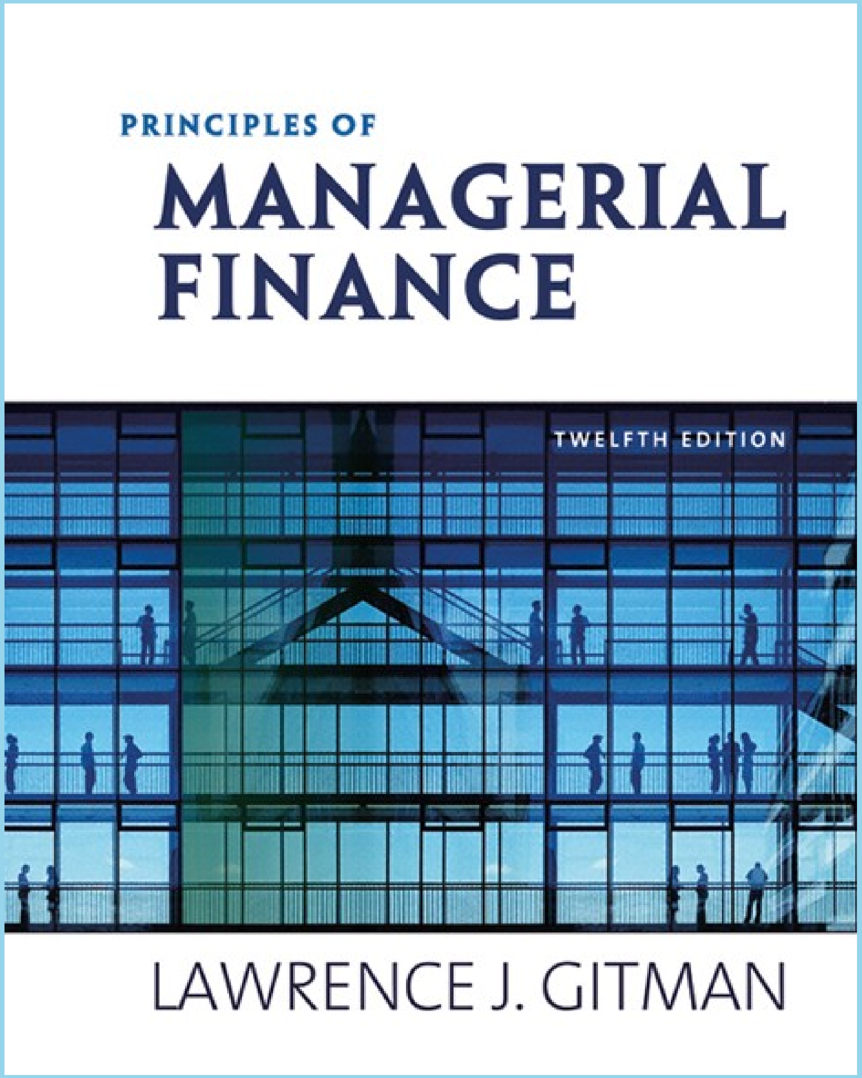
Chapter 5

Risk and Return



Topic outline

- Principle: “The higher the risk, the greater the returns.”
- “No investment should be undertaken unless the expected rate of return is high enough to compensate for the perceived risk.”
- Measuring risk and returns for a single/stand-alone asset.
- Measuring risk and returns for a portfolio of assets.
- CAPM

Risk and Return Fundamentals

- If everyone knew ahead of time how much a stock would sell for some time in the future, investing would be simple endeavor.
- Unfortunately, it is difficult—if not impossible—to make such predictions with any degree of certainty.
- As a result, investors often use history as a basis for predicting the future.
- We will begin this chapter by evaluating the risk and return characteristics of individual assets, and end by looking at portfolios of assets.

Risk Defined

- In the context of business and finance, **risk** is defined as the chance of suffering a financial loss.
- Assets (real or financial) which have a greater chance of loss are considered more risky than those with a lower chance of loss.
- Risk may be used interchangeably with the term **uncertainty** to refer to the variability of returns associated with a given asset.
- Other sources of risk are listed on the following slide.

Table 5.1 Popular Sources of Risk Affecting Financial Managers and Shareholders

Source of risk	Description
Firm-Specific Risks	
Business risk	The chance that the firm will be unable to cover its operating costs. Level is driven by the firm's revenue stability and the structure of its operating costs (fixed versus variable).
Financial risk	The chance that the firm will be unable to cover its financial obligations. Level is driven by the predictability of the firm's operating cash flows and its fixed-cost financial obligations.
Shareholder-Specific Risks	
Interest rate risk	The chance that changes in interest rates will adversely affect the value of an investment. Most investments lose value when the interest rate rises and increase in value when it falls.
Liquidity risk	The chance that an investment cannot be easily liquidated at a reasonable price. Liquidity is significantly affected by the size and depth of the market in which an investment is customarily traded.
Market risk	The chance that the value of an investment will decline because of market factors that are independent of the investment (such as economic, political, and social events). In general, the more a given investment's value responds to the market, the greater its risk; the less it responds, the smaller its risk.
Firm and Shareholder Risks	
Event risk	The chance that a totally unexpected event will have a significant effect on the value of the firm or a specific investment. These infrequent events, such as government-mandated withdrawal of a popular prescription drug, typically affect only a small group of firms or investments.
Exchange rate risk	The exposure of future expected cash flows to fluctuations in the currency exchange rate. The greater the chance of undesirable exchange rate fluctuations, the greater the risk of the cash flows and therefore the lower the value of the firm or investment.
Purchasing-power risk	The chance that changing price levels caused by inflation or deflation in the economy will adversely affect the firm's or investment's cash flows and value. Typically, firms or investments with cash flows that move with general price levels have a low purchasing-power risk, and those with cash flows that do not move with general price levels have a high purchasing-power risk.
Tax risk	The chance that unfavorable changes in tax laws will occur. Firms and investments with values that are sensitive to tax law changes are more risky.

Return Defined

- **Return** represents the total gain or loss on an investment.
- The most basic way to calculate return is as follows:

$$r_t = \frac{C_t + P_t - P_{t-1}}{P_{t-1}}$$

r_t = actual, expected, or required rate of return[2] during period t

C_t = cash (flow) received from the asset investment in the time period $t-1$ to t

P_t = price (value) of asset at time t

P_{t-1} = price (value) of asset at time $t-1$

Return Defined (cont.)

Robin's Gameroom wishes to determine the returns on two of its video machines, Conqueror and Demolition. Conqueror was purchased 1 year ago for $20,000 and currently has a market value of $21,500. During the year, it generated $800 worth of after-tax receipts. Demolition was purchased 4 years ago; its value in the year just completed declined from $12,000 to $11,800. During the year, it generated $1,700 of after-tax receipts.

Conqueror (C):

$$r_C = \frac{\$800 + \$21{,}500 - \$20{,}000}{\$20{,}000} = \frac{\$2{,}300}{\$20{,}000} = \underline{\underline{11.5\%}}$$

Demolition (D):

$$r_D = \frac{\$1{,}700 + \$11{,}800 - \$12{,}000}{\$12{,}000} = \frac{\$1{,}500}{\$12{,}000} = \underline{\underline{12.5\%}}$$

