CHAPTER 12

# Return, Risk and the Security Market Line

PART FOUR: RISK AND RETURN

## KEY NOTATIONS

| | |
|---|---|
| CAPM | Capital asset pricing model |
| E($R$) | Expected return |
| $R_f$ | Risk-free rate of return |
| $R_P$ | Portfolio return |
| $\beta$ | Beta or systematic risk |
| $\beta_P$ | Portfolio beta |
| $\sigma$ | Standard deviation of returns |
| $\sigma^2$ | Variance of returns |

## LEARNING OBJECTIVES

After studying this chapter, you should understand:

**LO1** How to calculate expected returns.

**LO2** The impact of diversification.

**LO3** The systematic risk principle.

**LO4** The security market line and the risk-return trade-off.

EVERY DAY, companies release news about their operations, and share prices respond as a result. In March 2010, WPP, ITV and Standard Chartered joined a host of other companies in announcing earnings. WPP announced a 'brutal year', with pre-tax profits down by 16.1 per cent. ITV stated that, while group revenues were down 7 per cent, it was able to make a pre-tax profit of £25 million. Finally, Standard Chartered announced a 13 per cent increase in pre-tax profits and a 7.2 per cent increase in dividends to shareholders. You would expect earnings increases to be good news and decreases to be bad news – they usually are. Even so, WPP's share price increased by 4.2 per cent, ITV fell by 3.5 per cent, and Standard Chartered grew by 6.4 per cent.

Although WPP's news seemed negative, its share price went up. Similarly, ITV's news seemed positive, but its share price fell. So when is good news really good news? The answer is fundamental to understanding risk and return, and the good news is this chapter explores it in some detail.

In our last chapter we learned some important lessons from capital market history. Most importantly, we learned 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 larger for riskier investments. This chapter explores the economic and managerial implications of this basic idea.

Thus far we have concentrated mainly on the return behaviour of a few large portfolios. We need to expand our consideration to include individual assets. Specifically, we have two tasks to accomplish. First, we have to define risk, and discuss how to measure it. We then must quantify the relationship between an asset's risk and its required return.

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 shall see, systematic risk affects almost all assets in the economy, at least to some degree, whereas unsystematic risk affects at most a small number of assets. We then develop the principle of diversification, which shows that highly diversified portfolios will tend to have almost no unsystematic risk.

The principle of diversification has an important implication: to a diversified investor, only systematic risk matters. It follows that in deciding whether to buy a particular individual asset, a diversified investor will be concerned only with that asset's systematic risk. This is a key observation, and it 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 centrepieces 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 determine the required return on an investment.

## 12.1 Expected Returns and Variances

In our previous chapter we discussed how to calculate average returns and variances using historical data. We now begin to discuss how to analyse returns and variances when the information we have concerns future possible returns and their probabilities.

### Expected Return

We start with a straightforward case. Consider a single period of time – say a year. We have two equities, L and U, which have the following characteristics. Equity L is expected to have a return of 25 per cent in the coming year. Equity U is expected to have a return of 20 per cent for the same period.

In a situation like this, if all investors agreed on the expected returns, why would anyone want to hold Equity U? After all, why invest in one equity when the expectation is that another will do better? Clearly, the answer must depend on the risk of the two investments. The return on Equity L, although it is *expected* to be 25 per cent, could actually turn out to be higher or lower.

For example, suppose the economy booms. In this case we think Equity L will have a 70 per cent return. If the economy enters a recession, we think the return will be –20 per cent. In this case we say that there are two *states of the economy*, which means that these are the only two possible situations. This set-up is oversimplified, of course, but it allows us to illustrate some key ideas without a lot of computation.

Suppose we think a boom and a recession are equally likely to happen, for a 50–50 chance of each. Table 12.1 illustrates the basic information we have described, and some

**TABLE 12.1**

| State of economy | Probability of state of economy | Rate of return if state occurs (%) | |
|---|---|---|---|
| | | Equity L | Equity U |
| Recession | 0.50 | –20 | 30 |
| Boom | 0.50 | 70 | 10 |
| | 1.00 | | |

**Table 12.1** States of the economy and equity returns

TABLE 12.2

| (1) State of economy | (2) Probability of state of economy | Equity L (3) Rate of return if state occurs | Equity L (4) Product (2) × (3) | Equity U (5) Rate of return if state occurs | Equity U (6) Product (2) × (5) |
|---|---|---|---|---|---|
| Recession | 0.50 | −0.20 | −0.10 | 0.30 | 0.15 |
| Boom | 0.50 | 0.70 | 0.35 | 0.10 | 0.05 |
| | 1.00 | $E(R_L) = 0.25 = 25\%$ | | $E(R_U) = 0.20 = 20\%$ | |

**Table 12.2** Calculation of expected return

additional information about Equity U. Notice that Equity U earns 30 per cent if there is a recession, and 10 per cent if there is a boom.

**expected return** The return on a risky asset expected in the future.

Obviously, if you buy one of these equities, say Equity U, what you earn in any particular year depends on what the economy does during that year. However, suppose the probabilities stay the same through time. If you hold Equity U for a number of years, you'll earn 30 per cent about half the time and 10 per cent the other half. In this case we say that your **expected return** on Equity U, $E(R_U)$, is 20 per cent:

$$E(R_U) = 0.50 \times 30\% + 0.50 \times 10\% = 20\%$$

In other words, you should expect to earn 20 per cent from this equity, on average.

For Equity L the probabilities are the same, but the possible returns are different. Here, we lose 20 per cent half the time, and we gain 70 per cent the other half. The expected return on L, $E(R_L)$, is thus 25 per cent:

$$E(R_L) = 0.50 \times -20\% + 0.50 \times 70\% = 25\%$$

Table 12.2 illustrates these calculations.

In our previous chapter we defined the risk premium as the difference between the return on a risky investment and that on a risk-free investment, and we calculated the historical risk premiums on some different investments. Using our projected returns, we can calculate the *projected*, or *expected*, *risk premium* as the difference between the expected return on a risky investment and the certain return on a risk-free investment.

For example, suppose risk-free investments are currently offering 8 per cent. We shall say that the risk-free rate, which we label as $R_f$, is 8 per cent. Given this, what is the projected risk premium on Equity U? On Equity L? Because the expected return on Equity U, $E(R_U)$, is 20 per cent, the projected risk premium is

$$\begin{aligned}\text{Risk premium} &= \text{Expected return} - \text{Risk-free rate} \\ &= E(R_U) - R_f \\ &= 20\% - 8\% \\ &= 12\%\end{aligned} \quad \textbf{(12.1)}$$

Similarly, the risk premium on Equity L is 25% – 8% = 17%.

In general, the expected return on a security or other asset is simply equal to the sum of the possible returns multiplied by their probabilities. So, if we had 100 possible returns, we would multiply each one by its probability and add up the results. The result would be the expected return. The risk premium would then be the difference between this expected return and the risk-free rate.

EXAMPLE 12.1

## Unequal Probabilities

Look again at Tables 12.1 and 12.2. Suppose you think a boom will occur only 20 per cent of the time instead of 50 per cent. What are the expected returns on Equities U and L in this case? If the risk-free rate is 10 per cent, what are the risk premiums?

The first thing to notice is that a recession must occur 80 per cent of the time (1 – 0.20 = 0.80), because there are only two possibilities. With this in mind, we see that Equity U has a 30 per cent return in 80 per cent of the years and a 10 per cent return in 20 per cent of the years. To calculate the expected return, we again just multiply the possibilities by the probabilities and add up the results:

$$E(R_U) = 0.80 \times 30\% + 0.20 \times 10\% = 26\%$$

Table 12.3 summarizes the calculations for both equities. Notice that the expected return on L is –2 per cent.

The risk premium for Equity U is 26% – 10% = 16% in this case. The risk premium for Equity L is negative: –2% – 10% = –12%. This is a little odd; but, for reasons we discuss later, it is not impossible.

| | | Equity L | | Equity U | |
|---|---|---|---|---|---|
| (1) State of economy | (2) Probability of state of economy | (3) Rate of return if state occurs | (4) Product (2) × (3) | (5) Rate of return if state occurs | (6) Product (2) × (5) |
| Recession | 0.80 | −0.20 | −0.16 | 0.30 | 0.24 |
| Boom | 0.20 | 0.70 | 0.14 | 0.10 | 0.02 |
| | | $E(R_L) = -0.2\%$ | | $E(R_U) = 0.26\%$ | |

**Table 12.3** Calculation of expected return

## Calculating the Variance

To calculate the variances of the returns on our two equities, we first determine the squared deviations from the expected return. We then multiply each possible squared deviation by its probability. We add these up, and the result is the variance. The standard deviation, as always, is the square root of the variance.

