Chapter 8

Risk and Return: Capital Market Theory

Chapter 8 Contents

Learning Objectives

1. Portfolio Returns and Portfolio Risk
   1. Calculate the expected rate of return and volatility for a portfolio of investments and describe how diversification affects the returns to a portfolio of investments.

2. Systematic Risk and the Market Portfolio
   1. Understand the concept of systematic risk for an individual investment and calculate portfolio systematic risk (beta).

3. The Security Market Line and the CAPM
   1. Estimate an investor’s required rate of return using capital asset pricing model.
Portfolio Returns and Portfolio Risk

- With appropriate diversification, can lower risk of the portfolio without lowering the portfolio’s expected rate of return.

- Some risk can be eliminated by diversification, and those risks that can be eliminated are not necessarily rewarded in the financial marketplace.

Calculating Expected Return of a Portfolio

- To calculate a portfolio’s expected rate of return, weight each individual investment’s expected rate of return using the fraction of the portfolio that is invested in each investment.

- Example 8.1: Invest 25% of your money in Citi bank stock (C) with expected return = -32% and 75% in Apple (AAPL) with expected return=120%. Compute the expected rate of return on portfolio.

- Expected rate of return

\[ = 0.25(-32\%) + 0.75 (120\%) = 82\% \]
Calculating Expected Return of Portfolio

**Portfolio Expected Rate of Return**

\[ E(r_{portfolio}) = [W_1 \times E(r_1)] + [W_2 \times E(r_2)] + [W_3 \times E(r_3)] + \cdots + [W_n \times E(r_n)] \]

- \( E(r_{portfolio}) \) = the expected rate of return on a portfolio of \( n \) assets.
- \( W_i \) = the portfolio weight for asset \( i \).
- Sum of \( W_i = 1 \)
- \( E(r_i) \) = the expected rate of return earned by asset \( i \).
- \( W_1 \times E(r_1) \) = the contribution of asset 1 to the portfolio expected return. Weight times the rate!

Checkpoint 8.1

Calculating a Portfolio’s Expected Rate of Return

Penny Simpson has her first full-time job and is considering how to invest her savings. Her dad suggested she invest no more than 25% of her savings in the stock of her employer, Emerson Electric (EMR), so she is considering investing the remaining 75% in a combination of a risk-free investment in U.S. Treasury bills, currently paying 4%, and Starbucks (SBUX) common stock. Penny’s father has invested in the stock market for many years and suggested that Penny might expect to earn 9% on the Emerson shares and 12% from the Starbucks shares. Penny decides to put 25% in Emerson, 25% in Starbucks, and the remaining 50% in Treasury bills. Given Penny’s portfolio allocation, what rate of return should she expect to receive on her investment?
**Class Problem – modify previous**

Evaluate the expected return for Penny’s portfolio where she places 1/4th of her money in Treasury bills, half in Starbucks stock, and the remainder in Emerson Electric stock.

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>E(Return)</th>
<th>X Weight</th>
<th>= Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury bills</td>
<td>4.0%</td>
<td>.25</td>
<td>1%</td>
</tr>
<tr>
<td>EMR stock</td>
<td>8.0%</td>
<td>.25</td>
<td>2%</td>
</tr>
<tr>
<td>SBUX stock</td>
<td>12.0%</td>
<td>.50</td>
<td>6%</td>
</tr>
<tr>
<td><strong>Expected Return on Portfolio</strong></td>
<td><strong>12.0%</strong></td>
<td><strong>.25</strong></td>
<td><strong>5%</strong></td>
</tr>
</tbody>
</table>
Evaluating Portfolio Risk and Diversification

- Unlike expected return, standard deviation is not generally equal to the weighted average of the standard deviations of the returns of investments held in the portfolio.
  - This is because of diversification effects.

- Effect of reducing risks by including large number of investments in portfolio is called diversification.

- As a consequence of diversification, the standard deviation of the returns of a portfolio is typically less than the average of the standard deviation of the returns of each of the individual investments.

Portfolio Diversification

- The diversification gains achieved by adding more investments will depend on the degree of correlation among the investments.

- The degree of correlation is measured by using the correlation coefficient.

- Correlation coefficient can range from -1.0 (perfect negative correlation), meaning two variables move in perfectly opposite directions to +1.0 (perfect positive correlation), which means the two assets move exactly together.

- Correlation coefficient of 0 means no relationship exists between returns earned by the two assets.
Portfolio Diversification (cont.)

