CHAPTER 10

Capital Markets and the Pricing of Risk

Chapter Synopsis

10.1 A First Look at Risk and Return

Historically there has been a large difference in the returns and variability from investing in different types of investments. Figure 10.1 below shows the value of $100 in 2004 if it were invested in different portfolios of assets at the beginning of 1926.
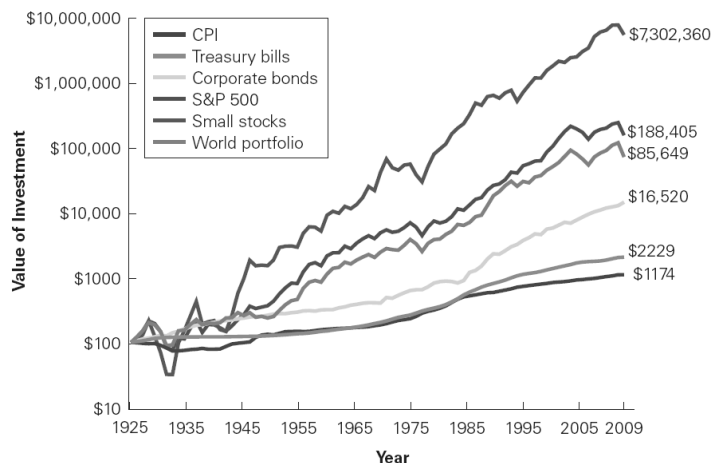

Figure 10.1

The value of $100 Invested at the end of 1925 in U.S. Large Stocks (S&P 500), Small Stocks, World Stocks, Corporate Bonds, and Treasury Bills. Also shown is the change in the consumer price index.

10.2 Common Measures of Risk and Return

When the return on an investment is uncertain and its possible returns can be specified, its future returns can be represented by a **probability distribution**, which shows the probability that each possible return will occur.

Given the probability distribution of returns:

■ The expected return, $E(R)$, is the mean return,

$$E[R] = \sum_R p_r \times R$$

which is the sum of the probability that each return will occur, p_r, times the return, R, for all possible returns.

■ The most common measures of risk of a probability distribution are the **variance**, $VAR(R)$, and **standard deviation**, $SD(R)$:

$$VAR(R) = E(R - E[R])^2 = \sum_R p_R \times (R - E[R])^2, \text{ and } SD(R) = \sqrt{SD(R)}.$$

10.3 Historical Returns of Stocks and Bonds

The **realized return** is the sum of the dividend yield and the capital gain rate of return over a time period. If you assume that all dividends are immediately reinvested and used to purchase additional shares of the same security, and the stock pays dividends at the end of each quarter, then the total annual return is:

$$R_{annual} = (1 + R_{Q1})(1 + R_{Q2})(1 + R_{Q3})(1 + R_{Q4}) - 1$$

Once realized annual returns have been computed, the **average annual return** of an investment during a period is the average of the realized returns for each year:

$$\overline{R} = \frac{1}{T}(R_1 + R_2 + \cdots + R_T) = \left(\frac{1}{T}\right)\sum_{t=1}^{T} R_t.$$

The standard deviation of the probability distribution can be estimated as:

$$VAR(R) = \left(\frac{1}{T-1}\right)\sum_{t=1}^{T}(R_t - \overline{R})^2.$$

Because a security's historical average return is only an estimate of its true return, the standard error of the estimate can be used to measure the amount estimation error. If the distribution of a stock's return is identical each year, and each year's return is independent of prior years' returns, then the standard error of the estimate of the expected return is:

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

In a large sample, the average return will be within two standard errors of the true expected return approximately 95% of the time, so the standard error can be used to determine a reasonable range for the true expected value. For example, a **95% confidence interval** for the expected return is equal to the historical average return $\pm$ (2 × the standard error).

10.4 The Historical Trade-off between Risk and Return

Between 1926 and 2009, the average return and standard deviation for the large portfolios in Figure 10.1 are shown in the following table.