To illustrate, let us return to the Equity U we originally discussed, which has an expected return of $E(R_U) = 20\%$. In a given year it will actually return either 30 per cent or 10 per cent. The possible deviations are thus 30% – 20% = 10% and 10% – 20% = –10%. In this case, the variance is

$$\text{Variance} = \sigma^2 = 0.50 \times (10\%)^2 + 0.50 \times (-10\%)^2 = 0.01$$

The standard deviation is the square root of this:

$$\text{Standard deviation} = \sigma = \sqrt{0.01} = 0.10 = 10\%$$

TABLE 12.4

| (1) State of economy | (2) Probability of state of economy | (3) Return deviation from expected return | (4) Squared return deviation from expected return | (5) Product (2) × (4) |
|---|---|---|---|---|
| *Equity L* | | | | |
| Recession | 0.50 | −0.20 − 0.25 = −0.45 | $-0.45^2 = 0.2025$ | 0.10125 |
| Boom | 0.50 | 0.70 − 0.25 = 0.45 | $0.45^2 = 0.2025$ | 0.10125 |
| | | | | $\sigma_L^2 = 0.20250$ |
| *Equity U* | | | | |
| Recession | 0.50 | 0.30 − 0.20 = 0.10 | $0.10^2 = 0.01$ | 0.005 |
| Boom | 0.50 | 0.10 − 0.20 = −0.45 | $-0.10^2 = 0.01$ | 0.005 |
| | | | | $\sigma_U^2 = 0.010$ |

**Table 12.4** Calculation of variance

Table 12.4 summarizes these calculations for both equities. Notice that Equity L has a much larger variance.

When we put the expected return and variability information for our two equities together, we have the following:

| | **Equity L** | **Equity U** |
|---|---|---|
| Expected return, E(*R*) (%) | 25 | 20 |
| Variance, $\sigma^2$ | 0.2025 | 0.0100 |
| Standard deviation, $\sigma$ (%) | 45 | 10 |

Equity L has a higher expected return, but U has less risk. You could get a 70 per cent return on your investment in L, but you could also lose 20 per cent. Notice that an investment in U will always pay at least 10 per cent.

Which of these two equities should you buy? We can't really say; it depends on your personal preferences. We can be reasonably sure that some investors would prefer L to U, and some would prefer U to L.

You've probably noticed that the way we have calculated expected returns and variances here is somewhat different from the way we did it in the last chapter. The reason is that in Chapter 11 we were examining actual historical returns, so we estimated the average return and the variance based on some actual events. Here, we have projected *future* returns and their associated probabilities, so this is the information with which we must work.

EXAMPLE 12.2

## More Unequal Probabilities

Going back to Example 12.1, what are the variances on the two equities once we have unequal probabilities? The standard deviations?

We can summarize the needed calculations as follows:

| (1) State of economy | (2) Probability of state of economy | (3) Return deviation from expected return | (4) Squared return deviation from expected return | (5) Product (2) × (4) |
|---|---|---|---|---|
| *Equity L* | | | | |
| Recession | 0.80 | −0.20 − (−0.02) = −0.18 | 0.0324 | 0.02592 |
| Boom | 0.20 | 0.70 − (−0.02) = 0.72 | 0.5184 | 0.10368 |
| | | | | $\sigma_L^2 = 0.12960$ |
| *Equity U* | | | | |
| Recession | 0.80 | 0.30 − 0.26 = 0.04 | 0.0016 | 0.00128 |
| Boom | 0.20 | 0.10 − 0.26 = −0.16 | 0.0256 | 0.00512 |
| | | | | $\sigma_U^2 = 0.00640$ |

Based on these calculations, the standard deviation for L is $\sigma_L = \sqrt{0.1296} = 0.36 = 36\%$. The standard deviation for U is much smaller: $\sigma_U = \sqrt{0.0064} = 0.08 = 8\%$.

CONCEPT QUESTIONS

**12.1a** How do we calculate the expected return on a security?

**12.1b** In words, how do we calculate the variance of the expected return?

## 12.2 Portfolios

Thus far in this chapter we have concentrated on individual assets considered separately. However, most investors actually hold a **portfolio** of assets. All we mean by this is that investors tend to own more than just a single equity, bond, or other asset. Given that this is so, portfolio return and portfolio risk are of obvious relevance. Accordingly, we now discuss portfolio expected returns and variances.

**portfolio**
A group of assets such as equities and bonds held by an investor.

**portfolio weight**
The percentage of a portfolio's total value that is in a particular asset.

### Portfolio Weights

There are many equivalent ways of describing a portfolio. The most convenient approach is to list the percentage of the total portfolio's value that is invested in each portfolio asset. We call these percentages the **portfolio weights**.

For example, if we have €50 in one asset and €150 in another, our total portfolio is worth €200. The percentage of our portfolio in the first asset is €50/€200 = 0.25. The percentage of our portfolio in the second asset is €150/€200, or 0.75. Our portfolio weights are thus 0.25 and 0.75. Notice that the weights have to add up to 1.00, because all of our money is invested somewhere.[1]

### Portfolio Expected Returns

Let's go back to Equities L and U. You put half your money in each. The portfolio weights are obviously 0.50 and 0.50. What is the pattern of returns on this portfolio? The expected return?

TABLE 12.5

| (1) State of economy | (2) Probability of state of economy | (3) Portfolio return if state occurs | (4) Product (2) × (3) |
|---|---|---|---|
| Recession | 0.50 | $0.50 \times -20\% + 0.50 \times 30\% = 5\%$ | 0.025 |
| Boom | 0.50 | $0.50 \times 70\% + 0.50 \times 10\% = 40\%$ | 0.200 |
| | | | $E(R_P) = 22.5\%$ |

**Table 12.5** Expected return on an equally weighted portfolio of Equity L and Equity U

To answer these questions, suppose the economy actually enters a recession. In this case, half your money (the half in L) loses 20 per cent. The other half (the half in U) gains 30 per cent. Your portfolio return, $R_P$, in a recession is thus

$$R_P = 0.50 \times -20\% + 0.50 \times 30\% = 5\%$$

Table 12.5 summarizes the remaining calculations. Notice that when a boom occurs, your portfolio will return 40 per cent:

$$R_P = 0.50 \times 70\% + 0.50 \times 10\% = 40\%$$

As indicated in Table 12.5, the expected return on your portfolio, $E(R_P)$, is 22.5 per cent.

We can save ourselves some work by calculating the expected return more directly. Given these portfolio weights, we could have reasoned that we expect half of our money to earn 25 per cent (the half in L) and half of our money to earn 20 per cent (the half in U). Our portfolio expected return is thus

$$\begin{aligned} E(R_P) &= 0.50 \times E(R_L) + 0.50 \times E(R_U) \\ &= 0.50 \times 25\% + 0.50 \times 20\% \\ &= 22.5\% \end{aligned}$$

This is the same portfolio expected return we calculated previously.

This method of calculating the expected return on a portfolio works no matter how many assets there are in the portfolio. Suppose we had $n$ assets in our portfolio, where $n$ is any number. If we let $x_i$ stand for the percentage of our money in Asset $i$, then the expected return would be

$$E(R_P) = x_1 \times E(R_1) + x_2 \times E(R_2) + \ldots + x_n \times E(R_n) \qquad \textbf{(12.2)}$$

This says that the expected return on a portfolio is a straightforward combination of the expected returns on the assets in that portfolio. This seems somewhat obvious; but, as we shall examine next, the obvious approach is not always the right one.

EXAMPLE 12.3

## Portfolio Expected Return

Suppose we have the following projections for three equities:

| State of economy | Probability of state of economy | Returns if state occurs (%) | | |
|---|---|---|---|---|
| | | Equity A | Equity B | Equity C |
| Boom | 0.40 | 10 | 15 | 20 |
| Bust | 0.60 | 8 | 4 | 0 |

We want to calculate portfolio expected returns in two cases. First, what would be the expected return on a portfolio with equal amounts invested in each of the three equities? Second, what would be the expected return if half of the portfolio were in A, with the remainder equally divided between B and C?

Based on what we've learned from our earlier discussions, we can determine that the expected returns on the individual equities are (check these for practice):

$E(R_A) = 8.8\%$

$E(R_B) = 8.4\%$

$E(R_C) = 8.0\%$

If a portfolio has equal investments in each asset, the portfolio weights are all the same. Such a portfolio is said to be *equally weighted*. Because there are three equities in this case, the weights are all equal to $^1/_3$. The portfolio expected return is thus

$$E(R_P) = (1/3) \times 8.8\% + (1/3) \times 8.4\% + (1/3) \times 8\% = 8.4\%$$

In the second case, verify that the portfolio expected return is 8.5 per cent.

## Portfolio Variance

From our earlier discussion, the expected return on a portfolio that contains equal investments in Equities U and L is 22.5 per cent. What is the standard deviation of return on this portfolio? Simple intuition might suggest that because half of the money has a standard deviation of 45 per cent and the other half has a standard deviation of 10 per cent, the portfolio's standard deviation might be calculated as

$$\sigma_P = 0.50 \times 45\% + 0.50 \times 10\% = 27.5\%$$

Unfortunately, this approach is completely incorrect!

Let's see what the standard deviation really is. Table 12.6 summarizes the relevant calculations. As we see, the portfolio's variance is about 0.031, and its standard deviation is less than we thought – it's only 17.5 per cent. What is illustrated here is that the variance on a portfolio is not generally a simple combination of the variances of the assets in the portfolio.

