Chapter 10
Capital Markets and the Pricing of Risk
• How would $100 have grown if it were placed in one of the following investments?
  – Standard & Poor’s 500: 90 U.S. stocks up to 1957 and 500 after that. Leaders in their industries and among the largest firms traded on U.S. Markets.
  – Small stocks: Securities traded on the NYSE with market capitalizations in the bottom 20%.
• How would $100 have grown if it were placed in one of the following investments?
  – World Portfolio: International stocks from all the world’s major stock markets in North America, Europe, and Asia.
  – Corporate Bonds: Long-term, AAA-rated U.S. corporate bonds with maturities of approximately 20 years.
Figure 10.1 Value of $100 Invested at the End of 1925

Source: Chicago Center for Research in Security Prices, Standard and Poor’s, MSCI, and Global Financial Data.
10.1 Risk and Return: Insights from 86 Years of Investor History (cont’d)

- Small stocks had the highest long-term returns, while T-Bills had the lowest long-term returns.

- Small stocks had the largest fluctuations in price, while T-Bills had the lowest.
  - Higher risk requires a higher return.
• Few people ever make an investment for 86 years.

• More realistic investment horizons and different initial investment dates can greatly influence each investment's risk and return.
Figure 10.2  Value of $100 Invested for Alternative Investment Horizons

Source: Chicago Center for Research in Security Prices, Standard and Poor’s, MSCI, and Global Financial Data.
10.2 Common Measures of Risk and Return

- **Probability Distributions**
  - When an investment is risky, there are different returns it may earn. Each possible return has some likelihood of occurring. This information is summarized with a probability distribution, which assigns a probability, $P_R$, that each possible return, $R$, will occur.

- Assume BFI stock currently trades for $100 per share. In one year, there is a 25% chance the share price will be $140, a 50% chance it will be $110, and a 25% chance it will be $80.
Table 10.1  Probability Distribution of Returns for BFI

<table>
<thead>
<tr>
<th>Current Stock Price ($)</th>
<th>Stock Price in One Year ($)</th>
<th>Probability Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>140</td>
<td>Return, $R$</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$-0.20$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probability, $P_R$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25%</td>
</tr>
</tbody>
</table>
Figure 10.3  Probability Distribution of Returns for BFI
Expected Return

- Expected (Mean) Return
  - Calculated as a weighted average of the possible returns, where the weights correspond to the probabilities.

\[
\text{Expected Return} = E[R] = \sum_{R} P_R \times R
\]

\[
E[R_{BFI}] = 25\%(-0.20) + 50\%(0.10) + 25\%(0.40) = 10\%
\]
Variance and Standard Deviation

• Variance
  – The expected squared deviation from the mean

\[
Var(R) = E\left( (R - E[R])^2 \right) = \sum_R P_R \times (R - E[R])^2
\]

• Standard Deviation
  – The square root of the variance

\[
SD(R) = \sqrt{Var(R)}
\]

• Both are measures of the risk of a probability distribution
Variance and Standard Deviation (cont'd)

• For BFI, the variance and standard deviation are:

\[ Var[R_{BFI}] = 25\% \times (-0.20 - 0.10)^2 + 50\% \times (0.10 - 0.10)^2 \]
\[ + 25\% \times (0.40 - 0.10)^2 = 0.045 \]

\[ SD(R) = \sqrt{Var(R)} = \sqrt{0.045} = 21.2\% \]

– In finance, the standard deviation of a return is also referred to as its *volatility*. The standard deviation is easier to interpret because it is in the same units as the returns themselves.
Calculating the Expected Return and Volatility

Problem
Suppose AMC stock is equally likely to have a 45% return or a −25% return. What are its expected return and volatility?

Solution
First, we calculate the expected return by taking the probability-weighted average of the possible returns:

\[ E[R] = \sum_R p_R \times R = 50\% \times 0.45 + 50\% \times (-0.25) = 10.0\% \]

To compute the volatility, we first determine the variance:

\[ Var(R) = \sum_R p_R \times (R - E[R])^2 = 50\% \times (0.45 - 0.10)^2 + 50\% \times (-0.25 - 0.10)^2 \]
\[ = 0.1225 \]

Then, the volatility or standard deviation is the square root of the variance:

\[ SD(R) = \sqrt{Var(R)} = \sqrt{0.1225} = 35\% \]
• Problem
  – TXU stock has the following probability distribution:

<table>
<thead>
<tr>
<th>Probability</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>.25</td>
<td>8%</td>
</tr>
<tr>
<td>.55</td>
<td>10%</td>
</tr>
<tr>
<td>.20</td>
<td>12%</td>
</tr>
</tbody>
</table>

– What are its expected return and standard deviation?
Alternative Example 10.1 (cont’d)

• Solution

  – Expected Return
    • \( E[R] = (0.25)(0.08) + (0.55)(0.10) + (0.20)(0.12) \)
    • \( E[R] = 0.020 + 0.055 + 0.024 = 0.099 = 9.9\% \)