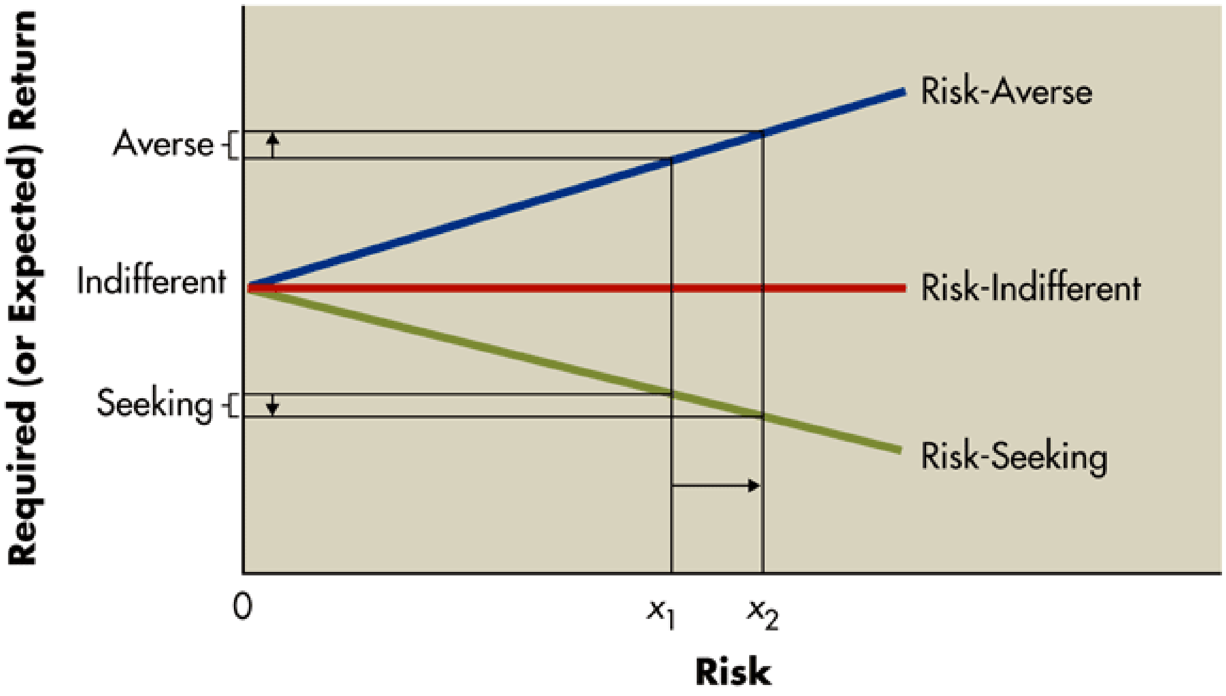
Historical Returns

Table 5.2 Historical Returns for Selected Security Investments (1926–2006)

Investment	Average annual return
Large-company stocks	12.3%
Small-company stocks	17.4
Long-term corporate bonds	6.2
Long-term government bonds	5.8
U.S. Treasury bills	3.8
Inflation	3.1%

Source: Stocks, Bonds, Bills, and Inflation, 2007 Yearbook (Chicago: Ibbotson Associates, Inc., 2007).

Figure 5.1 Risk Preferences



Risk of a Single Asset

Norman Company, a custom golf equipment manufacturer, wants to choose the better of two investments, A and B. Each requires an initial outlay of $10,000 and each has a most likely annual rate of return of 15%. Management has estimated the returns associated with each investment. The three estimates for each assets, along with its range, is given in Table 5.3. Asset A appears to be less risky than asset B. The risk averse decision maker would prefer asset A over asset B, because A offers the same most likely return with a lower range (risk).

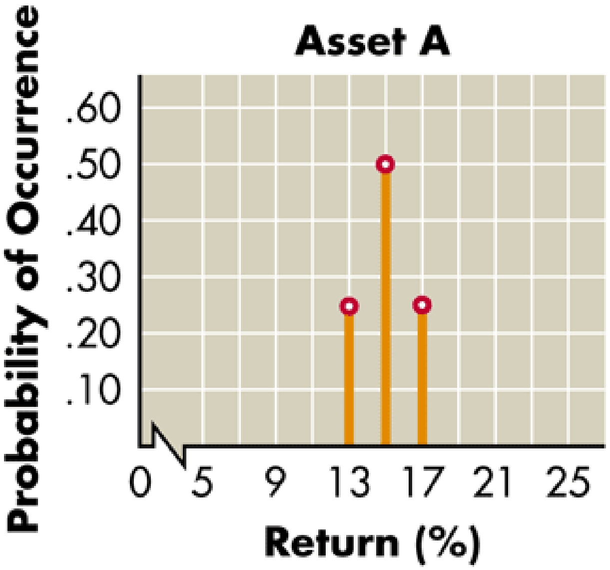
Risk of a Single Asset (cont.)

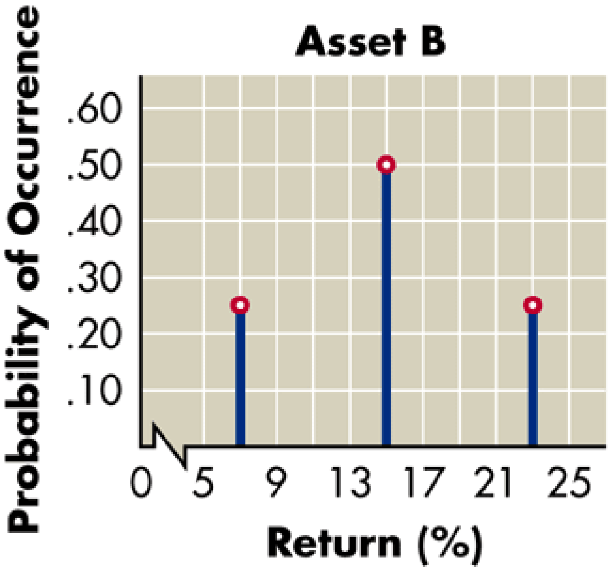
Table 5.3 Assets A and B

	Asset A	Asset B
Initial investment	$10,000	$10,000
Annual rate of return		
Pessimistic	13%	7%
Most likely	15%	15%
Optimistic	17%	23%
Range	4%	16%

Risk of a Single Asset: Discrete Probability Distributions

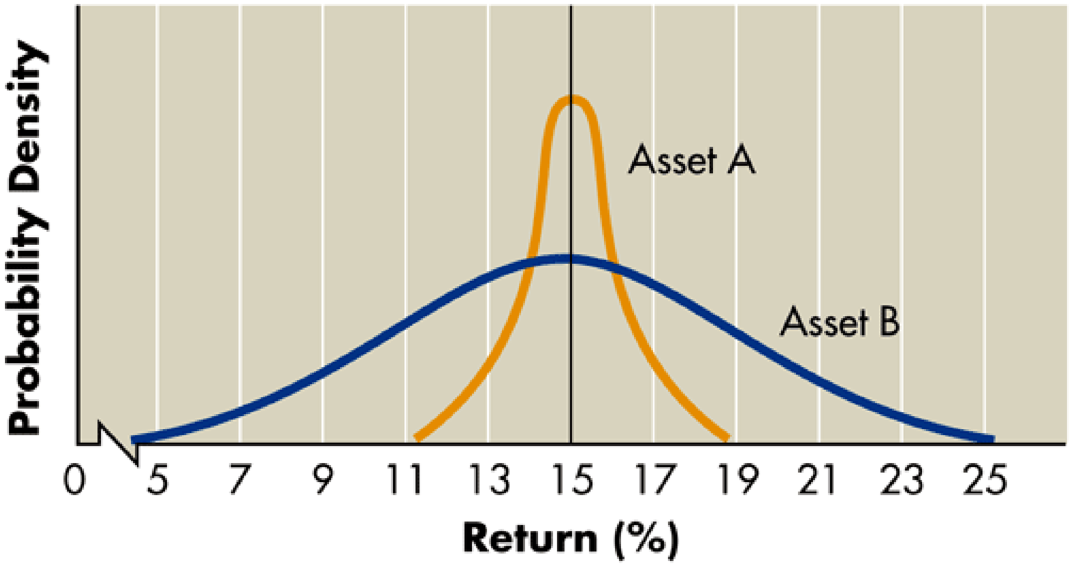
Figure 5.2 Bar Charts





Risk of a Single Asset: Continuous Probability Distributions

Figure 5.3 Continuous Probability Distributions



Return Measurement for a Single Asset: Expected Return

- The most common statistical indicator of an asset's risk is the **standard deviation**, σ_k, which measures the dispersion around the expected value.
- The **expected value of a return**, ***r-bar***, is the most likely return of an asset.

$$\bar{r} = \sum_{j=1}^{n} r_j \times Pr_j$$

$$\bar{r} = \frac{\sum_{j=1}^{n} r_j}{n}$$

r_j = return for the jth outcome

Pr_j = probability of occurrence of the jth outcome

n = number of outcomes considered

Return Measurement for a Single Asset: Expected Return (cont.)

Table 5.4 Expected Values of Returns for Assets A and B

Possible outcomes	Probability (1)	Returns (2)	Weighted value [(1) × (2)] (3)
Asset A			
Pessimistic	.25	13%	3.25%
Most likely	.50	15	7.50
Optimistic	.25	17	4.25
Total	1.00	Expected return	15.00%
Asset B			
Pessimistic	.25	7%	1.75%
Most likely	.50	15	7.50
Optimistic	.25	23	5.75
Total	1.00	Expected return	15.00%

Risk Measurement for a Single Asset: Standard Deviation

- The expression for the standard deviation of returns, σ_k, is given in Equation 5.3 below.

$$\sigma_r = \sqrt{\sum_{j=1}^{n} (r_j - \bar{r})^2 \times Pr_j}$$

$$\sigma_r = \sqrt{\frac{\sum_{j=1}^{n} (r_j - \bar{r})^2}{n - 1}}$$

Risk Measurement for a Single Asset: Standard Deviation (cont.)

