stocks of large U.S. corporations. Betas outside this range occur, but they are less common.

Table 18.1 Beta Coefficients

Company	Beta (β)
Exxon	.65
AT&T	.90
IBM	.95
Wal-Mart	1.10
General Motors	1.15
Microsoft	1.30
Harley-Davidson	1.65
America Online	2.40

The important thing to remember is that the expected return, and thus the risk premium, on an asset depends only on its systematic risk. Because assets with larger betas have greater systematic risks, they will have greater expected returns. Thus from Table 18.1, an investor who buys stock in Exxon, with a beta of .65, should expect to earn less, on average, than an investor who buys stock in General Motors, with a beta of about 1.15.

One cautionary note is in order: Not all betas are created equal. For example, in Table 18.1, the source used, *Value Line*, reports a beta for Harley-Davidson of 1.65. At the same time, however, another widely used source, *S&P Stock Reports*, puts Harley-Davidson's beta at 1.13, substantially smaller. The difference derives from the different procedures used to come up with beta coefficients. We will have more to say on this subject when we explain how betas are calculated in a later section.

Example 18.3 Total Risk versus Beta. Consider the following information on two securities. Which has greater total risk? Which has greater systematic risk? Greater unsystematic risk? Which asset will have a higher risk premium?

	Standard Deviation	Beta
Security A	40%	.50
Security B	20	1.50

From our discussion in this section, Security A has greater total risk, but it has substantially less systematic risk. Because total risk is the sum of systematic and unsystematic risk. Security A must have greater unsystematic risk. Finally, from the systematic risk principle, Security B will have a higher risk premium and a greater expected return, despite the fact that it has less total risk.

Portfolio Betas

Earlier, we saw that the riskiness of a portfolio has no simple relation to the risks of the assets in the portfolio. By contrast, a portfolio beta can be calculated just like a portfolio expected return. For example, looking again at Table 18.1, suppose you put half of your money in AT&T and half in General Motors. What would the beta of this combination be? Because AT&T has a beta of .90 and General Motors has a beta of 1.15, the portfolio's beta, β_p, would be

$$\begin{aligned} \beta_P &= .50 \times \beta_{AT\&T} + .50 \times \beta_{GM} \\ &= .50 \times 0.90 + .50 \times 1.15 \\ &= 1.025 \end{aligned}$$

In general, if we had a large number of assets in a portfolio, we would multiply each asset's beta by its portfolio weight and then add the results to get the portfolio's beta.

Example 18.4 Portfolio Betas: Suppose we have the following information:

Security	Amount Invested	Expected Return	Beta
Stock A	$1,000	8%	.80
Stock B	2,000	12	.95
Stock C	3,000	15	1.10
Stock D	4,000	18	1.40

What is the expected return on this portfolio? What is the beta of this portfolio? Does this portfolio have more or less systematic risk than an average asset?

To answer, we first have to calculate the portfolio weights. Notice that the total amount invested is $10,000. Of this, $1,000/$10,000 = 10% is invested in Stock A. Similarly, 20 percent is invested in Stock B, 30 percent is invested in Stock C, and 40 percent is invested in Stock D. The expected return, $E(R_P)$, is thus

$$\begin{aligned} E(R_P) &= .10 \times E(R_A) + .20 \times E(R_B) + .30 \times E(R_C) + .40 \times E(R_D) \\ &= .10 \times 8\% + .20 \times 12\% + .30 \times 15\% + .40 \times 18\% \\ &= 14.9\% \end{aligned}$$

Similarly, the portfolio beta, β_P, is

$$\begin{aligned} \beta_P &= .10 \text{ x } \beta_A + .20 \text{ x } \beta_B + 0.30 \times \beta_C + .40 \times \beta_D \\ &= .10 \times .80 + .20 \times .95 + .30 \times 1.10 + .40 \times 1.40 \\ &= 1.16 \end{aligned}$$

This portfolio thus has an expected return of 14.9 percent and a beta of 1.16. Because the beta is larger than 1, this portfolio has greater systematic risk than an average asset.

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18.4a What is the systematic risk principle?

18.4b What does a beta coefficient measure?

18.4c How do you calculate a portfolio beta?

18.4d True or false: The expected return on a risky asset depends on that asset's total risk. Explain.

18.5 The Security Market Line

We're now in a position to see how risk is rewarded in the marketplace. To begin, suppose that Asset A has an expected return of $E(R_A)$ = 20% and a beta of β_A = 1.6. Further, suppose that the risk-free rate is R_f = 8%. Notice that a risk-free asset, by definition, has no systematic risk (or unsystematic risk), so a risk-free asset has a beta of zero.

Beta and the Risk Premium

Consider a portfolio made up of Asset A and a risk-free asset. We can calculate some different possible portfolio expected returns and betas by varying the percentages invested in these two assets. For example, if 25 percent of the portfolio is invested in Asset A, then the expected return is

$$\begin{aligned} E(R_P) &= .25 \times \mathrm{E}(R_A) + (1 - .25) \times R_f \\ &= .25 \times 20\% + .75 \times 8\% \\ &= 11\% \end{aligned}$$

Similarly, the beta on the portfolio, β_P, would be

$$\beta_P = .25 \times \beta_A + (1 - .25) \times 0$$

$$= .25 \times 1.6$$

$$= .40$$

Notice that, because the weights have to add up to 1, the percentage invested in the risk-free asset is equal to 1 minus the percentage invested in Asset A.

One thing that you might wonder about is whether it is possible for the percentage invested in Asset A to exceed 100 percent. The answer is yes. This can happen if the investor borrows at the risk-free rate and invests the proceeds in stocks. For example, suppose an investor has $100 and borrows an additional $50 at 8 percent, the risk-free rate. The total investment in Asset A would be $150, or 150 percent of the investor's wealth. The expected return in this case would be

$$E(R_P) = 1.50 \times E(R_A) + (1 - 1.50) \times R_f$$

$$= 1.50 \times 20\% - .50 \times 8\%$$

$$= 26\%$$

The beta on the portfolio would be

$$\beta_P = 1.50 \text{ x } \beta_A + (1 - 1.50) \times 0$$

$$= 1.50 \times 1.6$$

$$= 2.4$$

We can calculate some other possibilities, as follows:

Percentage of Portfolio in Asset A	Portfolio Expected Return	Portfolio Beta
0%	8%	.0
25	11	.4
50	14	.8
75	17	1.2
100	20	1.6
125	23	2.0
150	26	2.4

In Figure 18.1A, these portfolio expected returns are plotted against portfolio betas. Notice that all the combinations fall on a straight line.

Figure 18.1 about here

The Reward-to-Risk Ratio

What is the slope of the straight line in Figure 18.1A? As always, the slope of a straight line is equal to the rise over the run. In this case, as we move out of the risk-free asset into Asset A, the beta increases from zero to 1.6 (a run of 1.6). At the same time, the expected return goes from 8 percent to 20 percent, a rise of 12 percent. The slope of the line is thus 12% / 1.6 = 7.5%.

Notice that the slope of our line is just the risk premium on Asset A, $E(R_A) - R_f$ divided by Asset A's beta, β_A:

$$Slope = \frac{E(R_A) - R_f}{\beta_A} = \frac{20\% - 8\%}{1.6} = 7.50\%$$

What this tells us is that Asset A offers a *reward-to-risk* ratio of 7.5 percent.[1] In other words, Asset A has a risk premium of 7.50 percent per "unit" of systematic risk.

