CHAPTER SIX
ELEMENTARY PORTFOLIO MATHEMATICS

6.1 AN INTRODUCTION TO PORTFOLIO ANALYSIS
(Background reading: sections 5.1 and 5.5)

An investor's portfolio is the set of all her investments. The investor's wealth and ability to spend is a function of her entire portfolio of investments. Thus, it is reasonable for an investor to be concerned with the performance of individual securities only to the extent that their performance affects overall portfolio performance. Since the returns of individual investments tend to be related to one another, the composition of the investor's portfolio is of primary importance. We can demonstrate that investors can more effectively control their investment risk by selecting appropriate securities in appropriate combinations.

The return on an investor's portfolio is a simple weighted average of the component individual security returns. One calculates the expected return of a portfolio based on either a function of potential portfolio returns and their associated probabilities (as computed in chapter 5) or finding the weighted average of expected returns on individual securities. In the vast majority of cases, portfolio returns variance or standard deviation will be less than the weighted average of the individual security return variances or standard deviations. The extent to which overall portfolio risk is less than the weighted average of component asset risk levels will depend on the nature of comovement between the assets.

6.2 PORTFOLIO RETURN
(Background reading: sections 2.8, 5.5, and 6.1)

In section 5.5, we computed the expected return of a security as a function of potential return outcomes and associated probabilities. The expected return of a portfolio is calculated similarly, using equation (6.1), where the subscript p designates the portfolio and the subscript j is a counter designating a particular outcome out of m potential outcomes:

$$E[R_p] = \sum_{j=1}^{m} R_{p,j} P_j. \tag{6.1}$$

For many portfolio management applications, it is useful to express portfolio return as a function of the returns of the individual securities that comprise the portfolio:

$$E[R_p] = \sum_{i=1}^{n} w_i E[R_i]. \tag{6.2}$$

The subscript i designates a particular security out of n in the portfolio. The weights w_i are the portfolio proportions. Thus, a security weight w_i specifies how much money is invested in security i relative to the total amount invested in the entire portfolio:

$$w_i = \frac{\$\text{ invested in security } i}{\text{Total }\$\text{ invested in portfolio p}}.$$

Thus, portfolio return is simply a weighted average of individual security returns.

Consider a portfolio made up of two securities, one and two. The expected return of security one is 10% and the expected return of security two is 20%. If 40% of the dollar value of the portfolio is invested in security one (that is, $[w_1] = 0.40$), and the remainder is invested in security two ($[w_2] = 0.60$), the expected return of the portfolio may be determined as follows by equation (6.2):

$$E[R_p] = (w_1 \cdot E[R_1]) + (w_2 \cdot E[R_2]),$$
$$E[R_p] = (0.4 \cdot 0.10) + (0.6 \cdot 0.20) = 0.16.$$

6.3 Portfolio Variance
(Background reading: sections 2.9, 5.7–5.10, and 6.2)

Portfolio return variance may also be defined as a function of potential portfolio returns and associated probabilities:

$$\sigma_p^2 = \sum_{j=1}^{m} (R_{pj} - E[R_p])^2 P_j. \tag{6.3}$$

Again, it is usually helpful to express portfolio variance as a function of individual security characteristics. However, we stress that the variance of portfolio returns is not simply a weighted average of individual security return variances. We will actually be able to demonstrate that we can combine a set of high-risk assets into a low-risk portfolio. This is due to the important relationship between portfolio risk and return covariances between pairs of securities. The portfolio returns variance can be computed by solving the following function:

$$\sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_i \sigma_j \rho_{i,j} = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{i,j}. \tag{6.4}$$

Section 2.9 discussed the general process for working with double summations. We would solve equation (6.4) to compute the variance of a two-security portfolio as follows:

$$\sigma_p^2 = w_1 \cdot w_1 \cdot \sigma_1 \cdot \sigma_1 \cdot \rho_{1,1} + w_1 \cdot w_2 \cdot \sigma_1 \cdot \sigma_2 \cdot \rho_{1,2} + w_2 \cdot w_1 \cdot \sigma_2 \cdot \sigma_1 \cdot \rho_{2,1} + w_2 \cdot w_2 \cdot \sigma_2 \cdot \sigma_2 \cdot \rho_{2,2}. \tag{6.5}$$

Notice that we start the summation operations at $i = 1$ and $j = 1$. This means that in the first stage of operation, both i and j refer to security 1. In the second stage, i still refers to security 1 but j refers to security 2. Since n, the number of securities, equals 2, the third stage starts j over again at 1 and i now refers to security 2. In the fourth stage, both i and j refer to security 2. We simplify the result to complete the computational process.