  – Standard Deviation
    • \( SD(R) = [(0.25)(0.08 - 0.099)^2 + (0.55)(0.10 - 0.099)^2 +
                  (0.20)(0.12 - 0.099)^2]^{1/2} \)
    • \( SD(R) = [0.00009025 + 0.00000055 + 0.0000882]^{1/2} \)
    • \( SD(R) = 0.000179^{1/2} = 0.01338 = 1.338\% \)
Figure 10.4 Probability Distributions for BFI and AMC Returns
10.3 Historical Returns of Stocks and Bonds

• Computing Historical Returns
  – Realized Return
    • The return that actually occurs over a particular time period.

\[
R_{t+1} = \frac{Div_{t+1} + P_{t+1}}{P_t} - 1 = \frac{Div_{t+1}}{P_t} + \frac{Div_{t+1} - P_t}{P_t}
\]

= Dividend Yield + Capital Gain Rate
10.3 Historical Returns of Stocks and Bonds (cont'd)

• Computing Historical Returns

  - If you hold the stock beyond the date of the first dividend, then to compute your return you must specify how you invest any dividends you receive in the interim. Let’s assume that all dividends are immediately reinvested and used to purchase additional shares of the same stock or security.
10.3 Historical Returns of Stocks and Bonds (cont'd)

- Computing Historical Returns

  - If a stock pays dividends at the end of each quarter, with realized returns \( R_{Q1}, \ldots, R_{Q4} \) each quarter, then its annual realized return, \( R_{\text{annual}} \), is computed as:

\[
1 + R_{\text{annual}} = (1 + R_{Q1})(1 + R_{Q2})(1 + R_{Q3})(1 + R_{Q4})
\]
Textbook Example 10.2

Realized Returns for Microsoft Stock

Problem
What were the realized annual returns for Microsoft stock in 2004 and 2008?
Textbook Example 10.2 (cont'd)

Solution
When we compute Microsoft’s annual return, we assume that the proceeds from the dividend payment were immediately reinvested in Microsoft stock. That way, the return corresponds to remaining fully invested in Microsoft over the entire period. To do that we look up Microsoft stock price data at the start and end of the year, as well as at any dividend dates (Yahoo!Finance is a good source for such data; see also MyFinanceLab or www.pearsonhighered.com/berk_demarzo for additional sources). From these data, we can construct the following table (prices and dividends in $/share):

<table>
<thead>
<tr>
<th>Date</th>
<th>Price</th>
<th>Dividend</th>
<th>Return</th>
<th>Date</th>
<th>Price</th>
<th>Dividend</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/03</td>
<td>27.37</td>
<td></td>
<td></td>
<td>12/31/07</td>
<td>35.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/23/04</td>
<td>27.24</td>
<td>0.08</td>
<td>−0.18%</td>
<td>2/19/08</td>
<td>28.17</td>
<td>0.11</td>
<td>−20.56%</td>
</tr>
<tr>
<td>11/15/04</td>
<td>27.39</td>
<td>3.08</td>
<td>11.86%</td>
<td>5/13/08</td>
<td>29.78</td>
<td>0.11</td>
<td>6.11%</td>
</tr>
<tr>
<td>12/31/04</td>
<td>26.72</td>
<td></td>
<td>−2.45%</td>
<td>8/19/08</td>
<td>27.32</td>
<td>0.11</td>
<td>−7.89%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11/18/08</td>
<td>19.62</td>
<td>0.13</td>
<td>−27.71%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12/31/08</td>
<td>19.44</td>
<td></td>
<td>0.92%</td>
</tr>
</tbody>
</table>

The return from December 31, 2003, until August 23, 2004, is equal to

\[
\frac{0.08 + 27.24}{27.37} - 1 = -0.18\%
\]

The rest of the returns in the table are computed similarly. We then calculate the annual returns using Eq. 10.5:

\[
R_{2004} = (0.9982)(1.1186)(0.9755) - 1 = 8.92\%
\]

\[
R_{2008} = (0.7944)(1.0611)(0.9211)(0.7229)(0.9908) - 1 = -44.39\%
\]
Alternative Example 10.2

• Problem:
  – What were the realized annual returns for NRG stock in 2008 and in 2012?
Alternative Example 10.2 (cont’d)

- **Solution**
  - First, we look up stock price data for NRG at the start and end of the year, as well as dividend dates. From these data, we construct the following table:

<table>
<thead>
<tr>
<th>Date</th>
<th>Price ($)</th>
<th>Dividend ($)</th>
<th>Return</th>
<th>Date</th>
<th>Price ($)</th>
<th>Dividend ($)</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/31/2007</td>
<td>58.69</td>
<td></td>
<td></td>
<td>12/31/2011</td>
<td>6.73</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1/31/2008</td>
<td>61.44</td>
<td>0.26</td>
<td>5.13%</td>
<td>3/31/2012</td>
<td>5.72</td>
<td>0</td>
<td>-15.01%</td>
</tr>
<tr>
<td>4/30/2008</td>
<td>63.94</td>
<td>0.26</td>
<td>4.49%</td>
<td>6/30/2012</td>
<td>4.81</td>
<td>0</td>
<td>-15.91%</td>
</tr>
<tr>
<td>7/31/2008</td>
<td>48.5</td>
<td>0.26</td>
<td>-23.74%</td>
<td>9/30/2012</td>
<td>5.2</td>
<td>0</td>
<td>8.11%</td>
</tr>
<tr>
<td>10/31/2008</td>
<td>54.88</td>
<td>0.29</td>
<td>13.75%</td>
<td>12/21/2012</td>
<td>2.29</td>
<td>0</td>
<td>-55.96%</td>
</tr>
<tr>
<td>12/31/2008</td>
<td>53.31</td>
<td>-2.86%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Alternative Example 10.2 (cont’d)

