10.8 Beta and the Cost of Capital

- The market risk premium is the expected excess return of the market portfolio:

$$\text{Market Risk Premium} = E[R_{Mkt}] - r_f \tag{10.10}$$

  It reflects investors' overall risk tolerance and represents the market price of risk in the economy.
- The cost of capital for a risky investment equals the risk-free rate plus a risk premium. The Capital Asset Pricing Model (CAPM) states that the risk premium equals the investment's beta times the market risk premium:

$$r_I = r_f + \beta_I \times (E[R_{Mkt}] - r_f) \tag{10.11}$$

Key Terms

95% confidence interval *p. 325*
average annual return *p. 321*
beta (β) *p. 339*
Capital Asset Pricing Model (CAPM) *p. 342*
common risk *p. 330*
diversification *p. 330*
efficient portfolio *p. 337*
empirical distribution *p. 321*
excess return *p. 327*
expected (mean) return *p. 316*
firm-specific, idiosyncratic, unique, or diversifiable risk *p. 332*
independent risk *p. 330*
market portfolio *p. 337*
probability distribution *p. 316*
realized return *p. 319*
standard deviation *p. 317*
standard error *p. 324*
systematic, undiversifiable, or market risk *p. 332*
variance *p. 317*
volatility *p. 318*

Further Reading

The original work on diversification was developed in the following papers: H. Markowitz, "Portfolio Selection," *Journal of Finance* 7 (1952): 77–91; A. Roy, "Safety First and the Holding of Assets," *Econometrica* 20 (July 1952): 431–449; and, in the context of insurance, B. deFinetti, "Il problema de pieni," *Giornale dell'Instituto Italiano degli Attuari*, 11 (1940): 1–88.

For information on historical returns of different types of assets, see: E. Dimson, P. Marsh, and M. Staunton, *Triumph of the Optimist: 101 Years of Global Equity Returns* (Princeton University Press, 2002); and Ibbotson Associates, Inc., *Stocks, Bonds, Bills, and Inflation* (Ibbotson Associates, 2009).

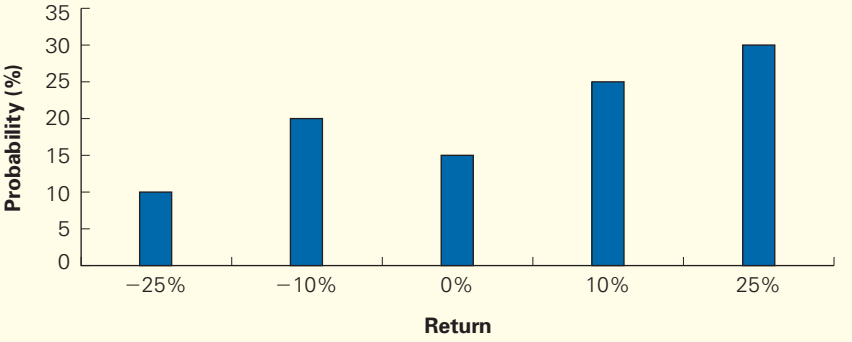
Many books address the topics of this chapter in more depth: E. Elton, M. Gruber, S. Brown, and W. Goetzmann, *Modern Portfolio Theory and Investment Analysis* (John Wiley & Sons, 2006); J. Francis, *Investments: Analysis and Management* (McGraw-Hill, 1991); R. Radcliffe, *Investment: Concepts, Analysis, and Strategy* (Harper-Collins, 1994); F. Reilly and K. Brown, *Investment Analysis and Portfolio Management* (Dryden Press, 1996); and Z. Bodie, A. Kane, and A. Marcus, *Investments* (McGraw-Hill/Irwin, 2008).

Problems

All problems are available in MyFinanceLab. *An asterisk (*) indicates problems with a higher level of difficulty.*

Common Measures of Risk and Return

1. The figure below shows the one-year return distribution for RCS stock. Calculate
   a. The expected return.
   b. The standard deviation of the return.



2. The following table shows the one-year return distribution of Startup, Inc. Calculate
a. The expected return.
b. The standard deviation of the return.

Probability	40%	20%	20%	10%	10%
Return	−100%	−75%	−50%	−25%	1000%

3. Characterize the difference between the two stocks in Problems 1 and 2. What trade-offs would you face in choosing one to hold?

