Chapter 8
Risk and Rates of Return

Defining and Measuring Risk

Stand-alone risk—the risk of an asset held in isolation

- Risk is the chance that an outcome other than expected will occur
- A probability distribution is a listing of all possible outcomes with a probability assigned to each—the listing must sum to 100%

Expected Rate of Return

- The rate of return expected to be realized from an investment
- The mean value of the probability distribution of possible returns

<table>
<thead>
<tr>
<th>State of the Economy</th>
<th>Probability of This State Occurring</th>
<th>Rate of Return on Stock if This State Occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Martin Products</td>
</tr>
<tr>
<td>Boom</td>
<td>20%</td>
<td>110%</td>
</tr>
<tr>
<td>Normal</td>
<td>50%</td>
<td>22%</td>
</tr>
<tr>
<td>Recession</td>
<td>30%</td>
<td>-60%</td>
</tr>
</tbody>
</table>

Expected Rate of Return is the rate of return to be realized from an investment—the weighted average of the outcomes, where the weights are the probabilities. Calculate the expected return of Martin Products (the expected return for U.S. Electric is 15%)

\[ \hat{r} = \sum P_i \times r_i \]

Measuring Risk: The standard deviation

Calculate Martin Product’s standard deviation, \( \sigma \)

\[ \sigma = \sqrt{\sigma^2} = \sqrt{\sum_{i=1}^{n} (r_i - \hat{r})^2 P_i} \]
The standard deviation of U.S. Electric is 3.6%. Which company has the riskiest returns?

**Coefficient of Variation**
- *Standardized* measure of risk per unit of return
- Calculated as the standard deviation divided by the expected return
- Useful where investments differ in risk and expected returns

\[
CV = \frac{\text{risk}}{\text{return}} = \frac{\sigma}{\bar{r}}
\]

Calculate the coefficient of variation for Martin Products.

\[
CV = \frac{\sigma}{\bar{r}} = \frac{\text{risk}}{\text{return}} = \frac{\sigma}{\bar{r}} = \frac{\text{FCF}_e}{\text{EBIT}_e}
\]

The coefficient of variation of U.S. Electric is 0.2404. Which company has the riskiest returns?

**Risk Aversion**
Risk-averse investors require higher rates of return to invest in higher-risk securities

**Risk premium (RP)**
- The portion of the expected return that can be attributed to the additional risk of an investment
- The difference between the expected rate of return on a given risky asset and that on a less risky asset

**Portfolio Risk**

**Portfolio Returns**
A portfolio is a collection of investment securities
Expected return on a portfolio, $r_p$, is the weighted average expected return on the stocks held in the portfolio:

$$\hat{r}_p = \sum_{i=1}^{N} w_i \hat{r}_i$$

<table>
<thead>
<tr>
<th>Security</th>
<th>Dollars Invested</th>
<th>Weight of Security in Portfolio</th>
<th>Security returns $\hat{r}_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$25,000</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>B</td>
<td>$50,000</td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>C</td>
<td>$75,000</td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>$150,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$$\hat{r}_p = \sum w_i \hat{r}_i =$$

**Realized rate of return**, $\bar{r}$, the return that is actually earned.

Actual return is usually different from the expected return.

**Correlation coefficient**, $\rho$

- A measure of the degree of relationship between two variables
- Negatively correlated stocks have rates of return that move in opposite directions (Figure 8-4)

**Risk reduction**

Combining stock that are not perfectly positively correlated will reduce the portfolio risk – **diversification**

Generally, the riskiness of a portfolio is reduced as the number of stocks in the portfolio increases (Figure 8-6)
The Capital Asset Pricing Model
CAPM A model based on the proposition that any stock's required rate of return is equal to the risk-free rate of return plus a risk premium

Firm-Specific Risk versus Market risk

Firm-specific risk is that part of a security's risk associated with random outcomes generated by events, or behaviors, specific to the firm. It can be eliminated by proper diversification.

Market risk is that part of a security's risk that cannot be eliminated by diversification because it is associated with economic, or market factors that systematically affect most firms. It cannot be eliminated by diversification.