Table 5.5 The Calculation of the Standard Deviation of the Returns for Assets A and B[a]

j	r_j	$\bar{r}$	$r_j - \bar{r}$	$(r_j - \bar{r})^2$	Pr_j	$(r_j - \bar{r})^2 \times Pr_j$
Asset A						
1	13%	15%	−2%	4%	.25	1%
2	15	15	0	0	.50	0
3	17	15	2	4	.25	1

$$\sum_{j=1}^{3}(r_j - \bar{r})^2 \times Pr_j = 2\%$$

$$\sigma_{r_A} = \sqrt{\sum_{j=1}^{3}(r_j - \bar{r})^2 \times Pr_j} = \sqrt{2\%} = \underline{\underline{1.41}}\%$$

j	r_j	$\bar{r}$	$r_j - \bar{r}$	$(r_j - \bar{r})^2$	Pr_j	$(r_j - \bar{r})^2 \times Pr_j$
Asset B						
1	7%	15%	−8%	64%	.25	16%
2	15	15	0	0	.50	0
3	23	15	8	64	.25	16

$$\sum_{j=1}^{3}(r_j - \bar{r})^2 \times Pr_j = 32\%$$

$$\sigma_{r_B} = \sqrt{\sum_{j=1}^{3}(r_j - \bar{r})^2 \times Pr_j} = \sqrt{32\%} = \underline{\underline{5.66}}\%$$

[a]Calculations in this table are made in percentage form rather than decimal form—e.g., 13% rather than 0.13. As a result, some of the intermediate computations may appear to be inconsistent with those that would result from using decimal form. Regardless, the resulting standard deviations are correct and identical to those that would result from using decimal rather than percentage form.

Risk Measurement for a Single Asset: Standard Deviation (cont.)

Table 5.6 Historical Returns, Standard Deviations, and Coefficients of Variation for Selected Security Investments (1926–2006)

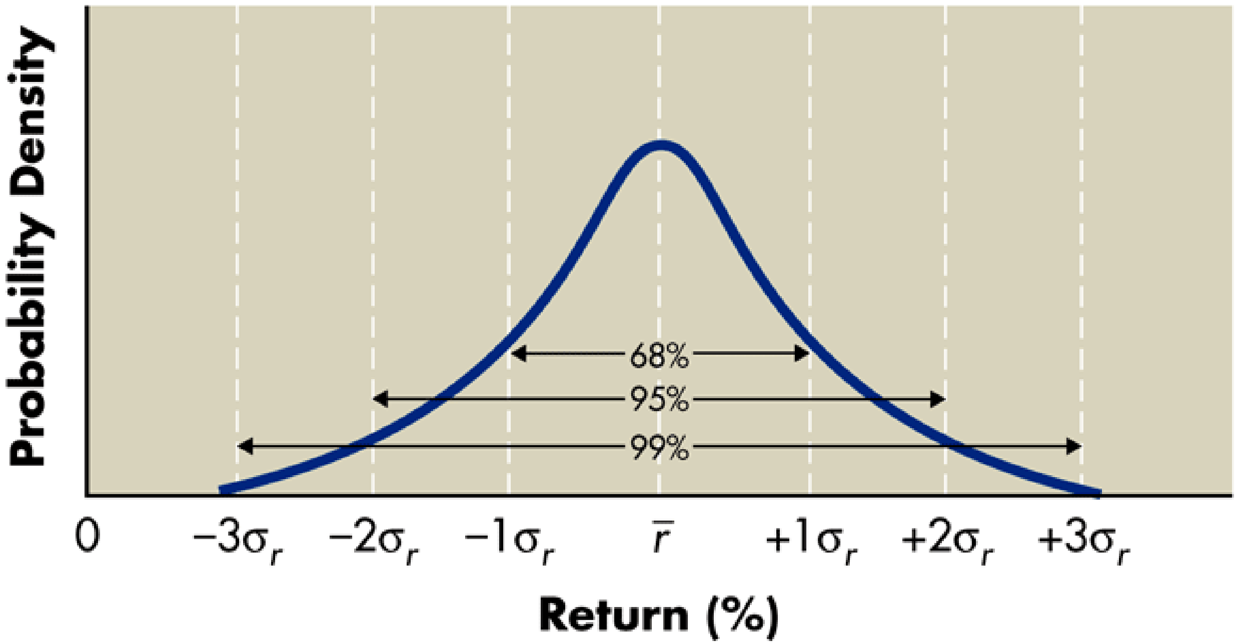
Investment	Average annual return (1)	Standard deviation (2)	Coefficient of variation[a] (3)
Large-company stocks	12.3%	20.1%	1.63
Small-company stocks	17.4	32.7	1.88
Long-term corporate bonds	6.2	8.5	1.37
Long-term government bonds	5.8	9.2	1.59
U.S. Treasury bills	3.8	3.1	0.82
Inflation	3.1%	4.3%	1.39

[a]Calculated by dividing the standard deviation in column 2 by the average annual return in column 1.

Source: Stocks, Bonds, Bills, and Inflation, 2007 Yearbook (Chicago: Ibbotson Associates, Inc., 2007).

Risk Measurement for a Single Asset: Standard Deviation (cont.)

Figure 5.4 Bell-Shaped Curve



Risk Measurement for a Single Asset: Coefficient of Variation

- The **coefficient of variation**, *CV*, is a measure of relative dispersion that is useful in comparing risks of assets with differing expected returns.
- Equation 5.4 gives the expression of the coefficient of variation.

$$CV = \frac{\sigma_r}{\bar{r}}$$

Risk Measurement for a Single Asset: Coefficient of Variation (cont.)

Statistics	Asset C	Asset D
(1) Expected return	12%	20%
(2) Standard deviation	9%[a]	10%
(3) Coefficient of variation [(2) ÷ (1)]	0.75	0.50[a]

[a]Preferred asset using the given risk measure.

Portfolio Risk and Return

- An investment **portfolio** is any collection or combination of financial assets.
- If we assume all investors are rational and therefore **risk averse**, that investor will ALWAYS choose to invest in portfolios rather than in single assets.
- Investors will hold portfolios because he or she will **diversify** away a portion of the risk that is inherent in "putting all your eggs in one basket."
- If an investor holds a single asset, he or she will fully suffer the consequences of poor performance.
- This is not the case for an investor who owns a **diversified portfolio** of assets.

Portfolio Return

- The **return of a portfolio** is a weighted average of the returns on the individual assets from which it is formed and can be calculated as shown in Equation 5.5.

$$r_p = (w_1 \times r_1) + (w_2 \times r_2) + \cdots + (w_n \times r_n) = \sum_{j=1}^{n} w_j \times r_j$$

w_j = proportion of the portfolio's total dollar value represented by asset j

r_j = return on asset j

Portfolio Risk and Return: Expected Return and Standard Deviation

Assume that we wish to determine the expected value and standard deviation of returns for portfolio XY, created by combining equal portions (50%) of assets X and Y. The expected returns of assets X and Y for each of the next 5 years are given in columns 1 and 2, respectively in part A of Table 5.7. In column 3, the weights of 50% for both assets X and Y along with their respective returns from columns 1 and 2 are substituted into equation 5.5. Column 4 shows the results of the calculation – an expected portfolio return of 12%.

Portfolio Risk and Return: Expected Return and Standard Deviation (cont.)

Table 5.7 Expected Return, Expected Value, and Standard Deviation of Returns for Portfolio XY (cont.)

A. Expected portfolio returns				
	Forecasted return			
Year	Asset X (1)	Asset Y (2)	Portfolio return calculation[a] (3)	Expected portfolio return, r_p (4)
2010	8%	16%	$(.50 \times 8\%) + (.50 \times 16\%) =$	12%
2011	10	14	$(.50 \times 10\%) + (.50 \times 14\%) =$	12
2012	12	12	$(.50 \times 12\%) + (.50 \times 12\%) =$	12
2013	14	10	$(.50 \times 14\%) + (.50 \times 10\%) =$	12
2014	16	8	$(.50 \times 16\%) + (.50 \times 8\%) =$	12

Portfolio Risk and Return: Expected Return and Standard Deviation (cont.)

As shown in part B of Table 5.7, the expected value of these portfolio returns over the 5-year period is also 12%. In part C of Table 5.7, Portfolio XY's standard deviation is calculated to be 0%. This value should not be surprising because the expected return each year is the same at 12%. No variability is exhibited in the expected returns from year to year.