Historical Returns of Stocks and Bonds

4. You bought a stock one year ago for $50 per share and sold it today for $55 per share. It paid a $1 per share dividend today.
a. What was your realized return?
b. How much of the return came from dividend yield and how much came from capital gain?

5. Repeat Problem 4 assuming that the stock fell $5 to $45 instead.
a. Is your capital gain different? Why or why not?
b. Is your dividend yield different? Why or why not?

6. Using the data in the following table, calculate the return for investing in Boeing stock (BA) from January 2, 2008, to January 2, 2009, and also from January 3, 2011, to January 3, 2012, assuming all dividends are reinvested in the stock immediately.

Historical Stock and Dividend Data for Boeing

Date	Price	Dividend	Date	Price	Dividend
1/2/2008	86.62		1/3/2011	66.40	
2/6/2008	79.91	0.40	2/9/2011	72.63	0.42
5/7/2008	84.55	0.40	5/11/2011	79.08	0.42
8/6/2008	65.40	0.40	8/10/2011	57.41	0.42
11/5/2008	49.55	0.40	11/8/2011	66.65	0.42
1/2/2009	45.25		1/3/2012	74.22	

7. The last four years of returns for a stock are as follows:

Year	1	2	3	4
Return	−4%	+28%	+12%	+4%

a. What is the average annual return?
b. What is the variance of the stock's returns?
c. What is the standard deviation of the stock's returns?

***8.** Assume that historical returns and future returns are independently and identically distributed and drawn from the same distribution.

a. Calculate the 95% confidence intervals for the expected annual return of four different investments included in Tables 10.3 and 10.4 (the dates are inclusive, so the time period spans 86 years).

b. Assume that the values in Tables 10.3 and 10.4 are the true expected return and volatility (i.e., estimated without error) and that these returns are normally distributed. For each investment, calculate the probability that an investor will not lose more than 5% in the next year. (*Hint*: you can use the function normdist (*x*,mean,volatility,1) in Excel to compute the probability that a normally distributed variable with a given mean and volatility will fall below *x*.)

c. Do all the probabilities you calculated in part (b) make sense? If so, explain. If not, can you identify the reason?

9. Using the data in Table 10.2,

a. What was the average annual return of Microsoft stock from 2002–2011?

b. What was the annual volatility for Microsoft stock from 2002–2011?

10. Using the data in Table 10.2,

a. What was the average dividend yield for the SP500 from 2002–2011?

b. What was the volatility of the dividend yield?

c. What was the average annual return of the SP500 from 2002–2011 excluding dividends (i.e., from capital gains only)?

d. What was the volatility of the S&P 500 returns from capital gains?

e. Were dividends or capital gains a more important component of the S&P 500's average returns during this period? Which were the more important source of volatility?

11. Consider an investment with the following returns over four years:

Year	1	2	3	4
Return	10%	20%	−5%	15%

a. What is the compound annual growth rate (CAGR) for this investment over the four years?

b. What is the average annual return of the investment over the four years?

c. Which is a better measure of the investment's past performance?

d. If the investment's returns are independent and identically distributed, which is a better measure of the investment's expected return next year?

12. Download the spreadsheet from MyFinanceLab that contains historical monthly prices and dividends (paid at the end of the month) for Ford Motor Company stock (Ticker: F) from August 1994 to August 1998. Calculate the realized return over this period, expressing your answer in percent per month (i.e., what monthly return would have led to the same cumulative performance as an investment in Ford stock over this period).

13. Using the same data as in Problem 12, compute the

a. Average monthly return over this period.

b. Monthly volatility (or standard deviation) over this period.

14. Explain the difference between the average return you calculated in Problem 13(a) and the realized return you calculated in Problem 12. Are both numbers useful? If so, explain why.

15. Compute the 95% confidence interval of the estimate of the average monthly return you calculated in Problem 13(a).

The Historical Trade-Off Between Risk and Return

16. How does the relationship between the average return and the historical volatility of individual stocks differ from the relationship between the average return and the historical volatility of large, well-diversified portfolios?

17. Download the spreadsheet from MyFinanceLab containing the data for Figure 10.1.
   a. Compute the average return for each of the assets from 1929 to 1940 (The Great Depression).
   b. Compute the variance and standard deviation for each of the assets from 1929 to 1940.
   c. Which asset was riskiest during the Great Depression? How does that fit with your intuition?