Equation (6.5) can only be used for a two-security portfolio. Equation (6.4) and variations of it to be discussed later may be used to compute portfolio variances when n exceeds 2 (see equation (6.9)). Hence, equation (6.5) is only a special case of equation (6.4).

Consider the portfolio constructed in section 6.2. The weights associated with securities 1 and 2 are 0.4 and 0.6, respectively. Assume that the standard deviations of returns for securities one and two are 0.20 and 0.30, respectively, and that the correlation coefficient ρ_{ij} between returns on the two securities is 0.5. We should also note that $\rho_{1,2} = \rho_{2,1}$ and that $\rho_{1,1} = \rho_{2,2} = 1$ because the correlation coefficient between anything and itself equals 1. Following equations (6.4) and (6.5), we compute the variance and standard deviation of portfolio returns as follows:

$$\sigma_p^2 = 0.4 \cdot 0.4 \cdot 0.2 \cdot 0.2 \cdot 1 + 0.4 \cdot 0.6 \cdot 0.2 \cdot 0.3 \cdot 0.5 + 0.6 \cdot 0.4 \cdot 0.3 \cdot 0.2 \cdot 0.5 + 0.6 \cdot 0.6 \cdot 0.3 \cdot 0.3 \cdot 1 = 0.0532. \tag{6.6}$$

Thus, the standard deviation of portfolio returns would be 0.23, the square root of its 0.0532 variance level. By simplifying the expressions in the first and fourth sets of parentheses, combining the terms in the second and third sets, and rearranging, one can simplify equations (6.5) and (6.6) for two-security portfolios:

$$\sigma_p^2 = w_1^2 \cdot \sigma_1^2 + w_2^2 \cdot \sigma_2^2 + 2(w_1 \cdot w_2 \cdot \sigma_1 \cdot \sigma_2 \cdot \rho_{1,2}),$$

$$\sigma_p^2 = 0.4^2 \cdot 0.2^2 + 0.6^2 \cdot 0.3^2 + 2(0.4 \cdot 0.6 \cdot 0.2 \cdot 0.3 \cdot 0.5) = 0.0504.$$

A careful examination of these expressions will reveal that equation (6.4) can also be rewritten as follows:

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{\substack{i=1 \\ i \neq j}}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{i,j}. \tag{6.7}$$

When a portfolio consists of only two securities, its variance can be determined by equation (6.8):

$$\sigma_p^2 = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\sigma_{1,2}. \tag{6.8}$$

Larger portfolios require the use of equations (6.4) or (6.7), accounting for all products of security weights and standard deviations squared and all possible combinations of pair-wise security covariances and weight products. For example, equation (6.8) can be rewritten for a three-security portfolio as

$$\sigma_p^2 = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + w_3^2\sigma_3^2 + 2w_1w_2\sigma_{1,2} + 2w_1w_3\sigma_{1,3} + 2w_2w_3\sigma_{2,3}. \tag{6.9}$$

Notice that equation (6.9) involves working with three individual security variances (one for each security) and three sets of covariances (between 1 and 2, 1 and 3, and 2 and 3). Also notice the similarities between equation (6.8) for a two-security portfolio and security 9 for a three-security portfolio.

As the number of securities in the portfolio increases, the amount of computational effort increases disproportionately. The number of sets of covariances between nonidentical pairs of securities equals $(n^2 - n)/2$. If 50 securities were to be included in the investor's portfolio, 1,225 sets of covariances would be required to combine with 50 variance terms in order to solve equation (6.7). Obviously, as the number of securities in the portfolio becomes large, computers and computer spreadsheets become quite useful in working through the repetitive calculations. The equations are not difficult to solve; they are merely repetitive and time-consuming.