The Basic Argument

Now suppose we consider a second asset, Asset B. This asset has a beta of 1.2 and an expected return of 16 percent. Which investment is better, Asset A or Asset B? You might think that we really cannot say—some investors might prefer A; some investors might prefer B. Actually, however, we can say: A is better because, as we will demonstrate, B offers inadequate compensation for its level of systematic risk, at least relative to A.

To begin, we calculate different combinations of expected returns and betas for portfolios of Asset B and a risk-free asset, just as we did for Asset A. For example, if we put 25 percent in Asset B and the remaining 75 percent in the risk-free asset, the portfolio's expected return will be

$$\begin{aligned} E(R_P) &= .25 \times E(R_B) + (1 - .25) \times R_f \\ &= .25 \times 16\% + .75 \times 8\% \\ &= 10\% \end{aligned}$$

Similarly, the beta on the portfolio, β_P, would be

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[1]This ratio is sometimes called the *Treynor index*, after one of its originators.

$$\beta_P = .25 \times \beta_B + (1 - .25) \times 0$$

$$= .25 \times 1.2$$

$$= .30$$

Some other possibilities are as follows:

Percentage of Portfolio in Asset B	Portfolio Expected Return	Portfolio Beta
0%	8%	.0
25	10	.3
50	12	.6
75	14	.9
100	16	1.2
125	18	1.5
150	20	1.8

When we plot these combinations of portfolio expected returns and portfolio betas in Figure 18.1B, we get a straight line just as we did for Asset A.

The key thing to notice is that when we compare the results for Assets A and B, as in Figure 18.1C, the line describing the combinations of expected returns and betas for Asset A is higher than the one for Asset B. What this tells us is that for any given level of systematic risk (as measured by beta), some combination of Asset A and the risk-free asset always offers a larger return. This is why we were able to state that Asset A is a better investment than Asset B.

Another way of seeing that Asset A offers a superior return for its level of risk is to note that the slope of our line for Asset B is

$$Slope = \frac{E(R_B) - R_f}{\beta_B}$$
$$= \frac{16\% - 8\%}{1.2}$$
$$= 6.67\%$$

Thus, Asset B has a reward-to-risk ratio of 6.67 percent, which is less than the 7.5 percent offered by Asset A.

The Fundamental Result

The situation we have described for Assets A and B could not persist in a well-organized, active market because investors would be attracted to Asset A and away from Asset B. As a result, Asset A's price would rise and Asset B's price would fall. Because prices and returns move in opposite directions, A's expected return would decline and B's would rise.

This buying and selling would continue until the two assets plotted on exactly the same line, which means they would offer the same reward for bearing risk. In other words, in an active, competitive market, we must have the situation that

$$\frac{E(R_A) - R_f}{\beta_A} = \frac{E(R_B) - R_f}{\beta_B} \qquad [18.6]$$

This is the fundamental relation between risk and return.

Our basic argument can be extended to more than just two assets. In fact, no matter how many assets we had, we would always reach the same conclusion:

The reward-to-risk ratio must be the same for all assets in a competitive financial market.

This result is really not too surprising. What it says is that, for example, if one asset has twice as much systematic risk as another asset, its risk premium will simply be twice as large.

Because all assets in the market must have the same reward-to-risk ratio, they all must plot on the same line. This argument is illustrated in Figure 18.2, where the subscript *i* in the return R_i and beta β_i indexes Assets A, B, C, and D.. As shown, Assets A and B plot directly on the line and thus have the same reward-to-risk ratio. If an asset plotted above the line, such as C in Figure 18.2, its price would rise and its expected return would fall until it plotted exactly on the line. Similarly, if an asset plotted below the line, such as D in Figure 18.2, its expected return would rise until it too plotted directly on the line.

Figure 18.2 about here

The arguments we have presented apply to active, competitive, well-functioning markets. Active financial markets, such as the NYSE, best meet these criteria. Other markets, such as real asset markets, may or may not. For this reason, these concepts are most useful in examining active financial markets.

Example 18.5 Buy Low, Sell High. A security is said to be *overvalued* relative to another security if its price is too high given its expected return and risk. Suppose you observe the following situation:

Security	Beta	Expected Return
Melan Co.	1.3	14%
Choly Co.	.8	10

The risk-free rate is currently 6 percent. Is one of the two securities overvalued relative to the other?

To answer, we compute the reward-to-risk ratio for both. For Melan, this ratio is (14% - 6%) /1.3 = 6.15%. For Choly, this ratio is 5 percent. What we conclude is that Choly offers an insufficient expected return for its level of risk, at least relative to Melan. Because its expected return is too low, its price is too high. In other words, Choly is overvalued relative to Melan, and we would expect to see its price fall relative to Melan. Notice that we could also say Melan is *undervalued* relative to Choly.

(*marg. def.* **security market line (SML)** Graphical representation of the linear relationship between systematic risk and expected return in financial markets.)

The Security Market Line

The line that results when we plot expected returns and beta coefficients is obviously of some importance, so it's time we gave it a name. This line, which we use to describe the relationship between systematic risk and expected return in financial markets, is usually called the **security market line (SML)**, and it is one of the most important concepts in modern finance.

Market Portfolios We will find it very useful to know the equation of the SML. Although there are many different ways we could write it, we will discuss the most frequently-seen version. Suppose we consider a portfolio made up of all of the assets in the market. Such a portfolio is called a market portfolio, and we will express the expected return on this market portfolio as $E(R_M)$.

Because all the assets in the market must plot on the SML, so must a market portfolio made up of those assets. To determine where it plots on the SML, we need to know the beta of the market portfolio, β_M. Because this portfolio is representative of all of the assets in the market, it must have average systematic risk. In other words, it has a beta of 1. We could therefore express the slope of the SML as

$$SML\ \ Slope = \frac{E(R_M) - R_f}{\beta_M} = \frac{E(R_M) - R_f}{1} = E(R_M) - R_f$$

The term $E(R_M) - R_f$ is often called the **market risk premium** because it is the risk premium on a market portfolio.

(*marg. def.* **market risk premium** The risk premium on a market portfolio; i.e., a portfolio made of all assets in the market)

The Capital Asset Pricing Model To finish up, if we let $E(R_i)$ and β_i stand for the expected return and beta, respectively, on any asset in the market, then we know that asset must plot on the SML. As a result, we know that its reward-to-risk ratio is the same as that of the overall markets:

$$\frac{E(R_i) - R_f}{\beta_i} = E(R_M) - R_f$$

If we rearrange this, then we can write the equation for the SML as

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i \qquad [18.7]$$

This result is the famous **capital asset pricing model (CAPM).**[2]

---

[2] Our discussion of the CAPM is actually closely related to the more recent development, arbitrage pricing theory (APT). The theory underlying the CAPM is more complex than we have

(*marg. def.* **capital asset pricing model (CAPM)** A theory of risk and return for securities in a competitive capital market.)

What the CAPM shows is that the expected return for an asset depends on three things:

1. *The pure time value of money*. As measured by the risk-free rate, R_f, this is the reward for merely waiting for your money, without taking any risk.

2. *The reward for bearing systematic risk*. As measured by the market risk premium, $E(R_M)$ - R_f, this component is the reward the market offers for bearing an average amount of systematic risk.

3. *The amount of systematic risk*. As measured by β_i, this is the amount of systematic risk present in a particular asset relative to that in an average asset.

By the way, the CAPM works for portfolios of assets just as it does for individual assets. In an earlier section, we saw how to calculate a portfolio's beta in the CAPM equation.

