7 Risk and Return

"Believe me! The secret of reaping the greatest fruitfulness and the greatest enjoyment from life is to live dangerously!"

—Friedrich Wilhelm Nietzsche

Are You the "Go-for-It" Type?

In finance we frequently talk about the risk-return tradeoff. Riskier bonds must have higher interest rates to get people to buy them. Yet we also see people line up to buy a Powerball lottery ticket that has 80,000,000 to 1 odds against the player hitting the big jackpot. These behaviors don't seem to be consistent.

Some people also like to skydive, climb challenging mountains, do 720 degree horizontal spins on a snowboard, and 360 degree vertical spins on a motorcycle. The Gen X Games attract millions of viewers, many of them young people with a "go-for-it" attitude. The adrenaline rush, or perhaps the adulation from fans who watch these athletes display their skill, make the risk worth taking. The better performers also can make some nice money doing this.

Essentially every successful new business needs a founder with a willingness to take risks. This is at the heart of entrepreneurship. Bill Gates of Microsoft took big risks. So too did Steve Jobs of Apple Computer and Larry Page and Sergey Brin of Google. These are some very wealthy people.

What is all this talk then about investors not liking risk? The key is that each of these risk takers saw an upside to what they were doing that made the risk worth taking. The risk wasn't taken for its own sake. Risk in a business setting is examined in this chapter. How can we measure the

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risk a business faces, along with the potential rewards that business may attain? Risk that does not lead to greater rewards can be eliminated in some cases and reduced in others. Managing the risk-return tradeoff is a central tenet of finance.

Learning Objectives

After reading this chapter, you should be able to:

1. Define risk, risk aversion, and the risk-return relationship.
2. Measure risk using the standard deviation and coefficient of variation.
3. Identify the types of risk that business firms encounter.
4. Explain methods of risk reduction.
5. Describe how firms compensate for assuming risk.
6. Discuss the capital asset pricing model (CAPM).

Chapter Overview

Business firms face risk in nearly everything they do. Assessing risk is one of the most important tasks financial managers perform. In this chapter we will discuss *risk*, *risk aversion*, and the *risk-return relationship*. We will measure risk using *standard deviation* and the *coefficient of variation*. We will identify types of risk and examine ways to reduce risk exposure or compensate for risk. Finally, we will see how the capital asset pricing model (CAPM) explains the risk-return relationship.

Risk

The world is a risky place. For instance, if you get out of bed in the morning and go to class, you run the risk of getting hit by a bus. If you stay in bed to minimize the chance of getting run over by a bus, you run the risk of getting coronary artery disease because of a lack of exercise. In everything we do—or don't do—there is a chance that something will happen that we didn't expect. Risk is the potential for unexpected events to occur.

Risk Aversion

Most people try to avoid risks if possible. Risk aversion doesn't mean that some people don't enjoy risky activities, such as skydiving, rock climbing, or automobile racing. In a financial setting, however, evidence shows that most people avoid risk when possible, unless there is a higher expected rate of return to compensate for the risk. Faced with financial alternatives that are equal except for their degree of risk, most people will choose the less risky alternative.

Risk aversion is the tendency to avoid additional risk. Risk-averse people will avoid risk if they can, unless they receive additional compensation for assuming that risk. In finance, the added compensation is a higher expected rate of return.

The Risk-Return Relationship

The relationship between risk and required rate of return is known as the **risk-return relationship**. It is a positive relationship because the more risk assumed, the higher the required rate of return most people will demand. It takes compensation to convince people to suffer.

Suppose, for instance, that you were offered a job in the Sahara Desert, working long hours for a boss everyone describes as a tyrant. You would surely be averse to the idea of taking such a job. But think about it: Is there any way you would take this job? What if you were told that your salary would be $1 million per year? This compensation might cause you to sign up immediately. Even though there is a high probability you would hate the job, you'd take that risk because of the high compensation.[1]

Not everyone is risk averse, and among those who are, not all are equally risk averse. Some people would demand $2 million before taking the job in the Sahara Desert, whereas others would do it for a more modest salary.

People sometimes engage in very risky financial activities, such as buying lottery tickets or gambling in casinos. This suggests that they like risk and will pay to experience it. Most people, however, view these activities as entertainment rather than financial investing. The entertainment value may be the excitement of being in a casino with all sorts of people, or being able to fantasize about spending the multimillion-dollar lotto jackpot. But in the financial markets, where people invest for the future, they almost always seek to avoid risk unless they are adequately compensated.

Risk aversion explains the positive risk-return relationship. It explains why risky junk bonds carry a higher market interest rate than essentially risk-free U.S. Treasury bonds. Hardly anyone would invest $5,000 in a risky junk bond if the interest rate on the bond were lower than that of a U.S. Treasury bond having the same maturity.

[1]We do not wish to suggest that people can be coaxed into doing anything they are averse to doing merely by offering them a sufficient amount of compensation. If people are asked to do something that offends their values, there may be no amount of compensation that can entice them.

Measuring Risk

We can never avoid risk entirely. That's why businesses must make sure that the anticipated return is sufficient to justify the degree of risk assumed. To do that, however, firms must first determine how much risk is present in a given financial situation. In other words, they must be able to answer the question, "How risky is it?"

Measuring risk quantitatively is a rather tall order. We all know when something feels risky, but we don't often quantify it. In business, risk measurement focuses on the degree of **uncertainty** present in a situation—the chance, or probability, of an unexpected outcome. The greater the probability of an unexpected outcome, the greater the degree of risk.

Using Standard Deviation to Measure Risk

In statistics, *distributions* are used to describe the many values variables may have. A company's sales in future years, for example, is a variable with many possible values. So the sales forecast may be described by a distribution of the possible sales values with different probabilities attached to each value. If this distribution is symmetric, its mean—the average of a set of values—would be the expected sales value. Similarly, possible returns on any investment can be described by a *probability distribution*—usually a graph, table, or formula that specifies the probability associated with each possible return the investment may generate. The mean of the distribution is the most likely, or expected, rate of return.

The graph in Figure 7-1 shows the distributions of forecast sales for two companies, Company Calm and Company Bold. Note how the distribution for Company Calm's possible sales values is clustered closely to the mean and how the distribution of Company Bold's possible sales values is spread far above and far below the mean.[2]

The narrowness or wideness of a distribution reflects the degree of uncertainty about the expected value of the variable in question (sales, in our example). The distributions in Figure 7-1 show, for instance, that although the most probable value of sales for both companies is \$1,000, sales for Company Calm could vary between \$600 and \$1,400, whereas sales for Company Bold could vary between \$200 and \$1,800. Company Bold's relatively wide variations show that there is more uncertainty about its sales forecast than about Company Calm's sales forecast.

One way to measure risk is to compute the **standard deviation** of a variable's distribution of possible values. The standard deviation is a numerical indicator of how widely dispersed the possible values are around a mean. The more widely dispersed a distribution is, the larger the standard deviation, and the greater the probability that the value of a variable will be significantly above or below the expected value. The standard deviation, then, indicates the likelihood that an outcome different from what is expected will occur.

Let's calculate the standard deviations of the sales forecast distributions for Companies Calm and Bold to illustrate how the standard deviation can measure the degree of uncertainty, or risk, that is present.

[2]These two distributions are discrete. If sales could take on any value within a given range, the distribution would be continuous and would be depicted by a curved line.

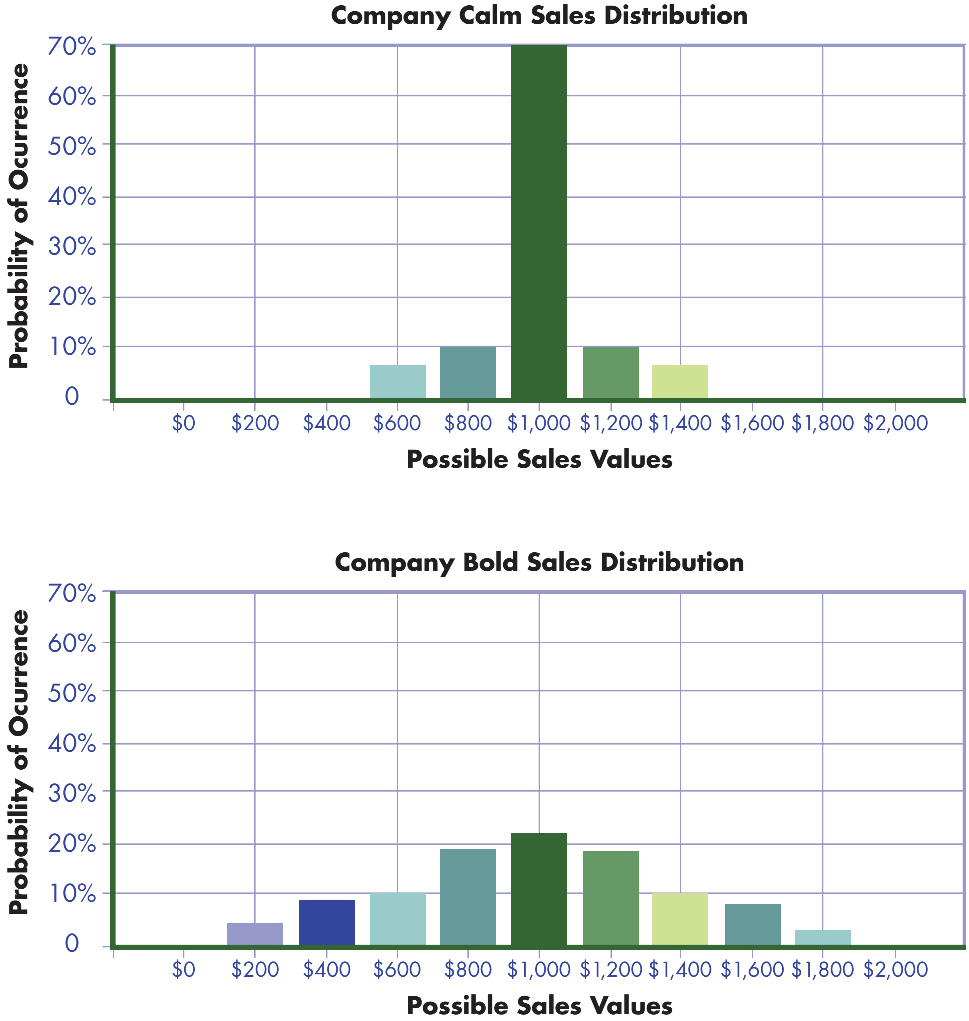


Figure 7-1 Sales Forecast Distributions for Companies Calm and Bold

Possible future sales distribution for two companies. Calm has a relatively "tight" distribution, and Bold has a relatively "wide" distribution. Note that sales for Company Bold has many more possible values than the sales for Company Calm.