6.4 Diversification and Efficiency

The important contribution of the covariance terms in equations (6.4)–(6.9) is that portfolio risk is a function of the extent to which security returns are related to one another. Security risk can be diversified away by constructing portfolios of unrelated assets. The statement "Don't put all your eggs in one basket" has a strong basis in reality. Investment in a variety of different securities with different return structures really does result in portfolio risk reductions. One should expect that portfolio risk levels will be lower than the weighted average security risk levels. Diversification is most effective when the returns of the individual securities are inversely correlated. Lower covariances $\sigma_{i,j}$ result in lower portfolio risk. Portfolio risk is quite dependent on the correlation coefficient of returns ρ_{ij} between securities included in the portfolio. Lower correlation levels imply lower risk levels. Because the covariance between security returns $\sigma_{i,j}$ equals the product $\sigma_i\sigma_j\rho_{i,j}$, reduced covariances imply reduced correlation coefficients. Thus, lower correlation coefficients between securities imply lower portfolio risk. Portfolio risk should be expected to decline whenever ρ_{ij} is less than one and diversification increases. We will normally expect any randomly selected pair of securities to have a correlation coefficient less than one. Hence, we should normally expect that adding securities to a randomly selected portfolio will tend to reduce portfolio risk.

In our first example with securities 1 and 2, the weighted average of the standard deviation of returns of the two securities is 26%:

$$\textit{Weighted Average}\ \sigma_i = 0.4 \cdot 0.2 + 0.6 \cdot 0.3 = 0.26.$$

However, recall that the standard deviation of returns of the portfolio that they combine to make is only 23%:

$$\sigma_p = \sqrt{0.4^2 \cdot 0.2^2 + 0.6^2 \cdot 0.3^2 + 2(0.4 \cdot 0.6 \cdot 0.2 \cdot 0.3 \cdot 0.5)} = 0.23.$$

Clearly, some risk has been diversified away by combining the two securities into the portfolio. In fact, the risk of a portfolio will almost always be lower than the weighted average of the standard deviations of the securities that comprise that portfolio. The only two exceptions occur when:

1 The returns correlation coefficient between all pairs of securities equals 1.
2 One of two assets in a two-asset portfolio has a zero standard deviation of returns.

For a more extreme example of the benefits of diversification, consider two securities, 3 and 4, whose potential return outcomes are perfectly inversely related. Data relevant to these securities is listed in table 6.1. If outcome one occurs, security three will realize a return of 30%, and security four will realize a 10% return level. If outcome two is realized, both securities will attain returns of 20%. If outcome three is realized, securities three and four will attain return levels of 10% and 30%, respectively. If each

Table 6.1 A portfolio return with perfectly inversely correlated securities: $w_3 = w_4 = 0.5$

i	R_{3i}	R_{4i}	R_{pi}	P_i
1	0.30	0.10	0.20	0.333
2	0.20	0.20	0.20	0.333
3	0.10	0.30	0.20	0.333

Given:

$$\bar{R}_3 = 0.20, \qquad \bar{R}_4 = 0.20,$$
$$\sigma_3 = 0.08165, \qquad \sigma_4 = 0.08165,$$
$$w_3 = 0.50, \qquad w_4 = 0.50, \qquad \rho_{3,4} = -1.$$

Then:

$$\bar{R}_p = w_3\bar{R}_3 + w_4\bar{R}_4 = (0.5 \cdot 0.20) + (0.5 \cdot 0.20) = 0.20,$$

$$\sigma_p = \sqrt{w_3^2\sigma_3^2 + w_4^2\sigma_4^2 + 2w_3w_4\sigma_3\sigma_4\rho_{3,4}},$$

$$\sigma_p = \sqrt{0.5^2 \cdot 0.0066667 + 0.5^2 \cdot 0.0066667 + 2 \cdot 0.5 \cdot 0.5 \cdot 0.08165 \cdot 0.08165 \cdot (-1)} = 0.$$

outcome is equally likely to occur (P_i is 0.333 for all outcomes), the expected return level of each security is 20%; the standard deviation of returns for each security is 0.08165. The expected return of a portfolio combining the two securities is 20% if each security has equal portfolio weight ($w_3 = w_4 = 0.5$), yet the standard deviation of portfolio returns is zero. Thus, two relatively risky securities have been combined into a portfolio that is virtually risk-free. Application 3.5 in chapter 3 provides a general format for constructing a riskless portfolio in the presence of two perfectly inversely correlated assets.