Investment	Average Return	Standard Deviation
Small stocks	20.9%	41.5%
S&P 500	11.6%	20.6%
Corporate bonds	6.6%	7.0%
Treasury bills	3.9%	3.1%

The statistics show that there is a positive relation between risk (as measured by standard deviation) and average return for portfolios of assets. However, this is not true for individual stocks. When the same statistics are calculated for stocks comprising the S&P 500 from 1926–2004, you find that:

■ There is not a clear positive relation between a stock's average return and its volatility;

■ Larger stocks tend to have lower overall volatility, but even the largest stocks are typically more risky than a portfolio of large stocks;

■ All stocks seem to have higher risk and lower returns than would be predicted based on extrapolation of data for large portfolios.

Thus, while volatility (standard deviation) seems be a reasonable measure of risk when evaluating a large portfolio, it is not adequate to explain the returns of individual securities, since there is no clear relation between volatility and return for individual stocks.

10.5 Common Versus Independent Risk

The averaging out of independent risks in a large portfolio is called **diversification**. The principle of diversification is used routinely in the insurance industry. For example, the theft insurance industry relies on the fact that the number of claims is relatively predictable in a large portfolio. Since thefts in different houses are not related to each other, the risk of theft is uncorrelated and independent across homes. There are thus two kinds of risk:

■ **Independent risk** is risk that is uncorrelated and independent for all risky assets; it can be eliminated in a diversified portfolio. For example, if theft insurance policy risks are independent, the number of claims is predictable for a large insurance company in a given period and thus the number of claims expected in not very risky.

■ **Common risk** is risk that affects the value of all risky assets, and it cannot be eliminated in a diversified portfolio. For example, common risk cannot be eliminated for a large portfolio of earthquake insurance policies in the same geographic region, and so the number of claims expected is very risky, even for a large insurance company.

10.6 Diversification in Stock Portfolios

Given the fact that the value of most stocks is affected by common risks, there are two kinds of risk from investing in a stock.

■ **Idiosyncratic risk** is variation in a stock's return due to firm-specific news. This type of risk is also called **firm-specific**, **unsystematic**, **unique**, or **diversifiable risk**.

■ **Systematic risk**, or **undiversifiable risk**, refers to the risk that market-wide news will simultaneously affect the value of all assets.

Diversification eliminates idiosyncratic risk but does not eliminate systematic risk. Because investors can eliminate idiosyncratic risk, they should not require a risk premium for bearing it. Because investors cannot eliminate systematic risk, they must be compensated for taking on that risk. As a consequence, the risk premium for an asset depends on the amount of its systematic risk, rather than its total risk (standard deviation).

10.7 Measuring Systematic Risk

When evaluating the risk of an investment, an investor with a diversified portfolio will only care about its systematic risk, which cannot be eliminated through diversification. In exchange for bearing systematic risk, investors want to be compensated by earning a higher return. So determining investors' expected return requires both measuring the investment's systematic risk and determining the risk premium required to compensate for that amount of systematic risk.

Measuring systematic risk requires locating a portfolio that contains only systematic risk. Changes in the market value of this portfolio will correspond to systematic shocks to the economy. Such a portfolio is called an **efficient portfolio**. Because diversification improves with the number of stocks held in a portfolio, an efficient portfolio should be a large portfolio containing many different stocks. Thus, it is reasonable to consider a portfolio that contains all shares of all stocks and securities in the market, which is called the **market portfolio**. It is standard to use the S&P 500 portfolio as a proxy for the unobservable market portfolio of all risky assets.

The systematic risk of a security's return is most often measured by its beta. The **beta** (β) of a security is the sensitivity of the security's return to the return of the overall market; it measures the expected percent change in the excess return of a security for a 1% change in the excess return of the market portfolio.

10.8 Beta and the Cost of Capital

A firm's cost of capital for a project is the expected return that its investors could earn on other securities with the same risk and maturity. Because the risk that determines expected returns is systematic risk, which is measured by beta, the cost of capital for a project is the expected return available on securities with the same beta. A common assumption is to assume that the project has the same risk as the firm, or other firms with similar assets.

The **market risk premium** investors can earn by holding the market portfolio (or a stock with a beta of 1) is the difference between the market portfolio's expected return and the risk-free interest rate, so they earn the market return. For investments with a beta different than 1, the expected return, r_I, is given by the **Capital Asset Pricing Model** (CAPM) equation:

$$r_I = \text{Risk-Free Interest Rate} + \text{Risk Premium} = r_f + \beta_I \times (E[R_{Mkt}] - r_f).$$

Selected Concepts and Key Terms

Excess Return

The difference between the average return for the investment and the average return for Treasury bills, which are generally considered a risk-free investment.