Calculating the Standard Deviation To calculate the standard deviation of the distribution of Company Calm's possible sales, we must first find the expected value, or mean, of the distribution using the following formula:

Formula for Expected Value, or Mean (μ)

$$\mu = \sum (V \times P) \tag{7-1}$$

where: μ = the expected value, or mean

$\sum$ = the sum of

V = the possible value for some variable

P = the probability of the value V occurring

Applying Equation 7-1, we can calculate the expected value, or mean, of Company Calm's forecasted sales. The following values for V and P are taken from Figure 7-1:

Calculating the Mean (μ) of Company Calm's Possible Future Sales Distribution

Possible Sales Value (V)	Probability of Occurrence (P)	V x P
\$ 600	.05	30
\$ 800	.10	80
\$ 1,000	.70	700
\$ 1,200	.10	120
\$ 1,400	.05	70
	Σ = 1.00	Σ = 1,000 = μ

Each possible sales value is multiplied by its respective probability. The probability values, taken from Figure 7-1, may be based on trends, industry ratios, experience, or other information sources. We add together the products of each value times its probability to find the mean of the possible sales distribution.

We now know that the mean of Company Calm's sales forecast distribution is \$1,000. We are ready to calculate the standard deviation of the distribution using the following formula:

The Standard Deviation (σ) Formula

$$s = \sqrt{\hat{A}\ P(V - m)^2} \qquad (7\text{-}2)$$

where: σ = the standard deviation

Σ = the sum of

P = the probability of the value V occurring

V = the possible value for a variable

μ = the expected value

To calculate the standard deviation of Company Calm's sales distribution, we subtract the mean from each possible sales value, square that difference, and then multiply by the probability of that sales outcome. These differences squared, times their respective probabilities, are then added together, and the square root of this number is taken. The result is the standard deviation of the distribution of possible sales values.

Calculating the Standard Deviation(s) of Company Calm's Possible Future Sales Distribution

Possible Sales Value (V)	Probability of Occurrence (P)	$V - \mu$	$(V - \mu)^2$	$P(V - \mu)^2$
\$ 600	.05	–400	160,000	8,000
\$ 800	.10	–200	40,000	4,000
\$1,000	.70	0	0	0
\$1,200	.10	200	40,000	4,000
\$1,400	.05	400	160,000	8,000
				Σ = 24,000

$$\sqrt{24{,}000} = 155 = s$$

This standard deviation result, 155, serves as the measure of the degree of risk present in Company Calm's sales forecast distribution.

Let's calculate the standard deviation of Company Bold's sales forecast distribution.

Mean (μ) and Standard Deviation (σ) of Company Bold's Possible Future Sales Distribution

Possible Sales Value (V)	Probability of Occurrence (P)	Mean Calculation V × P	$V - \mu$	$(V - \mu)^2$	$P(V - \mu)^2$
$ 200	.04	8	–800	640,000	25,600
$ 400	.07	28	–600	360,000	25,200
$ 600	.10	60	–400	160,000	16,000
$ 800	.18	144	–200	40,000	7,200
$ 1,000	.22	220	0	0	0
$ 1,200	.18	216	200	40,000	7,200
$ 1,400	.10	140	400	160,000	16,000
$ 1,600	.07	112	600	360,000	25,200
$ 1,800	.04	72	800	640,000	25,600
		$\Sigma = 1{,}000 = \mu$			$\Sigma = 148{,}000$

$$\sqrt{148{,}000} = 385 = s$$

Take Note

In the preceding procedure, we combine two steps: (1 finding the mean of the distribution with Equation 7-1; and (2) calculating the standard deviation with Equation 7-2.

As you can see, Company Bold's standard deviation of 385 is over twice that of Company Calm. This reflects the greater degree of risk in Company Bold's sales forecast.

Interpreting the Standard Deviation Estimates of a company's possible sales, or a proposed project's future possible cash flows, can generally be thought of in terms of a normal probability distribution. The normal distribution is a special type of distribution. It allows us to make statements about how likely it is that the variable in question will be within a certain range of the distribution.

Figure 7-2 shows a normal distribution of possible returns on an asset. The vertical axis measures probability density for this continuous distribution so that the area under the curve always sums to one. Statistics tells us that when a distribution is normal, there is about a 67 percent chance that the observed value will be within one standard deviation of the mean. In the case of Company Calm, that means that, if sales were normally distributed, there would be a 67 percent probability that the actual sales will be $1,000 plus or minus $155 (between $845 and $1,155). For Company Bold it means, if sales were normally distributed, there would be a 67 percent probability that sales will be $1,000 plus or minus $385 (between $615 and $1,385).

Another characteristic of the normal distribution is that approximately 95 percent of the time, values observed will be within two standard deviations of the mean. For Company Calm this means that there would be a 95 percent probability that sales will be $1,000 plus or minus $155 × 2, or $310 (between $690 and $1,310). For Company Bold it means that sales will be $1,000 plus or minus $385 × 2, or $770 (between $230 and $1,770). These relationships are shown graphically in Figure 7-3.

The greater the standard deviation value, the greater the uncertainty about what the actual value of the variable in question will be. The greater the value of the standard deviation, the greater the possible deviations from the mean.

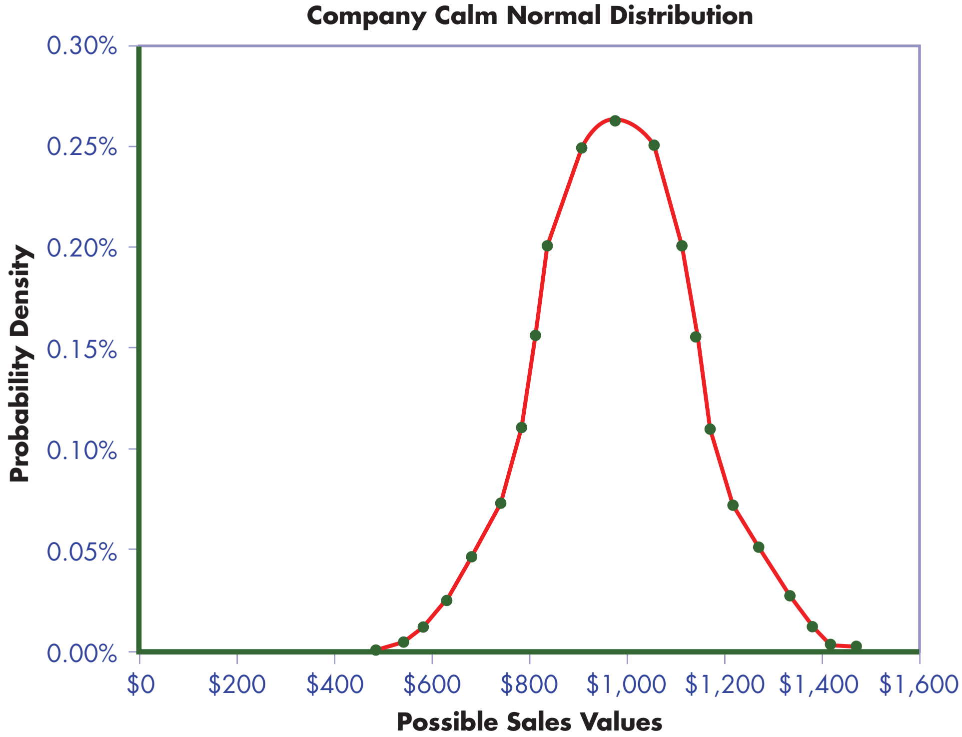


Figure 7-2 Normal Distribution

This normal probability distribution of possible returns has a mean, the expected value of $1,000.

Using the Coefficient of Variation to Measure Risk

Whenever we want to compare the risk of investments that have different means, we use the *coefficient of variation*. We were safe in using the standard deviation to compare the riskiness of Company Calm's possible future sales distribution with that of Company Bold because the mean of the two distributions was the same ($1,000). Imagine, however, that Company Calm's sales were 10 times that of Company Bold. If that were the case and all other factors remained the same, then the standard deviation of Company Calm's possible future sales distribution would increase by a factor of 10, to $1,550. Company Calm's sales would appear to be much more risky than Company Bold's, whose standard deviation was only $385.

To compare the degree of risk among distributions of different sizes, we should use a statistic that measures *relative* riskiness. The **coefficient of variation** (CV) measures relative risk by relating the standard deviation to the mean. The formula follows:

Coefficient of Variation (CV)

$$CV = \frac{\text{Standard Deviation}}{\text{Mean}} \tag{7-3}$$

The coefficient of variation represents the standard deviation's percentage of the mean. It provides a standardized measure of the degree of risk that can be used to compare alternatives.

To illustrate the use of the coefficient of variation, let's compare the relative risk depicted in Company Calm's and Company Bold's possible sales distributions. When we plug the figures into Equation 7-3, we see:

Interactive Module
Go to the Interactive Spreadsheets you downloaded for chapter 7. Follow the instructions there. Change the mean, standard deviation, weight, and correlation values and watch the graph.