Figure 18.3 summarizes our discussion of the SML and the CAPM. As before, we plot expected return against beta. Now we recognize that, based on the CAPM, the slope of the SML is equal to the market risk premium, $E(R_M)$ - R_f.

Figure 18.3 about here

This concludes our presentation of concepts related to the risk-return trade-off. Table 18.2 summarizes the various concepts in the order in which we discussed them.

indicated here, and it has implications beyond the scope of this discussion. As we present it here, the CAPM has essentially identical implications to those of the APT, so we don't distinguish between them.

Table 18.2 about here

Example 18.6 Risk and Return. Suppose the risk-free rate is 4 percent, the market risk premium is 8.6 percent, and a particular stock has a beta of 1.3. Based on the CAPM, what is the expected return on this stock? What would the expected return be if the beta were to double?

With a beta of 1.3, the risk premium for the stock is 1.3 × 8.6%, or 11.18 percent. The risk-free rate is 4 percent, so the expected return is 15.18 percent. If the beta were to double to 2.6, the risk premium would double to 22.36 percent, so the expected return would be 26.36 percent.

CHECK THIS

18.5a What is the fundamental relationship between risk and return in active markets?

18.5b What is the security market line? Why must all assets plot directly on it in a well-functioning market?

18.5c What is the capital asset pricing model (CAPM)? What does it tell us about the required return on a risky investment?

18.6 More on Beta

In our last several sections, we discussed the basic economic principles of risk and return. We found that the expected return on a security depends on its systematic risk, which is measured using the security's beta coefficient, β. In this final section, we examine beta in more detail. We first illustrate more closely what it is that beta measures. We then show how betas can be estimated for individual securities, and we discuss why it is that different sources report different betas for the same security.

A Closer Look at Beta

Going back to the beginning of the chapter, we discussed how the actual return on a security, *R*, could be written as follows:

$$R - E(R) = m + \epsilon \tag{18.8}$$

Recall that in Equation 18.8, *m* stands for the systematic or market-wide portion of the unexpected return. Based on our discussion of the CAPM, we can now be a little more precise about this component.

Specifically, the systematic portion of an unexpected return depends on two things. Firstl, it depends on the size of the systematic effect. We will measure this as R_M - E(R_M), which is simply the difference between the actual return on the overall market and the expected return. Second, as we have discussed, some securities have greater systematic risk than others, and we measure this risk using beta. Putting it together, we have

$$m = \beta \times [R_M - E(R_M)] \tag{18.9}$$

In other words, the market-wide or systematic portion of the return on a security depends on both the size of the market-wide surprise, $R_M - E(R_M)$, and the sensitivity of the security to such surprises, β.

Now, if we combine equations 18.6 and 18.7, we have

$$\begin{aligned} R - E(R) &= m + \varepsilon \\ &= \beta \times [R_M - E(R_M)] + \epsilon \end{aligned} \tag{18.10}$$

Equation 18.10 gives us some additional insight into beta by telling us why some securities have higher betas than others. A high beta security is simply one that is relatively sensitive to overall market movements, whereas a low beta security is one that is relatively insensitive. In other words, the systematic risk of a security is just a reflection of its sensitivity to overall market movements.

A hypothetical example is useful for illustrating the main point of Equation 18.8. Suppose a particular security has a beta of 1.2, the risk-free rate is 5 percent, and the expected return on the market is 12 percent. From the CAPM, we know that the expected return on the security is

$$
\begin{aligned}
E(R) &= R_f + [E(R_M) - R_f] \times \beta \\
&= .05 + (.12 - .05) \times 1.2 \\
&= .134
\end{aligned}
$$

Thus, the expected return on this security is 13.4 percent. However, we know that in any given year the actual return on this security will be more or less than 13.4 percent because of unanticipated systematic and unsystematic events.

Columns 1 and 2 of Table 18.3 list the actual returns on our security, R, for a five-year period along with the actual returns for the market as a whole, R_M, for the same period. Given these actual returns and the expected returns on the security (13.4 percent) and the market as a whole (12 percent), we can calculate the unexpected returns on the security, $R - E(R)$, along with the unexpected return on the market as a whole, $R_M - E(R_M)$. The results are shown in columns 3 and 4 of Table 18.3

Table 18.3 Decomposition of Total Returns into Systematic and Unsystematic Portions

	Actual Returns		Unexpected Returns		Systematic Portion	Unsystematic Portion (ε)
Year	R	R_M	R - E(R)	R_M - E(R_M)	[R_M - E(R_M)] × β	R - [R_M - E(R_M)] × β
1995	20%	15%	6.6%	3%	3.6%	3%
1996	-24.6	-3	-38	-15	-18	-20
1997	23	10	9.6	-2	-2.4	12
1998	36.8	24	23.4	12	14.4	9
1999	3.4	7	-10	-5	-6	-4

Next we decompose the unexpected returns on the security - that is, we break them down into their systematic and unsystematic components in columns 5 and 6. From Equation 18.9, we calculate the systematic portion of the unexpected return by taking the security's beta, 1.2, and multiplying it by the market's unexpected return:

$$\text{Systematic portion} = m = \beta \times [R_M - E(R_M)]$$

Finally, we calculate the unsystematic portion by subtracting the systematic portion from the total unexpected return:

$$\text{Unsystematic portion} = \varepsilon = R - E(R) - \beta \times [\mathrm{R}_M - E(\mathrm{R}_M)]$$

Notice that the unsystematic portion is essentially whatever is left over after we account for the systematic portion. For this reason, it is sometimes called the "residual" portion of the unexpected return.

Figure 18.4 illustrates the main points of this discussion by plotting the unexpected returns on the security in Table 18.3 against the unexpected return on the market as a whole. These are the individual points in the graph, each labeled with its year. We also plot the systematic portions of the unexpected returns in Table 18.3 and connect them with a straight line. Notice that the slope of the straight line is equal to 1.2, the beta of the security. As indicated, the distance from the straight line to an individual point is the unsystematic portion of the return, ε, for a particular year.

Figure 18.4 about here

Where Do Betas Come From?

As our discussion to this point shows, beta is a useful concept. It allows us to estimate the expected return on a security, it tells how sensitive a security's return is to unexpected market events, and it lets us separate out the systematic and unsystematic portions of a security's return. In our example just above, we were given that the beta was 1.2, so the required calculations were all pretty straightforward. Suppose, however, that we didn't have the beta ahead of time. In this case, we would have to estimate it.

A security's beta is a measure of how sensitive the security's return is to overall market movements. That sensitivity depends on two things: (1) how closely correlated the security's return is with the overall market's return, and (2) how volatile the security is relative to the market. Specifically, going back to our previous chapter, let $\text{Corr}(R_i, R_M)$ stand for the correlation between the return on a particular security i and the overall market. As before, let σ_i and σ_M be the standard deviations on the security and the market, respectively. Given these numbers, the beta for the security, β_i, is simply

$$\beta_i = \text{Corr}(R_i, R_M) \times \sigma_i / \sigma_M \qquad [18.11]$$

In other words, the beta is equal to the correlation multiplied by the ratio of the standard deviations.

From previous chapters, we know how to calculate the standard deviations in Equation 18.11. However, we have not yet discussed how to calculate correlations. This is our final task for this chapter. The simplest way to proceed is to construct a worksheet like Table 18.4.