Common Risk

Risk that affects the value of all risky assets; it cannot be eliminated in a diversified portfolio.

Independent Risk

Risk that is uncorrelated and independent for all risky assets; it can be eliminated in a diversified portfolio.

Diversification

The averaging out of independent risks in a large portfolio.

Firm-Specific, Idiosyncratic, Unsystematic, Unique, or Diversifiable Risk

Risk arising from investing in a risky asset that is due to potential firm-specific news and events.

Systematic, Undiversifiable, or Market Risk

The risk that market-wide news and events will simultaneously affect the value of all assets.

Efficient Portfolio

A portfolio of risky assets that contains only systematic risk. Changes in the value of this portfolio correspond to systematic shocks to the economy.

Market Portfolio

A portfolio that contains all risky assets in the market. It is standard to use the S&P 500 portfolio as a proxy for the unobservable market portfolio of all risky assets.

Beta (β)

The sensitivity of a security's return to the return of the overall market; it measures the expected percent change in the excess return of a security for a 1% change in the excess return of the market portfolio.

Concept Check Questions and Answers

10.1.1. From 1926 to 2009, which of the following investments had the highest return: Standard & Poor's 500, small stocks, world portfolio, corporate bonds, or Treasury bills?

From 1926 to 2009, the small stock portfolio (the smallest 10% of all stocks traded on the NYSE) had the highest rate of return.

10.1.2. From 1926 to 2009, which investment grew in value in every year? Which investment had the greatest variability?

From 1926 to 2009, the investment in three-month Treasury Bills made modest gains every year and the investment in the small stock portfolio experienced the largest fluctuations in its value.

10.2.1. How do we calculate the expected return of a stock?

The expected return of a stock is calculated as a weighted average of the possible returns, where the weights correspond to the probabilities.

10.2.2. What are the two most common measures of risk, and how are they related to each other?

The two most common measures used to measure the risk of a probability distribution are the variance and standard deviation. The variance is the expected squared deviation from the mean, and the standard deviation is the aware root of the variance.

10.3.1. How do we estimate the average annual return of an investment?

The average annual return of an investment during some historical period is simply the average of the realized returns for each year.

10.3.2. We have 83 years of data on the S&P 500 returns, yet we cannot estimate the expected return of the S&P 500 very accurately. Why?

We cannot estimate the expected return of the S&P 500 very accurately because the standard error of the estimate of the expected return is large. Furthermore, if we believe the distribution of the S&P 500 returns may have charged over time, and we can only use more recent data to estimate the expected return, then the estimate will be even less accurate.

10.4.1. What is the excess return?

The excess return is the difference between the average return for the investment and the average return for Treasury Bills, a risk free investment.

10.4.2. Do expected returns of well-diversified large portfolios of stocks appear to increase with volatility?

Yes, there is a positive relation between the standard deviation of the portfolios and their historical returns.

10.4.3. Do expected returns for individual stocks appear to increase with volatility?

No, there is no clear relationship between the volatility and return of individual stocks. While the smallest stocks have a slightly higher average return, many stocks have higher volatility and lower average returns than other stocks. And all stocks seem to have higher risk and lower returns than would be predicted based on extrapolation of data for large portfolios.

10.5.1. What is the difference between common risk and independent risk?

Common risk is the risk that is perfectly correlated across assets. On the other hand, independent risk is the risk that is uncorrelated and independent across assets.

10.5.2. Under what circumstances will risk be diversified in a large portfolio of insurance contracts?

Diversification is the average from independent risks in a large portfolio. When risks are independent, insurance companies routinely use diversification to reduce risk for a large portfolio of insurance contracts.

10.6.1. Explain why the risk premium of diversifiable risk is zero.

The risk premium for diversification risk is zero because this risk can be eliminated in a large portfolio. Investors are not compensated for holding firm-specific (unsystematic) risk.

10.6.2. Why is the risk premium of a security determined only by its systematic risk?

Because investors cannot eliminate systematic risk, they must be compensated for holding that risk. As a consequence, the risk premium for a security depends on the amount of its systematic risk rather than its total risk.