• Solution
  - We compute each period’s return using Equation 10.4. For example, the return from December 31, 2007 to January 31, 2008 is:

\[
\frac{61.44 + 0.26}{58.69} - 1 = 5.13\%
\]

- We then determine annual returns using Eq. 10.5:

\[
R_{2008} = (1.0513)(1.0449)(0.7626)(1.1375)(0.9714) - 1 = -7.43\%
\]

\[
R_{2012} = (0.8499)(0.8409)(1.0811)(0.440) - 1 = -66.0\%
\]
Alternative Example 10.2 (cont’d)

• Solution
  – Note that, since NRG did not pay dividends during 2012, the return can also be computed as:

\[
\frac{2.29}{6.73} - 1 = -66.0\%
\]
**Table 10.2  Realized Return for the S&P 500, Microsoft, and Treasury Bills, 2001–2011**

<table>
<thead>
<tr>
<th>Year End</th>
<th>S&amp;P 500 Index</th>
<th>Dividends Paid*</th>
<th>S&amp;P 500 Realized Return</th>
<th>Microsoft Realized Return</th>
<th>1-Month T-Bill Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1148.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>879.82</td>
<td>14.53</td>
<td>−22.1%</td>
<td>−22.0%</td>
<td>1.6%</td>
</tr>
<tr>
<td>2003</td>
<td>1111.92</td>
<td>20.80</td>
<td>28.7%</td>
<td>6.8%</td>
<td>1.0%</td>
</tr>
<tr>
<td>2004</td>
<td>1211.92</td>
<td>20.98</td>
<td>10.9%</td>
<td>8.9%</td>
<td>1.2%</td>
</tr>
<tr>
<td>2005</td>
<td>1248.29</td>
<td>23.15</td>
<td>4.9%</td>
<td>−0.9%</td>
<td>3.0%</td>
</tr>
<tr>
<td>2006</td>
<td>1418.30</td>
<td>27.16</td>
<td>15.8%</td>
<td>15.8%</td>
<td>4.8%</td>
</tr>
<tr>
<td>2007</td>
<td>1468.36</td>
<td>27.86</td>
<td>5.5%</td>
<td>20.8%</td>
<td>4.7%</td>
</tr>
<tr>
<td>2008</td>
<td>903.25</td>
<td>21.85</td>
<td>−37.0%</td>
<td>−44.4%</td>
<td>1.5%</td>
</tr>
<tr>
<td>2009</td>
<td>1115.10</td>
<td>27.19</td>
<td>26.5%</td>
<td>60.5%</td>
<td>0.1%</td>
</tr>
<tr>
<td>2010</td>
<td>1257.64</td>
<td>25.44</td>
<td>15.1%</td>
<td>−6.5%</td>
<td>0.1%</td>
</tr>
<tr>
<td>2011</td>
<td>1257.60</td>
<td>26.59</td>
<td>2.1%</td>
<td>−4.5%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

*Total dividends paid by the 500 stocks in the portfolio, based on the number of shares of each stock in the index, adjusted until the end of the year, assuming they were reinvested when paid.

Source: Standard & Poor’s, Microsoft and U.S. Treasury Data
10.3 Historical Returns of Stocks and Bonds (cont'd)

• Computing Historical Returns
  - By counting the number of times a realized return falls within a particular range, we can estimate the underlying probability distribution.
  - Empirical Distribution
    • When the probability distribution is plotted using historical data
Figure 10.5  The Empirical Distribution of Annual Returns for U.S. Large Stocks (S&P 500), Small Stocks, Corporate Bonds, and Treasury Bills, 1926–2011
Table 10.3  Average Annual Returns for U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2011

<table>
<thead>
<tr>
<th>Investment</th>
<th>Average Annual Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small stocks</td>
<td>18.7%</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>11.7%</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>6.6%</td>
</tr>
<tr>
<td>Treasury bills</td>
<td>3.6%</td>
</tr>
</tbody>
</table>
Average Annual Return

\[ \bar{R} = \frac{1}{T} \left( R_1 + R_2 + \cdots + R_T \right) = \frac{1}{T} \sum_{t=1}^{T} R_t \]

- Where \( R_t \) is the realized return of a security in year \( t \), for the years 1 through \( T \)

- Using the data from Table 10.2, the average annual return for the S&P 500 from 2002-2011 is:

\[
\bar{R} = \frac{1}{10} (-0.221 + 0.287 + 0.109 + 0.049 + 0.158 \\
+ 0.055 - 0.37 + 0.265 + 0.151 + 0.021) = 5.0\%
\]
The Variance and Volatility of Returns

- Variance Estimate Using Realized Returns

\[
Var(R) = \frac{1}{T - 1} \sum_{t=1}^{T} (R_t - \bar{R})^2
\]

- The estimate of the standard deviation is the square root of the variance.
Textbook Example 10.3

Computing a Historical Volatility

**Problem**
Using the data from Table 10.2, what are the variance and volatility of the S&P 500’s returns for the years 2002–2011?