Table 18.4 Calculating Beta

Year	Returns		Return Deviations		Squared Deviations		Product of Deviations
	Security	Market	Security	Market	Security	Market	
1995	10%	8%	0%	-4%	0	16	0
1996	-8	-12	-18	-24	324	576	432
1997	-4	16	-14	4	196	16	-56
1998	40	26	30	14	900	196	420
1999	12	22	2	10	4	100	20
Totals	50	60	0	0	1424	904	816

	Average Returns:	Variances:	Standard Deviations:
Security	50/5 = 10%	1424/4 = 356	$\sqrt{356}$ = 18.87%
Market	60/5 = 12%	904/4 = 226	$\sqrt{226}$ = 15.03%

Covariance = $\text{Cov}(R_i, R_M)$ = 816/4 = 204

Correlation = $\text{Corr}(R_i, R_M)$ = 204/(18.87 × 15.03) = .72

Beta = β = .72 × (18.87/15.03) = .9031 ≈.9

The first six columns of Table 18.4 are familiar from Chapter 1. The first two contain five years of returns on a particular security and the overall market. We add these up and divide by 5 to get the average returns of 10 percent and 12 percent for the security and the market, respectively, as shown in the table. In the third and fourth columns we calculate the return deviations by taking each individual return and subtracting out the average return. In columns 5 and 6 we square these return deviations. To calculate the variances, we total these squared deviations and divide by 5 - 1 = 4. We calculate the standard deviations by taking the square roots of the variances, and we find that the standard deviations for the security and the market are 18.87 percent and 15.03 percent, respectively.

Now we come to the part that's new. In the last column of Table 18.4, we have calculated the *product* of the return deviations by simply multiplying columns 3 and 4. When we total these products and divide by 5 - 1 = 4, the result is called the **covariance**.

(*marg. def.* **covariance.** A measure of the tendency of two things to move or vary together.)

Covariance, as the name suggests, is a measure of the tendency of two things to vary together. If the covariance is positive, then the tendency is to move in the same direction, and vice versa for a negative covariance. A zero covariance means there is no particular relation. For our security in Table 18.4, the covariance is +204, so the security tends to move in the same direction as the market.

A problem with covariances is that, like variances, the actual numbers are hard to interpret (the sign, of course, is not). For example, our covariance is 204, but, just from this number, we can't really say if the security has a strong tendency to move with the market or only a weak one. To fix this problem, we divide the covariance by the product of the two standard deviations. The result is the correlation coefficient, we introduced in the previous chapter.

From Table 18.4, the correlation between our security and the overall market is .72. Recalling that correlations range from -1 to +1, this .72 tells us that the security has a fairly strong tendency to move with the overall market, but that tendency is not perfect.

Now we have reached our goal of calculating the beta coefficient. As shown in the last row of Table 18.4, from Equation 18.9, we have

$$\beta_i = \text{Corr}(R_i, R_M) \times \sigma_i / \sigma_M$$

$$= .72 \times (18.87 / 15.03)$$

$$= .90$$

We find that this security has a beta of .9, so it has slightly less than average systematic risk.

Why do Betas Differ?

Finally, we consider why different sources report different betas. The important thing to remember is that betas are estimated from actual data. Different sources estimate differently, possibly using different data. We discuss some of the key differences next.

First, there are two issues concerning data. Betas can be calculated using daily, weekly, month, quarterly, or annual returns. In principle, it does not matter which is chosen, but with real data, different estimates will result. Second, betas can be estimated over relatively short periods such as a few weeks or over long periods of 5 to 10 years or even more.

The trade-off here is not hard to understand. Betas obtained from high-frequency returns, such as daily returns, are less reliable than those obtained from less frequent returns, such as monthly returns. This argues for using monthly or longer returns. On the other hand, any time we estimate something, we would like to have a large number of recent observations. This argues for using weekly or daily returns. There is no ideal balance; the most common choices are three to five years of monthly data or a single year of weekly data. The betas we get from a year of weekly data are more current in the sense that they reflect only the previous year, but they tend to be less stable than those obtained from longer periods.

Another issue has to do with choice of a market index. All along, we have discussed the return on the "overall market," but we have not been very precise about how to measure this. By far the most common choice is to use the S&P 500 stock market index to measure the overall market, but this is not the only alternative. Different sources use different indexes to capture the overall market, and different indexes will lead to different beta estimates.

You might wonder whether some index is the "correct" one. The answer is yes, but a problem comes up. In principle, in the CAPM, when we speak of the overall market, what we really mean is the market for *every* risky asset of every type. In other words, what we would need is an index that included all the stocks, bonds, real estate, precious metals, and everything else in the entire world (not just the United States). Obviously, no such index exists, so instead we must choose some smaller index to proxy for this much larger one.

Last, a few sources (including *Value Line*, the source for Table 18.1) calculate betas the way we described in Table 18.4, but then they go on to adjust them for statistical reasons. The nature of the adjustment goes beyond our discussion, but such adjustments are another reason why betas differ across sources.

18.7 Summary and Conclusions

This chapter has covered the essentials of risk and return. Along the way, we have introduced a number of definitions and concepts. The most important of these is the security market line, or SML. The SML is important because it tells us the reward offered in financial markets for bearing risk.

Because we have covered quite a bit of ground, it's useful to summarize the basic economic logic underlying the SML as follows:

1. Based on capital market history, there is a reward for bearing risk. This reward is the risk premium on an asset.

2. The total risk associated with an asset has two parts: systematic risk and unsystematic risk. Unsystematic risk can be freely eliminated by diversification (this is the principle of diversification), so only systematic risk is rewarded. As a result, the risk premium on an asset is determined by its systematic risk. This is the systematic risk principle.

3. An asset's systematic risk, relative to the average, can be measured by its beta coefficient, β_i. The risk premium on an asset is then given by its beta coefficient multiplied by the market risk premium, $[E(R_M) - R_f] \times \beta_i$.

4. The expected return on an asset, $E(R_i)$, is equal to the risk-free rate, R_f, plus the risk premium:

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i$$

This is the equation of the SML, and it is often called the capital asset pricing model (CAPM).

Finally, to close out the chapter we showed how betas are calculated, and we discussed some of the main reasons different sources report different beta coefficients.

Key Terms

systematic risk

unsystematic risk

systematic risk principle

beta coefficient (β)

security market line (SML)

market risk premium

capital asset pricing model (CAPM)

covariance

Get Real!

This chapter introduced you to the famous capital asset pricing model, or CAPM for short. For investors, the CAPM has a stunning implication: What you earn, through time, on your portfolio depends only on the level of systematic risk you bear. The corollary is equally striking: As a diversified investor, you don't need to be concerned with the total risk or volatility of any individual asset in your portfolio–it is simply irrelevant.

An immediate implication of the CAPM is that you, as an investor, need to be aware of the level of systematic risk you are carrying. Look up the betas of the stocks you hold in your simulated brokerage account and compute your portfolio's systematic risk. Is it bigger or smaller than 1.0? More important, is the portfolio's beta consistent with your desired level of portfolio's risk?

Betas are particularly useful for understanding mutual fund risk and return. Since most mutual funds are at least somewhat diversified (the exceptions being sector funds and other specialized funds), they have relatively little unsystematic risk and their betas can be measured with some precision. Look at the funds you own and learn their betas (www.morningstar.com is a good source). Are the risk levels what you intended? As you study mutual fund risk, you will find some other measures exist, most of which are closely related to the measures discussed in this chapter. Take a few minutes to understand these as well.

Of course, we should note that the CAPM is a theory, and, as with any theory, whether it is correct or not is a question for the data. So does the CAPM work or not? Put more directly, does expected return depend on beta, and beta alone, or do other factors come into play? There is no more hotly debated question in all of finance, and the research that exists to date is inconclusive (Some researchers would dispute this!). At a minimum, it appears that beta is a useful measure of market-related volatility, but whether it is a useful measure of expected return (much less a comprehensive one) awaits more research. Lots more research.