Portfolio Risk and Return: Expected Return and Standard Deviation (cont.)

Table 5.7 Expected Return, Expected Value, and Standard Deviation of Returns for Portfolio XY (cont.)

B. Expected value of portfolio returns, 2010–2014[b]

$$\bar{r}_p = \frac{12\% + 12\% + 12\% + 12\% + 12\%}{5} = \frac{60\%}{5} = \underline{\underline{12\%}}$$

C. Standard deviation of expected portfolio returns[c]

$$\sigma_{r_p} = \sqrt{\frac{(12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2 + (12\% - 12\%)^2}{5 - 1}}$$

$$= \sqrt{\frac{0\% + 0\% + 0\% + 0\% + 0\%}{4}}$$

$$= \sqrt{\frac{0\%}{4}} = \underline{\underline{0\%}}$$

[a]Using Equation 5.5.

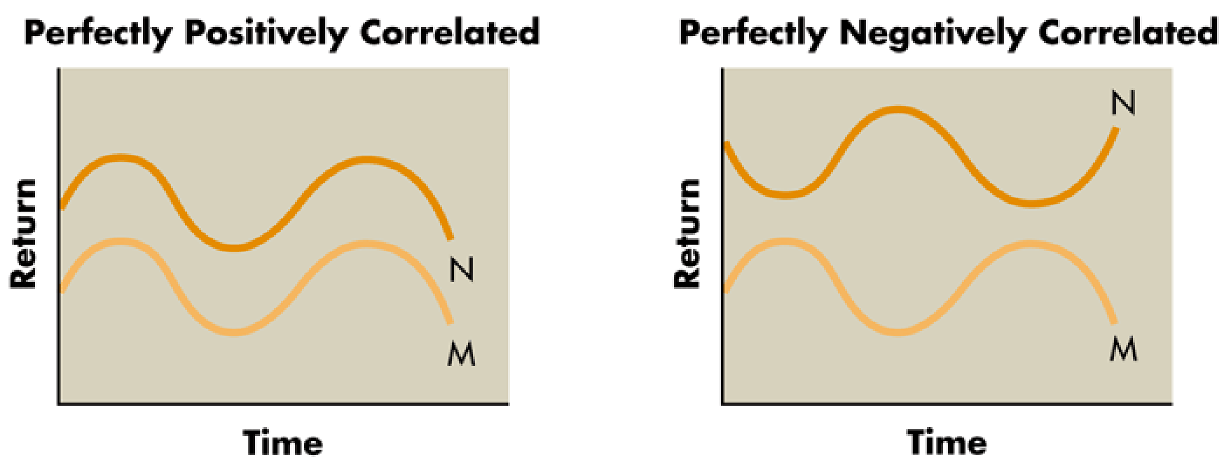
[b]Using Equation 5.2a found in footnote 9.

[c]Using Equation 5.3a found in footnote 10.

Risk of a Portfolio

- **Diversification** is enhanced depending upon the extent to which the returns on assets "move" together.
- This movement is typically measured by a statistic known as **"correlation"** as shown in the figure below.

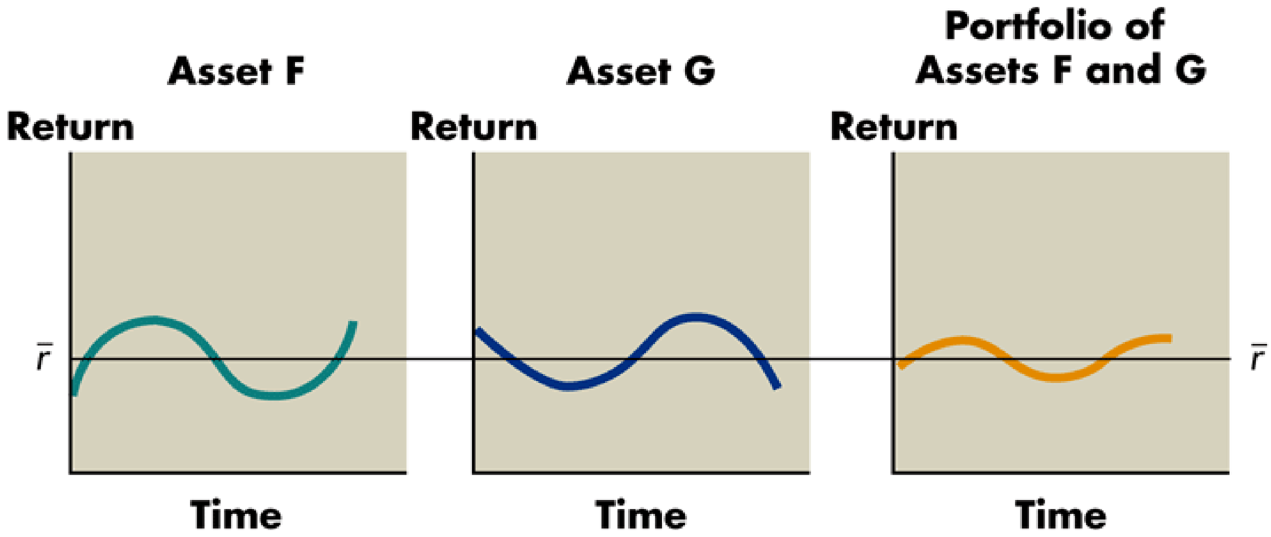
Figure 5.5 Correlations



Risk of a Portfolio (cont.)

- Even if two assets are not perfectly negatively correlated, an investor can still realize diversification benefits from combining them in a portfolio as shown in the figure below.

Figure 5.6 Diversification



Risk of a Portfolio (cont.)

Table 5.8 Forecasted Returns, Expected Values, and Standard Deviations for Assets X, Y, and Z and Portfolios XY and XZ

	Assets			Portfolios	
Year	X	Y	Z	XY[a] (50% X + 50% Y)	XZ[b] (50% X + 50% Z)
2010	8%	16%	8%	12%	8%
2011	10	14	10	12	10
2012	12	12	12	12	12
2013	14	10	14	12	14
2014	16	8	16	12	16
Statistics:[c]					
Expected value	12%	12%	12%	12%	12%
Standard deviation[d]	3.16%	3.16%	3.16%	0%	3.16%

[a] Portfolio XY, which consists of 50% of asset X and 50% of asset Y, illustrates *perfect negative correlation* because these two return streams behave in completely opposite fashion over the 5-year period. Its return values shown here were calculated in part A of Table 5.7.

[b] Portfolio XZ, which consists of 50% of asset X and 50% of asset Z, illustrates *perfect positive correlation* because these two return streams behave identically over the 5-year period. Its return values were calculated by using the same method demonstrated for portfolio XY in part A of Table 5.7.

[c] Because the probabilities associated with the returns are not given, the general equations, Equation 5.2a in footnote 9 and Equation 5.3a in footnote 10, were used to calculate expected values and standard deviations, respectively. Calculation of the expected value and standard deviation for portfolio XY is demonstrated in parts B and C, respectively, of Table 5.7.

[d] The portfolio standard deviations can be directly calculated from the standard deviations of the component assets with the following formula:

$$\sigma_{r_p} = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2c_{1,2}\sigma_1\sigma_2}$$

where w_1 and w_2 are the proportions of component assets 1 and 2, σ_1 and σ_2 are the standard deviations of component assets 1 and 2, and $c_{1,2}$ is the correlation coefficient between the returns of component assets 1 and 2.