We can illustrate this point a little more dramatically by considering a slightly different set of portfolio weights. Suppose we put 2/11 (about 18 per cent) in L and the other 9/11 (about 82 per cent) in U. If a recession occurs, this portfolio will have a return of:

$$R_P = (2/11) \times -20\% + (9/11) \times 30\% = 20.91\%$$

**TABLE 12.6**

| (1) State of economy | (2) Probability of state of economy | (3) Portfolio return if state occurs (%) | (4) Squared deviation from expected return | (5) Product (2) × (4) |
|---|---|---|---|---|
| Recession | 0.50 | 5 | $(0.05 - 0.225)^2 = 0.030625$ | 0.0153125 |
| Boom | 0.50 | 40 | $(0.40 - 0.225)^2 = 0.030625$ | 0.0153125 |
| | | | | $\sigma_P^2 = 0.030625$ |
| | | | | $\sigma_P = \sqrt{0.030625} = 17.5\%$ |

**Table 12.6** Variance on an equally weighted portfolio of Equity L and Equity U

If a boom occurs, this portfolio will have a return of

$$R_P = (2/11) \times 70\% + (9/11) \times 10\% = 20.91\%$$

Notice that the return is the same, no matter what happens. No further calculations are needed: this portfolio has a zero variance. Apparently, combining assets into portfolios can substantially alter the risks faced by the investor. This is a crucial observation, and we shall begin to explore its implications in the next section.

EXAMPLE 12.4

## Portfolio Variance and Standard Deviation

In Example 12.3, what are the standard deviations on the two portfolios? To answer, we first have to calculate the portfolio returns in the two states. We shall work with the second portfolio, which has 50 per cent in Equity A and 25 per cent in each of Equities B and C. The relevant calculations can be summarized as follows:

| State of economy | Probability of state of economy | Rate of return if state occurs (%) | | | |
|---|---|---|---|---|---|
| | | Equity A | Equity B | Equity C | Portfolio |
| Boom | 0.40 | 10 | 15 | 20 | 13.75 |
| Bust | 0.60 | 8 | 4 | 0 | 5.00 |

The portfolio return when the economy booms is calculated as

$$E(R_P) = 0.50 \times 10\% + 0.25 \times 15\% + 0.25 \times 20\% = 13.75\%$$

The return when the economy goes bust is calculated the same way. The expected return on the portfolio is 8.5 per cent. The variance is thus

$$\begin{aligned}\sigma_P^2 &= 0.40 \times (0.1375 - 0.085)^2 + 0.60 \times (0.05 - 0.085)^2 \\ &= 0.0018375\end{aligned}$$

The standard deviation is thus about 4.3 per cent. For our equally weighted portfolio, check to see that the standard deviation is about 5.4 per cent.

CONCEPT QUESTIONS

**12.2a** What is a portfolio weight?

**12.2b** How do we calculate the expected return on a portfolio?

**12.2c** Is there a simple relationship between the standard deviation on a portfolio and the standard deviations of the assets in the portfolio?

## 12.3 Announcements, Surprises and Expected Returns

Now that we know how to construct portfolios and evaluate their returns, we 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, for concreteness, we consider the return on the equity of a company called Flyers. What will determine this equity's return in, say, the coming year?

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

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

- News about Flyers research
- Government figures released on gross domestic product (GDP)
- 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' equity in the coming year would be

$$\begin{aligned}\text{Total return} &= \text{Expected return} + \text{Unexpected return}\\ R &= \mathrm{E}(R) + U\end{aligned} \qquad \textbf{(12.3)}$$

where $R$ stands for the actual total return in the year, $\mathrm{E}(R)$ 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, $\mathrm{E}(R)$, 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 the return. For example, suppose Flyers' business is such that the company prospers when GDP grows at a relatively high rate, and suffers when GDP is stagnant. In this case, in deciding what return to expect this year from owning equity in Flyers, shareholders either implicitly or explicitly must think about what GDP is likely to be for the year.

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

At the beginning of the year, market participants will have some idea or forecast of what the yearly GDP 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 equity, $\mathrm{E}(R)$. On the other hand, if the announced GDP is a surprise, 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 0.5 per cent. If the actual announcement this year is exactly 0.5 per cent, 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 share price as a result. This is like receiving confirmation of something you suspected all along; it doesn't reveal anything new.

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 cash in the future, we say it is worth less to us because of the time value of money. When we discount an announcement or a news item, we say that it has less of an impact on the price, because the market already knew much of it.

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

This distinction explains why what seems to be good news can actually be bad news (and vice versa). Going back to the companies we discussed in our chapter opener, even though ITV's earnings were up £25 million, the company experienced a drop in revenues, and the share price fell. Clearly, shareholders were concerned more by the fall in revenues than by the increase in earnings.

A key idea to keep in mind about news and price changes is that news about the future is what matters. For WPP, analysts accepted the bad news about earnings, but also noted that those numbers were, in a very real sense, yesterday's news. Looking to the future, the company's CEO announced that 2009 was a brutal year but 2010 'should be less worse!' and the market would stabilize.

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

$$\text{Announcement} = \text{Expected part} + \text{Surprise} \qquad \textbf{(12.4)}$$

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 equity. The surprise is the news that influences the unanticipated return on the equity, $U$.

Our discussion of market efficiency in the previous chapter 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.

Henceforth, when we speak of news, we shall mean the surprise part of an announcement, and not the portion that the market has expected and therefore already discounted.

CONCEPT QUESTIONS

**12.3a** What are the two basic parts of a return?

**12.3b** Under what conditions will a company's announcement have no effect on common share prices?

## 12.4 Risk: Systematic and Unsystematic

The unanticipated part of the return, that portion resulting from surprises, is the true 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 news about Flyers' chairman, its research, or its sales is of specific interest to Flyers. We shall distinguish between these two types of event because, as we shall see, they have different implications.

## Systematic and Unsystematic Risk

The first type of surprise – the one that affects many assets – we shall 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*.

**systematic risk**
A risk that influences a large number of assets. Also, *market risk*.

**unsystematic risk**
A risk that affects at most a small number of assets. Also, *unique* or *asset-specific risk*.

The second type of surprise we shall call **unsystematic risk**. An unsystematic risk is one that affects a single asset or 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 shall use these terms interchangeably.

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 the 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 company will primarily affect that company and, perhaps, a few others (such as main 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 make it out 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. We'll see some evidence on this point in just a moment.

The distinction between the types of risk allows us to break down the surprise portion, $U$, of the return on Flyers' equity into two parts. Earlier, we had the actual return broken down into its expected and surprise components:

$$R = \mathrm{E}(R) + U$$

We now recognize that the total surprise component for Flyers, $U$, has a systematic and an unsystematic component, so:

$$R = \mathrm{E}(R) + \text{Systematic portion} + \text{Unsystematic portion} \qquad \textbf{(12.5)}$$

Because it is traditional, we shall use the Greek letter epsilon, $\varepsilon$, to stand for the unsystematic portion. Because systematic risks are often called market risks, we shall 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:

$$\begin{aligned} R &= \mathrm{E}(R) + U \\ &= \mathrm{E}(R) + m + \varepsilon \end{aligned}$$

The important thing about the way we have broken down the total surprise, $U$, is that the unsystematic portion, $\varepsilon$, 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.

**CONCEPT QUESTIONS**

**12.4a** What are the two basic types of risk?
**12.4b** What is the distinction between the two types of risk?

## 12.5 Diversification and Portfolio Risk

We've seen earlier that portfolio risks can, in principle, be quite different from the risks of the assets that make up the portfolio. We now look more closely at the riskiness of an individual asset versus the risk of a portfolio of many different assets. We shall once again examine some market history to get an idea of what happens with actual investments in European capital markets.

### The Effect of Diversification: Another Lesson from Market History

In our previous chapter we saw that the standard deviation of the annual return on a portfolio of large European equities has historically been between 20 and 30 per cent per year. Does this mean that the standard deviation of the annual return on a typical equity in Europe is between 20 and 30 per cent? As you might suspect by now, the answer is *no*. This is an extremely important observation.

To illustrate the relationship between portfolio size and portfolio risk, Table 12.7 illustrates typical average annual standard deviations for equally weighted portfolios that contain different numbers of randomly selected securities.

In column 2 of Table 12.7 we see that the standard deviation for a 'portfolio' of one security is about 49 per cent. What this means is that if you randomly selected a single equity and put all your money into it, your standard deviation of return would typically be a substantial 49 per cent per year. If you were to randomly select two equities and invest half your money in each, your standard deviation would be about 37 per cent on average, and so on.

TABLE 12.7

| (1) Number of equities in portfolio | (2) Average standard deviation of annual portfolio returns (%) | (3) Ratio of portfolio standard deviation to standard deviation of a single equity |
|---|---|---|
| 1 | 49.24 | 1.00 |
| 2 | 37.36 | 0.76 |
| 4 | 29.69 | 0.60 |
| 6 | 26.64 | 0.54 |
| 8 | 24.98 | 0.51 |
| 10 | 23.93 | 0.49 |
| 20 | 21.68 | 0.44 |
| 30 | 20.87 | 0.42 |
| 40 | 20.46 | 0.42 |
| 50 | 20.20 | 0.41 |
| 100 | 19.69 | 0.40 |
| 200 | 19.42 | 0.39 |
| 300 | 19.34 | 0.39 |
| 400 | 19.29 | 0.39 |
| 500 | 19.27 | 0.39 |
| 1,000 | 19.21 | 0.39 |

*Source*: Table 1 in M. Statman, 'How many stocks make a diversified portfolio?' *Journal of Financial and Quantitative Analysis* (1987), vol. 22, no. 3, pp. 353–364. Derived from E.J. Elton and M.J. Gruber, 'Risk reduction and portfolio size: an analytic solution', *Journal of Business* (1977), vol. 50, October, pp. 415–437.