Chapter 18
Return, Risk, and the Security Market Line

End of Chapter Questions and problems

Review Problems and Self-Test

1. **Risk and Return** Suppose you observe the following situation:

Security	Beta	Expected Return
Sanders	1.8	22.00%
Janicek	1.6	20.44

If the risk-free rate is 7 percent, are these two stocks correctly priced relative to each other? What must the risk-free rate be if they are correctly priced?

2. **CAPM** Suppose the risk-free rate is 8 percent. The expected return on the market is 16 percent. If a particular stock has a beta of .7, what is its expected return based on the CAPM? If another stock has an expected return of 24 percent, what must its beta be?

Answers to Self-Test Problems

1. If we compute the reward-to-risk ratios, we get (22% - 7%)/1.8 = 8.33% for Sanders versus 8.4% for Janicek. Relative to Sanders, Janicek's expected return is too high, so its price is too low.

If they are correctly priced, then they must offer the same reward-to-risk ratio. The risk-free rate would have to be such that:

$$(22\% - R_f)/1.8 = (20.44\% - R_f)/1.6$$

With a little algebra, we find that the risk-free rate must be 8 percent:

$$\begin{aligned} 22\% - R_f &= (20.44\% - R_f)(1.8/1.6) \\ 22\% - 20.44\% \times 1.125 &= R_f - R_f \times 1.125 \\ R_f &= 8\% \end{aligned}$$

2. Because the expected return on the market is 16 percent, the market risk premium is 16% - 8% = 8% (the risk-free rate is 8 percent). The first stock has a beta of .7, so its expected return is 8% + .7 × 8% = 13.6%.

For the second stock, notice that the risk premium is 24% - 8% = 16%. Because this is twice as large as the market risk premium, the beta must be exactly equal to 2. We can verify this using the CAPM:

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i$$
$$24\% = 8\% + (16\% - 8\%) \times \beta_i$$
$$\beta_i = 16\%/8\%$$
$$= 2.0$$

Test Your IQ (Investment Quotient)

1. **Portfolio Return** According to the CAPM, what is the rate of return of a portfolio with a beta of 1? (*1994 CFA Exam*)

a. between R_M and R_f
b. the risk-free rate, R_f
c. beta × (R_M - R_f)
d. the return on the market, R_M

2. **Stock Return** The return on a stock is said to have which two of the following basic parts?

a. an expected return and an unexpected return
b. a measurable return and an unmeasurable return
c. a predicted return and a forecast return
d. a total return and a partial return

3. **News Components** A news announcement about a stock is said to have which two of the following parts?

a. an expected part and a surprise
b. public information and private information
c. financial information and product information
d. a good part and a bad part

4. **News Effects** A company announces that its earnings have increased 50 percent over the previous year, which matches analysts' expectations. What is the likely effect on the stock price?

a. the stock price will increase
b. the stock price will decrease
c. the stock price will rise and then fall after an overreaction
d. the stock price will not be affected

5. **News Effects** A company announces that its earnings have decreased 25 percent from the previous year, but analysts only expected a small increase. What is the likely effect on the stock price?

a. the stock price will increase
b. the stock price will decrease
c. the stock price will rise and then fall after an overreaction
d. the stock price will not be affected

6. **News Effects** A company announces that its earnings have increased 25 percent from the previous year, but analysts actually expected a 50 percent increase. What is the likely effect on the stock price?

a. the stock price will increase
b. the stock price will decrease
c. the stock price will rise and then fall after an overreaction
d. the stock price will not be affected

7. **News Effects** A company announces that its earnings have decreased 50 percent from the previous year, but analysts only expected a 25 percent decrease. What is the likely effect on the stock price?

a. the stock price will increase
b. the stock price will decrease
c. the stock price will rise and then fall after an overreaction
d. the stock price will not be affected

8. **Security Risk** The systematic risk of a security is also called its

a. perceived risk
b. unique or asset-specific risk
c. market risk
d. fundamental risk

9. **Security Risk** The unsystematic risk of a security is also called its

a. perceived risk
b. unique or asset-specific risk
c. market risk
d. fundamental risk

10. **Security Risk** Which type of risk is essentially eliminated by diversification?

a. perceived risk
b. market risk
c. systematic risk
d. unsystematic risk

11. **Security Risk** The systematic risk principle states that

a. systematic risk doesn’t matter to investors
b. systematic risk can be essentially eliminated by diversification
c. the reward for bearing risk is independent of the systematic risk of an investment.
d. the reward for bearing risk depends only on the systematic risk of an investment.

12. **Security Risk** The systematic risk principle has an important implication, which is that

a. systematic risk is preferred to unsystematic risk
b. systematic risk is the only risk that can be reduced by diversification
c. the expected return on an asset is independent of its systematic risk.
d. the expected return on an asset depends only on it's systematic risk.

13. **Security Risk** The systematic risk of a stock is measured by its

a. beta coefficient
b. correlation coefficient
c. return standard deviation
d. return variance

14. **CAPM** A financial market’s security market line (SML) describes

a. the relationship between systematic risk and expected returns
b. the relationship between unsystematic risk and expected returns
c. the relationship between systematic risk and unexpected returns
d. the relationship between unsystematic risk and unexpected returns

15. **CAPM** In the capital asset pricing model (CAPM), a security's expected return is

a. the return on the market portfolio
b. the risk-free rate plus the return on the market portfolio
c. the return on the market portfolio plus a market risk premium
d. the risk-free rate plus a market risk premium

Questions and Problems

Core Questions

1. **Diversifiable Risk** In broad terms, why is some risk diversifiable? Why are some risks nondiversifiable? Does it follow that an investor can control the level of unsystematic risk in a portfolio, but not the level of systematic risk?

2. **Announcements and Prices** Suppose the government announces that, based on a just-completed survey, the growth rate in the economy is likely to be 2 percent in the coming year, as compared to 5 percent for the year just completed. Will security prices increase, decrease, or stay the same following this announcement? Does it make any difference whether or not the 2 percent figure was anticipated by the market? Explain.

3. **Announcements and Risk** Classify the following events as mostly systematic or mostly unsystematic. Is the distinction clear in every case?

A. Short-term interest rates increase unexpectedly.
B. The interest rate a company pays on its short-term debt borrowing is increased by its bank.
C. Oil prices unexpectedly decline.
D. An oil tanker ruptures, creating a large oil spill.
E. A manufacturer loses a multimillion-dollar product liability suit
F. A Supreme Court decision substantially broadens producer liability for injuries suffered by product users.

4. **Announcements and Risk** Indicate whether the following events might cause stocks in general to change price, and whether they might cause Big Widget Corp.'s stock to change price.

A. The government announces that inflation unexpectedly jumped by 2 percent last month.
B. Big Widget's quarterly earnings report, just issued, generally fell in line with analysts' expectations.
C. The government reports that economic growth last year was at 3 percent, which generally agreed with most economists' forecasts.
D. The directors of Big Widget die in a plane crash.
E. Congress approves changes to the tax code that will increase the top marginal corporate tax rate. The legislation had been debated for the previous six months.

5. **Diversification and Risk** True or false: the most important characteristic in determining the expected return of a well-diversified portfolio is the variances of the individual assets in the portfolio. Explain.