10.7.1. What is the market portfolio?

The market portfolio contains all shares of all stocks and securities in the market.

10.7.2. Define the beta of a security.

The beta is the expected percentage change in the excess return of a security for a 1% change in the excess return of the market portfolio.

10.8.1. How can you use a security's beta to estimate its cost of capital?

The cost of capital can be estimated by determining the expected return using the Capital Asset Pricing Model (CAPM) equation:

$$E[R] = \text{Risk-Free Interest Rate} + \text{Risk Premium} = r_f + \beta \times (E[R_{Mkt}] - r_f)$$

10.8.2. If a risky investment has a beta of zero, what should its cost of capital be according to the CAPM? How can you justify this?

It should equal the risk-free rate because it has no systematic risk.

Examples with Step-by-Step Solutions

Solving Problems

Problems using the concepts in this chapter may involve calculating the mean and standard deviation from a probability distribution. They may require calculating the realized return over a time period, the mean and standard deviation from historical returns, and comparing risk-return trade-offs. You also may need to consider the effect of diversification on the risk of a portfolio. Finally, problems may require using the Capital Asset Pricing Model to estimate a stock's expected return.

Examples

1. You are considering investing in Cisco and Yahoo, which have never paid dividends and had the following end of year stock prices (adjusted for splits):

	Cisco	Yahoo
12/31/1996	$7.07	$0.71
12/31/1997	9.29	4.33
12/31/1998	23.20	29.62
12/31/1999	53.56	108.17
12/31/2000	38.25	15.03
12/31/2001	18.11	8.87
12/31/2002	13.10	8.18
12/31/2003	24.23	22.51
12/31/2004	19.32	37.68
12/31/2005	17.12	39.18

Determine the risk-return trade-off based on the means and standard deviations of historical returns and graph the results. What is a better stock to buy?

Step 1. In order to calculate the means and standard deviations of historical returns, the annual returns must be determined.

The annual return $= \dfrac{P_{t+1} - P_1}{P_1}$, for example $\dfrac{P_{1997}^{Cisco} - P_{1996}^{Cisco}}{P_{1996}^{Cisco}} = \dfrac{9.29 - 7.07}{7.07} = 0.314 = 31.4\%$

The returns for 1997-2005 are as shown.

	Cisco	Yahoo
1997	0.314	5.099
1998	1.497	5.841
1999	1.309	2.652
2000	−0.286	−0.861
2001	−0.527	−0.410
2002	−0.277	−0.078
2003	0.850	1.752
2004	−0.203	0.674
2005	0.114	0.040

Step 2. Next, the mean returns can be calculated.

$$R_{Cisco}^{Mean} = \frac{1}{T}\sum_{t=1}^{T}R_t = \frac{0.314 + 1.497 + 1.309 + -0.286 + -0.527 + -0.277 + 0.850 + -0.203 + -0.114}{9} = 28.5\%$$

$$R_{Yahoo}^{Mean} = \frac{1}{T}\sum_{t=1}^{T}R_t = \frac{5.099 + 5.841 + 2.652 + -0.861 + -0.410 + -0.078 + 1.752 + 0.674 + 0.040}{9} = 163\%$$

Step 3. Now, the standard deviations can be calculated.

$$SD(R_{Cisco}) = \sqrt{VAR(R_{Cisco})} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(R_t - \overline{R})^2} =$$

$$= \sqrt{\frac{\begin{array}{c}(0.314 - 0.285)^2 + (1.497 - 0.285)^2 + (1.309 - 0.285)^2 + (-0.286 - 0.285)^2 + (-0.527 - 0.285)^2 \\ + (-0.277 - 0.285)^2 + (0.850 - 0.285)^2 + (-0.203 - 0.285)^2 + (-0.114 - 0.285)^2\end{array}}{8}}$$

$$= 0.753 = 75.3\%$$

$$SD(R_{Yahoo}) = \sqrt{VAR(R_{Yahoo})} = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(R_t - \overline{R})^2}$$