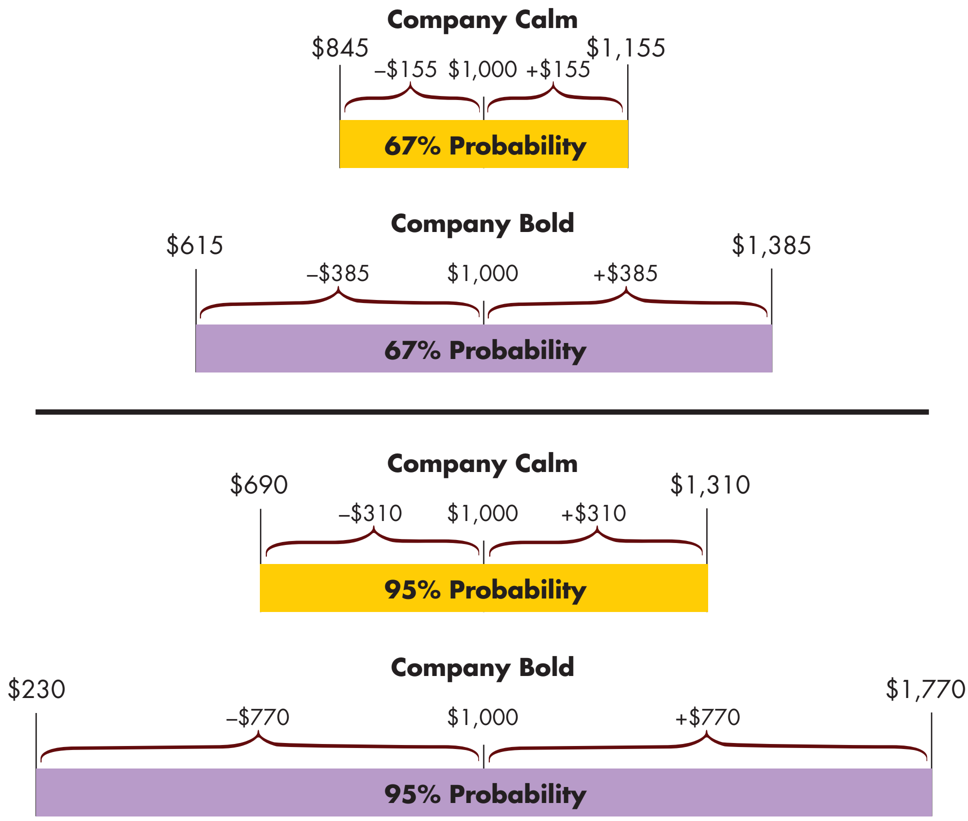


Figure 7-3 The Degree of Risk Present in Company Calm's and Company Bold's Possible Future Sales Values as Measured by Standard Deviation

The standard deviation shows there is much more risk present in Company Bold's sales probability distribution than in Company Calm's. If the distributions are normal, then there is a 67% probability that Company Calm's sales will be between $845 and $1,155, and a 95% probability sales will be between $690 and $1,310. For Company Bold there is a 67% probability that sales will be between $615 and $1,385, and a 95% probability that sales will be between $230 and $1,770.

$$\text{Company Calm CV}_{\text{sales}} = \frac{\text{Standard Deviation}}{\text{Mean}} = \frac{155}{1{,}000} = .155, \text{ or } 15.5\%$$

$$\text{Company Bold CV}_{\text{sales}} = \frac{\text{Standard Deviation}}{\text{Mean}} = \frac{385}{1{,}000} = .385, \text{ or } 38.5\%$$

Company Bold's coefficient of variation of possible sales (38.5 percent) is more than twice that of Company Calm (15.5 percent). Furthermore, even if Company Calm were 10 times the size of Company Bold—with a mean of its possible future sales of $10,000 and with a standard deviation of $1,550—it would not change the coefficient of variation. This would remain 1,550/10,000 = .155, or 15.5 percent. We use the coefficient of variation instead of the standard deviation to compare distributions that have means with different values because the CV adjusts for the difference, whereas the standard deviation does not.

The Types of Risks Firms Encounter

Risk refers to uncertainty—the chance that what you expect to happen *won't* happen. The forms of risk that businesses most often encounter are *business risk*, *financial risk*, and *portfolio risk*.

Business Risk

Business risk refers to the uncertainty a company has with regard to its operating income (also known as earnings before interest and taxes, or EBIT). The more uncertainty about a company's expected operating income, the more business risk the company has. For example, if we assume that grocery prices remain constant, the only grocery store in a small town probably has little business risk—the store owners can reliably predict how much their customers will buy each month. In contrast, a gold mining firm in Wyoming has a lot of business risk. Because the owners have no idea when, where, or how much gold they will strike, they can't predict how much they will earn in any period with any degree of certainty.

Measuring Business Risk The degree of uncertainty about operating income (and, therefore, the degree of business risk in the firm) depends on the volatility of operating income. If operating income is relatively constant, as in the grocery store example, then there is relatively little uncertainty associated with it. If operating income can take on many different values, as is the case with the gold mining firm, then there is a lot of uncertainty about it.

We can measure the variability of a company's operating income by calculating the standard deviation of the operating income forecast. A small standard deviation indicates little variability and, therefore, little uncertainty. A large standard deviation indicates a lot of variability and great uncertainty.

Some companies are large and others small. So to make comparisons among different firms, we must measure the risk by calculating the coefficient of variation of possible operating income values. The higher the coefficient of variation of possible operating income values, the greater the business risk of the firm.

Table 7-1 shows the expected value (μ), standard deviation (σ), and coefficient of variation (CV) of operating income for Company Calm and Company Bold, assuming that the expenses of both companies vary directly with sales (i.e., neither company has any fixed expenses).

The Influence of Sales Volatility Sales volatility affects business risk—the more volatile a company's sales, the more business risk the firm has. Indeed, when no fixed costs are present—as in the case of Company Calm and Company Bold—sales volatility is equivalent to operating income volatility. Table 7-1 shows that the coefficients of variation of Company Calm's and Company Bold's operating income are 15.5 percent and 38.5 percent, respectively. Note that these coefficient numbers are exactly the same numbers as the two companies' coefficients of variation of expected sales.

The Influence of Fixed Operating Costs In Table 7-1 we assumed that all of Company Calm's and Company Bold's expenses varied proportionately with sales. We did this to illustrate how sales volatility affects operating income volatility. In the real world, of course, most companies have some fixed expenses as well, such as rent, insurance premiums, and the like. It turns out that fixed expenses magnify the effect of sales volatility on operating income volatility. In effect, fixed expenses magnify business risk. The tendency of fixed expenses to magnify business risk is called operating leverage. To see how this works, refer to Table 7-2, in which we assume that all of Company Calm's and Company Bold's expenses are fixed.

Table 7-1 Expected Value (μ), Standard Deviation (σ), and Coefficient of Variation (CV) of Possible Operating Income Values for Company Calm and Bold, Assuming All Expenses Are Variable

Company Calm

	Probability of Occurrence				
	5%	**10%**	**70%**	**10%**	**5%**
Sales	$ 600	$ 800	$1,000	$1,200	$1,400
Variable Expenses	$ 516	$ 688	$ 860	$1,032	$1,204
Operating Income (EBIT)	$ 84	$ 112	$ 140	$ 168	$ 196

μ of possible operating income values per equation 7-1: $140
σ of possible operating income values per equation 7-2: $21.69
CV of possible operating income values per equation 7-3: 15.5%

Company Bold

	Probability of Occurrence								
	4%	**7%**	**10%**	**18%**	**22%**	**18%**	**10%**	**7%**	**4%**
Sales	$ 200	$ 400	$ 600	$ 800	$1,000	$1,200	$1,400	$1,600	$1,800
Variable Expenses	$ 172	$ 344	$ 516	$ 688	$ 860	$1,032	$1,204	$1,376	$1,548
Operating Income (EBIT)	$ 28	$ 56	$ 84	$ 112	$ 140	$ 168	$ 196	$ 224	$ 252

μ of possible operating income values per equation 7-1: $140
σ of possible operating income values per equation 7-2: $53.86
CV of possible operating income values per equation 7-3: 38.5%

As Table 7-2 shows, the effect of replacing each company's variable expenses with fixed expenses increased the volatility of operating income considerably. The coefficient of variation of Company Calm's operating income jumped from 15.49 percent when all expenses were variable to over 110 percent when all expenses were fixed. When all expenses are fixed, a 15.49 percent variation in sales is magnified to a 110.66 percent variation in operating income. A similar situation exists for Company Bold.

The greater the fixed expenses, the greater the change in operating income for a given change in sales. Capital-intensive companies, such as electric generating firms, have high fixed expenses. Service companies, such as consulting firms, often have relatively low fixed expenses.

> **Take Note**
> One group of businesses that is exposed to an extreme amount of financial risk because they operate almost entirely on borrowed money: banks and other financial institutions. Banks get almost all the money they use for loans from deposits—and deposits are liabilities on the bank's balance sheet. Banks must be careful to keep their revenues stable. Otherwise, fluctuations in revenues would cause losses that would drive the banks out of business. Now you know why the government regulates financial institutions so closely!

Financial Risk

When companies borrow money, they incur interest charges that appear as fixed expenses on their income statements. (For business loans, the entire amount borrowed normally remains outstanding until the end of the term of the loan. Interest on the unpaid balance, then, is a fixed amount that is paid each year until the loan matures.) Fixed interest charges act on a firm's net income in the same way that fixed operating expenses act on operating income—they increase volatility. The additional volatility of a firm's net income caused by the fixed interest expense is called **financial risk**. The phenomenon whereby a given change in operating income causes net income to change by a larger percentage is called **financial leverage**.

Table 7-2 Expected Value (μ), Standard Deviation (σ), and Coefficient of Variation (CV) of Possible Operating Income Values for Company Calm and Bold, Assuming All Expenses Are Fixed

Company Calm

	Probability of Occurrence				
	5%	**10%**	**70%**	**10%**	**5%**
Sales	$ 600	$ 800	$1,000	$1,200	$1,400
Fixed Expenses	$ 860	$ 860	$ 860	$ 860	$ 860
Operating Income (EBIT)	($260)	($ 60)	$ 140	$ 340	$ 540

μ of possible operating income values per equation 7-1: $140
σ of possible operating income values per equation 7-2: $154.92
CV of possible operating income values per equation 7-3: 110.7%

Company Bold

	Probability of Occurrence								
	4%	**7%**	**10%**	**18%**	**22%**	**18%**	**10%**	**7%**	**4%**
Sales	$ 200	$ 400	$ 600	$ 800	$1,000	$1,200	$1,400	$1,600	$1,800
Fixed Expenses	$ 860	$ 860	$ 860	$ 860	$ 860	$ 860	$ 860	$ 860	$ 860
Operating Income (EBIT)	($660)	($460)	($ 260)	($ 60)	$ 140	$ 340	$ 540	$ 740	$ 940

μ of possible operating income values per equation 7-1: $140
σ of possible operating income values per equation 7-2: $384.71
CV of possible operating income values per equation 7-3: 274.8%

Measuring Financial Risk Financial risk is the additional volatility of net income caused by the presence of interest expense. We measure financial risk by noting the difference between the volatility of net income when there is no interest expense and when there is interest expense. To measure financial risk, we subtract the coefficient of variation of net income without interest expense from the coefficient of variation of net income with interest expense. The coefficient of variation of net income is the same as the coefficient of variation of operating income when no interest expense is present. Table 7-3 shows the calculation for Company Calm and Company Bold assuming (1) all variable operating expenses and (2) $40 in interest expense.