**Table 12.7** Standard deviations of annual portfolio returns

The important thing to notice in Table 12.7 is that the standard deviation declines as the number of securities is increased. By the time we have 100 randomly chosen equities, the portfolio's standard deviation has declined by about 60 per cent, from 49 per cent to about 20 per cent. With 500 securities the standard deviation is 19.27 per cent, similar to the 20 per cent we saw in our previous chapter for the large UK company portfolio.

## The Principle of Diversification

Figure 12.1 illustrates the point we've been discussing. What we have plotted is the standard deviation of return versus the number of equities in the portfolio. Notice in Fig. 12.1 that the benefit in terms of risk reduction from adding securities drops off as we add more and more. By the time we have 10 securities, most of the effect is already realized; and by the time we get to 30 or so, there is little remaining benefit.

Figure 12.1 illustrates two key points. First, some of the riskiness associated with individual assets can be eliminated by forming portfolios. The process of spreading an investment across assets (and thereby forming a portfolio) is called *diversification*. The **principle of diversification** tells us that spreading an investment across many assets will eliminate some of the risk. The blue shaded area in Fig. 12.1, labelled 'Diversifiable risk', is the part that can be eliminated by diversification.

**principle of diversification** Spreading an investment across a number of assets will eliminate some, but not all, of the risk.

The second point is equally important. There is a minimum level of risk that cannot be eliminated simply by diversifying. This minimum level is labelled 'Non-diversifiable risk' in Fig. 12.1. Taken together, these two points are another important lesson from capital market history: diversification reduces risk, but only up to a point. Put another way, some risk is diversifiable and some is not.

To give a recent example of the impact of diversification, the FTSE 100, which is a widely followed stock market index of 100 large, well-known British companies, stayed level on 9 March 2010. The biggest individual gainers for the day were Antofagasta (up 1.1 per cent), GlaxoSmithKline (up 1.6 per cent), and SAB Miller (up 1.1 per cent). The losers included Liberty International (down 4.1 per cent) and various banks (e.g. Lloyds Banking Group, Royal Bank of Scotland, and HSBC), who were down between 0.7 and 2.8 per cent. Again, the lesson is clear: diversification reduces exposure to extreme outcomes, both good and bad.

FIGURE 12.1

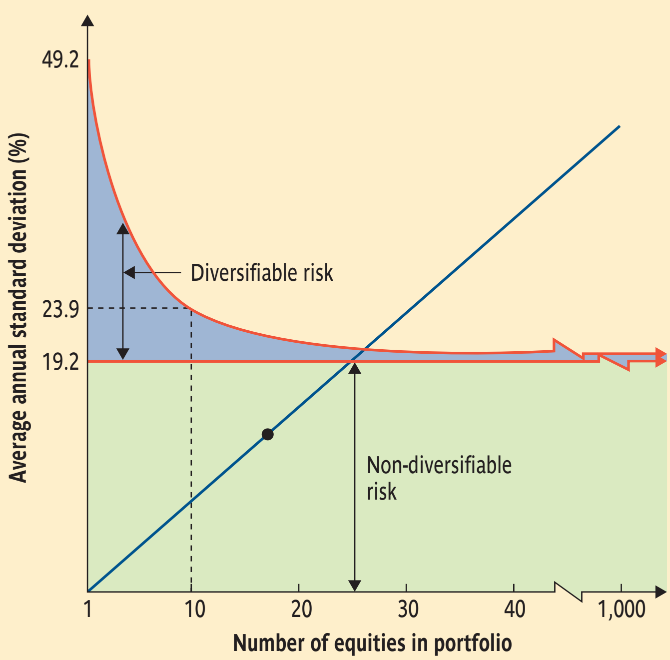



**Figure 12.1** Portfolio diversification

## Diversification and Unsystematic Risk

From our discussion of portfolio risk, we know 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 we made earlier between systematic and unsystematic risk.

By definition, an unsystematic risk is one that is particular to a single asset or, at most, a small group. For example, if the asset under consideration is equity in a single company, the discovery of positive-NPV projects such as successful new products and innovative cost savings will tend to increase the value of the equity. 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 held only a single equity, the value of our investment would fluctuate because of company-specific events. If we hold a large portfolio, on the other hand, some of the equities 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 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 diversifying. 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 to some degree. As a result, no matter how many assets we put into a portfolio, the systematic risk doesn't go away. Thus, for obvious reasons, the terms *systematic risk* and *non-diversifiable 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, as measured by the standard deviation of its return, can be written as

$$\text{Total risk} = \text{Systematic risk} + \text{Unsystematic risk} \qquad \textbf{(12.6)}$$

Systematic risk is also called *non-diversifiable risk* or *market risk*. Unsystematic risk is also called *diversifiable risk*, *unique risk*, or *asset-specific risk*. For a well-diversified portfolio, the unsystematic risk is negligible. For such a portfolio, essentially all of the risk is systematic.

**CONCEPT QUESTIONS**

**12.5a** What happens to the standard deviation of return for a portfolio if we increase the number of securities in the portfolio?
**12.5b** What is the principle of diversification?
**12.5c** Why is some risk diversifiable? Why is some risk not diversifiable?
**12.5d** Why can't systematic risk be diversified away?

# 12.6 Systematic Risk and Beta

The question that we now begin to address is this: 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 to these questions, 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 essentially be 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, 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. 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. Put another way, the market does not reward risks that are borne unnecessarily.

**systematic risk principle** The expected return on a risky asset depends only on that asset's systematic risk.

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

*The expected return on an asset depends only on that asset's 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 shall use is called the **beta coefficient**, for which we shall use the Greek letter $\beta$. A beta coefficient, or 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 0.50, therefore, has half as much systematic risk as an average asset; an asset with a beta of 2.0 has twice as much.

**beta coefficient** The amount of systematic risk present in a particular risky asset relative to that in an average risky asset.

Table 12.8 contains the estimated beta coefficients for the equities of some well-known companies. The range of betas in Table 12.8 is typical for equities of large European corporations. Betas outside this range occur, but they are less common.

The important thing to remember is that the expected return, and thus the risk premium, of 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 12.8, an investor who buys equity in Volkswagen, with a beta of 0.40, should expect to earn less, on average, than an investor who buys equity in Renault, with a beta of about 1.64.

One cautionary note is in order: not all betas are created equal. Different providers use somewhat different methods for estimating betas, and significant differences sometimes

TABLE 12.8

| Equity | Beta |
|---|---|
| Alcatel-Lucent | 1.44 |
| L'Oreal | 0.45 |
| SAP | 0.56 |
| Siemens | 1.51 |
| Daimler | 1.25 |
| Philips Electron | 0.92 |
| Renault | 1.64 |
| Volkswagen | 0.40 |

*Source*: Yahoo! Finance. 

**Table 12.8** Beta coefficients for selected companies occur. As a result, it is a good idea to look at several sources. See our nearby Work the Web box for more about beta.

EXAMPLE 12.5

## Total Risk versus Beta

Consider the following information about 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 | 0.50 |
| 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 relationship to the risks of the assets in the portfolio. A portfolio beta, however, can be calculated, just like a portfolio expected return. For example, looking again at Table 12.8, suppose you put half of your money in L'Oréal and half in Siemens. What would the beta of this combination be? Because L'Oréal has a beta of 0.45 and Siemens has a beta of 1.51, the portfolio's beta, $\beta_P$, would be

$$\begin{aligned}\beta_P &= 0.50 \times \beta_{\text{L'Oréal}} + 0.50 \times \beta_{\text{Siemens}} \\ &= 0.50 \times 0.45 + 0.50 \times 1.51 \\ &= 0.98\end{aligned}$$

## Work the Web

You can find beta estimates at many sites on the Web. One of the best is Yahoo! Finance. Here is a snapshot of the 'Key Statistics' screen for the brokerage firm ICAP plc:

| RISK ANALYSIS | |
|---|---|
| Alpha: | -0.004 |
| Beta: | 1.5436 |
| R2: | 0.329 |
| Relative Performance: | -23.9528% |
| Relative Strength: | -2.8183 |
| Retractment from maximum: | -22.2198% |
| Quarterly Volatility: | 57.6177% |
| Distance to 20 days moving average: | 9.797% |
| Distance to 200 days moving average: | -13.886% |

The reported beta for ICAP is 1.54, which means that ICAP has about one and a half times the systematic risk of a typical equity. You would expect that the company is quite risky; and, looking at the other numbers, we agree.

### QUESTIONS

1 Explore the other pages on Yahoo! Finance relating to ICAP plc. From your own assessment, explain why you think ICAP has greater risk than the average equity.