**Solution**
Earlier, we calculated the average annual return of the S&P 500 during this period to be 5.0%. Therefore,

\[
Var(R) = \frac{1}{T-1} \sum_t (R_t - \bar{R})^2
\]

\[
= \frac{1}{10 - 1} [(-0.221 - 0.05)^2 + (0.287 - 0.05)^2 + \cdots + (0.021 - 0.05)^2]
\]

\[
= 0.042
\]

The volatility or standard deviation is therefore

\[
SD(R) = \sqrt{Var(R)} = \sqrt{0.042} = 20.5\%
\]
Alternative Example 10.3

**Problem:**
- Using the data from Table 10.2, what are the variance and volatility of Microsoft’s returns from 2001 to 2011?
Alternative Example 10.3 (cont’d)

• Solution:
  – First, we need to calculate the average return for Microsoft’s over that time period, using equation 10.6:

\[
\bar{R} = \frac{1}{10} (-22.0\% + 6.8\% + 8.9\% - 0.9\% + 15.8\% + 20.8\% - 44.4\% + 60.5\% - 6.5\% - 4.5\%) \\
= 3.5\%
\]
Alternative Example 10.3 (cont’d)

Next, we calculate the variance using equation 10.7:

\[
Var(R) = \frac{1}{T-1} \sum (R_i - \bar{R})^2 \\
= \frac{1}{10-1} \left[ (-22.0\% - 3.5\%)^2 + (6.8\% - 3.5\%)^2 + \ldots + (-4.5\% - 3.5\%)^2 \right] \\
= 7.63\%
\]

The volatility or standard deviation is therefore

\[
SD(R) = \sqrt{Var(R)} = \sqrt{7.63\%} = 27.62\%
\]
### Table 10.4 Volatility of U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2011

<table>
<thead>
<tr>
<th>Investment</th>
<th>Return Volatility (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small stocks</td>
<td>39.2%</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>20.3%</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>7.0%</td>
</tr>
<tr>
<td>Treasury bills</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
Estimation Error: Using Past Returns to Predict the Future

• We can use a security’s historical average return to estimate its actual expected return. However, the average return is just an estimate of the expected return.
  – Standard Error
  • A statistical measure of the degree of estimation error
Estimation Error: Using Past Returns to Predict the Future (cont'd)

- Standard Error of the Estimate of the Expected Return

\[ SD(\text{Average of Independent, Identical Risks}) = \frac{SD(\text{Individual Risk})}{\sqrt{\text{Number of Observations}}} \]

- 95% Confidence Interval

Historical Average Return \( \pm (2 \times \text{Standard Error}) \)

- For the S&P 500 (1926–2011)

\[ 11.7\% \pm 2 \left( \frac{20.3\%}{\sqrt{86}} \right) = 11.7\% \pm 4.4\% \]

- Or a range from 7.3% to 13.1%
The Accuracy of Expected Return Estimates

Problem
Using the returns for the S&P 500 from 2002–2011 only (see Table 10.2), what is the 95% confidence interval you would estimate for the S&P 500’s expected return?

Solution
Earlier, we calculated the average return for the S&P 500 during this period to be 5.0%, with a volatility of 20.5% (see Example 10.3). The standard error of our estimate of the expected return is $20.5\% \div \sqrt{10} = 6.5\%$, and the 95% confidence interval is $5.0\% \pm (2 \times 6.5\%)$, or from $-8\%$ to $18\%$. As this example shows, with only a few years of data, we cannot reliably estimate expected returns for stocks.
10.4 The Historical Tradeoff Between Risk and Return

• The Returns of Large Portfolios
  – Excess Returns
    • The difference between the average return for an investment and the average return for T-Bills
Table 10.5 Volatility Versus Excess Return of U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2011

<table>
<thead>
<tr>
<th>Investment</th>
<th>Return Volatility (Standard Deviation)</th>
<th>Excess Return (Average Return in Excess of Treasury Bills)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small stocks</td>
<td>39.2%</td>
<td>15.1%</td>
</tr>
<tr>
<td>S&amp;P 500</td>
<td>20.3%</td>
<td>8.1%</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>7.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Treasury bills</td>
<td>3.1%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Figure 10.6  The Historical Tradeoff Between Risk and Return in Large Portfolios

Source: CRSP, Morgan Stanley Capital International
The Returns of Individual Stocks

• Is there a positive relationship between volatility and average returns for individual stocks?
  
  – As shown on the next slide, there is no precise relationship between volatility and average return for individual stocks.

  • Larger stocks tend to have lower volatility than smaller stocks.