Financial risk, which comes from borrowing money, compounds the effect of business risk and intensifies the volatility of net income. Fixed operating expenses increase the volatility of operating income and magnify business risk. In the same way, fixed financial expenses (such as interest on debt or a noncancellable lease expense) increase the volatility of net income and magnify financial risk.

Firms that have only equity financing have no financial risk because they have no debt on which to make fixed interest payments. Conversely, firms that operate primarily on borrowed money are exposed to a high degree of financial risk.

Portfolio Risk

A portfolio is any collection of assets managed as a group. Most large firms employ their assets in a number of different investments. Together, these make up the firm's portfolio of

Table 7-3 Expected Value (μ), Standard Deviation (σ), and Coefficient of Variation (CV) of Possible Net Income Values for Company Calm and Bold

Company Calm

Probability of Occurrence

	5%	10%	70%	10%	5%
Sales	$ 600	$ 800	$ 1,000	$1,200	$1,400
Variable Expenses	$ 516	$ 688	$ 860	$1,032	$1,204
Operating Income (EBIT)	$ 84	$ 112	$ 140	$ 168	$ 196
Interest Expense	$ 40	$ 40	$ 40	$ 40	$ 40
Net Income	$ 44	$ 72	$ 100	$ 128	$ 156

μ of possible net income values per equation 7-1: $100
σ of possible net income values per equation 7-2: $21.69
CV of possible net income values per equation 7-3: 21.7%

Summary:

CV of possible net income values when interest expense is present:	21.7%
CV of possible net income values when interest expense is not present (from Table 7-1):	15.5%
Difference (financial risk)	6.2%

Company Bold

Probability of Occurrence

	4%	7%	10%	18%	22%	18%	10%	7%	4%
Sales	$ 200	$ 400	$ 600	$ 800	$1,000	$1,200	$1,400	$1,600	$ 1,800
Variable Expenses	$ 172	$ 344	$ 516	$ 688	$ 860	$1,032	$1,204	$1,376	$ 1,548
Operating Income (EBIT)	$ 28	$ 56	$ 84	$ 112	$ 140	$ 168	$ 196	$ 224	$ 252
Interest Expense	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40
Net Income	($ 12)	$ 16	$ 44	$ 72	$ 100	$ 128	$ 156	$ 184	$ 212

μ of possible net income values per equation 7-1: $100
σ of possible net income values per equation 7-2: $53.86
CV of possible net income values per equation 7-3: 53.9%

Summary:

CV of possible net income values when interest expense is present:	53.9%
CV of possible net income values when interest expense is not present (from Table 7-1):	38.5%
Difference (financial risk)	15.4%

Take Note
For simplicity, Table 7-3 assumes that neither firm pays any income taxes. Income tax is not a fixed expense, so its presence would not change the volatility of net income.

assets. Individual investors also have portfolios containing many different stocks or other investments. Firms (and individuals for that matter) are interested in portfolio returns and the uncertainty associated with them. Investors want to know how much they can expect to get back from their portfolio compared with how much they invest (the portfolio's expected return) and what the chances are that they won't get that return (the portfolio's risk).

We can easily find the expected return of a portfolio, but calculating the standard deviation of the portfolio's possible returns is a little more difficult. For example, suppose Company Cool has a portfolio that is equally divided between two assets, Asset A and

Asset B. The expected returns and standard deviations of possible returns of Asset A and Asset B are as follows:

	Asset A	**Asset B**
Expected Return E(R)	10%	12%
Standard Deviation (σ)	2%	4%

Finding the expected return of Company Cool's portfolio is easy. We simply calculate the weighted average expected return, $E(R_p)$, of the two-asset portfolio using the following formula:

Expected Rate of Return of a Portfolio, $E(R_p)$
Comprised of Two Assets, A and B

$$E(R_p) = (w_A \times E(R_A)) + w_B \times E(R_B)) \qquad (7\text{-}4)$$

where: $E(R_p)$ = the expected rate of return of the portfolio composed of Asset A and Asset B

w_A = the weight of Asset A in the portfolio

$E(R_A)$ = the expected rate of return of Asset A

w_B = the weight of Asset B in the portfolio

$E(R_B)$ = the expected rate of return of Asset B

According to Equation 7-4, the expected rate of return of a portfolio containing 50 percent Asset A and 50 percent Asset B is

$$\begin{aligned} E(R_p) &= (.50 \times .10) + (.50 \times .12) \\ &= .05 + .06 \\ &= .11, \text{ or } 11\% \end{aligned}$$

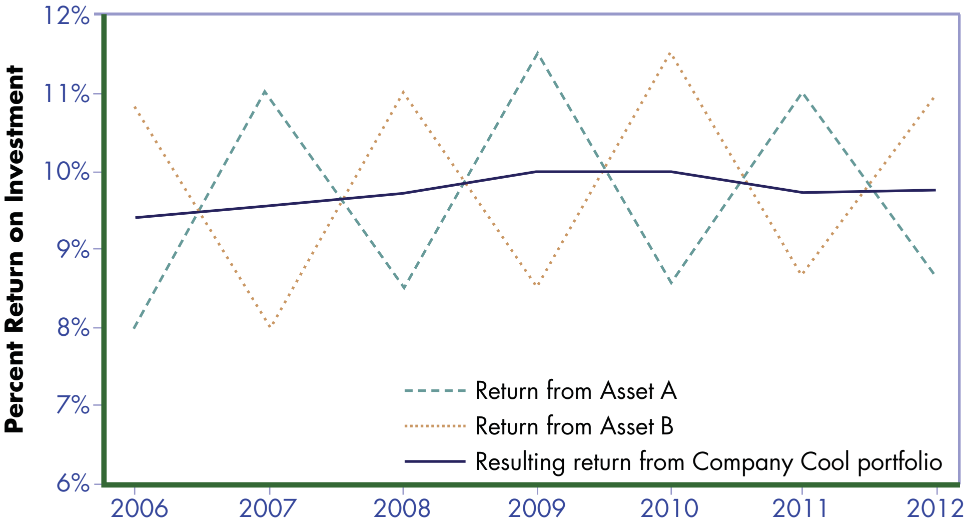
Now let's turn to the standard deviation of possible returns of Company Cool's portfolio. Determining the standard deviation of a portfolio's possible returns requires special procedures. Why? Because gains from one asset in the portfolio may offset losses from another, lessening the overall degree of risk in the portfolio. Figure 7-4 shows how this works.

Figure 7-4 shows that even though the returns of each asset vary, the timing of the variations is such that when one asset's returns increase, the other's decrease. Therefore, the net change in the Company Cool portfolio returns is very small—nearly zero. The weighted average of the standard deviations of returns of the two individual assets, then, does not result in the standard deviation of the portfolio containing both assets. The reduction in the fluctuations of the returns of Company Cool (the combination of assets A and B) is called the diversification effect.

Correlation How successfully diversification reduces risk depends on the degree of correlation between the two variables in question. **Correlation** indicates the degree to which one variable is linearly related to another. Correlation is measured by the correlation coefficient, represented by the letter r. The **correlation coefficient** can take on values between +1.0 (perfect positive correlation) to -1.0 (perfect negative correlation).

Figure 7-4 The Variation in Returns Over Time for Asset A, Asset B, and the Combined Company Cool Portfolio

Figure 7-4 shows how the returns of Asset A and Asset B might vary over time. Notice that the fluctuations of each curve are such that gains in one almost completely offset losses in the other. The risk of the Company Cool portfolio is small due to the offsetting effects.



If two variables are perfectly positively correlated, it means they move together—that is, they change values proportionately in the same direction at the same time. If two variables are perfectly negatively correlated, it means that every positive change in one value is matched by a proportionate corresponding negative change in the other. In the case of Assets A and B in Figure 7-4, the assets are negatively correlated.

The closer r is to +1.0, the more the two variables will tend to move with each other at the same time. The closer r is to -1.0, the more the two variables will tend to move opposite each other at the same time. An r value of zero indicates that the variables' values aren't related at all. This is known as *statistical independence*.

In Figure 7-4, Asset A and Asset B had perfect negative correlation (r = -1.0). So the risk associated with each asset was nearly eliminated by combining the two assets into one portfolio. The risk would have been completely eliminated had the standard deviations of the two assets been equal.

> **Take Note**
> Any time the correlation coefficient of the returns of two assets is less than +1.0, then the standard deviation of the portfolio consisting of those assets will be less than the weighted average of the individual assets' standard deviations.

Calculating the Correlation Coefficient Determining the precise value of r between two variables can be extremely difficult. The process requires estimating the possible values that each variable could take and their respective probabilities, simultaneously.

We can make a rough estimate of the degree of correlation between two variables by examining the nature of the assets involved. If one asset is, for instance, a firm's existing portfolio, and the other asset is a replacement piece of equipment, then the correlation between the returns of the two assets is probably close to +1.0. Why? Because there is no influence that would cause the returns of one asset to vary any differently than those of the other. A Coca-Cola® Bottling company expanding its capacity would be an example of a correlation of about +1.0.

What if a company planned to introduce a completely new product in a new market? In that case we might suspect that the correlation between the returns of the existing portfolio and the new product would be something significantly less than +1.0. Why? Because the cash flows of each asset would be due to different, and probably unrelated, factors. An example would be Disney buying the Anaheim Ducks National Hockey League team.