18. Using the data from Problem 17, repeat your analysis over the 1990s.
   a. Which asset was riskiest?
   b. Compare the standard deviations of the assets in the 1990s to their standard deviations in the Great Depression. Which had the greatest difference between the two periods?
   c. If you only had information about the 1990s, what would you conclude about the relative risk of investing in small stocks?

19. What if the last two decades had been "normal"? Download the spreadsheet from MyFinanceLab containing the data for Figure 10.1.
   a. Calculate the arithmetic average return on the S&P 500 from 1926 to 1989.
   b. Assuming that the S&P 500 had simply continued to earn the average return from (a), calculate the amount that $100 invested at the end of 1925 would have grown to by the end of 2011.
   c. Do the same for small stocks.

Common Versus Independent Risk

20. Consider two local banks. Bank A has 100 loans outstanding, each for $1 million, that it expects will be repaid today. Each loan has a 5% probability of default, in which case the bank is not repaid anything. The chance of default is independent across all the loans. Bank B has only one loan of $100 million outstanding, which it also expects will be repaid today. It also has a 5% probability of not being repaid. Explain the difference between the type of risk each bank faces. Which bank faces less risk? Why?

***21.** Using the data in Problem 20, calculate
   a. The expected overall payoff of each bank.
   b. The standard deviation of the overall payoff of each bank.

Diversification in Stock Portfolios

22. Consider the following two, completely separate, economies. The expected return and volatility of all stocks in both economies is the same. In the first economy, all stocks move together—in good times all prices rise together and in bad times they all fall together. In the second economy, stock returns are independent—one stock increasing in price has no effect on the prices of other stocks. Assuming you are risk-averse and you could choose one of the two economies in which to invest, which one would you choose? Explain.

23. Consider an economy with two types of firms, S and I. S firms all move together. I firms move independently. For both types of firms, there is a 60% probability that the firms will have a 15% return and a 40% probability that the firms will have a −10% return. What is the volatility (standard deviation) of a portfolio that consists of an equal investment in 20 firms of (a) type S, and (b) type I?

***24.** Using the data in Problem 23, plot the volatility as a function of the number of firms in the two portfolios.

25. Explain why the risk premium of a stock does not depend on its diversifiable risk.

26. Identify each of the following risks as most likely to be systematic risk or diversifiable risk:
   a. The risk that your main production plant is shut down due to a tornado.
   b. The risk that the economy slows, decreasing demand for your firm's products.
   c. The risk that your best employees will be hired away.
   d. The risk that the new product you expect your R&D division to produce will not materialize.

27. Suppose the risk-free interest rate is 5%, and the stock market will return either 40% or −20% each year, with each outcome equally likely. Compare the following two investment strategies: (1) invest for one year in the risk-free investment, and one year in the market, or (2) invest for both years in the market.
   a. Which strategy has the highest expected final payoff?
   b. Which strategy has the highest standard deviation for the final payoff?
   c. Does holding stocks for a longer period decrease your risk?

28. Download the spreadsheet from MyFinanceLab containing the realized return of the S&P 500 from 1929–2008. Starting in 1929, divide the sample into four periods of 20 years each. For each 20-year period, calculate the final amount an investor would have earned given a $1000 initial investment. Also express your answer as an annualized return. If risk were eliminated by holding stocks for 20 years, what would you expect to find? What can you conclude about long-run diversification?

Measuring Systematic Risk

29. What is an efficient portfolio?

30. What does the beta of a stock measure?

31. You turn on the news and find out the stock market has gone up 10%. Based on the data in Table 10.6, by how much do you expect each of the following stocks to have gone up or down: (1) Starbucks, (2) Tiffany & Co., (3) Hershey, and (4) McDonald's.

32. Based on the data in Table 10.6, estimate which of the following investments you expect to lose the most in the event of a severe market down turn: (1) A $1000 investment in eBay, (2) a $5000 investment in Abbott Laboratories, or (3) a $2500 investment in Walt Disney.

33. Suppose the market portfolio is equally likely to increase by 30% or decrease by 10%.
   a. Calculate the beta of a firm that goes up on average by 43% when the market goes *up* and goes down by 17% when the market goes *down*.
   b. Calculate the beta of a firm that goes up on average by 18% when the market goes *down* and goes down by 22% when the market goes *up*.
   c. Calculate the beta of a firm that is expected to go up by 4% *independently* of the market.