  • All stocks tend to have higher risk and lower returns than large portfolios.
Figure 10.7  Historical Volatility and Return for 500 Individual Stocks, Ranked Annually by Size
10.5 Common Versus Independent Risk

• Common Risk
  – Risk that is perfectly correlated
    • Risk that affects all securities

• Independent Risk
  – Risk that is uncorrelated
    • Risk that affects a particular security

• Diversification
  – The averaging out of independent risks in a large portfolio
**Textbook Example 10.5**

**Problem**
Roulette wheels are typically marked with the numbers 1 through 36 plus 0 and 00. Each of these outcomes is equally likely every time the wheel is spun. If you place a bet on any one number and are correct, the payoff is 35:1; that is, if you bet $1, you will receive $36 if you win ($35 plus your original $1) and nothing if you lose. Suppose you place a $1 bet on your favorite number. What is the casino’s expected profit? What is the standard deviation of this profit for a single bet? Suppose 9 million similar bets are placed throughout the casino in a typical month. What is the standard deviation of the casino’s average revenues per dollar bet each month?
Solution
Because there are 38 numbers on the wheel, the odds of winning are 1/38. The casino loses $35 if you win, and makes $1 if you lose. Therefore, using Eq. 10.1, the casino’s expected profit is

\[ E[\text{Payoff}] = \frac{1}{38} \times (-35) + \frac{37}{38} \times (1) = 0.0526 \]

That is, for each dollar bet, the casino earns 5.26 cents on average. For a single bet, we calculate the standard deviation of this profit using Eq. 10.2 as

\[ SD(\text{Payoff}) = \sqrt{\left(\frac{1}{38} \times (-35 - 0.0526)^2 + \frac{37}{38} \times (1 - 0.0526)^2\right)} = 5.76 \]

This standard deviation is quite large relative to the magnitude of the profits. But if many such bets are placed, the risk will be diversified. Using Eq. 10.8, the standard deviation of the casino’s average revenues per dollar bet (i.e., the standard error of their payoff) is only

\[ SD(\text{Average Payoff}) = \frac{5.76}{\sqrt{9,000,000}} = 0.0019 \]

In other words, by the same logic as Eq. 10.9, there is roughly 95% chance the casino’s profit per dollar bet will be in the interval $0.0526 \pm (2 \times 0.0019) = $0.0488 to $0.0564. Given $9 million in bets placed, the casino’s monthly profits will almost always be between $439,000 and $508,000, which is very little risk. The key assumption, of course, is that each bet is separate so that their outcomes are independent of each other. If the $9 million were placed in a single bet, the casino’s risk would be large—losing $35 \times $9 million = $315 million if the bet wins. For this reason, casinos often impose limits on the amount of any individual bet.
10.6 Diversification in Stock Portfolios

• Firm-Specific Versus Systematic Risk
  – Firm Specific News
    • Good or bad news about an individual company
  – Market-Wide News
    • News that affects all stocks, such as news about the economy
10.6 Diversification in Stock Portfolios (cont'd)

- Firm-Specific Versus Systematic Risk
  - Independent Risks
    - Due to firm-specific news
      - Also known as:
        » Firm-Specific Risk
        » Idiosyncratic Risk
        » Unique Risk
        » Unsystematic Risk
        » Diversifiable Risk
10.6 Diversification in Stock Portfolios (cont'd)

• Firm-Specific Versus Systematic Risk
  – Common Risks
    • Due to market-wide news
      – Also known as:
        » Systematic Risk
        » Undiversifiable Risk
        » Market Risk
10.6 Diversification in Stock Portfolios (cont'd)

- Firm-Specific Versus Systematic Risk
  - When many stocks are combined in a large portfolio, the firm-specific risks for each stock will average out and be diversified.
  - The systematic risk, however, will affect all firms and will not be diversified.
10.6 Diversification in Stock Portfolios (cont'd)

- Firm-Specific Versus Systematic Risk

  - Consider two types of firms:

    - Type S firms are affected only by systematic risk. There is a 50% chance the economy will be strong and type S stocks will earn a return of 40%; There is a 50% change the economy will be weak and their return will be -20%. Because all these firms face the same systematic risk, holding a large portfolio of type S firms will not diversify the risk.
• Firm-Specific Versus Systematic Risk
  – Consider two types of firms:
    • Type I firms are affected only by firm-specific risks. Their returns are equally likely to be 35% or –25%, based on factors specific to each firm’s local market. Because these risks are firm specific, if we hold a portfolio of the stocks of many type I firms, the risk is diversified.
10.6 Diversification in Stock Portfolios (cont'd)

• Firm-Specific Versus Systematic Risk
  
  – Actual firms are affected by both market-wide risks and firm-specific risks. When firms carry both types of risk, only the unsystematic risk will be diversified when many firm’s stocks are combined into a portfolio. The volatility will therefore decline until only the systematic risk remains.
Figure 10.8 Volatility of Portfolios of Type S and I Stocks
Textbook Example 10.6

Portfolio Volatility

Problem
What is the volatility of the average return of ten type S firms? What is the volatility of the average return of ten type I firms?
Textbook Example 10.6 (cont'd)

Solution
Type S firms have equally likely returns of 40% or −20%. Their expected return is
\[
\frac{1}{2} (40\%) + \frac{1}{2} (-20\%) = 10\%,
\]
so
\[
SD (R_S) = \sqrt{\frac{1}{2} (0.40 - 0.10)^2 + \frac{1}{2} (-0.20 - 0.10)^2} = 30\%
\]

Because all type S firms have high or low returns at the same time, the average return of
ten type S firms is also 40% or −20%. Thus, it has the same volatility of 30%, as shown in
Figure 10.8.