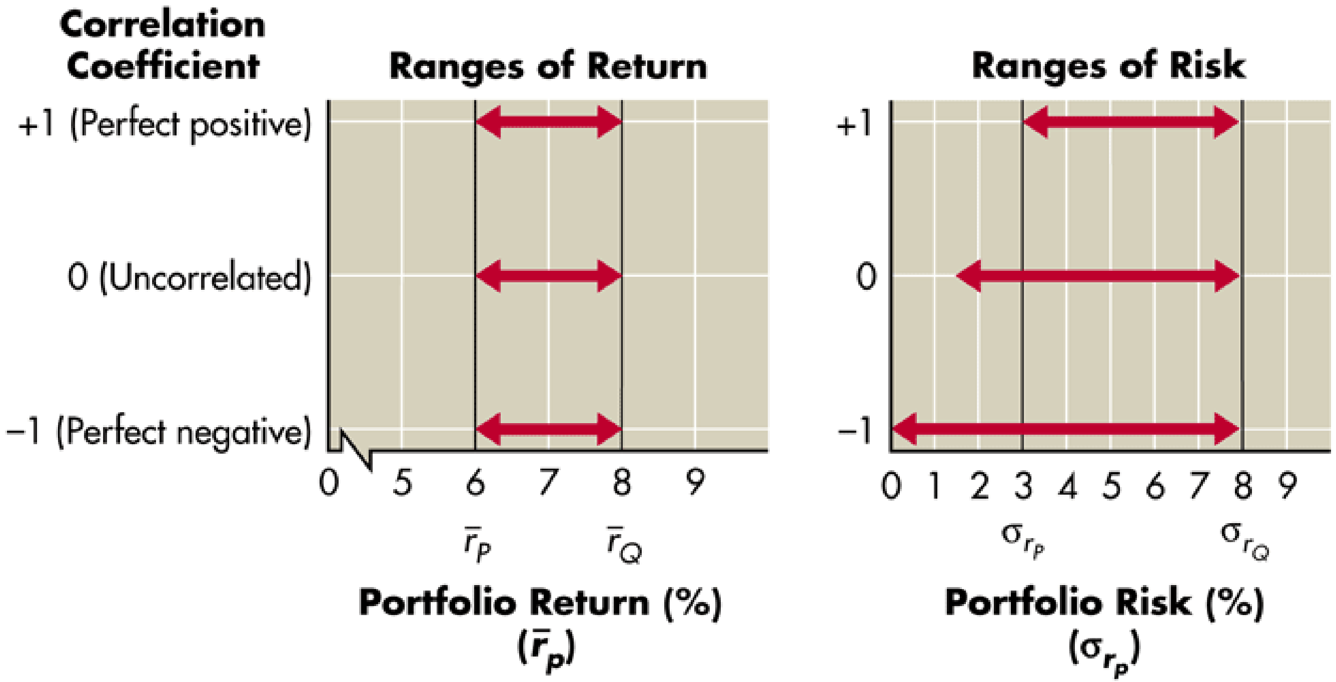
A firm has calculated the expected return and the risk for each of two assets—R and S.

Asset	Expected return, $\bar{k}$	Risk (standard deviation), σ
R	6%	3%
S	8	8

Correlation coefficient	Ranges of return	Ranges of risk
+1 (perfect positive)	Between returns of two assets held in isolation	Between risk of two assets held in isolation
0 (uncorrelated)	Between returns of two assets held in isolation	Between risk of most risky asset and an amount less than risk of least risky asset but greater than 0
−1 (perfect negative)	Between returns of two assets held in isolation	Between risk of most risky asset and 0

Risk of a Portfolio (cont.)