$$= \sqrt{\frac{\begin{array}{c}(5.099 - 1.634)^2 + (5.841 - 1.634)^2 + (2.652 - 1.634)^2 + (-0.861 - 1.634)^2 + (-0.410 - 1.634)^2 \\ + (-0.078 - 1.634)^2 + (1.752 - 1.634)^2 + (0.674 - 1.634)^2 + (0.040 - 1.634)^2\end{array}}{8}}$$

$$= 2.438 = 244\%$$

Step 4. Graph the results.
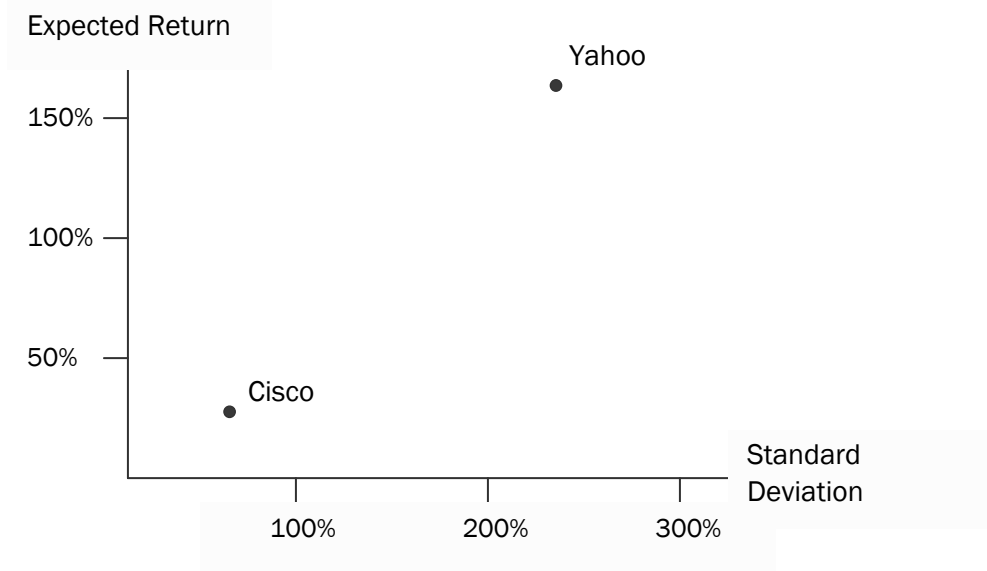
Step 5. Interpret the results.

It is not possible to conclude that either stock is a better choice. Yahoo is has a much higher expected return, but it also has a much higher standard deviation; Cisco has a lower expected return, but a lower standard deviation. Some investors may prefer Cisco and some may prefer Yahoo.

2. **The stock prices and dividends for General Electric (GE) for a 1-year period are below.**

Date	Price	Dividend
06/15/06	32.22	0.25
03/15/06	33.45	0.25
12/15/05	31.34	0.22
09/15/05	30.22	0.22
06/16/05	30.44	

What was the annual return on GE in this period?

Step 1. The quarterly returns must first be computed.

The quarterly return is calculated as:

$$= \frac{P_{t+1} + \text{Div}_{t+1} - P_t}{P_t},$$

for example, $\dfrac{P_{6/15/2006} + \text{Div}_{6/15/2006} - P_{3/15/2006}}{P_{3/15/2006}}$

$$= \frac{32.22 + 0.25 - 33.45}{33.25} = -0.029 = -2.9\%.$$

For all four quarters, the returns are:

Date	Price	Dividend	Return
06/15/06	32.22	0.25	-0.029
03/15/06	33.45	0.25	0.075
12/15/05	31.34	0.22	0.044
09/15/05	30.22	0.22	0.000
06/16/05	30.44		

Step 2. Calculate the annual return.

$$R_{annual} = (1 + R_{Q1})(1 + R_{Q2})(1 + R_{Q3})(1 + R_{Q4}) - 1$$

$$= (1.000)(1.044)(1.075)(0.971) - 1 = 1.090 - 1 = 0.090, \text{ or } 9.0\%$$

3. You are considering investing in 10 stocks in two different industries (all 10 stocks you chose will be in the same industry).

   ■ The first industry is biotechnology. You believe that the returns of all biotech stocks are totally independent because they are all developing different drugs with different probabilities of having those drugs approved. Each year you believe there is a 50% chance a stock will have a 30% return and a 50% chance a stock will have a –10% return.