Type I firms have equally likely returns of 35% or −25%. Their expected return is
\[
\frac{1}{2} (35\%) + \frac{1}{2} (-25\%) = 5\%,
\]
so
\[
SD (R_I) = \sqrt{\frac{1}{2} (0.35 - 0.05)^2 + \frac{1}{2} (-0.25 - 0.05)^2} = 30\%
\]

Because the returns of type I firms are independent, using Eq. 10.8, the average return of 10 type
I firms has volatility of 30% \(\div\sqrt{10} = 9.5\%\), as shown in Figure 10.8.
The risk premium for diversifiable risk is zero, so investors are not compensated for holding firm-specific risk.

- If the diversifiable risk of stocks were compensated with an additional risk premium, then investors could buy the stocks, earn the additional premium, and simultaneously diversify and eliminate the risk.
No Arbitrage and the Risk Premium (cont'd)

- By doing so, investors could earn an additional premium without taking on additional risk. This opportunity to earn something for nothing would quickly be exploited and eliminated. Because investors can eliminate firm-specific risk "for free" by diversifying their portfolios, they will not require or earn a reward or risk premium for holding it.
No Arbitrage and the Risk Premium (cont'd)

- The risk premium of a security is determined by its systematic risk and does not depend on its diversifiable risk.

  - This implies that a stock’s volatility, which is a measure of total risk (that is, systematic risk plus diversifiable risk), is not especially useful in determining the risk premium that investors will earn.
No Arbitrage
and the Risk Premium (cont'd)

• Standard deviation is not an appropriate measure of risk for an individual security. There should be no clear relationship between volatility and average returns for individual securities. Consequently, to estimate a security’s expected return, we need to find a measure of a security’s systematic risk.
Textbook Example 10.7

Diversifiable Versus Systematic Risk

Problem
Which of the following risks of a stock are likely to be firm-specific, diversifiable risks, and which are likely to be systematic risks? Which risks will affect the risk premium that investors will demand?

a. The risk that the founder and CEO retires
b. The risk that oil prices rise, increasing production costs
c. The risk that a product design is faulty and the product must be recalled
d. The risk that the economy slows, reducing demand for the firm’s products
Textbook Example 10.7 (cont'd)

Solution
Because oil prices and the health of the economy affect all stocks, risks (b) and (d) are system-
atic risks. These risks are not diversified in a large portfolio, and so will affect the risk premium
that investors require to invest in a stock. Risks (a) and (c) are firm-specific risks, and so are
diversifiable. While these risks should be considered when estimating a firm’s future cash flows,
they will not affect the risk premium that investors will require and, therefore, will not affect a
firm’s cost of capital.
10.7 Measuring Systematic Risk

• To measure the systematic risk of a stock, determine how much of the variability of its return is due to systematic risk versus unsystematic risk.
  
  – To determine how sensitive a stock is to systematic risk, look at the average change in the return for each 1% change in the return of a portfolio that fluctuates solely due to systematic risk.
• Efficient Portfolio
  – A portfolio that contains only systematic risk. There is no way to reduce the volatility of the portfolio without lowering its expected return.

• Market Portfolio
  – An efficient portfolio that contains all shares and securities in the market
    • The S&P 500 is often used as a proxy for the market portfolio.
10.7 Measuring Systematic Risk (cont'd)

• Sensitivity to Systematic Risk: Beta (β)
  
  – The expected percent change in the excess return of a security for a 1% change in the excess return of the market portfolio.

  • Beta differs from volatility. Volatility measures total risk (systematic plus unsystematic risk), while beta is a measure of only systematic risk.
Textbook Example 10.8

Estimating Beta

Problem
Suppose the market portfolio tends to increase by 47% when the economy is strong and decline by 25% when the economy is weak. What is the beta of a type S firm whose return is 40% on average when the economy is strong and −20% when the economy is weak? What is the beta of a type I firm that bears only idiosyncratic, firm-specific risk?

Solution
The systematic risk of the strength of the economy produces a 47% − (−25%) = 72% change in the return of the market portfolio. The type S firm’s return changes by 40% − (−20%) = 60% on average. Thus the firm’s beta is $\beta_S = 60%/72% = 0.833$. That is, each 1% change in the return of the market portfolio leads to a 0.833% change in the type S firm’s return on average.

The return of a type I firm has only firm-specific risk, however, and so is not affected by the strength of the economy. Its return is affected only by factors specific to the firm. Because it will have the same expected return, whether the economy is strong or weak, $\beta_I = 0%/72% = 0$. 

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Alternative Example 10.8

• Problem:
  – Suppose the market portfolio tends to increase by 52% when the economy is strong and decline by 21% when the economy is weak.
  – What is the beta of a type S firm whose return is 55% on average when the economy is strong and -24% when the economy is weak?
  – What is the beta of a type I firm that bears only idiosyncratic, firm-specific risk?
Solution:

- The systematic risk of the strength of the economy produces a $52\% - (-21\%) = 73\%$ change in the return of the market portfolio.
- The type S firm’s return changes by $55\% - (-24\%) = 79\%$ on average.
- Thus the firm’s beta is $\beta_S = 79\%/73\% = 1.082$. That is, each 1% change in the return of the market portfolio leads to a 1.082% change in the type S firm’s return on average.
Alternative Example 10.8 (cont’d)