The relevant risk for a security is that which cannot be diversified away, or its market risk. It also reflects a security's contribution to the risk of a portfolio

The Concept of Beta

Beta coefficient, $\beta$, is a measure of the extent to which the returns on a given stock move with the stock market. The beta for a stock of average risk is 1.0. Beta is a measure of relative risk.

$\beta = 0.5$; stock is only half as volatile, or risky, as the average stock in the market
$\beta = 1.0$; stock is of average risk
$\beta = 2.0$; stock is twice as risky as the average stock

Portfolio Beta Coefficients

The beta of any set of securities is the weighted average of the individual securities' betas

$$\beta_p = \sum_{i=1}^{n} w_i \beta_i$$

<table>
<thead>
<tr>
<th>Security</th>
<th>Dollars Invested</th>
<th>Weight of Security in Portfolio</th>
<th>Security Beta $\beta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$25,000</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>B</td>
<td>$50,000</td>
<td></td>
<td>1.50</td>
</tr>
<tr>
<td>C</td>
<td>$75,000</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>$150,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$$\beta_p = \sum w_i \beta_i =$$
The Relationship between Risk and Rates of Return

To invest in the market portfolio, m, you will require a rate of return, \( r_m \), greater than the risk-free rate, \( r_{RF} \).

\[
\begin{align*}
    r_m &= r_{RF} + \text{market risk premium} \\
    r_m &= r_{RF} + (r_m - r_{RF})
\end{align*}
\]

The market risk premium is the additional return over the risk-free rate needed to compensate investors for assuming the average amount of risk, \( (r_m - r_{RF}) \).

To invest in a risky security, j, you will require a rate of return greater than the risk-free rate. The risk premium for security j can be stated relative to the market risk premium, \( (r_m - r_{RF})\beta_j \).

\[
\begin{align*}
    r_j &= r_{RF} + \text{risk premium} \\
    r_j &= r_{RF} + (r_m - r_{RF})\beta_j
\end{align*}
\]

Example:
Assume Treasury bonds yield = 6%, the average stock's required return = 14%, and the beta for security i is 1.5.

The \textbf{market risk premium} is: \( RP_m = r_m - r_{RF} = \)

The \textbf{risk premium for stock i} is: \( RP_i = RP_m \times \beta_i = \)

And, the \textbf{required rate of return for Stock i} is: \( r_i = r_{RF} + (r_m - r_{RF})\beta_i = \)
Security Market Line (SML) is the line that shows the relationship between risk as measured by beta and the required rate of return for individual securities

\[ r_i = r_{RF} + (r_m - r_{RF})\beta_i \]

What is the impact of inflation on the Security Market Line?

Recall that the nominal risk-free rate, \( r_{RF} \), consists of the real risk-free rate, \( r^* \), and an inflation premium, IP. An increase in the expected inflation would increase the risk-free rate. This would shift the SML upward.

\[ r_{RF} \] \[ \uparrow \]

\[ r_{RF} \] \[ \uparrow \]
How does risk aversion affect the SML?

The slope, \((r_m - r_{RF})\), of the SML reflects the extent to which investors are averse to risk. An increase in risk aversion increases the risk premium and increases the slope, so the SML would rotate counterclockwise.

\[
\begin{align*}
    r_j &= r_{RF} + (r_m - r_{RF})\beta_i
\end{align*}
\]

Changes in a Stock's Beta Coefficient. The Beta risk of a stock is affected by
- The composition of the firm's assets
- Its use of debt financing
- Increased competition
- Expiration of patents
- Any change in the required return (from change in beta or in expected inflation) affects the stock price

Stock Market Equilibrium is the condition under which the expected return on a security is just equal to its required return

Caution concerning the CAPM:
Based on expected conditions
Only have historical data
As conditions change, future volatility may differ from past volatility
Estimates are subject to error
Some other useful formulas:

\[
Rate \ of \ return = \frac{(Expected \ ending \ value - Cost) + cash \ flows}{Cost}
\]

Average return and standard deviation using historical returns (sample):

\[
\bar{r} = \frac{\sum_{i=1}^{N} r_i}{N} \quad \sigma = \sqrt{\frac{\sum_{i=1}^{N} (r_i - \bar{r})^2}{N - 1}}
\]