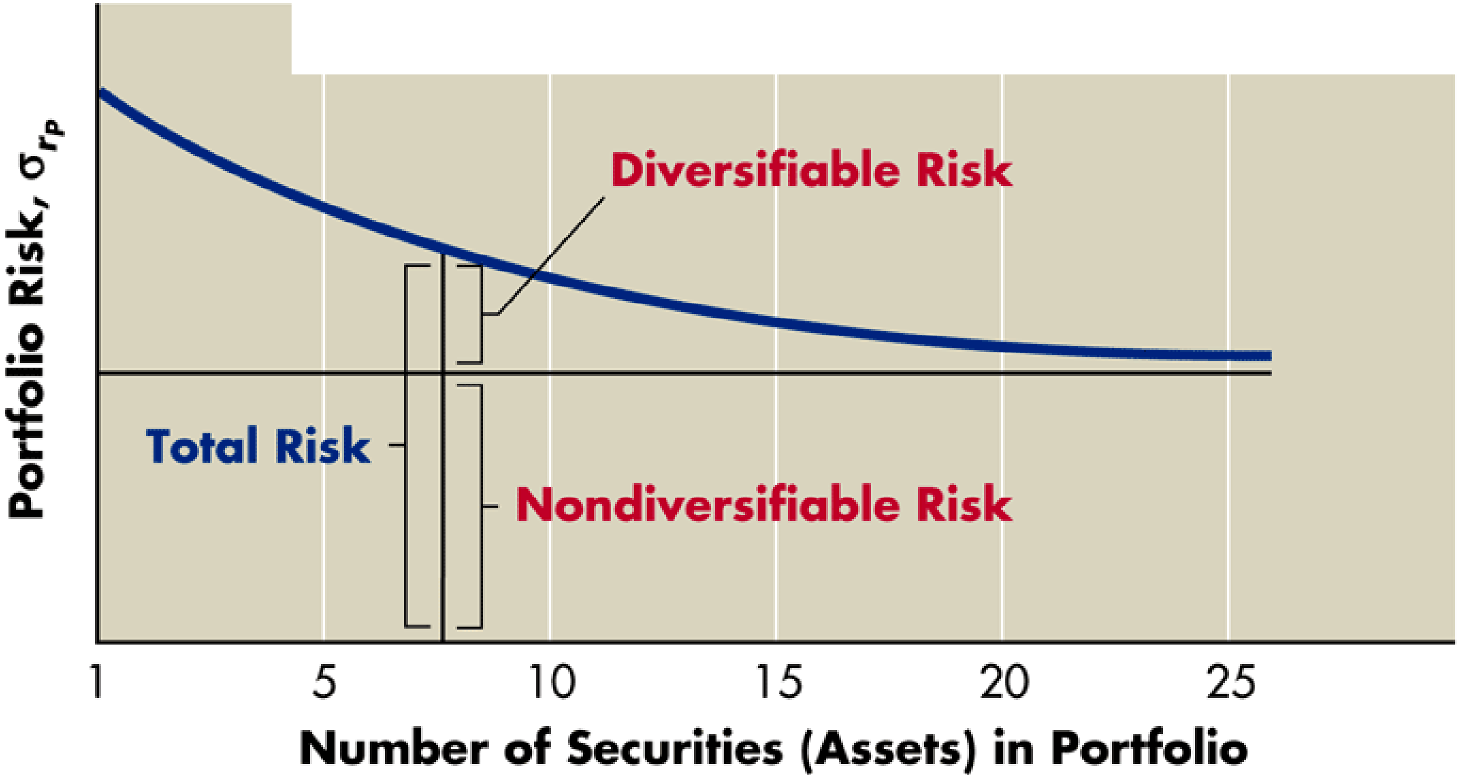
Figure 5.7 Possible Correlations



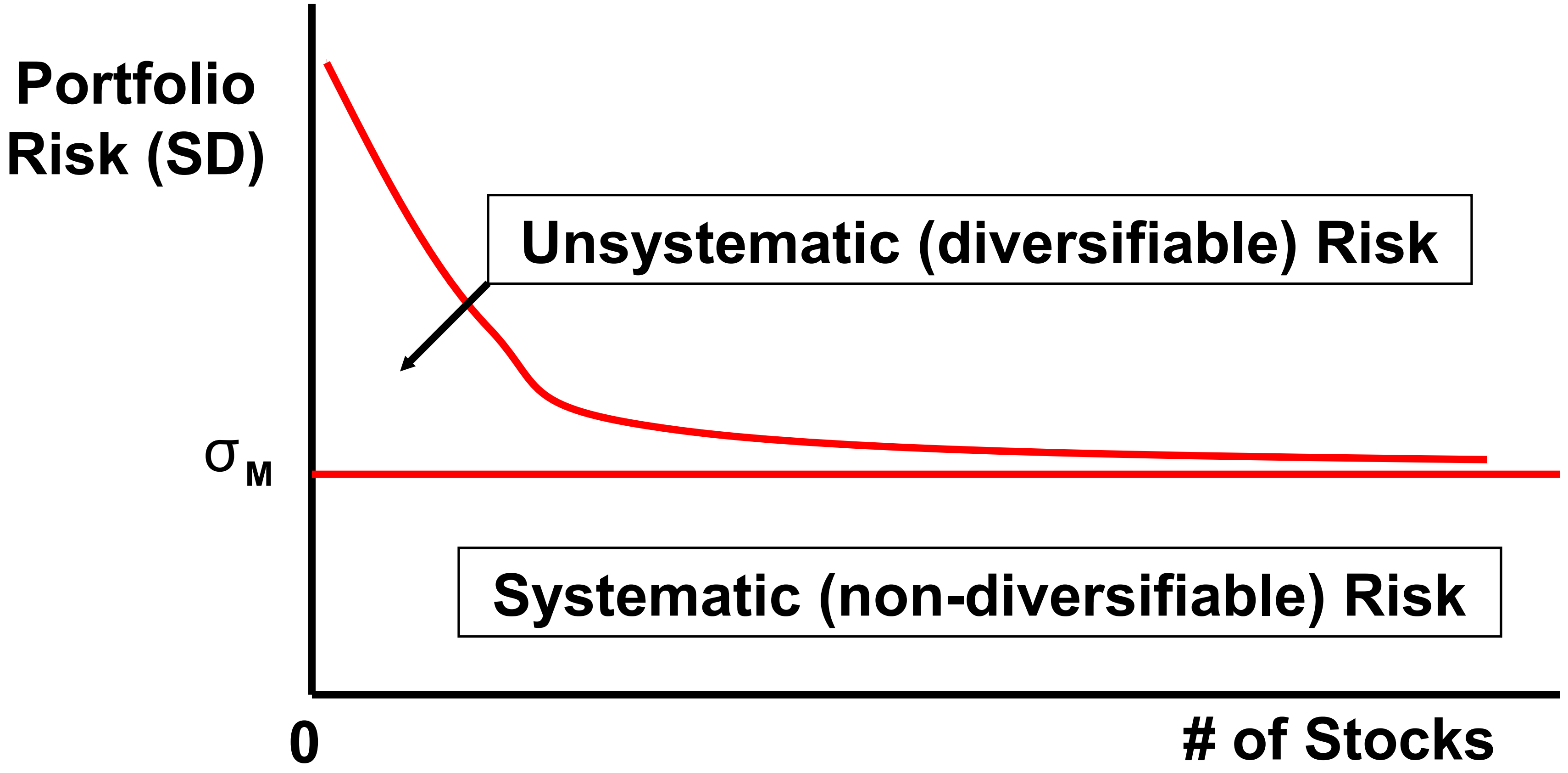
Risk of a

The risk that remains once a stock is in a diversified portfolio is its contribution to the portfolio's market risk, and that risk can be measured by the extent to which the stock moves up or down with the market.

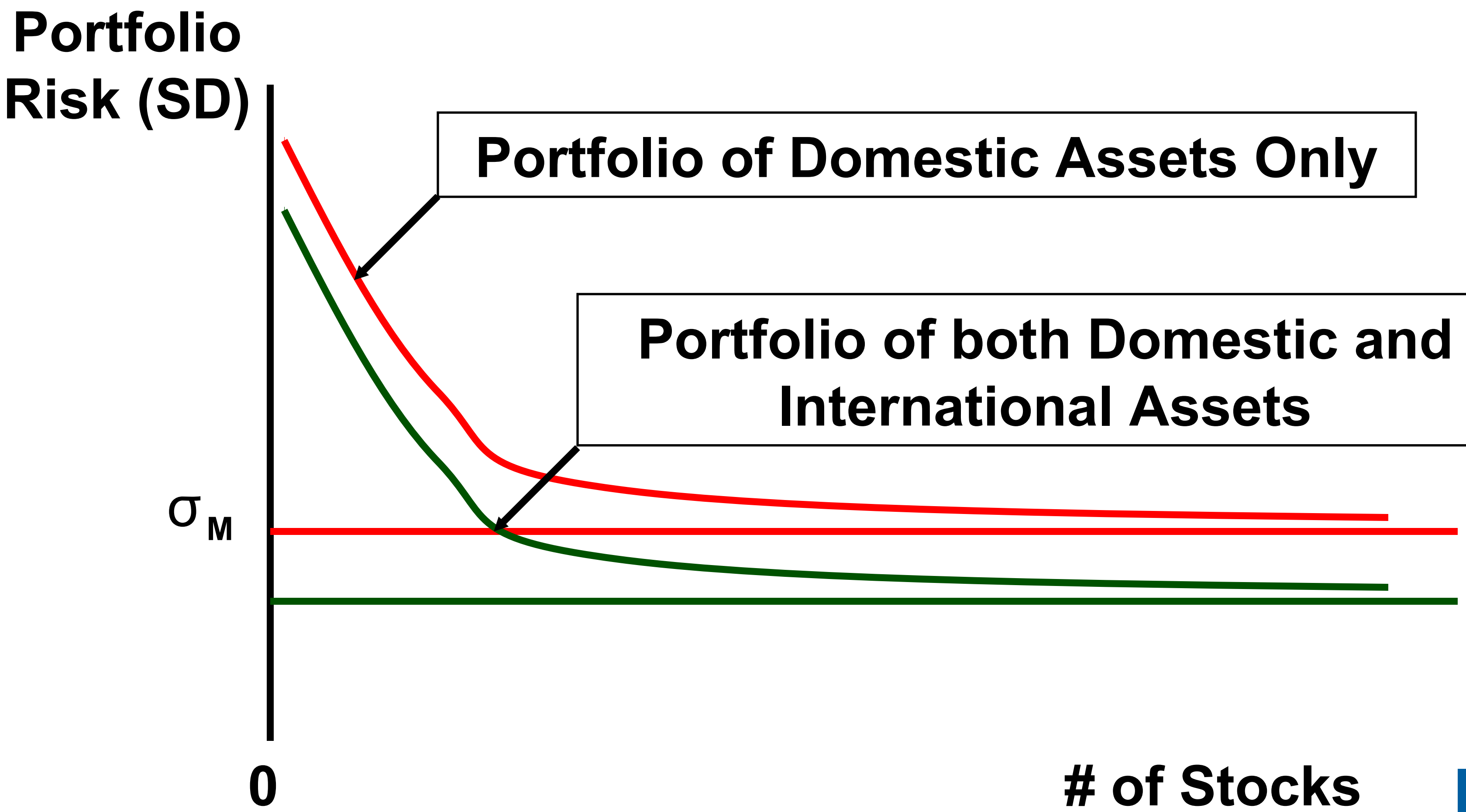
Figure 5.8 R



Risk of a Portfolio: Adding Assets to a Portfolio



Risk of a Portfolio: Adding Assets to a Portfolio (cont.)



Risk and Return: The Capital Asset Pricing Model (CAPM)

- If you notice in the last slide, a good part of a portfolio's risk (the standard deviation of returns) can be eliminated simply by holding a lot of stocks.
- The risk you can't get rid of by adding stocks (**systematic**) cannot be eliminated through diversification because that variability is caused by events that affect most stocks similarly.
- Examples would include changes in macroeconomic factors such interest rates, inflation, and the business cycle.

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

- In the early 1960s, finance researchers (Sharpe, Treynor, and Lintner) developed an asset pricing model that measures only the amount of systematic risk a particular asset has.
- In other words, they noticed that most stocks go down when interest rates go up, but some go down a whole lot more.
- They reasoned that if they could measure this variability—the systematic risk—then they could develop a model to price assets using only this risk.
- The **unsystematic (company-related) risk** is irrelevant because it could easily be eliminated simply by diversifying.