• Solution:
  - The return of a type I firm has only firm-specific risk, however, and so is not affected by the strength of the economy. Its return is affected only by factors specific to the firm.
  - Because it will have the same expected return, whether the economy is strong or weak, $\beta_I = 0%/72% = 0$. 
Table 10.6  Betas with Respect to the S&P 500 for Individual Stocks (based on monthly data for 2007–2012) (cont’d)

<table>
<thead>
<tr>
<th>Company</th>
<th>Ticker</th>
<th>Industry</th>
<th>Equity Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Mills</td>
<td>GIS</td>
<td>Packaged Foods</td>
<td>0.20</td>
</tr>
<tr>
<td>Consolidated Edison</td>
<td>ED</td>
<td>Utilities</td>
<td>0.28</td>
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<tr>
<td>The Hershey Company</td>
<td>HSY</td>
<td>Packaged Foods</td>
<td>0.28</td>
</tr>
<tr>
<td>Abbott Laboratories</td>
<td>ABT</td>
<td>Pharmaceuticals</td>
<td>0.31</td>
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<tr>
<td>Newmont Mining</td>
<td>NEM</td>
<td>Gold</td>
<td>0.32</td>
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<tr>
<td>Wal-Mart Stores</td>
<td>WMT</td>
<td>Superstores</td>
<td>0.35</td>
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<tr>
<td>Clorox</td>
<td>CLX</td>
<td>Household Products</td>
<td>0.39</td>
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<tr>
<td>Kroger</td>
<td>KR</td>
<td>Food Retail</td>
<td>0.42</td>
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<tr>
<td>Altria Group</td>
<td>MO</td>
<td>Tobacco</td>
<td>0.43</td>
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<tr>
<td>Amgen</td>
<td>AMGN</td>
<td>Biotechnology</td>
<td>0.44</td>
</tr>
<tr>
<td>McDonald’s</td>
<td>MCD</td>
<td>Restaurants</td>
<td>0.47</td>
</tr>
<tr>
<td>Procter &amp; Gamble</td>
<td>PG</td>
<td>Household Products</td>
<td>0.47</td>
</tr>
<tr>
<td>Pepsi</td>
<td>PEP</td>
<td>Soft Drinks</td>
<td>0.51</td>
</tr>
<tr>
<td>Coca-Cola</td>
<td>KO</td>
<td>Soft Drinks</td>
<td>0.54</td>
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<tr>
<td>Johnson &amp; Johnson</td>
<td>JNJ</td>
<td>Pharmaceuticals</td>
<td>0.59</td>
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<td>PetSmart</td>
<td>PETM</td>
<td>Specialty Stores</td>
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<td>Molson Coors Brewing</td>
<td>TAP</td>
<td>Brewers</td>
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<tr>
<td>Nike</td>
<td>NKE</td>
<td>Footwear</td>
<td>0.91</td>
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<tr>
<td>Microsoft</td>
<td>MSFT</td>
<td>Systems Software</td>
<td>1.01</td>
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<tr>
<td>Southwest Airlines</td>
<td>LUV</td>
<td>Airlines</td>
<td>1.09</td>
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<tr>
<td>Intel</td>
<td>INTC</td>
<td>Semiconductors</td>
<td>1.09</td>
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<tr>
<td>Whole Foods Market</td>
<td>WFM</td>
<td>Food Retail</td>
<td>1.10</td>
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<tr>
<td>Foot Locker</td>
<td>FL</td>
<td>Apparel Retail</td>
<td>1.11</td>
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<tr>
<td>Oracle</td>
<td>ORCL</td>
<td>Systems Software</td>
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<tr>
<td>Amazon.com</td>
<td>AMZN</td>
<td>Internet Retail</td>
<td>1.13</td>
</tr>
<tr>
<td>Google</td>
<td>GOOG</td>
<td>Internet Software and Services</td>
<td>1.14</td>
</tr>
</tbody>
</table>
### Table 10.6 Betas with Respect to the S&P 500 for Individual Stocks (based on monthly data for 2007–2012)