Calculating the Standard Deviation of a Two-Asset Portfolio To calculate the standard deviation of a portfolio, we must use a special formula that takes the diversification effect into account. Here is the formula for a portfolio containing two assets.[3] For convenience, they are labeled Asset A and Asset B:

Standard Deviation of a Two-Asset Portfolio

$$\sigma_p = \sqrt{w_a^2\sigma_a^2 + w_b^2\sigma_b^2 + 2w_a w_b r_{a,b}\sigma_a\sigma_b} \tag{7-5}$$

where: σ_p = the standard deviation of the returns of the combined portfolio containing Asset A and Asset B

w_a = the weight of Asset A in the two-asset portfolio

σ_a = the standard deviation of the returns of Asset A

w_b = the weight of Asset B in the two-asset portfolio

σ_b = the standard deviation of the returns of Asset B

$r_{a,b}$ = the correlation coefficient of the returns of Asset A and Asset B

The formula may look scary, but don't panic. Once we know the values for each factor, we can solve the formula rather easily with a calculator. Let's use the formula to find the standard deviation of a portfolio composed of equal amounts invested in Asset A and Asset B (i.e., Company Cool).

To calculate the standard deviation of possible returns of the portfolio of Company Cool, we need to know that Company Cool's portfolio is composed of 50 percent Asset A ($w_a = .5$) and 50 percent Asset B ($w_b = .5$). The standard deviation of Asset A's expected returns is 2 percent ($\sigma_a = .02$), and the standard deviation of Asset B's expected returns is 4 percent ($\sigma_b = .04$). To begin, assume the correlation coefficient (r) is -1.0, as shown in Figure 7-4.

Now we're ready to use Equation 7-5 to calculate the standard deviation of Company Cool's returns.

$$\begin{aligned}
\sigma_p &= \sqrt{w_a^2\sigma_a^2 + w_b^2\sigma_b^2 + 2w_a w_b r_{a,b}\sigma_a\sigma_b} \\
&= \sqrt{(.50^2)(0.02^2) + (.50^2)(0.04^2) + (2)(.50)(.50)(-1.0)(.02)(.04)} \\
&= \sqrt{(.25)(.0004) + (.25)(.0016) - .0004} \\
&= \sqrt{.0001 + .0004 - .0004} \\
&= \sqrt{.0001} \\
&= .01, \text{ or } 1\%
\end{aligned}$$

The diversification effect results in risk reduction. Why? Because we are combining two assets that have returns that are negatively correlated (r = -1.0). The standard deviation of the combined portfolio is much lower than that of either of the two individual assets (1 percent for Company Cool compared with 2 percent for Asset A and 4 percent for Asset B).

[3]You can adapt the formula to calculate the standard deviations of the returns of portfolios containing more than two assets, but doing so is complicated and usually unnecessary. Most of the time, you can view a firm's existing portfolio as one asset and a proposed addition to the portfolio as the second asset.

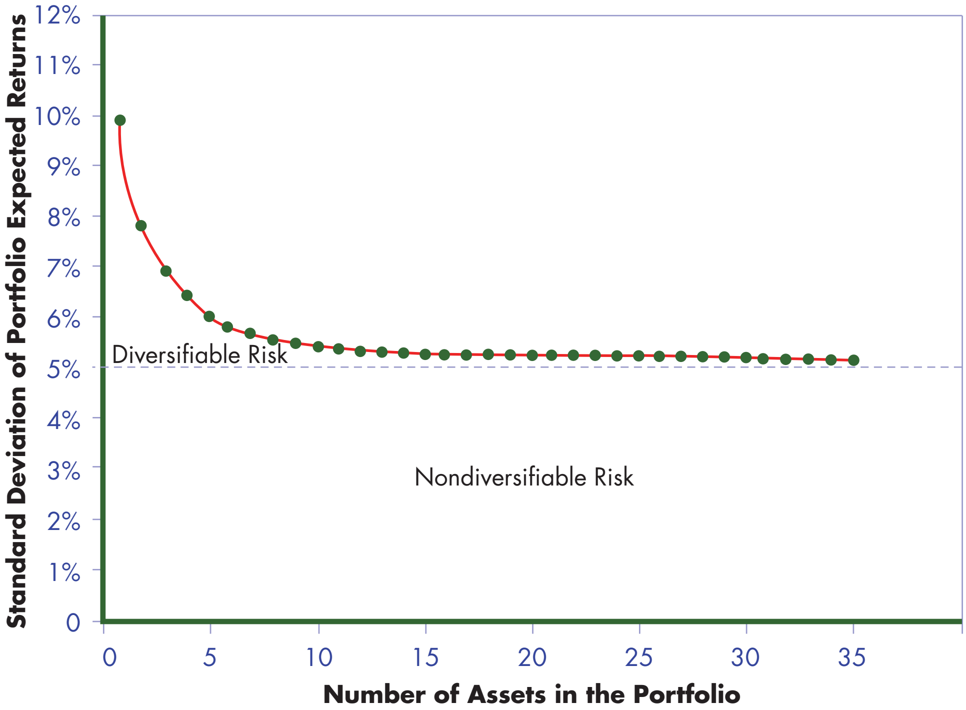


Figure 7-5 The Relationship between the Number of Assets in a Portfolio and the Riskiness of the Portfolio

The graph shows that as each new asset is added to a portfolio, the diversification effect causes the standard deviation of the portfolio to decrease. After 20 assets have been added, however, the effect of adding further assets is slight. The remaining degree of risk is nondiversifiable risk.

Nondiversifiable Risk Unless the returns of one-half the assets in a portfolio are perfectly negatively correlated with the other half—which is extremely unlikely—some risk will remain after assets are combined into a portfolio. The degree of risk that remains is **nondiversifiable risk**, the part of a portfolio's total risk that can't be eliminated by diversifying.

Nondiversifiable risk is one of the characteristics of market risk because it is produced by factors that are shared, to a greater or lesser degree, by most assets in the market. These factors might include inflation and real gross domestic product changes. Figure 7-5 illustrates nondiversifiable risk.

In Figure 7-5 we assumed that the portfolio begins with one asset with possible returns having a probability distribution with a standard deviation of 10 percent. However, if the portfolio is divided equally between two assets, each with possible returns having a probability distribution with a standard deviation of 10 percent, and the correlation of the returns of the two assets is, say +.25, then the standard deviation of the returns of the portfolio drops to about 8 percent. If the portfolio is divided among greater numbers of stocks, the standard deviation of the portfolio will continue to fall—as long as the newly added stocks have returns that are less than perfectly positively correlated with those of the existing portfolio.

Note in Figure 7-5, however, that after about 20 assets have been included in the portfolio, adding more has little effect on the portfolio's standard deviation. Almost all the risk that can be eliminated by diversifying is gone. The remainder, about 5 percent in this example, represents the portfolio's nondiversifiable risk.

Measuring Nondiversifiable Risk Nondiversifiable risk is measured by a term called **beta** (β). The ultimate group of diversified assets, the market, has a beta of 1.0. The

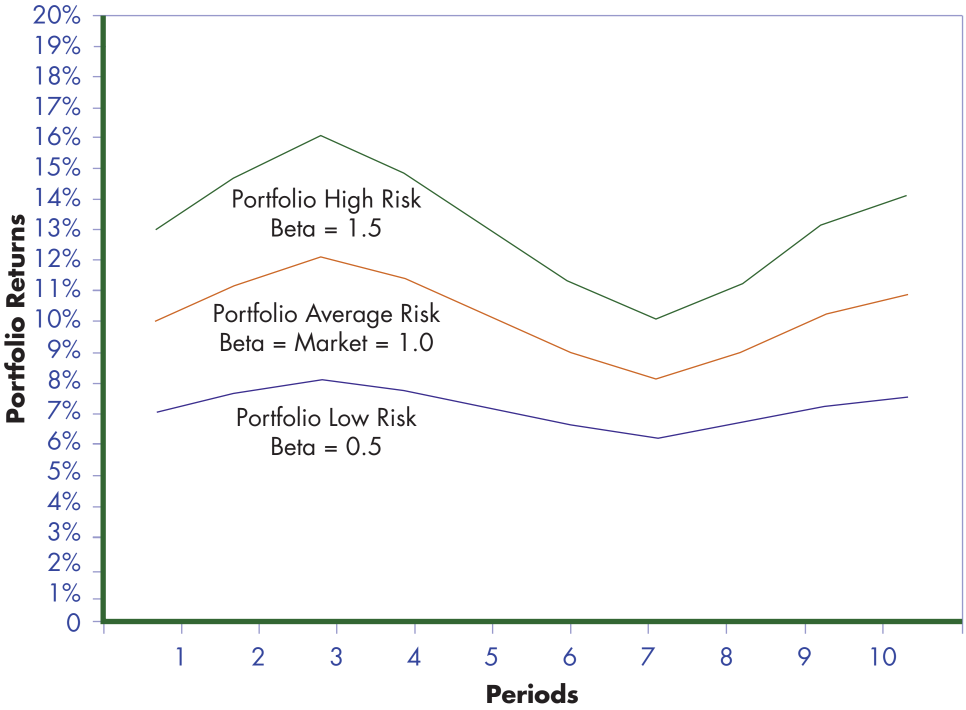


Figure 7-6 Portfolio Fluctuations and Beta

The relative fluctuation in returns for portfolios of different betas. The higher the beta, the more the portfolio's returns fluctuate relative to the overall market. The market itself has a beta of 1.0.

betas of portfolios, and individual assets, relate their returns to those of the overall stock market. Portfolios with betas higher than 1.0 are relatively more risky than the market. Portfolios with betas less than 1.0 are relatively less risky than the market. (Risk-free portfolios have a beta of zero.) The more the return of the portfolio in question fluctuates relative to the return of the overall market, the higher the beta, as shown graphically in Figure 7-6.

Figure 7-6 shows that returns of the overall market fluctuated between about 8 percent and 12 percent during the 10 periods that were measured. By definition, the market's beta is 1.0. The returns of the average-risk portfolio fluctuated exactly the same amount, so the beta of the average-risk portfolio is also 1.0. Returns of the low-risk portfolio fluctuated between 6 percent and 8 percent, half as much as the market. So the low-risk portfolio's beta is 0.5, only half that of the market. In contrast, returns of the high-risk portfolio fluctuated between 10 percent and 16 percent, one and a half times as much as the market. As a result, the high-risk portfolio's beta is 1.5, half again as high as the market.