Notice in the previous paragraph that we first combined securities 3 and 4 into a portfolio and then found that portfolio's return given each outcome. The portfolio's return is 20% regardless of the outcome; thus, it is risk-free. The same result can be obtained with the variances of securities three and four, the correlation coefficient between their returns, and solving for portfolio variance with equation (6.8) as in table 6.1.

The implication of the two examples provided in this chapter is that security risk can be diversified away by combining the individual securities into portfolios. Spreading investments across a variety of securities does result in portfolio risk that is lower than the weighted average risks of the individual securities. This diversification is most effective when the returns of the individual securities are at least somewhat unrelated; or, better still, inversely related, as were securities three and four in the previous example. For example, returns on a retail food company stock and on a furniture company stock are not likely to be perfectly positively correlated; therefore, including both of them in a portfolio may result in a reduction of portfolio risk. From a mathematical perspective, the reduction of portfolio risk is dependent on the correlation coefficient of returns ρ_{ij} between securities included in the portfolio. Thus, the lower the correlation coefficients between these securities, the lower will be the resultant portfolio risk. In fact, as long as ρ_{ij} is less than one, which – realistically – is always the case, some reduction in risk can be realized from diversification.

Consider the Portfolio Possibilities Frontier displayed in figure 6.1. This frontier maps out portfolio return and standard deviation combinations as security weights vary. The correlation coefficient between returns of securities C and D is one. Remember that portfolio return is always a weighted average of individual security returns. The standard deviation of returns of any portfolio combining these two securities is a weighted average of the returns of the two securities' standard deviations, but only because the correlation coefficient between returns on these securities equals 1. Thus, both portfolio returns and portfolio standard deviation are linearly related to the proportions invested in each of the two securities. Diversification here yields no benefits. In figure 6.2, the correlation coefficient between returns on securities A and B is 0.5. Portfolios combining these two securities will have standard deviations less than the weighted average of the standard deviations of the two securities. Hence, the portfolio possibilities frontier for these two securities arches toward the vertical axis. Given this lower correlation coefficient, which is more representative of "real-world" correlations, there are clear benefits to diversification. In fact, we can see in figures 6.3 and 6.4 that decreases in correlation coefficients result in increased diversification benefits. Lower correlation coefficients result in lower risk levels at all levels of expected return. The portfolio possibilities frontier will exhibit a more significant arch toward the vertical axis as the correlation coefficient between security returns decreases. Thus, an investor will benefit by constructing his portfolio of securities with low correlation coefficients.

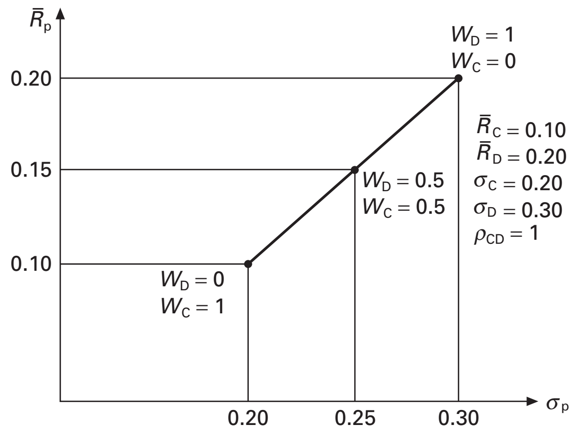

Figure 6.1 The relationship between portfolio return and risk when $\rho_{CD} = 1$.