2 What growth rate are analysts projecting for ICAP plc? How does this growth rate compare with the industry?

In general, if we had many 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 12.6

## Portfolio Betas

Suppose we had the following investments:

| Security | Amount invested (€) | Expected return (%) | Beta |
|---|---|---|---|
| Equity A | 1,000 | 8 | 0.80 |
| Equity B | 2,000 | 12 | 0.95 |
| Equity C | 3,000 | 15 | 1.10 |
| Equity 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 Equity A. Similarly, 20 per cent is invested in Equity B, 30 per cent is invested in Equity C, and 40 per cent is invested in Equity D. The expected return, $E(R_P)$, is thus

$$\begin{aligned} E(R_P) &= 0.10 \times E(R_A) + 0.20 \times E(R_B) + 0.30 \times E(R_C) + 0.40 \times E(R_D) \\ &= 0.10 \times 8\% + 0.20 \times 12\% + 0.30 \times 15\% + 0.40 \times 18\% \\ &= 14.9\% \end{aligned}$$

Similarly, the portfolio beta, $\beta_P$, is

$$\begin{aligned} \beta_P &= 0.10 \times \beta_A + 0.20 \times \beta_B + 0.30 \times \beta_C + 0.40 \times \beta_D \\ &= 0.10 \times 0.80 + 0.20 \times 0.95 + 0.30 \times 1.10 + 0.40 \times 1.40 \\ &= 1.16 \end{aligned}$$

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

CONCEPT QUESTIONS

12.6a What is the systematic risk principle?
12.6b What does a beta coefficient measure?
12.6c True or false: the expected return on a risky asset depends on that asset's total risk. Explain.
12.6d How do you calculate a portfolio beta?

# 12.7 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 $\beta_A = 1.6$. Furthermore, 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 per cent of the portfolio is invested in Asset A, then the expected return is

$$\begin{aligned} E(R_P) &= 0.25 \times E(R_A) + (1 - 0.25) \times R_f \\ &= 0.25 \times 20\% + 0.75 \times 8\% \\ &= 11\% \end{aligned}$$

Similarly, the beta on the portfolio, $\beta_P$, would be

$$\begin{aligned} \beta_P &= 0.25 \times \beta_A + (1 - 0.25) \times 0 \\ &= 0.25 \times 1.6 \\ &= 0.40 \end{aligned}$$

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 per cent. The answer is yes. This can happen if the investor borrows at the risk-free rate. For example, suppose an investor has €100 and borrows an additional €50 at 8 per cent, the risk-free rate. The total investment in Asset A would be €150, or 150 per cent of the investor's wealth. The expected return in this case would be

$$\begin{aligned} E(R_P) &= 1.50 \times E(R_A) + (1 - 1.50) \times R_f \\ &= 1.50 \times 20\% - 0.50 \times 8\% \\ &= 26\% \end{aligned}$$

The beta on the portfolio would be

$$\begin{aligned} \beta_P &= 1.50 \times \beta_A + (1 - 1.50) \times 0 \\ &= 1.50 \times 1.6 \\ &= 2.4 \end{aligned}$$

We can calculate some other possibilities, as follows:

| Percentage of portfolio in Asset A (%) | Portfolio expected return (%) | Portfolio beta |
|---|---|---|
| 0 | 8 | 0.0 |
| 25 | 11 | 0.4 |
| 50 | 14 | 0.8 |
| 75 | 17 | 1.2 |
| 100 | 20 | 1.6 |
| 125 | 23 | 2.0 |
| 150 | 26 | 2.4 |

In Fig. 12.2 these portfolio expected returns are plotted against the portfolio betas. Notice that all the combinations fall on a straight line.

**The Reward-to-Risk Ratio** What is the slope of the straight line in Fig. 12.2(a)? 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 per cent to 20 per cent, a 'rise' of 12 per cent. The slope of the line is thus 12%/1.6 = 7.5%.

FIGURE 12.2

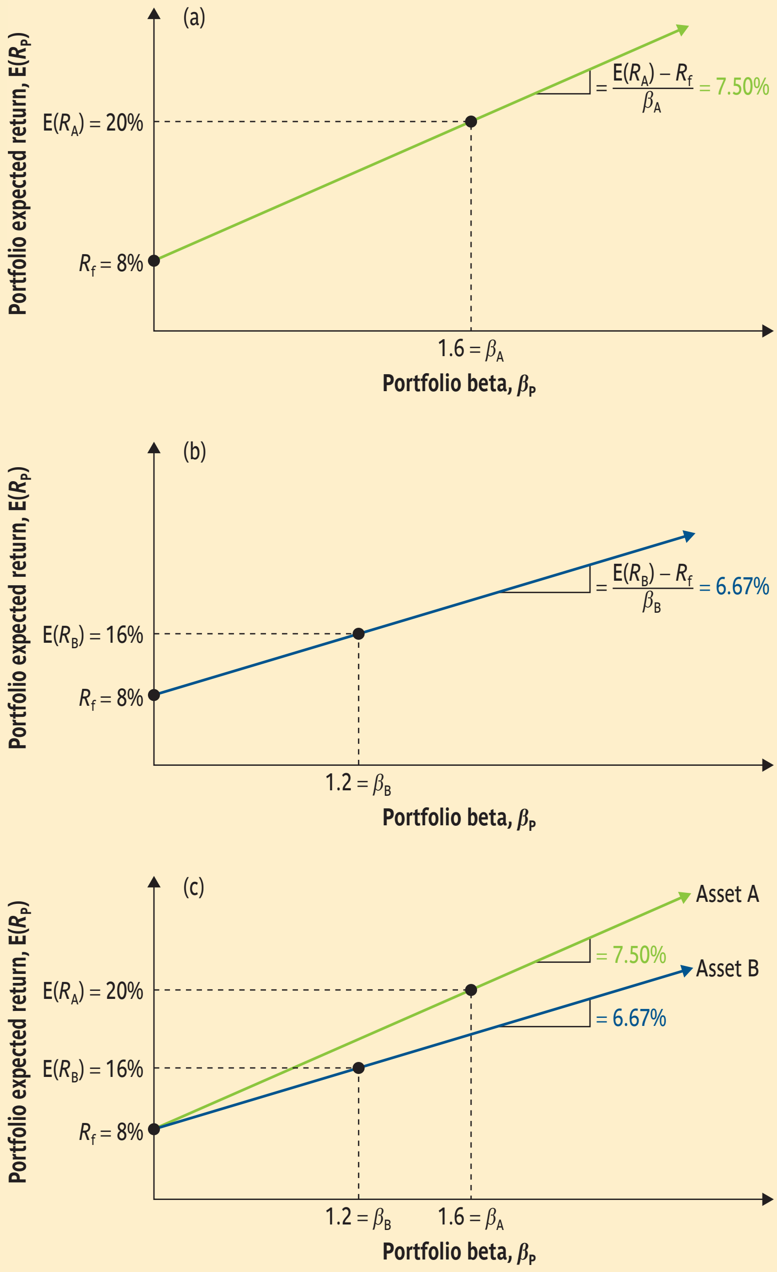



**Figure 12.2** (a) Portfolio expected returns and betas for Asset A; (b) Portfolio expected returns and betas for Asset B; (c) Portfolio expected returns and betas for both assets

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, $\beta_A$:

$$\text{Slope} = \frac{E(R_A) - R_f}{\beta_A} = \frac{20\% - 8\%}{1.6} = 7.5\%$$

What this tells us is that Asset A offers a *reward-to-risk* ratio of 7.5 per cent.[2] In other words, Asset A has a risk premium of 7.50 per cent 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 per cent. Which investment is better, Asset A or Asset B? You might think that, once again, 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 shall 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 per cent in Asset B and the remaining 75 per cent in the risk-free asset, the portfolio's expected return will be

$$\begin{aligned} E(R_P) &= 0.25 \times E(R_B) + (1 - 0.25) \times R_f \\ &= 0.25 \times 16\% + 0.75 \times 8\% \\ &= 10\% \end{aligned}$$

Similarly, the beta on the portfolio, $\beta_P$, would be

$$\begin{aligned} \beta_P &= 0.25 \times \beta_B + (1 - 0.25) \times 0 \\ &= 0.25 \times 1.2 \\ &= 0.30 \end{aligned}$$

Some other possibilities are as follows:

| Percentage of portfolio in Asset B (%) | Portfolio expected return (%) | Portfolio beta |
|---|---|---|
| 0 | 8 | 0.0 |
| 25 | 10 | 0.3 |
| 50 | 12 | 0.6 |
| 75 | 14 | 0.9 |
| 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 Fig. 12.2(b) 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 Fig. 12.2(c), the line describing the combinations of expected returns and betas for Asset A is higher than the one for Asset B. This tells us 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 A offers a superior return for its level of risk is to note that the slope of our line for Asset B is

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

Thus Asset B has a reward-to-risk ratio of 6.67 per cent, which is less than the 7.5 per cent 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

$$\frac{E(R_A) - R_f}{\beta_A} = \frac{E(R_B) - R_f}{\beta_B}$$

This is the fundamental relationship between risk and return.