Companies in low-risk, stable industries like public utilities will typically have low beta values because returns of their stock tend to be relatively stable. (When the economy goes into a recession, people generally continue to turn on their lights and use their refrigerators; and when the economy is booming, people do not splurge on additional electricity consumption.) Recreational boat companies, on the other hand, tend to have high beta values. That's because demand for recreational boats is volatile. (When times are tough, people postpone the purchase of recreational boats. During good economic times, when people have extra cash in their pockets, sales of these boats take off.)

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Dealing with Risk

Once companies determine the degree of risk present, what do they do about it? Suppose, for example, a firm determined that if a particular project were adopted, the standard deviation of possible returns of the firm's portfolio of assets would double. So what? How should a firm deal with the situation?

There are two broad classes of alternatives for dealing with risk. First, you might take some action to reduce the degree of risk present in the situation. Second (if the degree of risk can't be reduced), you may compensate for the degree of risk you are about to assume. We'll discuss these two classes of alternatives in the following sections.

Risk-Reduction Methods

One way companies can avoid risk is simply to avoid risky situations entirely. Most of the time, however, refusing to get involved is an unsatisfactory business decision. Carried to its logical conclusion, this would mean that everyone would invest in risk-free assets only, and no products or services would be produced. Bill Gates, founder and CEO of Microsoft, didn't get rich by avoiding risks. To succeed, businesses must take risks.

If we assume that firms (and individuals) are willing to take some risk to achieve the higher expected returns that accompany that risk, then the task is to reduce the degree of risk as much as possible. The following three methods help to reduce risk: reducing sales volatility and fixed costs, insurance, and diversification.

Reducing Sales Volatility and Fixed Costs Earlier in the chapter, we discussed how sales volatility and fixed operating costs contribute to a firm's business risk. Firms in volatile industries whose sales fluctuate widely are exposed to a high degree of business risk. That business risk is intensified even further if they have large amounts of fixed operating costs. Reducing the volatility of sales, and the amount of fixed operating costs a firm must pay, then, will reduce risk.

Reducing Sales Volatility If a firm could smooth out its sales over time, then the fluctuation of its operating income (business risk) would also be reduced. Businesses try to stabilize sales in many ways. For example, retail ski equipment stores sell tennis equipment in the summer, summer vacation resorts offer winter specials, and movie theaters offer reduced prices for early shows to encourage more patronage during slow periods.

Insurance Insurance is a time-honored way to spread risk among many participants and thus reduce the degree of risk borne by any one participant. Business firms insure themselves against many risks, such as flood, fire, and liability. However, one important risk—the risk that an investment might fail—is uninsurable. To reduce the risk of losing everything in one investment, firms turn to another risk-reduction technique, diversification.

Diversification Review Figure 7-4 and the discussion following the figure. We showed in that discussion how the standard deviation of returns of Asset A (2 percent) and Asset B (4 percent) could be reduced to 1 percent by combining the two assets into one portfolio. The diversification effect occurred because the returns of the two assets were not perfectly positively correlated. Any time firms invest in ventures whose returns are not perfectly positively correlated with the returns of their existing portfolios, they will experience diversification benefits.

Compensating for the Presence of Risk

In most cases it's not possible to avoid risk completely. Some risk usually remains even after firms use risk-reduction techniques. When firms assume risk to achieve an objective, they also take measures to receive compensation for assuming that risk. In the sections that follow, we discuss these compensation measures.

Adjusting the Required Rate of Return Most owners and financial managers are generally risk averse. So for a given expected rate of return, less risky investment projects are more desirable than more risky investment projects. The higher the expected rate of return, the more desirable the risky venture will appear. As we noted earlier in the chapter, the risk-return relationship is positive. That is, because of risk aversion, people demand a higher rate of return for taking on a higher-risk project.

Although we know that the risk-return relationship is positive, an especially difficult question remains: How much return is appropriate for a given degree of risk? Say, for example, that a firm has all assets invested in a chain of convenience stores that provides a stable return on investment of about 6 percent a year. How much more return should the firm require for investing some assets in a baseball team that may not provide steady returns[4]—8 percent? 10 percent? 25 percent? Unfortunately, no one knows for sure, but financial experts have researched the subject extensively.

One well-known model used to calculate the required rate of return of an investment is the **capital asset pricing model** (CAPM). We discuss CAPM next.

Take Note
Diversification is a hotly debated issue among financial theorists. Specifically, theorists question whether a firm provides value to its stockholders if it diversifies its asset portfolio to stabilize the firm's income. Many claim that individual stockholders can achieve diversification benefits more easily and cheaply than a firm, so firms that diversify actually do a disservice to their stockholders. What do you think?

Take Note
In capital budgeting a rate of return to reflect risk is called a risk-adjusted discount rate. See Chapter 10.

Relating Return and Risk: The Capital Asset Pricing Model

Financial theorists William F. Sharpe, John Lintner, and Jan Mossin worked on the risk-return relationship and developed the capital asset pricing model, or CAPM. We can use this model to calculate the appropriate required rate of return for an investment project given its degree of risk as measured by beta (β).[5] The formula for CAPM is presented in Equation 7-6.

CAPM Formula

$$k_p = k_{rf} + (k_m - k_{rf}) \times \beta \tag{7-6}$$

where: k_p = the required rate of return appropriate for the investment project

k_{rf} = the risk-free rate of return

k_m = the required rate of return on the overall market

β = the project's beta

[4]Some major league baseball teams lose money and others make a great deal. Television revenues differ greatly from team to team, as do ticket sales and salary expenses.

[5]See William Sharpe, "Capital Asset Prices: A Theory of Market Equilibrium," *Journal of Finance* (September 1964); John Lintner, "The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets," *Review of Economics and Statistics* (February 1965); and Jan Mossin, "Equilibrium in a Capital Asset Market," *Econometrica* (October 1966).

Table 7-4 Using the CAPM to Calculate Required Rates of Return for Investment Projects

Given:

The risk-free rate, k_{rf} = 4%

The required rate of return on the market, k_m = 12%

Project Low Risk's beta = 0.5

Project Average Risk's beta = 1.0

Project High Risk's beta = 1.5

Required rates of return on the project's per the CAPM:

Project Low Risk: $k_p = .04 + (.12 - .04) \times 0.5$
$= .04 + .04$
$= .08$, or 8%

Project Average Risk: $k_p = .04 + (.12 - .04) \times 1.0$
$= .04 + .08$
$= .12$, or 12%

Project High Risk: $k_p = .04 + (.12 - .04) \times 1.5$
$= .04 + .12$
$= .16$, or 16%

Given that the risk-free rate of return is 4 percent and the required rate of return on the market is 12 percent, the CAPM indicates the appropriate required rate of return for a low-risk investment project with a beta of .5 is 8 percent. The appropriate required rate of return for an average-risk project is the same as that for the market, 12 percent, and the appropriate rate for a high-risk project with a beta of 1.5 is 16 percent.

The three components of the CAPM include the risk-free rate of return (k_{rf}), the market risk premium ($k_m - k_{rf}$), and the project's beta (β). The **risk-free rate of return** (k_{rf}) is the rate of return that investors demand from a project that contains no risk. Risk-averse managers and owners will always demand at least this rate of return from any investment project.

The required rate of return on the overall market minus the risk-free rate ($k_m - k_{rf}$) represents the additional return demanded by investors for taking on the risk of investing in the market itself. The term is sometimes called the **market risk premium**. In the CAPM, the term for the market risk premium, ($k_m - k_{rf}$), can be viewed as the additional return over the risk-free rate that investors demand from an "average stock" or an "average-risk" investment project. The S&P 500 stock market index is often used as a proxy for the market.

As discussed earlier, a project's beta (β) represents a project's degree of risk relative to the overall stock market. In the CAPM, when the beta term is multiplied by the market risk premium term, ($k_m - k_{rf}$), the result is the additional return over the risk-free rate that investors demand from that individual project. Beta is the relevant risk measure according to the CAPM. High-risk (high-beta) projects have high required rates of return, and low-risk (low-beta) projects have low required rates of return.

Table 7-4 shows three examples of how the CAPM is used to determine the appropriate required rate of return for projects of different degrees of risk.

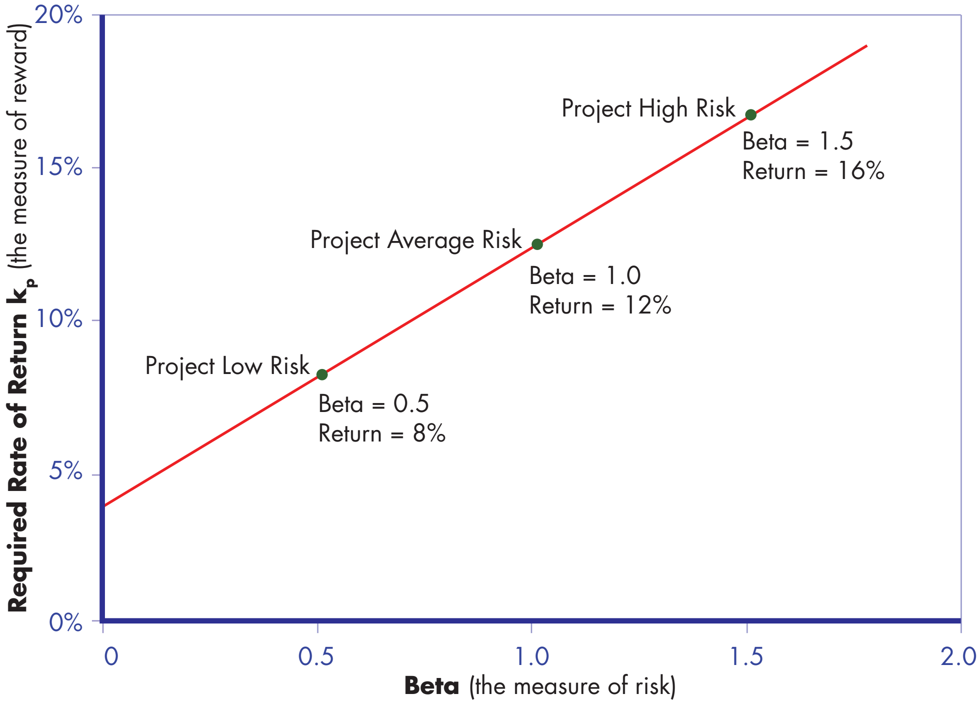

Figure 7-7 CAPM and the Risk-Return Relationship

This graph illustrates the increasing return required for increasing risk as indicated by the CAPM beta. This graphical depiction of the risk-return relationship according to the CAPM is called the security market line.