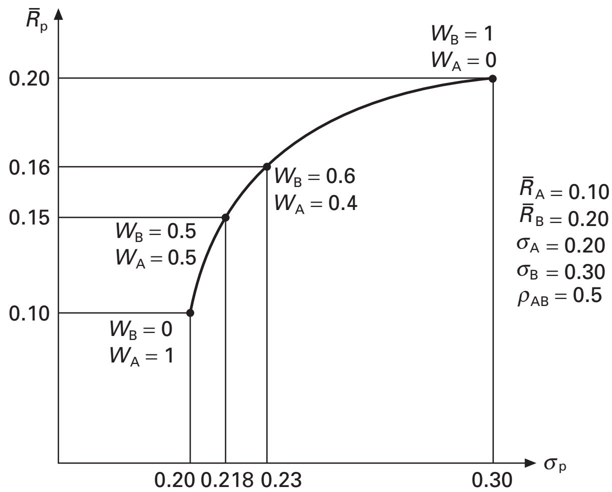

Figure 6.2 The relationship between portfolio return and risk when $\rho_{AB} = 0.5$.

To this point, we have focused on using correlation coefficients to manage the diversification of a portfolio. However, we will also consider a second powerful diversification tool. The risk of a portfolio will tend to decline as n, the number of securities in the portfolio, increases. This result will hold as long as the securities are not perfectly correlated.[1] It is perfectly reasonable to expect that securities will not be perfectly correlated. Thus, two factors govern the level of diversification in a portfolio:

[1] This result also requires that as securities are added to the portfolio, their individual variances are not increasing enough to offset the diversification benefits that they provide. If variances among all securities are approximately equal or are randomly distributed with a constant mean, this result will hold. This result will be demonstrated mathematically in application 8.5.

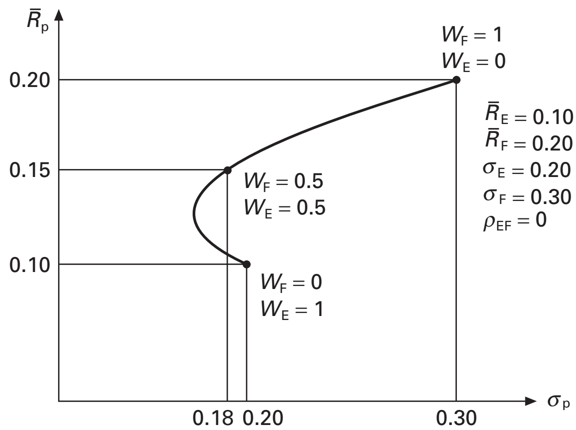

Figure 6.3 The relationship between portfolio return and risk when $\rho_{EF} = 0$.

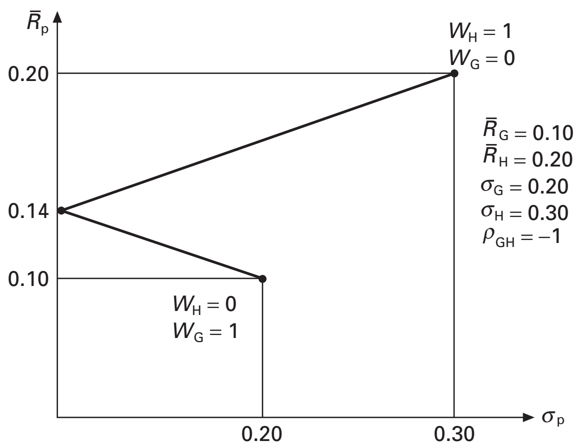

Figure 6.4 The relationship between portfolio return and risk when $\rho_{GH} = -1$.

1 The covariances between pairs of securities in the portfolio. Smaller return covariances of included securities lead to reduced portfolio risk.
2 The number of assets included in the portfolio. Larger numbers of included securities lead to decreased portfolio risk.

6.5 The Market Portfolio and Beta

The market portfolio is the collective set of all investments that are available to investors. That is, the market portfolio represents the combination or aggregation of all securities (or other assets) that are available for purchase. Investors may wish to consider the performance of this market portfolio to determine the performance of securities in general. Since portfolio return is a weighted average of individual security returns, the return on the market portfolio is the average of returns on securities. Thus, the return on the market portfolio is representative of the return on the "typical" asset. An investor may wish to know the market portfolio return to gauge performance of a particular security or investment portfolio relative to the performance of the market or a "typical" security. The market return is also very useful for constructing additional risk measures such as a security or investment portfolio beta:

$$\beta_i = \frac{\sigma_i}{\sigma_m} \cdot \rho_{i,m} = \frac{\sigma_i \sigma_m \rho_{i,m}}{\sigma_m^2} = \frac{\mathrm{COV}(i,m)}{\sigma_m^2}. \tag{6.10}$$