Beta and the Cost of Capital

34. Suppose the risk-free interest rate is 4%.
   a. i. Use the beta you calculated for the stock in Problem 33(a) to estimate its expected return.
      ii. How does this compare with the stock's actual expected return?
   b. i. Use the beta you calculated for the stock in Problem 33(b) to estimate its expected return.
      ii. How does this compare with the stock's actual expected return?

35. Suppose the market risk premium is 5% and the risk-free interest rate is 4%. Using the data in Table 10.6, calculate the expected return of investing in
   a. Starbucks' stock.
   b. Hershey's stock.
   c. Autodesk's stock.

36. Given the results to Problem 35, why don't all investors hold Autodesk's stock rather than Hershey's stock?

37. Suppose the market risk premium is 6.5% and the risk-free interest rate is 5%. Calculate the cost of capital of investing in a project with a beta of 1.2.

38. State whether each of the following is inconsistent with an efficient capital market, the CAPM, or both:
   a. A security with only diversifiable risk has an expected return that exceeds the risk-free interest rate.

b. A security with a beta of 1 had a return last year of 15% when the market had a return of 9%.
c. Small stocks with a beta of 1.5 tend to have higher returns on average than large stocks with a beta of 1.5.

Data Case

Today is April 30, 2012, and you have just started your new job with a financial planning firm. In addition to studying for all your license exams, you have been asked to review a portion of a client's stock portfolio to determine the risk/return profiles of 12 stocks in the portfolio. Unfortunately, your small firm cannot afford the expensive databases that would provide all this information with a few simple keystrokes, but that's why they hired you. Specifically, you have been asked to determine the monthly average returns and standard deviations for the 12 stocks for the past five years. In the following chapters, you will be asked to do more extensive analyses on these same stocks.

The stocks (with their symbols in parentheses) are:

Archer Daniels Midland (ADM)
Boeing (BA)
Caterpillar (CAT)
Deere & Co. (DE)
General Mills, Inc. (GIS)
Google Inc. (GOOG)
Hershey (HSY)
International Business Machines Corporation (IBM)
JPMorgan Chase & Co. (JPM)
Microsoft (MSFT)
Procter and Gamble (PG)
Wal-Mart (WMT)

1. Collect price information for each stock from Yahoo! Finance (finance.yahoo.com) as follows:
   a. Enter the stock symbol. On the page for that stock, click "Historical Prices" on the left side of the page.
   b. Enter the "start date" as April 30, 2007 and the "end date" as April 30, 2012 to cover the five-year period. Make sure you click "monthly" next to the date.
   c. After hitting "Get Prices," scroll to the bottom of the first page and click "Download to Spreadsheet." If you are asked if you want to open or save the file, click open.
   d. Copy the entire spreadsheet, open Excel, and paste the Web data into a spreadsheet. Delete all the columns except the date and the adjusted close (the first and last columns).
   e. Keep the Excel file open and go back to the Yahoo! Finance Web page and hit the back button. If you are asked if you want to save the data, click no.
   f. When you return to the prices page, enter the next stock symbol and hit "Get Prices" again. Do not change the dates or frequency, but make sure you have the same dates for all the stocks you will download. Again, click "Download to Spreadsheet" and then open the file. Copy the last column, "Adj. Close," paste it into the Excel file and change "Adj. Close" to the stock symbol. Make sure that the first and last prices are in the same rows as the first stock.
   g. Repeat these steps for the remaining 10 stocks, pasting each closing price right next to the other stocks, again making sure that the correct prices on the correct dates all appear on the same rows.
2. Convert these prices to monthly returns as the percentage change in the monthly prices. (*Hint*: Create a separate worksheet within the Excel file.) Note that to compute a return for each month, you need a beginning and ending price, so you will not be able to compute the return for the first month.
3. Compute the mean monthly returns and standard deviations for the monthly returns of each of the stocks.[16] Convert the monthly statistics to annual statistics for easier interpretation (multiply the mean monthly return by 12, and multiply the monthly standard deviation by $\sqrt{12}$).

[16] In Eq. 10.4, we showed how to compute returns with stock price and dividend data. The "adjusted close" series from Yahoo! Finance is already adjusted for dividends and splits, so we may compute returns based on the percentage change in monthly adjusted prices.