<table>
<thead>
<tr>
<th>Company</th>
<th>Ticker</th>
<th>Industry</th>
<th>Equity Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starbucks</td>
<td>SBUX</td>
<td>Restaurants</td>
<td>1.20</td>
</tr>
<tr>
<td>Walt Disney</td>
<td>DIS</td>
<td>Movies and Entertainment</td>
<td>1.21</td>
</tr>
<tr>
<td>Cisco Systems</td>
<td>CSCO</td>
<td>Communications Equipment</td>
<td>1.23</td>
</tr>
<tr>
<td>Apple</td>
<td>AAPL</td>
<td>Computer Hardware</td>
<td>1.26</td>
</tr>
<tr>
<td>PulteGroup</td>
<td>PHM</td>
<td>Homebuilding</td>
<td>1.28</td>
</tr>
<tr>
<td>Dell</td>
<td>DELL</td>
<td>Computer Hardware</td>
<td>1.41</td>
</tr>
<tr>
<td>salesforce.com</td>
<td>CRM</td>
<td>Application Software</td>
<td>1.47</td>
</tr>
<tr>
<td>Marriott International</td>
<td>MAR</td>
<td>Hotels and Resorts</td>
<td>1.48</td>
</tr>
<tr>
<td>eBay</td>
<td>EBAY</td>
<td>Internet Software and Services</td>
<td>1.48</td>
</tr>
<tr>
<td>Coach</td>
<td>COH</td>
<td>Apparel and Luxury Goods</td>
<td>1.60</td>
</tr>
<tr>
<td>Macy’s</td>
<td>M</td>
<td>Department Stores</td>
<td>1.67</td>
</tr>
<tr>
<td>Juniper Networks</td>
<td>JNPR</td>
<td>Communications Equipment</td>
<td>1.71</td>
</tr>
<tr>
<td>Williams-Sonoma</td>
<td>WSM</td>
<td>Home Furnishing Retail</td>
<td>1.72</td>
</tr>
<tr>
<td>Tiffany &amp; Co.</td>
<td>TIF</td>
<td>Apparel and Luxury Goods</td>
<td>1.80</td>
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<tr>
<td>Caterpillar</td>
<td>CAT</td>
<td>Construction Machinery</td>
<td>1.85</td>
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<tr>
<td>Ethan Allen Interiors</td>
<td>ETH</td>
<td>Home Furnishings</td>
<td>1.95</td>
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<tr>
<td>Autodesk</td>
<td>ADSK</td>
<td>Application Software</td>
<td>2.14</td>
</tr>
<tr>
<td>Harley-Davidson</td>
<td>HOG</td>
<td>Motorcycle Manufacturers</td>
<td>2.23</td>
</tr>
<tr>
<td>Advanced Micro Devices</td>
<td>AMD</td>
<td>Semiconductors</td>
<td>2.24</td>
</tr>
<tr>
<td>Ford Motor</td>
<td>F</td>
<td>Automobile Manufacturers</td>
<td>2.38</td>
</tr>
<tr>
<td>Sotheby’s</td>
<td>BID</td>
<td>Auction Services</td>
<td>2.39</td>
</tr>
<tr>
<td>Wynn Resorts Ltd.</td>
<td>WYNN</td>
<td>Casinos and Gaming</td>
<td>2.41</td>
</tr>
<tr>
<td>United States Steel</td>
<td>X</td>
<td>Steel</td>
<td>2.52</td>
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<tr>
<td>Saks</td>
<td>SKS</td>
<td>Department Stores</td>
<td>2.57</td>
</tr>
</tbody>
</table>

*Source: CapitalIQ*
Interpreting Beta (β)

- A security’s beta is related to how sensitive its underlying revenues and cash flows are to general economic conditions. Stocks in cyclical industries are likely to be more sensitive to systematic risk and have higher betas than stocks in less sensitive industries.
10.8 Beta and the Cost of Capital

- Estimating the Risk Premium
  - Market risk premium
    - The market risk premium is the reward investors expect to earn for holding a portfolio with a beta of 1.

\[
\text{Market Risk Premium} = E \left[ R_{Mkt} \right] - r_f
\]
10.8 Beta and Cost of Capital (cont'd)

• Adjusting for Beta
  – Estimating a Traded Security’s Cost of Capital of an investment from Its Beta

\[
E \left[ R \right] = \text{Risk-Free Interest Rate} + \text{Risk Premium}
\]
\[
= r_f + \beta \times \left( E \left[ R_{Mkt} \right] - r_f \right)
\]
Expected Returns and Beta

Problem
Suppose the risk-free rate is 5% and the economy is equally likely to be strong or weak. Use Eq. 10.11 to determine the cost of capital for the type S firms considered in Example 10.8. How does this cost of capital compare with the expected return for these firms?
Textbook Example 10.9 (cont'd)

Solution

If the economy is equally likely to be strong or weak, the expected return of the market is

\[ E[R_{Mkt}] = \frac{1}{2} (0.47) + \frac{1}{2} (-0.25) = 11\% \]

and the market risk premium is

\[ E[R_{Mkt}] - r_f = 11\% - 5\% = 6\% \]

Given the beta of 0.833 for type S firms that we calculated in Example 10.8, the estimate of the cost of capital for type S firms from Eq. 10.11 is

\[ r_s = r_f + \beta_s \times (E[R_{Mkt}] - r_f) = 5\% + 0.833 \times (11\% - 5\%) = 10\% \]

This matches their expected return: \( \frac{1}{2} \times (40\%) + \frac{1}{2} \times (-20\%) = 10\% \). Thus, investors who hold these stocks can expect a return that appropriately compensates them for the systematic risk they are bearing by holding them (as we should expect in a competitive market).
Alternative Example 10.9

• Problem

– Assume the economy has a 60% chance of the market return will 15% next year and a 40% chance the market return will be 5% next year.

– Assume the risk-free rate is 6%.

– If Microsoft’s beta is 1.18, what is its expected return next year?
Alternative Example 10.9 (cont’d)

• Solution

- $E[R_{Mkt}] = (60\% \times 15\%) + (40\% \times 5\%) = 11\%$
- $E[R] = r_f + \beta \times (E[R_{Mkt}] - r_f)$
- $E[R] = 6\% + 1.18 \times (11\% - 6\%)$
- $E[R] = 6\% + 5.9\% = 11.9\%$
10.8 Beta and the Cost of Capital (cont'd)

• Equation 10.11 is often referred to as the **Capital Asset Pricing Model (CAPM)**. It is the most important method for estimating the cost of capital that is used in practice.