6. **Portfolio Betas** You own a stock portfolio invested 30 percent in Stock Q, 20 percent in Stock R, 10 percent in Stock S, and 40 percent in Stock T. The betas for these four stocks are 1.2, .6, 1.5, and .8, respectively. What is the portfolio beta?

7. **Stock Betas** You own a portfolio equally invested in a risk-free asset and two stocks. If one of the stocks has a beta of 1.6 and the total portfolio is exactly as risky as the market, what must the beta be for the other stock in your portfolio?

8. **Expected Returns** A stock has a beta of 1.2, the expected return on the market is 17 percent, and the risk-free rate is 8 percent. What must the expected return on this stock be?

9. **Stock Betas** A stock has an expected return of 13 percent, the risk-free rate is 7 percent, and the market risk premium is 8 percent. What must the beta of this stock be?

10. **Market Returns** A stock has an expected return of 17 percent, its beta is .9, and the risk-free rate is 7.5 percent. What must the expected return on the market be?

11. **Risk-free Rates** A stock has an expected return of 22 percent, and a beta of 1.6, and the expected return on the market is 16 percent. What must the risk-free rate be?

12. **Portfolio Weights** A stock has a beta of .9 and an expected return of 13 percent. A risk-free asset currently earns 7 percent.

A. What is the expected return on a portfolio that is equally invested in the two assets?
B. If a portfolio of the two assets has a beta of .6, what are the portfolio weights?
C. If a portfolio of the two assets has an expected return of 11 percent, what is its beta?
D. If a portfolio of the two assets has a beta of 1.80, what are the portfolio weights? How do you interpret the weights for the two assets in this case? Explain.

Intermediate Questions

13. **Portfolio Risk and Return** Asset W has an expected return of 25 percent and a beta of 1.6. If the risk-free rate is 7 percent, complete the following table for portfolios of Asset W and a risk-free asset. Illustrate the relationship between portfolio expected return and portfolio beta by plotting the expected returns against the betas. What is the slope of the line that results?

Percentage of in Asset W	Portfolio Expected Return	Portfolio Beta
0%		
25		
50		
75		
100		
125		
150		

14. **Relative Valuation** Stock Y has a beta of 1.59 and an expected return of 25 percent. Stock Z has a beta of .44 and an expected return of 12 percent. If the risk-free rate is 6 percent and the market risk premium is 11.3 percent, are these stocks correctly priced?

15. **Relative Valuation** In the previous problem, what would the risk-free rate have to be for the two stocks to be correctly priced?

16. **CAPM** Using the CAPM, show that the ratio of the risk premiums on two assets is equal to the ratio of their betas.

17. **Relative Valuation** Suppose you observe the following situation:

Security	Beta	Expected Return
Oxy Co.	1.35	23%
More-On Co.	.90	17

Assume these securities are correctly priced. Based on the CAPM, what is the expected return on the market? What is the risk-free rate?

18. **Announcements** As indicated by examples in this chapter, earnings announcements by companies are closely followed by, and frequently result in, share price revisions. Two issues should come to mind. First, earnings announcements concern past periods. If the market values stocks based on expectations of the future, why are numbers summarizing past performance relevant? Second, these announcements concern accounting earnings. Such earnings may have little to do with cash flow, so, again, why are they relevant?

19. **Beta** Is it possible that a risky asset could have a beta of zero? Explain. Based on the CAPM, what is the expected return on such an asset? Is it possible that a risky asset could have a negative beta? What does the CAPM predict about the expected return on such an asset? Can you give an explanation for your answer?

20. **Relative Valuation** Suppose you identify a situation in which one security is overvalued relative to another. How would you go about exploiting this opportunity? Does it matter if the two securities are both overvalued relative to some third security? Are your profits certain in this case?

21. **Calculating Beta** Show that another way to calculate beta is to take the covariance between the security and the market and divide by the variance of the market's return.

22. **Calculating Beta** Fill in the following table, supplying all the missing information. Use this information to calculate the security's beta.

Year	Returns		Return Deviations		Squared Deviations		Product of Deviations
	Security	Market	Security	Market	Security	Market	
1995	12%	6%					
1996	-9	-12					
1997	-6	0					
1998	30	-4					
1999	18	30					
Totals	45	20					

Chapter 18
Return, Risk, and the Security Market Line
Answers and solutions

Answers to Multiple Choice Questions

1. **D**
2. **A**
3. **A**
4. **D**
5. **B**
6. **B**
7. **B**
8. **C**
9. **B**
10. **D**
11. **D**
12. **D**
13. **A**
14. **A**
15. **D**

Answers to Questions and Problems

Core Questions

1. Some of the risk in holding any asset is unique to the asset in question. By investing in a variety of assets, this unique portion of the total risk can be eliminated at little cost. On the other hand, there are some risks that affect all investments. This portion of the total risk of an asset cannot be costlessly eliminated. In other words, systematic risk can be controlled, but only by a costly reduction in expected returns.

2. If the market expected the growth rate in the coming year to be 2 percent, then there would be no change in security prices if this expectation had been fully anticipated and priced. However, if the market had been expecting a growth rate different than 2 percent and the expectation was incorporated into security prices, then the government's announcement would most likely cause security prices in general to change; prices would drop if the anticipated growth rate had been more than 2 percent, and prices would rise if the anticipated growth rate had been less than 2 percent.

3. A. systematic
B. unsystematic
C. both; probably mostly systematic
D. unsystematic
E. unsystematic
F. systematic

4. A. an unexpected, systematic event occurred; market prices in general will most likely decline.
B. no unexpected event occurred; company price will most likely stay constant.
C. no unexpected, systematic event occurred; market prices in general will most likely stay constant.
D. an unexpected systematic risk has occurred; company price will most likely decline.
E. no unexpected, systematic event occurred unless the outcome was a surprise; market prices in general will most likely stay constant.

5. False. Expected returns depend on systematic risk, not total risk.

6. $ß_p = .3(1.2) + .2(.6) + .1(1.5) + .4(.8) = .95$

7. $ß_p = 1.0 = 1/3(0) + 1/3(1.6) + 1/3(ß_X)$; $ß_X = 1.4$

8. $E[r_i] = .08 + (.17 - .08)(1.2) = .188$

9. $E[r_i] = .13 = .07 + .08ß_i$; $ß_i = .75$

10. $E[r_i] = .17 = .075 + (E[r_{mkt}] - .075)(.9)$; $E[r_{mkt}] = .1806$

11. $E[r_i] = .22 = rf + (.16 - r_f)(1.6)$; $r_f = .06$

12. A. $E[r_p] = (.13 + .07)/2 = .1$
B. $ß_p = 0.6 = x_S(0.9) + (1 - x_S)(0)$; $x_S = 0.6/0.9 = .6666$; $x_{rf} = 1 - .6666 = .3333$
C. $E[r_p] = .11 = .13x_S + .07(1 - x_S)$; $x_S = 2/3$; $ß_p = 2/3(0.9) + 1/3(0) = 0.6$
D. $ß_p = 1.8 = x_S(0.9) + (1 - x_S)(0)$; $x_S = 1.8/0.9 = 2$; $x_{rf} = 1 - 2 = -1$
The portfolio is invested 200% in the stock and -100% in the risk-free asset. This represents borrowing at the risk-free rate to buy more of the stock.