Consider a stock A whose standard deviation of returns is 0.4 and assume that the market portfolio standard deviation equals 0.2. Further assume that the correlation coefficient between returns on security A and the market equals 0.75. Then the beta (β_A) of security A would be 1.5:

$$\beta_i = \frac{\sigma_i}{\sigma_m} \cdot \rho_{i,m} = \frac{0.4}{0.2} \cdot 0.75 = 1.5.$$

The beta of a stock measures the risk of a stock relative to the risk of the market portfolio. Part of a stock's risk derives from diversifiable sources (firm-specific) and other risks are undiversifiable (market-related). The lower the correlation of a stock with the market, the greater is the risk that can be diversified away. Thus, lower-risk stocks and portfolios will have lower betas. Because beta only accounts for undiversified risk, the beta of a portfolio equals the weighted average beta of its component securities.

Determination of the return on the market portfolio requires the calculation of returns on all of the assets available to investors. Because there are hundreds of thousands of assets available to investors (including stocks, bonds, options, bank accounts, real estate, and so on), determining the exact return of the market portfolio may be impossible. Thus, investors generally make use of indices such as the Dow Jones Industrial Average or the Standard and Poor's 500 to gauge the performance of the market portfolio. These indices merely act as surrogates for the market portfolio; we assume that if the indices are increasing, then the market portfolio is performing well. For example, performance of the Dow Jones Industrials Average depends on the performance of the 30 stocks that comprise this index. Thus, if the Dow Jones market index is performing well, the 30 securities, on average, are probably performing well. This strong performance may imply that the market portfolio is performing well. In any case, it is easier to measure the performance of 30 or 500 stocks (for the Standard and Poor's 500) than it is to measure the performance of all of the securities that comprise the market portfolio.

6.6 Deriving the Portfolio Variance Expression **(Background reading: section 6.3)**

We first discussed variance as a function of potential squared deviations from expected return outcomes. This is consistent with definitions of variance in most other applications.

For practical purposes, it is normally more useful to define portfolio variance in terms of individual security variances and covariances between pairs of securities. This enables us to characterize risk as a function of portfolio weights. Knowing appropriate portfolio weights enables us to determine appropriate amounts to invest in each security. An understanding of the relationship between the two portfolio risk measures will help us understand more complex concepts concerning portfolio risk.

We will derive the variance of given portfolio p as a function of security variances, covariances, and weights as in equation (6.4). First, we start with the variance expressed as a function of m potential portfolio return outcomes j and associated probabilities:

$$\sigma_{\mathrm{p}}^2 = \sum_{j=1}^{m} (R_{\mathrm{p}j} - \mathrm{E}[R_{\mathrm{p}}])^2 P_j. \tag{6.3}$$

For the sake of simplicity, we will work with $n = 2$ securities in our portfolio. It will be easy to generalize this procedure from 2 to n securities. Portfolio variance may be rewritten from equation (6.3) as follows:

$$\sigma_{\mathrm{p}}^2 = \sum_{j=1}^{m} (w_1 R_{1j} + w_2 R_{2j} - w_1 \mathrm{E}[R_1] - w_2 \mathrm{E}[R_2])^2 P_j. \tag{A}$$

The first two terms inside the parentheses in combination refer to returns for securities 1 and 2 given outcome i. The last two terms in combination refer to expected returns for securities 1 and 2. Next, we "complete the square" for equation (A) and combine terms multiplied by w_1 and w_2:

$$\sigma_{\mathrm{p}}^2 = \sum_{j=1}^{m} [w_1^2 (R_{1j} - \mathrm{E}[R_1])^2 P_j + w_2^2 (R_{2j} - \mathrm{E}[R_2])^2 P_j + 2 w_1 w_2 (R_{1j} - \mathrm{E}[R_1])(R_{2j} - \mathrm{E}[R_2]) P_j]. \tag{B}$$