CAPM
=
Risk Free Rate
+
β
Beta
×
Excess Market Return

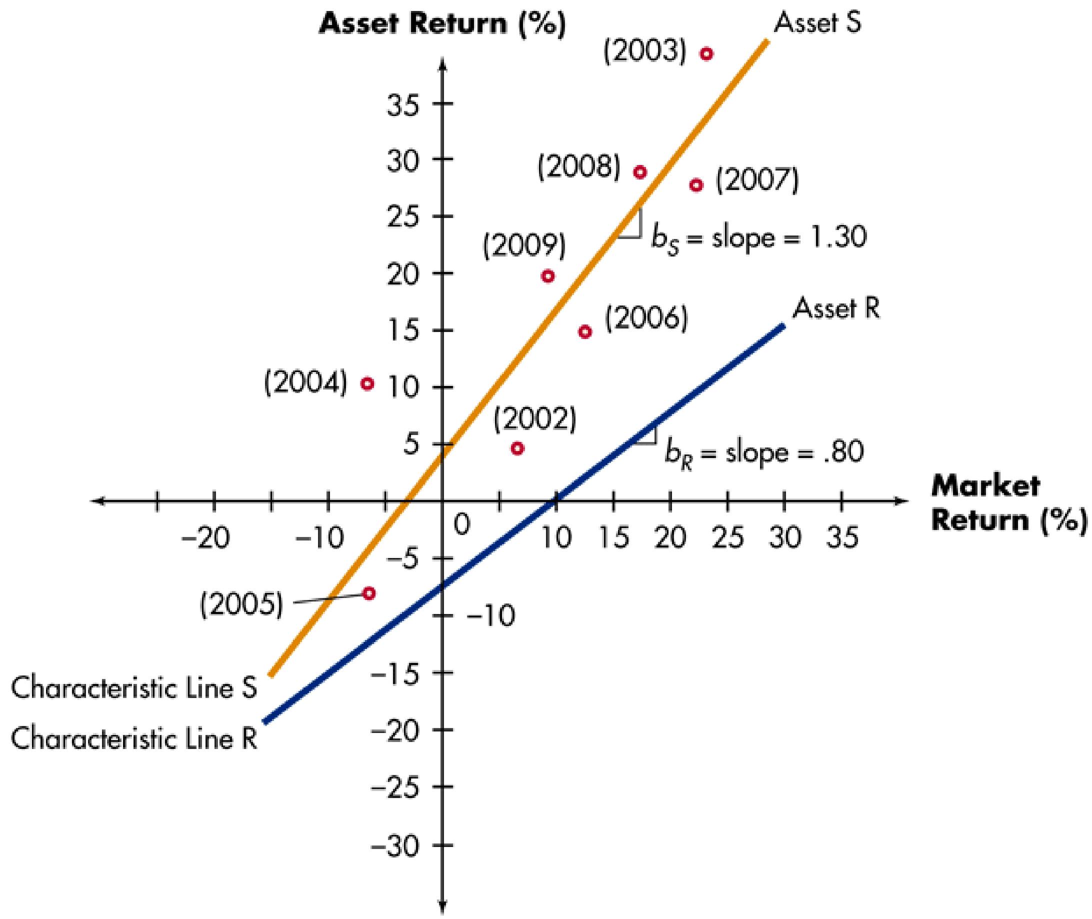

Excess Market Return
=
$
Market Return
−
Risk Free Rate

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

- To measure the amount of **systematic risk** an asset has, they simply regressed the returns for the “market portfolio”—the portfolio of ALL assets—against the returns for an individual asset.
- The slope of the regression line—**beta**—measures an assets systematic (non-diversifiable) risk.
- In general, cyclical companies like auto companies have high betas while relatively stable companies, like public utilities, have low betas.
- The calculation of beta is shown on the following slide.

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Figure 5.9 Beta Derivation[a]



[a] All data points shown are associated with asset S. No data points are shown for asset R.

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Table 5.10 Selected Beta Coefficients and Their Interpretations

Beta	Comment	Interpretation
2.0	Move in same direction as market	Twice as responsive as the market
1.0		Same response as the market
.5		Only half as responsive as the market
0		Unaffected by market movement
− .5	Move in opposite direction to market	Only half as responsive as the market
−1.0		Same response as the market
−2.0		Twice as responsive as the market

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Table 5.11 Beta Coefficients for Selected Stocks (July 10, 2007)

Stock	Beta	Stock	Beta
Amazon.com	1.20	JP Morgan Chase & Co.	1.40
Anheuser-Busch	.65	Merrill Lynch & Co.	1.35
DaimlerChrysler AG	1.30	Microsoft	.95
Disney	1.30	Nike, Inc.	.85
eBay	1.10	PepsiCo, Inc.	.75
ExxonMobil Corp.	.90	Qualcomm	1.00
Gap (The), Inc.	.95	Sempra Energy	1.05
General Electric	1.10	Wal-Mart Stores	.75
Intel	1.15	Xerox	1.40
Int'l Business Machines	1.05	Yahoo! Inc.	1.40

Source: Value Line Investment Survey (New York: Value Line Publishing, July 20, 2007).

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Table 5.12 Mario Austino's Portfolios V and W

	Portfolio V		Portfolio W	
Asset	Proportion	Beta	Proportion	Beta
1	.10	1.65	.10	.80
2	.30	1.00	.10	1.00
3	.20	1.30	.20	.65
4	.20	1.10	.10	.75
5	.20	1.25	.50	1.05
Totals	1.00		1.00	

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

- The **required return** for all assets is composed of two parts: the **risk-free rate** and a **risk premium**.

The risk premium is a function of both market conditions and the asset itself.

The risk-free rate (R_F) is usually estimated from the return on US T-bills

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

- The **risk premium** for a stock is composed of two parts:
- The **Market Risk Premium** which is the return required for investing in any risky asset rather than the risk-free rate
- **Beta**, a risk coefficient which measures the sensitivity of the particular stock's return to changes in market conditions.

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

- After estimating beta, which measures a specific asset or portfolio's systematic risk, estimates of the other variables in the model may be obtained to calculate an asset or portfolio's required return.

$$r_j = R_F + [b_j \times (r_m - R_F)]$$

r_j = required return on asset j

R_F = risk-free rate of return, commonly measured by the return on a U.S. Treasury bill

b_j = beta coefficient or index of nondiversifiable risk for asset j

r_m = market return; return on the market portfolio of assets

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Investment	Risk premium[a]
Large-company stocks	12.3% − 3.8% = 8.5%
Small company stocks	17.4 − 3.8 = 13.6
Long-term corporate bonds	6.2 − 3.8 = 2.4
Long-term government bonds	5.8 − 3.8 = 2.0
U.S. Treasury bills	3.8 − 3.8 = 0.0

[a]Return values obtained from Table 5.2.

Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

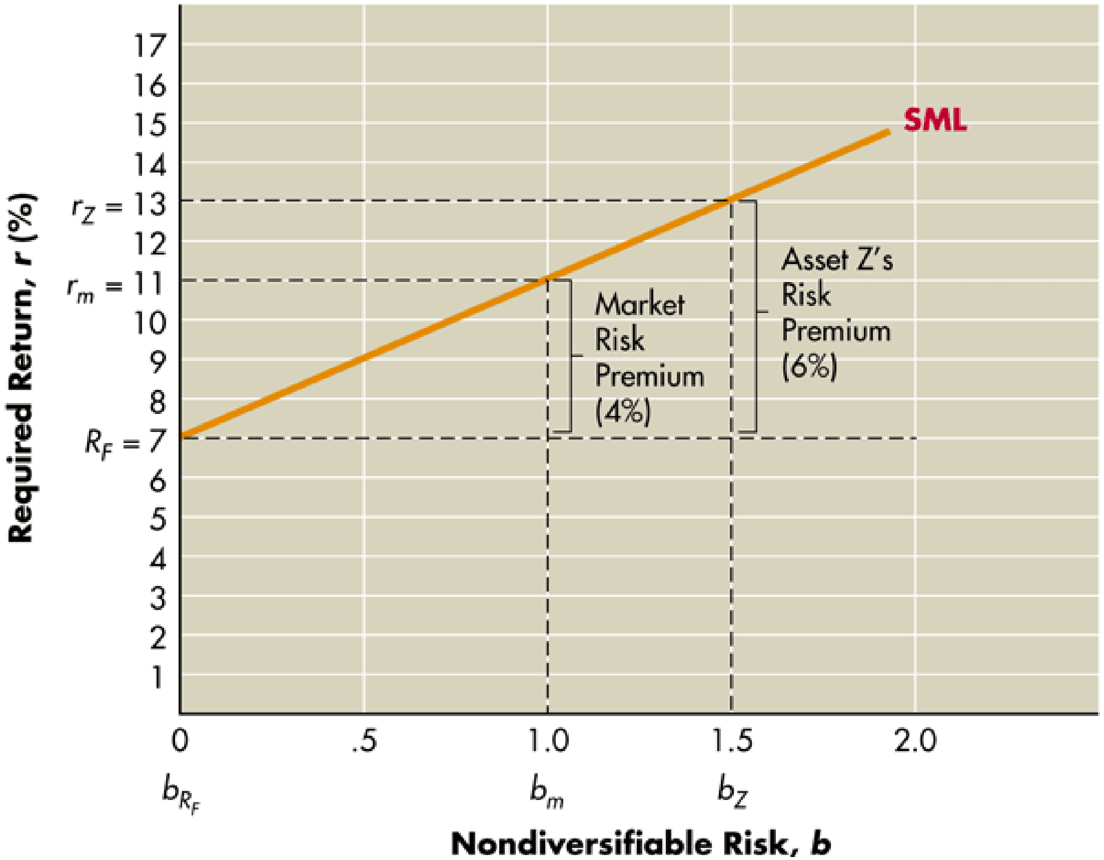
Benjamin Corporation, a growing computer software developer, wishes to determine the required return on asset Z, which has a beta of 1.5. The risk-free rate of return is 7%; the return on the market portfolio of assets is 11%. Substituting $b_Z = 1.5$, $R_F = 7\%$, and $k_m = 11\%$ into the CAPM yields a return of:

$$k_Z = 7\% + 1.5\,[11\% - 7\%]$$

$$k_Z = 13\%$$

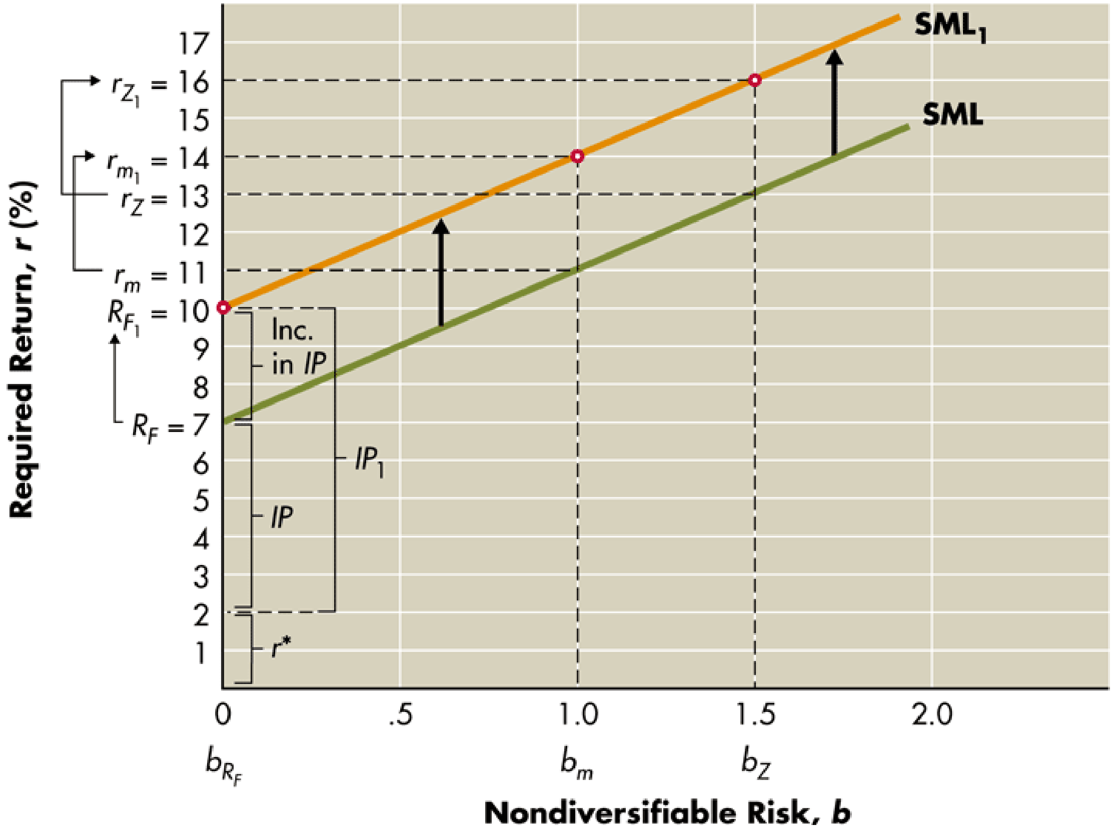
Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Figure 5.10 Security Market Line



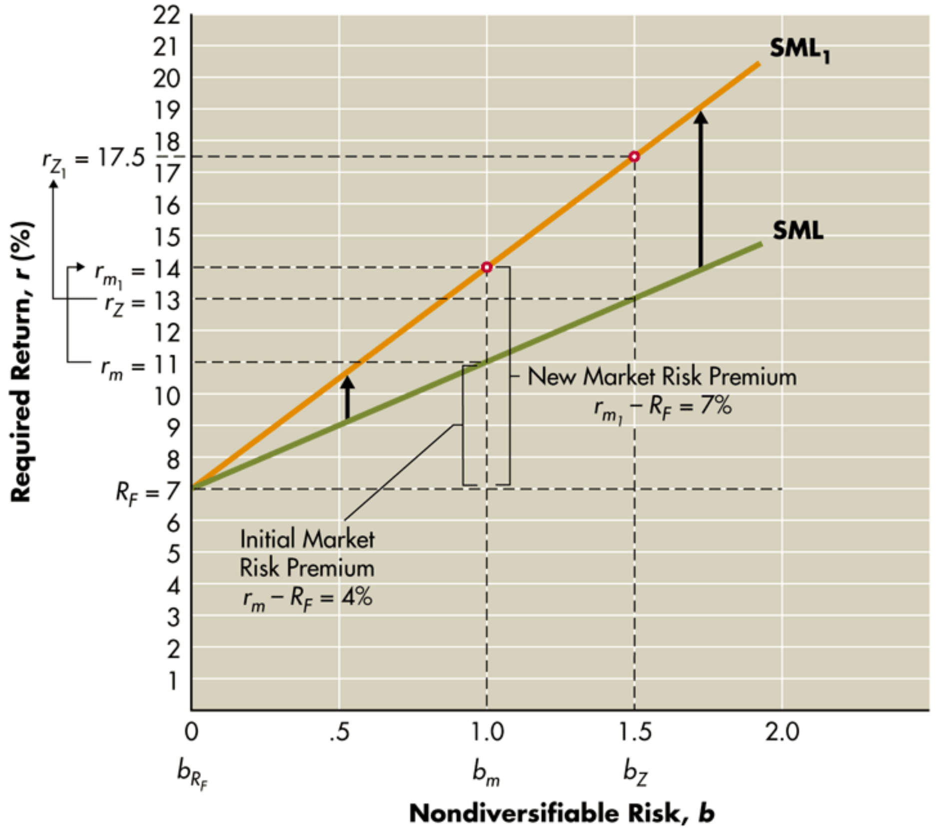
Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Figure 5.11 Inflation Shifts SML



Risk and Return: The Capital Asset Pricing Model (CAPM) (cont.)

Figure 5.12 Risk Aversion Shifts SML



Risk and Return:
Some Comments on the CAPM

- The CAPM relies on historical data which means the betas may or may not actually reflect the future variability of returns.
- Therefore, the required returns specified by the model should be used only as rough approximations.
- The CAPM also assumes markets are efficient.
- Although the perfect world of efficient markets appears to be unrealistic, studies have provided support for the existence of the expectational relationship described by the CAPM in active markets such as the NYSE.

Table 5.13 Summary of Key Definitions and Formulas for Risk and Return (cont.)

Definitions of variables

b_j	= beta coefficient or index of nondiversifiable risk for asset *j*
b_p	= portfolio beta
C_t	= cash received from the asset investment in the time period $t-1$ to t
CV	= coefficient of variation
$\bar{r}$	= expected value of a return
r_j	= return for the *j*th outcome; return on asset *j*; required return on asset *j*
r_m	= market return; the return on the market portfolio of assets
r_p	= portfolio return
r_t	= actual, expected, or required rate of return during period *t*
n	= number of outcomes considered
P_t	= price (value) of asset at time *t*
P_{t-1}	= price (value) of asset at time $t-1$
Pr_j	= probability of occurrence of the *j*th outcome
R_F	= risk-free rate of return
σ_r	= standard deviation of returns
w_j	= proportion of total portfolio dollar value represented by asset *j*

Table 5.13 Summary of Key Definitions and Formulas for Risk and Return (cont.)

Risk and return formulas

Rate of return during period *t*:

$$r_t = \frac{C_t + P_t - P_{t-1}}{P_{t-1}} \qquad \text{[Equation 5.1]}$$

Expected value of a return:

For probabilistic data:

$$\bar{r} = \sum_{j=1}^{n} r_j \times Pr_j \qquad \text{[Equation 5.2]}$$

General formula:

$$\bar{r} = \frac{\sum_{j=1}^{n} r_j}{n} \qquad \text{[Equation 5.2a]}$$

Standard deviation of return:

For probabilistic data:

$$\sigma_r = \sqrt{\sum_{j=1}^{n} (r_j - \bar{r})^2 \times Pr_j} \qquad \text{[Equation 5.3]}$$

General formula:

$$\sigma_r = \sqrt{\frac{\sum_{j=1}^{n} (r_j - \bar{r})^2}{n - 1}} \qquad \text{[Equation 5.3a]}$$

Coefficient of variation:

$$CV = \frac{\sigma_r}{\bar{r}} \qquad \text{[Equation 5.4]}$$

Portfolio return:

$$r_p = \sum_{j=1}^{n} w_j \times r_j \qquad \text{[Equation 5.5]}$$

Total security risk = Nondiversifiable risk + Diversifiable risk [Equation 5.6]

Portfolio beta:

$$b_p = \sum_{j=1}^{n} w_j \times b_j \qquad \text{[Equation 5.7]}$$

Capital asset pricing model (CAPM):

$$r_j = R_F + [b_j \times (r_m - R_F)] \qquad \text{[Equation 5.8]}$$