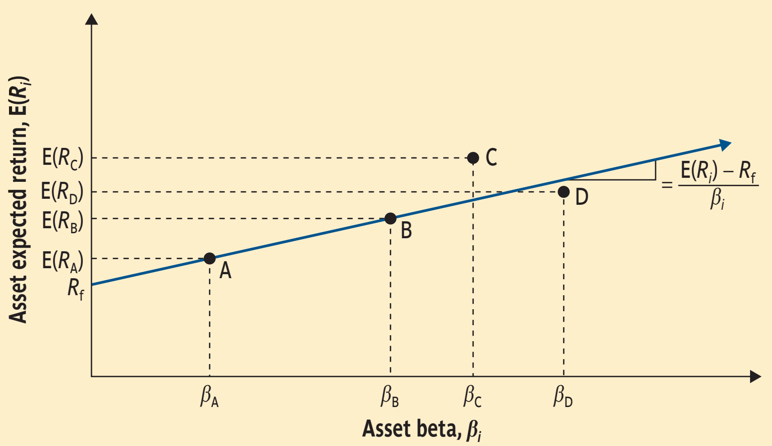
Our basic argument can be extended to more than just two assets. In fact, no matter how many assets we had, we would always reach the same conclusion:

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

This result is really not so 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 of the 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 Fig. 12.3. 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 Fig. 12.3, its price would rise and its expected

FIGURE 12.3




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 behaviour. Asset C's expected return is too high; asset D's is too low.

**Figure 12.3** Expected returns and systematic risk return would fall until it plotted exactly on the line. Similarly, if an asset plotted below the line, such as D in Fig. 12.3, its expected return would rise until it too plotted directly on the line.

The arguments we have presented apply to active, competitive, well-functioning markets. The financial markets, including the LSE, Euronext and Deutsche Börse, 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 financial markets. We shall thus focus on such markets here. However, as discussed in a later section, the information about risk and return gleaned from financial markets is crucial in evaluating the investments that a corporation makes in real assets.

EXAMPLE 12.7

### Buy Low, Sell High

An asset is said to be *overvalued* if its price is too high, given its expected return and risk. Suppose you observe the following situation:

| Security | Beta | Expected return (%) |
|---|---|---|
| SWMS plc | 1.3 | 14 |
| Insec plc | 0.8 | 10 |

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

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

## The Security Market Line

**security market line (SML)**
A positively sloped straight line displaying the relationship between expected return and beta.

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)**. After NPV, the SML is arguably the most important concept in modern finance.

**Market Portfolios** It will be very useful to know the equation of the SML. There are many different ways we could write it, but one way is particularly common. 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 shall 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, $\beta_M$. 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

$$\begin{aligned}\text{SML slope} &= \frac{E(R_M) - R_f}{\beta_M} \\ &= \frac{E(R_M) - R_f}{1} \\ &= E(R_M) - R_f\end{aligned}$$

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

**market risk premium** The slope of the SML – the difference between the expected return on a market portfolio and the risk-free rate.

**capital asset pricing model (CAPM)** The equation of the SML showing the relationship between expected return and beta.

**The Capital Asset Pricing Model** To finish up, if we let $E(R_i)$ and $\beta_i$ 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 the overall market's:

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

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

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i \qquad \textbf{(12.7)}$$

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

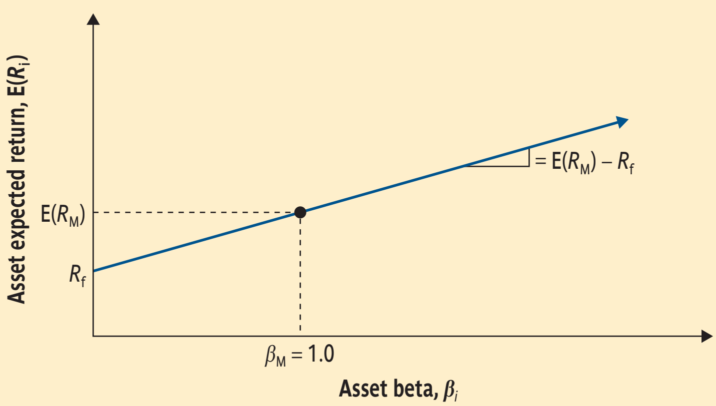
The CAPM shows that the expected return for a particular asset depends on three things:

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 in addition to waiting.
3. *The amount of systematic risk*: As measured by $\beta_i$, this is the amount of systematic risk present in a particular asset or portfolio, 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 $\beta$. To find the expected return on a portfolio, we simply use this $\beta$ in the CAPM equation.

Figure 12.4 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 12.4




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

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

which is the capital asset pricing model (CAPM).

**Figure 12.4** The security market line (SML)

This concludes our presentation of concepts related to the risk–return trade-off. For future reference, Table 12.9 summarizes the various concepts in the order in which we discussed them.

TABLE 12.9

**Total risk**

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

**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.

**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 economy-wide. *Unsystematic risks* are unanticipated events that affect single assets or small groups of assets. Unsystematic risks are also called *unique* or *asset-specific risks*.

**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.

**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.

**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, $\beta_i$:

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

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).

**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, ($\beta_i$).

**Table 12.9** Summary of risk and return

EXAMPLE 12.8

## Risk and Return

Suppose the risk-free rate is 4 per cent, the market risk premium is 8.6 per cent, and a particular equity has a beta of 1.3. Based on the CAPM, what is the expected return on this equity? What would the expected return be if the beta were to double?

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

CONCEPT QUESTIONS

**12.7a** What is the fundamental relationship between risk and return in well-functioning markets?

**12.7b** What is the security market line? Why must all assets plot directly on it in a well-functioning market?

**12.7c** What is the capital asset pricing model (CAPM)? What does it tell us about the required return on a risky investment?

# 12.8 The SML and the Cost of Capital: A Preview

Our goal in studying risk and return is twofold. First, risk is an extremely important consideration in almost all business decisions, so we want to discuss just what risk is and how it is rewarded in the market. Our second purpose is to learn what determines the appropriate discount rate for future cash flows. We briefly discuss this second subject now; we shall discuss it in more detail in a subsequent chapter.

## The Basic Idea

The security market line tells us the reward for bearing risk in financial markets. At an absolute minimum, any new investment our firm undertakes must offer an expected return that is no worse than what the financial markets offer for the same risk. The reason for this is simply that our shareholders can always invest for themselves in the financial markets.

The only way we benefit our shareholders is by finding investments with expected returns that are superior to what the financial markets offer for the same risk. Such an investment will have a positive NPV. So, if we ask 'What is the appropriate discount rate?', the answer is that we should use the expected return offered in financial markets on investments with the same systematic risk.

In other words, to determine whether an investment has a positive NPV, we essentially compare the expected return on that new investment with what the financial market offers on an investment with the same beta. This is why the SML is so important: it tells us the 'going rate' for bearing risk in the economy.

## The Cost of Capital

The appropriate discount rate on a new project is the minimum expected rate of return an investment must offer to be attractive. This minimum required return is often called the **cost of capital** associated with the investment. It is called this because the required return is what the firm must earn on its capital investment in

**cost of capital**
The minimum required return on a new investment.

a project just to break even. It can thus be interpreted as the opportunity cost associated with the firm's capital investment.

Notice that when we say an investment is attractive if its expected return exceeds what is offered in financial markets for investments of the same risk, we are effectively using the internal rate of return (IRR) criterion that we developed and discussed in Chapter 8. The only difference is that we now have a much better idea of what determines the required return on an investment. This understanding will be critical when we discuss cost of capital and capital structure in Part Five of our book.

**CONCEPT QUESTIONS**

**12.8a** If an investment has a positive NPV, would it plot above or below the SML? Why?

**12.8b** What is meant by the term *cost of capital?*

## Summary and Conclusions

This chapter has covered the essentials of risk. 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. Once we know this, we have a benchmark against which we can compare the returns expected from real asset investments to determine whether they are desirable.

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, $\beta_i$. 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).

This chapter completes our discussion of risk and return. Now that we have a better understanding of what determines a firm's cost of capital for an investment, the next several chapters will examine more closely how firms raise the long-term capital needed for investment.

## Chapter Review and Self-Test Problems

**12.1 Expected Return and Standard Deviation** This problem will give you some practice calculating measures of prospective portfolio performance. There are two assets and three states of the economy:

| State of economy | Probability of state of economy | Rate of return if state occurs | |
|---|---|---|---|
| | | Equity A | Equity B |
| Recession | 0.20 | –0.15 | 0.20 |
| Normal | 0.50 | 0.20 | 0.30 |
| Boom | 0.30 | 0.60 | 0.40 |

What are the expected returns and standard deviations for these two equities?

**12.2 Portfolio Risk and Return** Using the information in the previous problem, suppose you have £20,000 total. If you put £15,000 in Equity A and the remainder in Equity B, what will be the expected return and standard deviation of your portfolio?

**12.3 Risk and Return** Suppose you observe the following situation:

| Security | Beta | Expected return (%) |
|---|---|---|
| Cooley NV | 1.8 | 22.00 |
| Moyer NV | 1.6 | 20.44 |

If the risk-free rate is 7 per cent, are these securities correctly priced? What would the risk-free rate have to be if they are correctly priced?

**12.4 CAPM** Suppose the risk-free rate is 8 per cent. The expected return on the market is 16 per cent. If a particular equity has a beta of 0.7, what is its expected return based on the CAPM? If another equity has an expected return of 24 per cent, what must its beta be?