- As long as the investment returns are not perfectly positively correlated, there will be diversification benefits.
  - However, the diversification benefits will be greater when the correlations are low or positive.
  - The returns on most investment assets tend to be positively correlated.

Diversification Lessons

1. A portfolio can be less risky than the average risk of its individual investments in the portfolio.
2. Key to reducing risk through diversification is combine investments whose returns do not move together.

Calculating the Standard Deviation of a Portfolio Returns – The Formula

\[ \sigma_{\text{portfolio}} = \sqrt{W_1^2 \sigma_1^2 + W_2^2 \sigma_2^2 + 2W_1W_2\rho_{12}\sigma_1\sigma_2} \]

Important Definitions and Concepts:

- \( \sigma_{\text{portfolio}} \) = the standard deviation in portfolio returns,
- \( W_i \) = the proportion of the portfolio that is invested in asset \( i \),
- \( \sigma_i \) = the standard deviation in the rate of return earned by asset \( i \), and
- \( \rho_{ij} \) = the correlation coefficient between the rates of return earned by assets \( i \) and \( j \). The symbol \( \rho_{ij} \) (pronounced “rho”) represents the correlation coefficient between the rates of return for asset 1 and asset 2.
Calculating the Standard Deviation of a Portfolio Returns (Example)

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Weight</th>
<th>Expected Return</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>.50</td>
<td>.14</td>
<td>.20</td>
</tr>
<tr>
<td>Coca-Cola</td>
<td>.50</td>
<td>.14</td>
<td>.20</td>
</tr>
</tbody>
</table>

- Determine the expected return and standard deviation of above portfolio consisting of two stocks that have a correlation coefficient of .75.
- Expected Return = .5 (.14) + .5 (.14)
  = .14 or 14%

Calculating the Standard Deviation of a Portfolio Returns (cont.)

\[ \sigma_{portfolio} = \sqrt{W_1^2 \sigma_1^2 + W_2^2 \sigma_2^2 + 2W_1 W_2 \rho_{1,2} \sigma_1 \sigma_2} \]

- Standard deviation of portfolio
  = \[ \sqrt{(.5^2 \times .2^2) + (.5^2 \times .2^2) + (2 \times .5 \times .5 \times .75 \times .2 \times .2)} \]
  = \[ \sqrt{.035} \]
  = .187 or 18.7%
Calculating the Standard Deviation of a Portfolio Returns (Example-cont.)

- Had we taken a simple weighted average of the standard deviations of the Apple and Coca-Cola stock returns, it would produce a portfolio standard deviation of .20.

- Since the correlation coefficient is less than 1 (.75), it reduces the risk of portfolio to 0.187.
Figure 8.1 cont.

Legend:

<table>
<thead>
<tr>
<th>Correlation</th>
<th>E(Return)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.00</td>
<td>0.14</td>
<td>0%</td>
</tr>
<tr>
<td>-0.80</td>
<td>0.14</td>
<td>6%</td>
</tr>
<tr>
<td>-0.60</td>
<td>0.14</td>
<td>9%</td>
</tr>
<tr>
<td>-0.40</td>
<td>0.14</td>
<td>11%</td>
</tr>
<tr>
<td>-0.20</td>
<td>0.14</td>
<td>13%</td>
</tr>
<tr>
<td>0.0</td>
<td>0.14</td>
<td>14%</td>
</tr>
<tr>
<td>0.20</td>
<td>0.14</td>
<td>15%</td>
</tr>
<tr>
<td>0.40</td>
<td>0.14</td>
<td>17%</td>
</tr>
<tr>
<td>0.60</td>
<td>0.14</td>
<td>18%</td>
</tr>
<tr>
<td>0.80</td>
<td>0.14</td>
<td>19%</td>
</tr>
<tr>
<td>1.00</td>
<td>0.14</td>
<td>20%</td>
</tr>
</tbody>
</table>

All portfolios are comprised of equal investments in Apple and Coca-Cola shares.

Standard Deviation of a Portfolio Returns and Diversification logic

- Figure 8-1 illustrates the impact of correlation coefficient on the risk of the portfolio. We observe that lower the correlation, greater is the benefit of diversification.

<table>
<thead>
<tr>
<th>Correlation between investment returns</th>
<th>Diversification Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1</td>
<td>No benefit</td>
</tr>
<tr>
<td>0.0</td>
<td>Substantial benefit</td>
</tr>
<tr>
<td>-1</td>
<td>Maximum benefit. Indeed, the risk of portfolio can be reduced to zero.</td>
</tr>
</tbody>
</table>