We next move the summation operation inside the brackets:

$$\sigma_{\mathrm{p}}^2 = w_1^2 \sum_{j=1}^{m} (R_{1j} - \mathrm{E}[R_1])^2 P_j + w_2^2 \sum_{j=1}^{m} (R_{2j} - \mathrm{E}[R_2])^2 P_j + 2 w_1 w_2 \sum_{j=1}^{m} (R_{1j} - \mathrm{E}[R_1])(R_{2j} - \mathrm{E}[R_2]) P_j. \tag{C}$$

The derivation is completed by substituting in equation (C) variances and covariances as defined in chapter 5:

$$\sigma_{\mathrm{p}}^2 = w_1^2 \sigma_1^2 + w_2^2 \sigma_2^2 + 2 w_1 w_2 \sigma_{1,2}, \tag{6.8}$$

which is the two-security equivalent for equation (6.4).

EXERCISES

6.1. Seventy-five percent of a portfolio is invested in Honeybell stock and the remaining 25% is invested in MBIB stock. Honeybell stock has an expected return of 6% and an expected standard deviation of returns of 9%. MBIB stock has an expected return of 20% and an expected standard deviation of 30%. The coefficient of correlation between returns of the two securities is expected to be 0.4. Determine the following:

(a) the expected return of the portfolio;
(b) the expected variance of the portfolio;
(c) the expected standard deviation for the portfolio.

6.2. What is the standard deviation of returns for an equally weighted portfolio comprising two independent securities with return variances equal to 0.09?

6.3. Each of the pairs of stock listed below will be combined into two-security portfolios. In each case, the first stock will comprise 60% of the portfolio and the second stock will comprise the remaining 40%. Compute the standard deviation of returns for each portfolio.

(a) $\sigma_1 = 0.60$, $\sigma_2 = 0.60$, $\sigma_{1,2} = 0.36$;
(b) $\sigma_1 = 0.60$, $\sigma_2 = 0.60$, $\sigma_{1,2} = 0.18$;
(c) $\sigma_1 = 0.60$, $\sigma_2 = 0.60$, $\sigma_{1,2} = 0$;
(d) $\sigma_1 = 0.60$, $\sigma_2 = 0.60$, $\sigma_{1,2} = -0.18$;
(e) $\sigma_1 = 0.60$, $\sigma_2 = 0.60$, $\sigma_{1,2} = -0.36$.

6.4. An equally weighted portfolio will consist of shares from AAB Company stock and ZZY Company stock. The expected return and standard deviation levels associated with the AAB Company stock are 5% and 12%, respectively. The expected return and standard deviation levels for ZZY Company stock are 10% and 20%. Find the expected return and standard deviation levels of this portfolio if returns on the two stocks are:

(a) perfectly correlated;
(b) independent;
(c) perfectly inversely correlated.

6.5. How do the coefficient of correlation between returns of securities in a portfolio affect the expected return and risk levels of that portfolio?

6.6. An investor will place one-third of his money into security 1, one-sixth into security 2, and the remainder (one-half) into security 3. Security data is given in the table below:

Security, i	$E[R]$	$\sigma(i)$	COV(i,1)	COV(i,2)	COV(i,3)
1	0.25	0.40	0.16	0.05	0
2	0.15	0.20	0.05	0.04	0
3	0.05	0	0	0	0

Find the expected return and variance of this portfolio.

6.7. The expected variance of returns on my two-security portfolio is 0.08. The variance of my only risky security is 0.10; my other security is riskless and has an expected return of 0.10. The expected return of the risky security is 0.25. What is the expected return of my portfolio?

6.8. There exists a market where all securities have a return standard deviation equal to 0.8. All securities are perceived to have independent return outcomes; that is, returns between pairs of securities are uncorrelated.

(a) What would be the return standard deviation of a two-security portfolio in this market?
(b) What would be the return standard deviation of a four-security portfolio in this market?
(c) What would be the return standard deviation of an eight-security portfolio in this market?
(d) What would be the return standard deviation of a 16-security portfolio in this market?
(e) Suppose that all securities in this market have an expected return equal to 0.10. How do the expected returns of the portfolios in parts (a) through (d) differ?