## Answers to Chapter Review and Self-Test Problems

12.1 The expected returns are just the possible returns multiplied by the associated probabilities:

$$E(R_A) = (0.20 \times -0.15) + (0.50 \times 0.20) + (0.30 \times 0.60) = 25\%$$
$$E(R_B) = (0.20 \times 0.20) + (0.50 \times 0.30) + (0.30 \times 0.40) = 31\%$$

The variances are given by the sums of the squared deviations from the expected returns multiplied by their probabilities:

$$\begin{aligned}\sigma_A^2 &= 0.20 \times (-0.15 - 0.25)^2 + 0.50 \times (0.20 - 0.25)^2 + 0.30 \times (0.60 - 0.25)^2 \\ &= (0.20 \times -0.40^2) + (0.50 \times -0.05^2) + (0.30 \times 0.35^2) \\ &= (0.20 \times 0.16) + (0.50 \times 0.0025) + (0.30 \times 0.1225) \\ &= 0.0700\end{aligned}$$

$$\begin{aligned}\sigma_B^2 &= 20 \times (0.20 - 0.31)^2 + 0.50 \times (0.30 - 0.31)^2 + 0.30 \times (0.40 - 0.31)^2 \\ &= (0.20 \times 0.11^2) + (0.50 \times 0.01^2) + (0.30 \times 0.09^2) \\ &= (0.20 \times 0.0121) + (0.50 \times 0.0001) + (0.30 \times 0.0081) \\ &= 0.0049\end{aligned}$$

The standard deviations are thus

$$\sigma_A = \sqrt{0.0700} = 26.46\%$$
$$\sigma_B = \sqrt{0.0049} = 7\%$$

**12.2** The portfolio weights are £15,000/20,000 = 0.75 and £5,000/20,000 = 0.25. The expected return is thus

$$\begin{aligned} E(R_P) &= 0.75 \times E(R_A) + 0.25 \times E(R_B) \\ &= (0.75 \times 25\%) + (0.25 \times 31\%) \\ &= 26.5\% \end{aligned}$$

Alternatively, we could calculate the portfolio's return in each of the states:

| State of economy | Probability of state of economy | Portfolio return if state occurs |
|---|---|---|
| Recession | .20 | (0.75 × –0.15) + (0.25 × 0.20) = –0.0625 |
| Normal | .50 | (0.75 × 0.20) + (0.25 × 0.30) = 0.2250 |
| Boom | .30 | (0.75 × 0.60) + (0.25 × 0.40) = 0.5500 |

The portfolio's expected return is

$$E(R_P) = (0.20 \times -0.0625) + (0.50 \times 0.2250) + (0.30 \times 0.5500) = 26.5\%$$

This is the same as we had before.

The portfolio's variance is

$$\begin{aligned} \sigma_P^2 &= 0.20 \times (-0.0625 - 0.265)^2 + 0.50 \times (0.225 - 0.265)^2 \\ &\quad + 0.30 \times (0.55 - 0.265)^2 \\ &= 0.0466 \end{aligned}$$

So the standard deviation is $\sqrt{0.0466} = 21.59\%$.

**12.3** If we compute the reward-to-risk ratios, we get (22% – 7%)/1.8 = 8.33% for Cooley versus 8.4% for Moyer. Relative to that of Cooley, Moyer'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 per cent:

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

**12.4** Because the expected return on the market is 16 per cent, the market risk premium is 16% – 8% = 8%. The first equity has a beta of 0.7, so its expected return is 8% + 0.7 × 8% = 13.6%.

For the second equity, 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:

$$\begin{aligned} E(R_i) &= R_f + [E(R_M) - R_f]\, \beta_i \\ 24\% &= 8\% + (16\% - 8\%) \times \beta_i \\ \beta_i &= 16\%/8\% \\ &= 2.0 \end{aligned}$$

## Concepts Review and Critical Thinking Questions

1 **Diversifiable and Non-Diversifiable Risks [LO3]** In broad terms, why is some risk diversifiable? Why are some risks non-diversifiable? Does it follow that an investor can control the level of unsystematic risk in a portfolio, but not the level of systematic risk?

2 **Information and Market Returns [LO3]** Suppose the government announces that, based on a just-completed survey, the growth rate in the economy is likely to be 2 per cent in the coming year, as compared with 5 per cent for the past year. Will security prices increase, decrease, or stay the same following this announcement? Does it make any difference whether the 2 per cent figure was anticipated by the market? Explain.

3 **Systematic versus Unsystematic Risk [LO3]** 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 European Court of Human Rights decision substantially broadens producer liability for injuries suffered by product users.

4 **Systematic versus Unsystematic Risk [LO3]** Indicate whether the following events might cause equities in general to change price, and whether they might cause Big Widget's share price to change:

(a) The government announces that inflation unexpectedly jumped by 2 per cent last month.

(b) Big Widget's earnings report, just issued, generally fell in line with analysts' expectations.

(c) The government reports that economic growth last year was at 3 per cent, which generally agreed with most economists' forecasts.

(d) The directors of Big Widget die in a plane crash.

(e) Parliament 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 **Expected Portfolio Returns [LO1]** If a portfolio has a positive investment in every asset, can the expected return on the portfolio be greater than that on every asset in the portfolio? Can it be less than that on every asset in the portfolio? If you answer yes to one or both of these questions, give an example to support your answer.

6 **Diversification [LO2]** True or false: the most important characteristic in determining the expected return of a well-diversified portfolio is the variance of the individual assets in the portfolio. Explain.

7 **Portfolio Risk [LO2]** If a portfolio has a positive investment in every asset, can the standard deviation on the portfolio be less than that on every asset in the portfolio? What about the portfolio beta?

8 **Beta and CAPM [LO4]** 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?

9 **Corporate Downsizing [LO1]** In recent years it has been common for companies to experience significant share price increases in reaction to announcements of massive layoffs. Critics charge that such events encourage companies to fire long-time employees, and that investors are cheering them on. Do you agree or disagree?

10 **Earnings and Equity Returns [LO1]** As indicated by a number of 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 equities based on expectations of the future, why are numbers summarizing past performance relevant? Second, these announcements concern accounting earnings. Going back to Chapter 3, such earnings may have little to do with cash flow – so, again, why are they relevant?

## connect™ Questions and Problems

BASIC
1 – 20

1 **Determining Portfolio Weights [LO1]** What are the portfolio weights for a portfolio that has 200 shares of Equity A that sell for £4.50 per share and 100 shares of Equity B that sell for £2.70 per share?

2 **Portfolio Expected Return [LO1]** You own a portfolio that has €2,950 invested in Equity A and €3,700 invested in Equity B. If the expected returns on these equities are 11 per cent and 15 per cent, respectively, what is the expected return on the portfolio?

3 **Portfolio Expected Return [LO1]** You own a portfolio that is 60 per cent invested in Equity X, 25 per cent in Equity Y, and 15 per cent in Equity Z. The expected returns on these three equities are 9 per cent, 17 per cent and 13 per cent, respectively. What is the expected return on the portfolio?

4 **Portfolio Expected Return [LO1]** You have £10,000 to invest in an equity portfolio. Your choices are Equity X with an expected return of 14 per cent and Equity Y with an expected return of 10.5 per cent. If your goal is to create a portfolio with an expected return of 12.4 per cent, how much money will you invest in Equity X? In Equity Y?

5 **Calculating Expected Return [LO1]** Based on the following information, calculate the expected return:

| State of economy | Probability of state of economy | Portfolio return if state occurs |
|---|---|---|
| Recession | 0.25 | –0.08 |
| Boom | 0.75 | 0.21 |

6 **Calculating Expected Return [LO1]** Based on the following information, calculate the expected return:

| State of economy | Probability of state of economy | Portfolio return if state occurs |
|---|---|---|
| Recession | 0.20 | –0.05 |
| Normal | 0.50 | 0.12 |
| Boom | 0.30 | 0.21 |

7 **Calculating Returns and Standard Deviations [LO1]** Based on the following information, calculate the expected return and standard deviation for the two equities:

| State of economy | Probability of state of economy | Rate of return if state occurs | |
|---|---|---|---|
| | | Equity A | Equity B |
| Recession | 0.25 | 0.05 | −0.17 |
| Normal | 0.55 | 0.08 | 0.12 |
| Boom | 0.20 | 0.13 | 0.29 |

8 **Calculating Expected Returns [LO1]** A portfolio is invested 25 per cent in Equity G, 55 per cent in Equity J, and 20 per cent in Equity K. The expected returns on these equities are 8 per cent, 15 per cent and 24 per cent, respectively. What is the portfolio's expected return? How do you interpret your answer?

9 **Returns and Variances [LO1]** Consider the following information:

| State of economy | Probability of state of economy | Rate of returns if state occurs | | |
|---|---|---|---|---|
| | | Equity A | Equity B | Equity C |
| Boom | 0.35 | 0.07 | 0.15 | 0.33 |
| Bust | 0.65 | 0.13 | 0.03 | −0.06 |

**(a)** What is the expected return on an equally weighted portfolio of these three equities?

**(b)** What is the variance of a portfolio invested 20 per cent each in A and B and 60 per cent in C?

10 **Returns and Standard Deviations [LO1]** Consider the following information:

| State of economy | Probability of state of economy | Rate of returns if state occurs | | |
|---|---|---|---|---|
| | | Equity A | Equity B | Equity C |
| Boom | 0.05 | 0.30 | 0.45 | 0.33 |
| Good | 0.45 | 0.12 | 0.10 | 0.15 |
| Poor | 0.35 | 0.01 | −0.15 | −0.05 |
| Bust | 0.15 | −0.06 | −0.30 | −0.09 |

**(a)** Your portfolio is invested 30 per cent each in A and C, and 40 per cent in B. What is the expected return of the portfolio?