As we can see in Table 7-4, Project High Risk, with its beta of 1.5, has a required rate of return that is twice that of Project Low Risk, with its beta of 0.5. After all, shouldn't we ask for a higher rate of return if the risk is higher? Note also that Project Average Risk, which has the same beta as the market, 1.0, also has the same required rate of return as the market (12 percent). The risk-return relationship for these three projects is shown in Figure 7-7.

Remember that the beta term in the CAPM reflects only the nondiversifiable risk of an asset, not its diversifiable risk. Diversifiable risk is irrelevant because the diversity of each investor's portfolio essentially eliminates (or should eliminate) that risk. (After all, most investors are well diversified. They will not demand extra return for adding a security to their portfolios that contains diversifiable risk.) The return that well-diversified investors demand when they buy a security, as measured by the CAPM and beta, relates to the degree of nondiversifiable risk in the security.

What's Next

In this chapter we examined the risk-return relationship, types of risk, risk measurements, risk-reduction techniques, and the CAPM. In the next chapter, we will discuss the time value of money.

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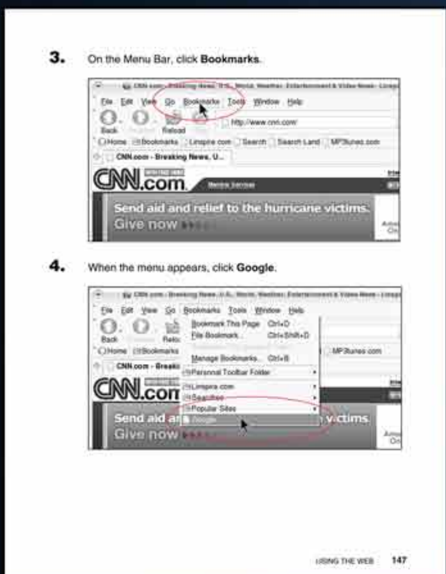

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Summary

1. Define risk, risk aversion, and the risk-return relationship.

In everything you do, or don't do, there is a chance that something will happen that you didn't count on. Risk is the potential for unexpected events to occur.

Given two financial alternatives that are equal except for their degree of risk, most people will choose the less risky alternative because they are risk averse. Risk aversion is a common trait among almost all investors. Most investors avoid risk if they can, unless they are compensated for accepting risk. In an investment context, the additional compensation is a higher expected rate of return.

The risk-return relationship refers to the positive relationship between risk and the required rate of return. Due to risk aversion, the higher the risk, the more return investors expect.

2. Measure risk using the standard deviation and the coefficient of variation.

Risk is the chance, or probability, that outcomes other than what is expected will occur. This probability is reflected in the narrowness or width of the distribution of the possible values of the financial variable. In a distribution of variable values, the standard deviation is a number that indicates how widely dispersed the possible values are around the expected value. The more widely dispersed a distribution is, the larger the standard deviation, and the greater the probability that an actual value will be different than the expected value. The standard deviation, then, can be used to measure the likelihood that some outcome substantially different than what is expected will occur.

When the degrees of risk in distributions of different sizes are compared, the coefficient of variation is a statistic used to measure relative riskiness. The coefficient of variation measures the standard deviation's percentage of the expected value. It relates the standard deviation to its mean to give a risk measure that is independent of the magnitude of the possible returns.

3. Identify the types of risk that business firms encounter.

Business risk is the risk that a company's operating income will differ from what is expected. The more volatile a company's operating income, the more business risk the firm contains. Business risk is a result of sales volatility, which translates into operating income volatility. Business risk is increased by the presence of fixed costs, which magnify the effect on operating income of changes in sales.

Financial risk occurs when companies borrow money and incur interest charges that show up as fixed expenses on their income statements. Fixed interest charges act on a firm's net income the same way fixed operating expenses act on operating income—they increase volatility. The additional volatility of a firm's net income caused by the presence of fixed interest expense is called financial risk.

Portfolio risk is the chance that investors won't get the return they expect from a portfolio. Portfolio risk can be measured by the standard deviation of possible returns of a portfolio. It is affected by the correlation of returns of the assets making up the portfolio. The less correlated these returns are, the more gains on some assets offset losses on others, resulting in a reduction of the portfolio's risk. This phenomenon is known as the diversification effect. Nondiversifiable risk is risk that remains in a portfolio after all diversification benefits have been achieved. Nondiversifiable risk is measured by a term called beta (β). The market has a beta of 1.0. Portfolios with betas greater than 1.0 contain more nondiversifiable risk than the market, and portfolios with betas less than 1.0 contain less nondiversifiable risk than the market.

4. Explain methods of risk reduction.

Firms can reduce the degree of risk by taking steps to reduce the volatility of sales or their fixed costs. Firms also obtain insurance policies to protect against many risks, and they diversify their asset portfolios to reduce the risk of income loss.

5. Describe how firms compensate for assuming risk.

Firms almost always demand a higher rate of return to compensate for assuming risk. The more risky a project, the higher the return firms demand.

6. Explain how the capital asset pricing model (CAPM) relates risk and return.

When investors adjust their required rates of return to compensate for risk, the question arises as to how much return is appropriate for a given degree of risk. The capital asset pricing model (CAPM) is a model that measures the required rate of return for an investment or project, given its degree of nondiversifiable risk as measured by beta (β).

Equations Introduced in This Chapter

Equation 7-1. The Expected Value, or Mean (μ), of a Probability Distribution:

$$\mu = \sum (V \times P)$$

where: μ = the expected value, or mean

$\sum$ = the sum of

V = the possible value for some variable

P = the probability of the value V occurring

Equation 7-2. The Standard Deviation:

$$\sigma = \sqrt{\sum P(V - \mu)^2}$$

where: σ = the standard deviation

$\sum$ = the sum of

P = the probability of the value V occurring

V = the possible value for a variable

μ = the expected value

Equation 7-3. The Coefficient of Variation of a Probability Distribution:

$$CV = \frac{\text{Standard Deviation}}{\text{Mean}}$$

Equation 7-4. The Expected Rate of Return, $E(R_p)$, of a portfolio comprised of Two Assets, A and B:

$$E(R_p) = (w_A \times E(R_A)) + w_b \times E(R_b))$$

where: $E(R_p)$ = the expected rate of return of the portfolio composed of Asset A and Asset B

w_A = the weight of Asset A in the portfolio

$E(R_A)$ = the expected rate of return of Asset A

w_B = the weight of Asset B in the portfolio

$E(R_B)$ = the expected rate of return of Asset B

Equation 7-5. The Standard Deviation of a Two-Asset Portfolio:

$$\sigma_p = \sqrt{w_a^2\sigma_a^2 + w_b^2\sigma_b^2 + 2w_a w_b r_{a,b}\sigma_a\sigma_b}$$

where: σ_p = the standard deviation of the returns of the combined portfolio containing Asset A and Asset B

w_a = the weight of Asset A in the two-asset portfolio

σ_a = the standard deviation of the returns of Asset A

w_b = the weight of Asset B in the two-asset portfolio

σ_b = the standard deviation of the returns of Asset B

$r_{a,b}$ = the correlation coefficient of the returns of Asset A and Asset B

Equation 7-6. The Capital Asset Pricing Model (CAPM):

$$k_p = k_{rf} + (k_m - k_{rf}) \times \beta$$

where: k_p = the required rate of return appropriate for the investment project

k_{rf} = the risk-free rate of return

k_m = the required rate of return on the overall market

β = the project's beta

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Self-Test

ST-1. For Bryan Corporation, the mean of the distribution of next year's possible sales is $5 million. The standard deviation of this distribution is $400,000. Calculate the coefficient of variation (CV) for this distribution of possible sales.

ST-2. Investors in Hoeven Industries common stock have a .2 probability of earning a return of 4 percent, a .6 probability of earning a return of 10 percent, and a .2 probability of earning a return of 20 percent. What is the mean of this probability distribution (the expected rate of return)?

ST-3. What is the standard deviation for the Hoeven Industries common stock return probability distribution described in ST-2?

ST-4. The standard deviation of the possible returns of Boris Company common stock is .08, whereas the standard deviation of possible returns of Natasha Company common stock is .12. Calculate the standard deviation of a portfolio comprised of 40 percent Boris Company stock and 60 percent Natasha Company stock. The correlation coefficient of the returns of Boris Company stock relative to the returns of Natasha Company stock is –.2.

ST-5. The mean of the normal probability distribution of possible returns of Gidney and Cloyd Corporation common stock is 18 percent. The standard deviation is 3 percent. What is the range of possible values that you would be 95 percent sure would capture the return that will actually be earned on this stock?

ST-6. Dobie's Bagle Corporation common stock has a beta of 1.2. The market risk premium is 6 percent and the risk-free rate is 4 percent. What is the required rate of return on this stock according to the CAPM?

ST-7. Using the information provided in ST-6, what is the required rate of return on the common stock of Zack's Salt Corporation? This stock has a beta of .4.

ST-8. A portfolio of three stocks has an expected value of 14 percent. Stock A has an expected return of 6 percent and a weight of .25 in the portfolio. Stock B has an expected return of 10 percent and a weight of .5 in the portfolio. Stock C is the third stock in this portfolio. What is the expected rate of return of Stock C?

Review Questions

1. What is risk aversion? If common stockholders are risk averse, how do you explain the fact that they often invest in very risky companies?

2. Explain the risk-return relationship.

3. Why is the coefficient of variation often a better risk measure when comparing different projects than the standard deviation?

4. What is the difference between business risk and financial risk?

5. Why does the riskiness of portfolios have to be looked at differently than the riskiness of individual assets?

6. What happens to the riskiness of a portfolio if assets with very low correlations (even negative correlations) are combined?

7. What does it mean when we say that the correlation coefficient for two variables is +1? What does it mean if this value is zero? What does it mean if it is +1?

8. What is nondiversifiable risk? How is it measured?

9. Compare diversifiable and nondiversifiable risk. Which do you think is more important to financial managers in business firms?