<u>Intermediate Questions</u>

13. $ßp = x_W(1.6) + (1 - x_W)(0) = 1.6x_W$
$E[r_W] = .25 = .07 + MRP(1.60)$; $MRP = .18/1.6 = .1125$
$E[r_p] = .07 + .1125ß_p$; slope of line = MRP = .1125; $E[r_p] = .07 + .1125ß_p = .07 + .18x_W$

x_W	$E[r_p]$	$ß_p$	x_W	$E[r_p]$	$ß_p$
0%	.070	0.0	100%	.358	1.6
25	.115	0.4	125	.430	2.0
50	.214	0.8	150	.502	2.4
75	.286	1.2			

14. $E[r_i] = .06 + .113ß_i$
$.25 > E[r_Y] = .06 + .113(1.59) = .2397$; Y plots above the SML and is undervalued.
$.12 > E[r_Z] = .06 + .113(0.44) = .1097$; Z plots above the SML and is undervalued.

15. $[.25 - r_f]/1.59 = [.12 - r_f]/0.44$; $r_f = .0703$

16. $(E[r_A] - r_f)/ß_A = (E[r_B] - r_f)/ß_B$
$ß_A/ß_B = (E[r_A] - r_f)/(E[r_B] - r_f)$

17. Here we have two equations in two unknowns:

$E[r_{\text{Oxy Co.}}] = .23 = r_f + 1.35(r_m - r_f)$;
$.23 = r_f + 1.35r_m - 1.35r_f = 1.35r_m - .35r_f$;
$r_f = (1.35r_m - .23)/.35$

$E[r_{\text{More-On Co.}}] = .17 = r_f + .9(r_m - r_f)$
$.17 = r + .9(r_m - r_f) = r_f + .9r_m - .9r_f$
$r_m = (.17 - .1r_f)/.9 = .18889 - .1111r_f$

$r_f = [1.35(.18889 - .1111r_f) - .23]/.35$
$1.42857r_f = .07143$
$r_f = .05$

$r_m = (.17 - .1r_f)/.9 = .18889 - .1111r_f = (.17 -.005)/.09 = .1833$

18. Earnings contain information about recent sales and costs. This information is useful for projecting future growth rates and cash flows. Thus, unexpectedly low earnings often lead market participants to reduce estimates of future growth rates and cash flows; price drops are the result. The reverse is often true for unexpectedly high earnings.

19. Yes. It is possible, in theory, for a risky asset to have a beta of zero. Such an asset's return is simply uncorrelated with the overall market. Based on the CAPM, this asset's expected return would be equal to the risk-free rate. It is also possible to have a negative beta; the return would be less than the risk-free rate. A negative beta asset would carry a negative risk premium because of its value as a diversification instrument. A negative beta asset can be created by shorting an asset with a positive beta. A portfolio with a zero beta can always be created by combining long and short positions.

20. The rule is always "buy low, sell high." In this case, we buy the undervalued asset and sell (short) the overvalued one. It does not matter whether the two securities are misvalued with regard to some third security; all that matters is their relative value. In other words, the trade will be profitable as long as the relative misvaluation disappears; however, there is no guarantee that the relative misvaluation will disappear, so the profits are not certain.

21. From the chapter, $\beta_i = CORR(R_i, R_M) \times \sigma_i / \sigma_M$. Also, $CORR(R_i, R_M) = COV(R_i, R_M)/ \sigma_i \times \sigma_M$. Substituting this second result into the expression for β_i produces the desired result.

22.

Year	Returns		Return deviations		Squared deviations		Product of deviations
	Security	Market	Security	Market	Security	Market	
1995	12	6	3	2	9	4	6
1996	-9	-12	-18	-16	324	256	288
1997	-6	0	-15	-4	225	16	60
1998	30	-4	21	-8	441	64	-168
1999	18	30	9	26	81	676	234
Totals	45	20	0	0	1,080	1,016	420

	Average returns:	Variances:	Standard deviations:
Security:	45/5 = 9%	1,080/4 = 270	$\sqrt{270}$ = 16.43%
Market:	20/5 = 4%	1,016/4 = 254	$\sqrt{254}$ = 15.94%

Covariance = $COV(R_i, R_M) = 420/4 = 105$

Correlation = $CORR(R_i, R_M) = 105/(16.43 \times 15.94) = .40$

Beta = $\beta = .40 \times (16.43/15.94) = .41$

Notice that the security's beta is only .41 even though its return was higher over this period. This tells us that the security experienced some unexpected high returns due to positive unsystematic events.

Table 18.2 Risk and Return Summary

Summary of risk and return

I. Total risk

The *total risk* of an investment is measured by the variance or, more commonly, the standard deviation of its return.

II. Total return

The *total return* on an investment has two components: the expected return and the unexpected return. The unexpected return comes about because of unanticipated events. The risk from investing stems from the possibility of an unanticipated event.

III. Systematic and unsystematic risks

Systematic risks (also called *market risks*) are unanticipated events that affect almost all assets to some degree because the effects are economywide. *Unsystematic risks* are unanticipated events that affect single assets or small groups of assets. Unsystematic risks are also called *unique* or *asset-specific risks.*

IV. The effect of diversification

Some, but not all, of the risk associated with a risky investment can be eliminated by diversification. The reason is that unsystematic risks, which are unique to individual assets, tend to wash out in a large portfolio, but systematic risks, which affect all of the assets in a portfolio to some extent, do not.

V. The systematic risk principle and beta

Because unsystematic risk can be freely eliminated by diversification, the *systematic risk principle* states that the reward for bearing risk depends only on the level of systematic risk. The level of systematic risk in a particular asset, relative to the average, is given by the *beta* of that asset.

VI. The reward-to-risk ratio and the security market line

The *reward-to-risk ratio* for Asset i is the ratio of its risk premium, $E(R_i) - R_f$, to its beta, β_i:

$$\frac{E(R_i) - R_f}{\beta_i}$$

In a well-functioning market, this ratio is the same for every asset. As a result, when asset expected returns are plotted against asset betas, all assets plot on the same straight line, called the *security market line* (SML).

VII. The capital asset pricing model

From the SML, the expected return on Asset i can be written:

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i$$

This is the *capital asset pricing model* (CAPM). The expected return on a risky asset thus has three components. The first is the pure time value of money (R_f), the second is the market risk premium $[E(R_M) - R_f]$, and the third is the beta for that asset, (β_i).