   ■ The other industry is firms offering S&P 500 exchange-traded funds (ETFs). Since these funds all seek to track the performance of the same index, you believe that the returns on these ETFs are perfectly correlated. Each year you believe there is a 50% chance a fund will have a 25% return and a 50% chance a fund will have a –5% return.

Which strategy is better?

Step 1. Determine what you should base your decision on.

To see if one strategy is better, you must calculate the expected return and risk (standard deviation) of each 10-stock portfolio. If one strategy has a higher expected return *and* a lower standard deviation, then it would always be preferred by a risk-averse investor. If neither satisfies these criteria, then different investors must select their preferred portfolio based on their preferences.

Step 2. Calculate expected returns of each investment.

$$E[R_{Biotech}] = \sum_R p_r \times R = .5(.3) + .5(-.1) = .10 = 10\%$$

$$E[R_{ETF}] = \sum_R p_r \times R = .5(.25) + .5(-.05) = .10 = 10\%$$

Step 3. Calculate the expected return on a 10-stock portfolio of each investment.

$$E[R_{Biotech}] = \frac{1}{T}\sum_{t=1}^{T} R_t = \frac{.10 + .10 + .10 + .10 + .10 + .10 + .10 + .10 + .10 + .10}{10} = 10\%$$

$$E[R_{ETF}] = \frac{1}{T}\sum_{t=1}^{T} R_t = \frac{.10 + .10 + .10 + .10 + .10 + .10 + .10 + .10 + .10 + .10}{10} = 10\%$$

Step 4. Calculate the standard deviation of each investment.

$$\sqrt{\text{VAR}(R_{\text{Biotech}})} = \sqrt{\sum_R p_R \times (R - E[R])^2} = \sqrt{.5(.3-.1)^2 + .5(-.1-.1)^2} = 20\%$$

$$\sqrt{\text{VAR}(R_{\text{ETF}})} = \sqrt{\sum_R p_R \times (R - E[R])^2} = \sqrt{.5(.25-.1)^2 + .5(-.05-.1)^2} = 15\%$$

Step 5. Calculate the standard deviation of a 10-stock portfolio of each investment.

Biotech stocks move independently. Hence the standard deviation of the portfolio is:

$$\text{SD}(\text{Portfolio of 10 biotech stocks}) = \frac{\text{SD(Individual Risk)}}{\sqrt{\text{Number of Observations}}} = \frac{0.20}{\sqrt{10}} = 6.3\%.$$

Because all ETF stocks in the portfolio move together, there is no diversification benefit. So the standard deviation of the portfolio is the same as the standard deviation of one ETF, 15%.

Step 6. Make a conclusion.
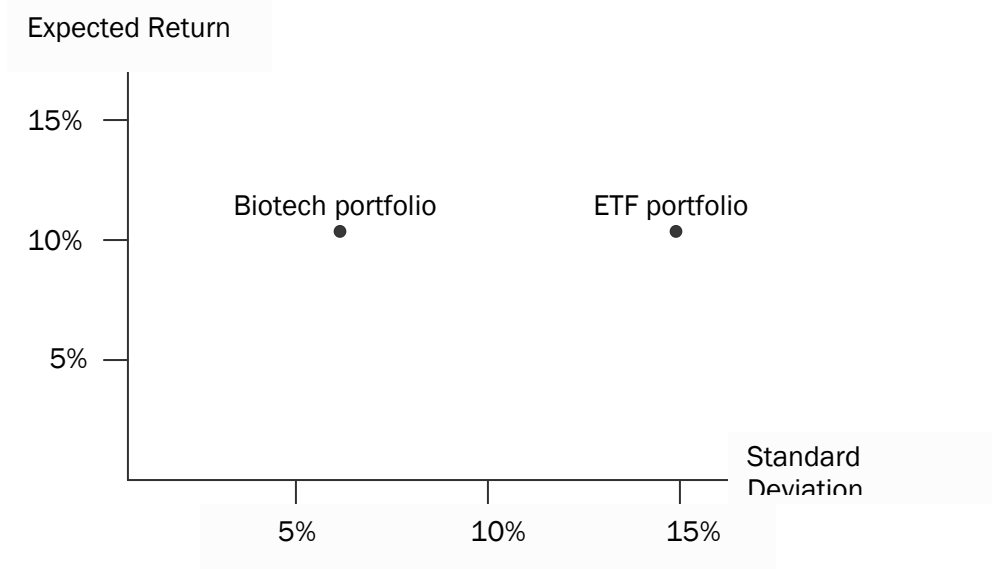
Since the biotech stock portfolio has a lower standard deviation, and both options offer a 10% return, the biotech stock portfolio is preferred to the ETF portfolio.