**(b)** What is the variance of this portfolio? The standard deviation?

11 **Calculating Portfolio Betas [LO4]** You own an equity portfolio invested 25 per cent in Equity Q, 20 per cent in Equity R, 15 per cent in Equity S, and 40 per cent in Equity T. The betas for these four equities are 0.84, 1.17, 1.11, and 1.36, respectively. What is the portfolio beta?

12 **Calculating Portfolio Betas [LO4]** You own a portfolio equally invested in a risk-free asset and two equities. If one of the equities has a beta of 1.38 and the total portfolio is equally as risky as the market, what must the beta be for the other equity in your portfolio?

13 **Using CAPM [LO4]** An equity has a beta of 1.05, the expected return on the market is 11 per cent, and the risk-free rate is 5.2 per cent. What must the expected return on this equity be?

14 **Using CAPM [LO4]** An equity has an expected return of 11.2 per cent, the risk-free rate is 1.5 per cent, and the market risk premium is 8.5 per cent. What must the beta of this equity be?

15 **Using CAPM [LO4]** An equity has an expected return of 13.5 per cent, its beta is 1.17, and the risk-free rate is 5.5 per cent. What must the expected return on the market be?

16 **Using CAPM [LO4]** An equity has an expected return of 14 per cent, its beta is 1.45, and the expected return on the market is 11.5 per cent. What must the risk-free rate be?

17 **Using CAPM [LO4]** An equity has a beta of 1.35 and an expected return of 16 per cent. A risk-free asset currently earns 4.8 per cent.

**(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 0.95, what are the portfolio weights?

**(c)** If a portfolio of the two assets has an expected return of 8 per cent, what is its beta?

**(d)** If a portfolio of the two assets has a beta of 2.70, what are the portfolio weights? How do you interpret the weights for the two assets in this case? Explain.

18 **Using the SML [LO4]** Asset W has an expected return of 15.2 per cent and a beta of 1.25. If the risk-free rate is 5.3 per cent, 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 portfolio in Asset W | Portfolio expected return | Portfolio beta |
|---|---|---|
| 0 | | |
| 25 | | |
| 50 | | |
| 75 | | |
| 100 | | |
| 125 | | |
| 150 | | |

19 **Reward-to-Risk Ratios [LO4]** Equity Y has a beta of 1.4 and an expected return of 18.5 per cent. Equity Z has a beta of 0.80 and an expected return of 12.1 per cent. If the risk-free rate is 2 per cent and the market risk premium is 7.5 per cent, are these equities correctly priced?

20 **Reward-to-Risk Ratios [LO4]** In the previous problem, what would the risk-free rate have to be for the two equities to be correctly priced?

INTERMEDIATE 21 – 24

21 **Portfolio Returns [LO2]** Using information from the previous chapter on capital market history, determine the return on a portfolio that is equally invested in large UK company equities and small UK company equities. What is the return on a portfolio that is equally invested in German and French equities?

22 **CAPM [LO4]** Using the CAPM, show that the ratio of the risk premiums on two assets is equal to the ratio of their betas.

23 **Portfolio Returns and Deviations [LO2]** Consider the following information about three equities:

| State of economy | Probability of state of economy | Rate of returns if state occurs | | |
|---|---|---|---|---|
| | | Equity A | Equity B | Equity C |
| Boom | 0.25 | 0.24 | 0.36 | 0.55 |
| Good | 0.50 | 0.17 | 0.13 | 0.09 |
| Bust | 0.25 | 0.00 | −0.28 | −0.45 |

**(a)** If your portfolio is invested 40 per cent each in A and B and 20 per cent in C, what is the portfolio expected return? The variance? The standard deviation?

**(b)** If the expected T-bill rate is 3.80 per cent, what is the expected risk premium on the portfolio?

**(c)** If the expected inflation rate is 3.50 per cent, what are the approximate and exact expected real returns on the portfolio? What are the approximate and exact expected real risk premiums on the portfolio?

**24 Analysing a Portfolio [LO2]** You want to create a portfolio equally as risky as the market, and you have £1,000,000 to invest. Given this information, fill in the rest of the following table:

| Asset | Investment (£) | Beta |
|---|---|---|
| Equity A | 210,000 | 0.85 |
| Equity B | 320,000 | 1.20 |
| Equity C | | 1.35 |
| Risk-free asset | | |

CHALLENGE 25 – 28

**25 Analysing a Portfolio [LO2, LO4]** You have £100,000 to invest in a portfolio containing Equity X and Equity Y. Your goal is to create a portfolio that has an expected return of 16.5 per cent. If Equity X has an expected return of 15.2 per cent and a beta of 1.4, and Equity Y has an expected return of 11.6 per cent and a beta of 0.95, how much money will you invest in equity Y? How do you interpret your answer? What is the beta of your portfolio?

**26 Systematic versus Unsystematic Risk [LO3]** Consider the following information about Equities I and II:

| State of economy | Probability of state of economy | Rate of return if state occurs | |
|---|---|---|---|
| | | Equity I | Equity II |
| Recession | 0.25 | 0.11 | −0.40 |
| Normal | 0.50 | 0.29 | 0.10 |
| Irrational exuberance | 0.25 | 0.13 | 0.56 |

The market risk premium is 8 per cent, and the risk-free rate is 4 per cent. Which equity has the most systematic risk? Which one has the most unsystematic risk? Which equity is 'riskier'? Explain.

**27 SML [LO4]** Suppose you observe the following situation:

| Security | Beta | Expected Return |
|---|---|---|
| Pete plc | 1.35 | 0.132 |
| Repete plc | 0.80 | 0.101 |

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

**28 SML [LO4]** Suppose you observe the following situation:

| State of economy | Probability of state | Return if state occurs | |
|---|---|---|---|
| | | Equity A | Equity B |
| Bust | 0.25 | −0.08 | −0.05 |
| Normal | 0.70 | 0.13 | 0.14 |
| Boom | 0.05 | 0.48 | 0.29 |

**(a)** Calculate the expected return on each equity.

**(b)** Assuming the capital asset pricing model holds, and equity B's beta is greater than equity A's beta by 0.25, what is the expected market risk premium?

MINI CASE

# The Beta for Vodafone

Joey Moss, a recent finance graduate, has just begun his job with the investment firm of Covili and Wyatt. Paul Covili, one of the firm's founders, has been talking to Joey about the firm's investment portfolio.

As with any investment, Paul is concerned about the risk of the investment as well as the potential return. More specifically, because the company holds a diversified portfolio, Paul is concerned about the systematic risk of current and potential investments. One such position the company currently holds is equity in Vodafone. Vodafone is the well-known mobile telecommunications firm that has operations throughout the world.

Covili and Wyatt currently uses a commercial data vendor for information about its positions. Because of this, Paul is unsure exactly how the numbers provided are calculated. The data provider considers its methods proprietary, and it will not disclose how equity betas and other information are calculated. Paul is uncomfortable with not knowing exactly how these numbers are being computed, and also believes that it could be less expensive to calculate the necessary statistics in-house. To explore this question, Paul has asked Joey to do the following assignments.

## QUESTIONS

1 Go to Yahoo! Finance and download the ending monthly equity prices for Vodafone for the last 60 months. Use the adjusted closing price, which adjusts for dividend payments and stock splits. Next, download the ending value of the FTSE 100 index over the same period. For the historical risk-free rate, download the historical three-month Treasury bill secondary market rate. What are the monthly returns, average monthly returns and standard deviations for Vodafone equity, the three-month Treasury bill, and the FTSE 100 for this period?

2 Beta is often estimated by linear regression. A model often used is called the *market model*, which is

$$R_t - R_{ft} = \alpha_i + \beta_i\,[R_{Mt} - R_{ft}] + \varepsilon_t$$

In this regression $R_t$ is the return on the equity and $R_{ft}$ is the risk-free rate for the same period. $R_{Mt}$ is the return on a stock market index such as the FTSE 100 index. $\alpha_i$ is the regression intercept, and $\beta_i$ is the slope (and the equity's estimated beta). $\varepsilon_t$ represents the residuals for the regression. What do you think is the motivation for this particular regression? The intercept, $\alpha_i$, is often called *Jensen's alpha*. What does it measure? If an asset has a positive Jensen's alpha, where would it plot with respect to the SML? What is the financial interpretation of the residuals in the regression?

3 Use the market model to estimate the beta for Vodafone using the last 36 months of returns (the regression procedure in Microsoft Excel is one easy way to do this). Plot the monthly returns on Vodafone against the index, and also show the fitted line.

4 When the beta of an equity is calculated using monthly returns, there is a debate over the number of months that should be used in the calculation. Rework the previous questions using the last 60 months of returns. How does this answer compare with what you calculated previously? What are some arguments for and against using shorter versus longer periods? Also, you've used monthly data, which are a common choice. You could have used daily, weekly, quarterly, or even annual data. What do you think are the issues here?

5 Compare your beta for Vodafone with the beta you find on Yahoo! Finance. How similar are they? Why might they be different?

## Endnotes

1 Some of it could be in cash, of course, but we would then just consider the cash to be one of the portfolio assets.

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

Online Learning Centre

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Among other helpful resources there are mini-cases tailored to individual chapters.