Figure 18.1 Betas and Portfolio Returns

Fig. 18.1A Portfolio expected returns and betas for Asset A

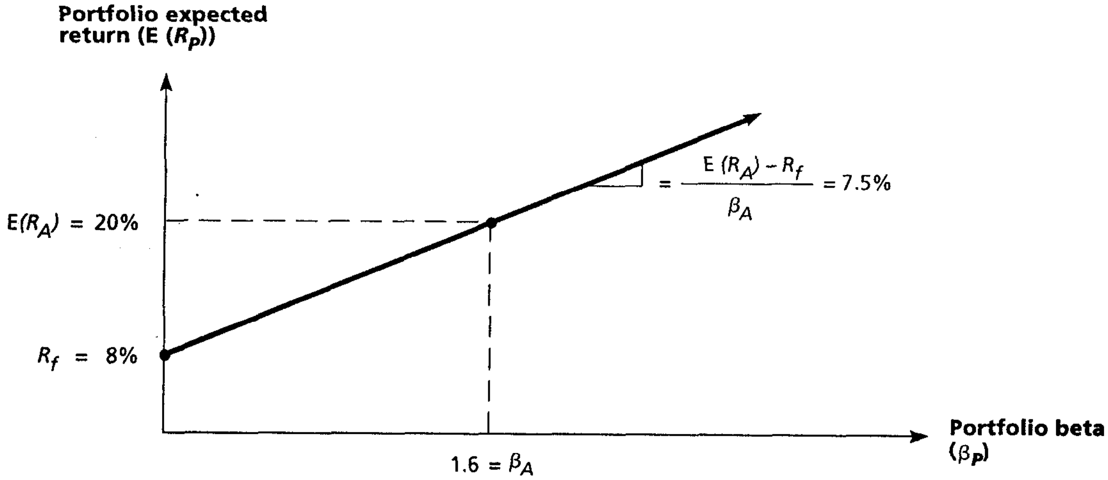


Fig. 18.1B Portfolio expected returns and betas for Asset B

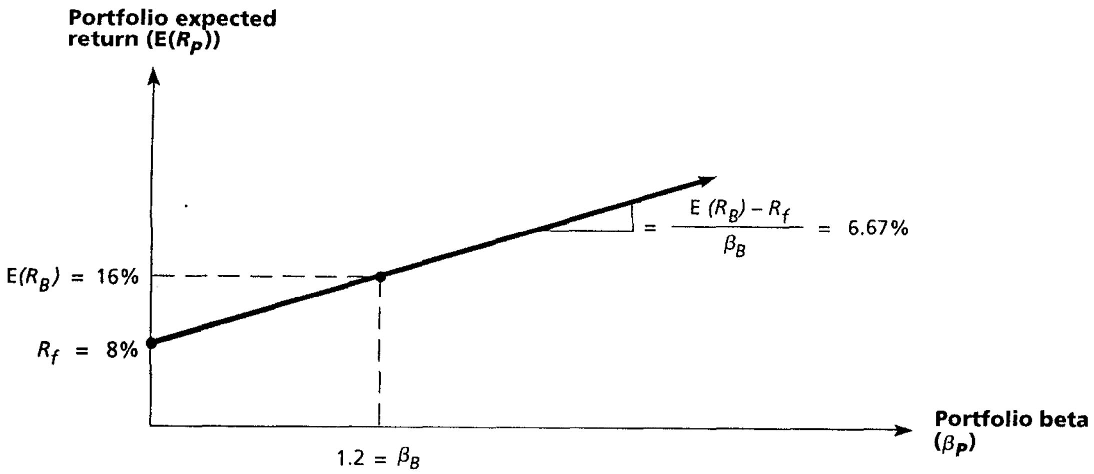


Fig. 18.1C Portfolio expected returns and betas for both assets

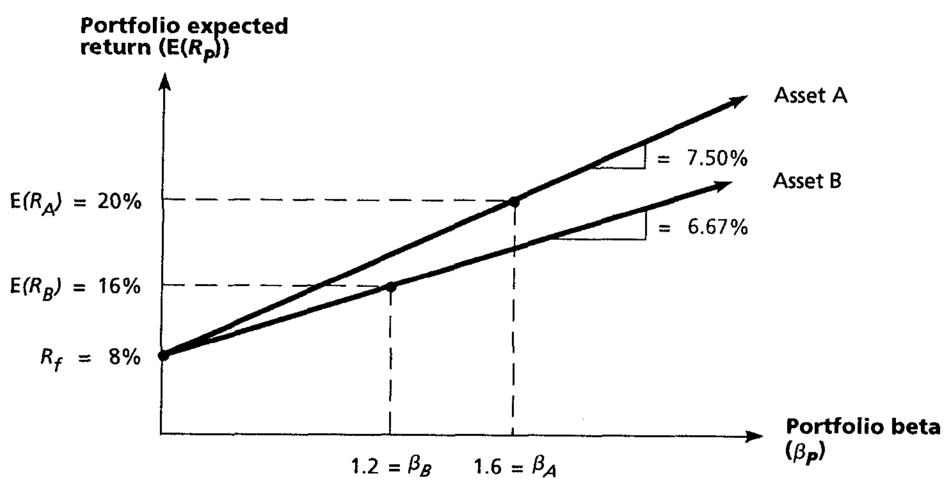
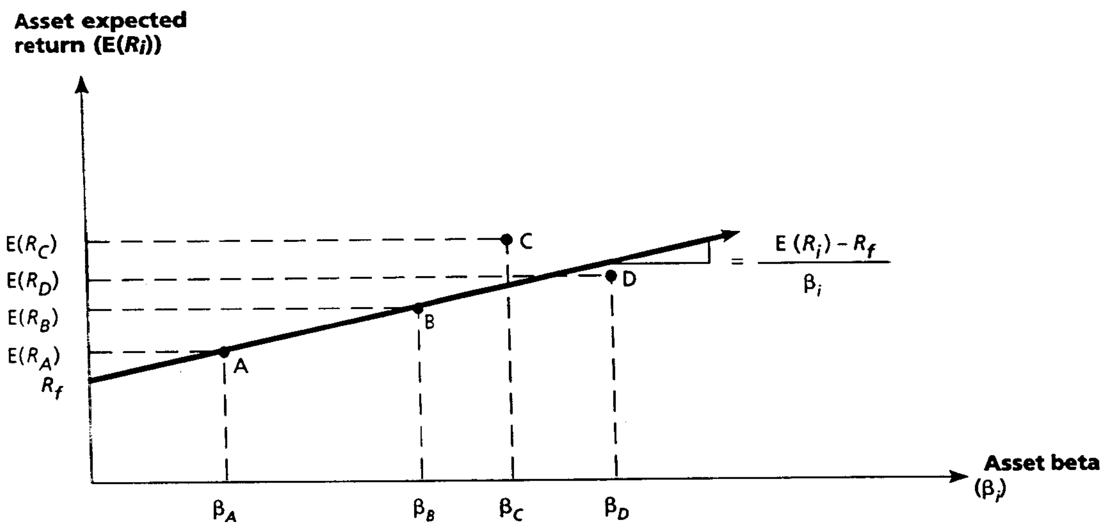
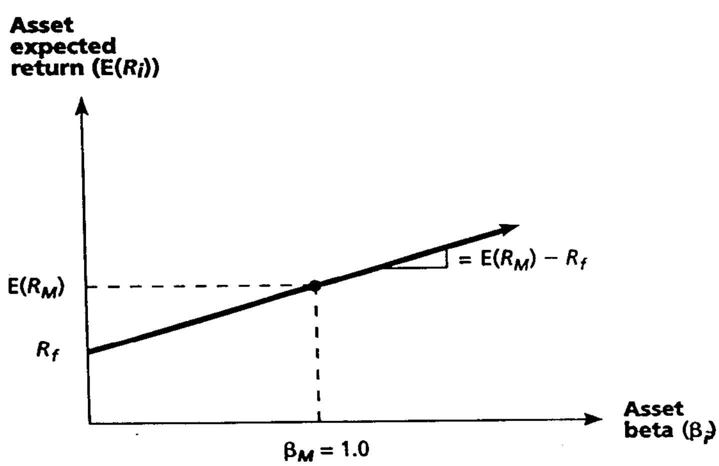


Figure 18.2 Expected returns and systematic risk



The fundamental relationship between beta and expected return is that all assets must have the same reward-to-risk ratio, $[E(R_i) - R_f]/\beta_i$. This means that they would all plot on the same straight line. Assets A and B are examples of this behavior. Asset C's expected return is too high; Asset D's is too low.

Figure 18.3 Security market line (SML)



The slope of the security market line is equal to the market risk premium; i.e., the reward for bearing an average amount of systematic risk. The equation describing the SML can be written:

$$E(R_i) = R_f + \beta_i \times [E(R_M) - R_f]$$

which is the capital asset pricing model (CAPM).

Figure 18.4

Unexpected Returns and Beta