Questions and Problems

1. Consider the following probability distributions:

   Asset A

Return	–30%	0%	20%	40%
Probability	0.20	0.40	0.20	0.20

   Asset B

Return	–30%	0%	20%	40%
Probability	0.20	0.40	0.20	0.20

   Which asset is the best investment for a risk-averse investor?

2. [A]   During the Depression era from 1929 to 1932, which investment made money in every year, and which investment had the worst performance?

   [B]   During the 1926–2009 period, which investment had the highest return, and which investment had the worst performance?

   [C]   During the 1926–2009 period, which investment had the highest standard deviation, and which investment had the lowest standard deviation?

3. Is it true that expected returns on individual stocks increase proportionately with standard deviation? Explain.

4. 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]   One of the firm's largest factories may be destroyed by fire.

   [B]   Interest rates may rise in the economy.

   [C]   The housing market may crash, leading to negative economic growth for several years.

   [D]   The firm's major drug may be found to cause cancer and never be approved.

5. Suppose the market risk premium is 6% and the risk-free interest rate is 4%. Calculate the expected return of investing in the following stocks:

	Boston Edison	Priceline
Standard Deviation	33%	76%
Beta	0.34	2.50

Solutions to Questions and Problems

1. Expected returns:

$$E[R_A] \;=\; \sum_R p_r \times R = .20(-.30) + .40(0) + .20(.20) + .20(.40) = 6\%$$

$$E[R_B] \;=\; \sum_R p_r \times R = .20(-.20) + .10(0) + .40(.10) + .30(.20) = 6\%$$

Standard Deviations:

$$\sqrt{VAR(R_A)} = \sqrt{\sum_R (R - E[R])^2}$$

$$= \sqrt{.2(-.3-.06)^2 + .4(0-.06)^2 + .2(.2-.06)^2 + .2(.3-.06)^2} = \sqrt{0.042} = .205 = 20.5\%$$

$$\sqrt{VAR(R_B)} = \sqrt{\sum_R (R - E[R])^2}$$

$$= \sqrt{.2(-.2-.06)^2 + .1(0-.06)^2 + .4(.1-.06)^2 + .3(.2-.06)^2} = \sqrt{0.020} = .143 = 14.3\%$$

So B is preferable. It has the same expected return as A, but has lower risk.

2. [A]   From the graph in Figure 10.1, Treasury bills were the only asset class to have a positive return in this period. Small stocks had the worst performance in this period, losing most of their value.

   [B]   Small stocks had the highest average annual return (20.9%), and Treasury bills had the lowest average annual return (3.9%).

   [C]   Small stocks had the highest standard deviation (41.5%), and Treasury bills had the lowest standard deviation (3.1%).

3. No, there is no clear relation between standard deviation and return for individual stocks. While the smallest stocks have a slightly higher average return, many stocks have higher volatility and lower average returns than other stocks. All stocks seem to have higher risk and lower returns than we would have predicted from a simple extrapolation of our data from large portfolios. Thus, while volatility seems to be a reasonable measure of risk when evaluating a large portfolio, it is inadequate to explain the returns of individual securities.

4. Because interest rates and the health of the economy affect all stocks, risks (B) and (C) are systematic risks. These risks are not diversified in a large portfolio, and they will affect the risk premium that investors require to invest in stocks. Firms with cash flows that are related to the health of the economy must offer larger risk premiums.

   Risks (A) and (D) are firm-specific risks, and so are diversifiable. While these risks should be considered when estimating the firm's future cash flows, they will not affect the risk premium that investors will require and, therefore, will not affect the firm's cost of capital.

5. Boston Edison

   $E[R] = 4 + 0.34(6) = 6.0\%$

   Priceline

   $E[R] = 4 + 2.50(6) = 19\%$