10. How do risk-averse investors compensate for risk when they take on investment projects?

11. Given that risk-averse investors demand more return for taking on more risk when they invest, how much more return is appropriate for, say, a share of common stock, than for a Treasury bill?

12. Discuss risk from the perspective of the capital asset pricing model (CAPM).

Build Your Communication Skills

CS-1. Go to the library, use business magazines, computer databases, the Internet, or other sources that have financial information about businesses. (See Chapter 5 for a list of specific resources.) Find three companies and compare their approaches to risk. Do the firms take a conservative or an aggressive approach? Write a one- to two-page report, citing specific evidence of the risk-taking approach of each of the three companies you researched.

CS-2. Research three to five specific mutual funds. Then form small groups of four to six. Discuss whether the mutual funds each group member researched will help investors diversify the risk of their portfolio. Are some mutual funds better than others for an investor seeking good diversification? Prepare a list of mutual funds the group would select to diversify its risk and explain your choices. Present your recommendations to the class.


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Problems

Standard Deviation and Coefficient of Variation

7-1. Manager Paul Smith believes an investment project will have the following yearly cash flows with the associated probabilities throughout its life of five years. Calculate the standard deviation and coefficient of variation of the cash flows.

Cash Flows($)	Probability of Occurrence
$10,000	.05
13,000	.10
16,000	.20
19,000	.30
22,000	.20
25,000	.10
28,000	.05

Measuring Risk

7-2. Milk-U, an agricultural consulting firm, has developed the following income statement forecast:

Milk-U Income Forecast (in 000's)

	Probability of Occurrence				
	2%	8%	80%	8%	2%
Sales	$500	$700	$1,200	$1,700	$1,900
Variable Expenses	250	350	600	850	950
Fixed Operating Expenses	250	250	250	250	250
Operating Income	0	100	350	600	700

a. Calculate the expected value of Milk-U's operating income.

b. Calculate the standard deviation of Milk-U's operating income.

c. Calculate the coefficient of variation of Milk-U's operating income.

d. Recalculate the expected value, standard deviation, and coefficient of variation of Milk-U's operating income if the company's sales forecast changed as follows:

	Probability of Occurrence				
	10%	15%	50%	15%	10%
Sales	$500	$700	$1,200	$1,700	$1,900

e. Comment on how Milk-U's degree of business risk changed as a result of the new sales forecast in part *d*.

Standard Deviation and Mean

7-3. The following data apply to Henshaw Corp. Calculate the mean and the standard deviation, using the following table.

Possible Sales	Probability of Occurrence
$ 1,000	.10
$ 5,000	.20
$10,000	.45
$15,000	.15
$20,000	.10
	$\sum = 1.00$

Measuring Risk

7-4. As a new loan officer in the Bulwark Bank, you are comparing the financial riskiness of two firms. Selected information from *pro forma* statements for each firm follows.

Equity Eddie's Company Net Income Forecast (in 000's)

	Probability of Occurrence				
	5%	10%	70%	10%	5%
Operating Income	$100	$200	$400	$600	$700
Interest Expense	0	0	0	0	0
Before-Tax Income	100	200	400	600	700
Taxes (28%)	28	56	112	168	196
Net Income	72	144	288	432	50

Barry Borrower's Company Net Income Forecast (in 000's)

	Probability of Occurrence				
	5%	10%	70%	10%	5%
Operating Income	$110.0	$220.0	$440.0	$660.0	$770.0
Interest Expense	40	40	40	40	40
Before-Tax Income	70	180	400	620	730
Taxes (28%)	19.6	50.4	112	173.6	204.4
Net Income	50.4	129.6	288	446.4	525.6

a. Calculate the expected values of Equity Eddie's and Barry Borrower's net incomes.

b. Calculate the standard deviations of Equity Eddie's and Barry Borrower's net incomes.

c. Calculate the coefficients of variation of Equity Eddie's and Barry Borrower's net incomes.

d. Compare Equity Eddie's and Barry Borrower's degrees of financial risk.

Standard Deviation and Coefficient of Variation

7-5. George Taylor, owner of a toy manufacturing company, is considering the addition of a new product line. Marketing research shows that gorilla action figures will be the next fad for the six- to ten-year-old age group. This new product line of gorilla-like action figures and their high-tech vehicles will be called Go-Rilla. George estimates that the most likely yearly incremental cash flow will be $26,000. There is some uncertainty about this value because George's company has never before made a product similar to the Go-Rilla. He has estimated the potential cash flows for the new product line along with their associated probabilities of occurrence. His estimates follow.

Go-Rilla Project

Cash Flows	Probability of Occurrence
$20,000	1%
$22,000	12%
$24,000	23%
$26,000	28%
$28,000	23%
$30,000	12%
$32,000	1%

a. Calculate the standard deviation of the estimated cash flows.

b. Calculate the coefficient of variation.

c. If George's other product lines have an average coefficient of variation of 12 percent, what can you say about the risk of the Go-Rilla Project relative to the average risk of the other product lines?

Portfolio Risk

7-6. Assume that a company has an existing portfolio A with an expected return of 9 percent and a standard deviation of 3 percent. The company is considering adding an asset B to its portfolio. Asset B's expected return is 12 percent with a standard deviation of 4 percent. Also assume that the amount invested in A is $700,000 and the amount to be invested in B is $200,000. If the degree of correlation between returns from portfolio A and project B is zero, calculate:

a. The standard deviation of the new combined portfolio and compare it with that of the existing portfolio.

b. The coefficient of variation of the new combined portfolio and compare it with that of the existing portfolio.

Coefficient of Variation

7-7. Zazzle Company has a standard deviation of 288 and a mean of 1,200. What is its coefficient of variation (CV)?

Expected Rate of Return

7-8. What is the expected rate of return on a portfolio that has $4,000 invested in Stock A and $6,000 invested in Stock B? The expected rates of return on these two stocks are 13 percent and 9 percent, respectively.

Standard Deviation

7-9. A two-stock portfolio has 30 percent in Stock A, with an expected return of 21 percent and a standard deviation of 5 percent, and the remainder in Stock B, with an 18 percent expected return and a standard deviation of 2 percent. The correlation coefficient is 0.6. Determine the standard deviation for this portfolio.

Measuring Risk

EXCEL SPREADSHEET

7-10. A firm has an existing portfolio of projects with an expected return of 11 percent a year. The standard deviation of these returns is 4 percent. The existing portfolio's value is $820,000. As financial manager, you are considering the addition of a new project, PROJ1. PROJ1's expected return is 13 percent with a standard deviation of 5 percent. The initial cash outlay for PROJ1 is expected to be $194,000.

a. Calculate the coefficient of variation for the existing portfolio.

b. Calculate the coefficient of variation for PROJ1.

c. If PROJ1 is added to the existing portfolio, calculate the weight (proportion) of the existing portfolio in the combined portfolio.

d. Calculate the weight (proportion) of PROJ1 in the combined portfolio.

e. Assume the correlation coefficient of the cash flows of the existing portfolio and PROJ1 is zero. Calculate the standard deviation of the combined portfolio. Is the standard deviation of the combined portfolio higher or lower than the standard deviation of the existing portfolio?

f. Calculate the coefficient of variation of the combined portfolio.

g. If PROJ1 is added to the existing portfolio, will the firm's risk increase or decrease?

CAPM

7-11. Assume the risk-free rate is 5 percent, the expected rate of return on the market is 15 percent, and the beta of your firm is 1.2. Given these conditions, what is the required rate of return on your company's stock per the capital asset pricing model?

CAPM

7-12. Calculate the expected rates of return for the low-, average-, and high-risk stocks:

a. Risk-free rate = 4.5 percent

b. Market risk premium = 12.5 percent

c. Low-risk beta = .5

d. Average-risk beta = 1.0

e. High-risk beta= 1.6

Challenge Problem

7-13. Your firm has a beta of 1.5 and you are considering an investment project with a beta of 0.8. Answer the following questions, assuming that short-term Treasury bills are currently yielding 5 percent and the expected return on the market is 15 percent.

a. What is the appropriate required rate of return for your company per the capital asset pricing model?

b. What is the appropriate required rate of return for the investment project per the capital asset pricing model?

c. If your firm invests 20 percent of its assets in the new investment project, what will be the beta of your firm after the project is adopted? (Hint: Compute the weighted average beta of the firm with the new asset, using Equation 7-4.)

The following problems (7-14 to 7-18) relate to the expected business of Power Software Company (PSC) (000's of dollars):

EXCEL SPREADSHEET

Power Software Company Forecasts

	Probability of Occurrence						
	2%	**8%**	**20%**	**40%**	**20%**	**8%**	**2%**
Sales	$800	$1,000	$1,400	$2,000	$2,600	$3,000	$3,200

7-14. Calculate the expected value, standard deviation, and coefficient of variation of sales revenue of PSC.

Measuring Risk

7-15. Assume that PSC has no fixed expense but has a variable expense that is 60 percent of sales as follows:

Business Risk

Power Software Company Forecasts

	Probability of Occurrence						
	2%	**8%**	**20%**	**40%**	**20%**	**8%**	**2%**
Sales	$800	$1,000	$1,400	$2,000	$2,600	$3,000	$3,200
Variable Expenses	480	600	840	1,200	1,560	1,800	1,920

Calculate PSC's business risk (coefficient of variation of operating income).

7-16. Now assume that PSC has a fixed operating expense of $400,000, in addition to the variable expense of 60 percent of sales, shown as follows:

Business Risk

Power Software Company Forecasts

	Probability of Occurrence						
	2%	**8%**	**20%**	**40%**	**20%**	**8%**	**2%**
Sales	$800	$1,000	$1,400	$2,000	$2,600	$3,000	$3,200
Variable Expenses	480	600	840	1,200	1,560	1,800	1,920
Fixed Expenses	400	400	400	400	400	400	400

Recalculate PSC's business risk (coefficient of variation of operating income). How does this figure compare with the business risk calculated with variable cost only?

Various Statistics and Financial Risk

7-17. Assume that PSC has a fixed interest expense of $60,000 on borrowed funds. Also assume that the applicable tax rate is 30 percent. What are the expected value, standard deviation, and coefficient of variation of PSC's net income? What is PSC's financial risk?

Business and Financial Risk

7-18. To reduce the various risks, PSC is planning to take suitable steps to reduce volatility of operating and net income. It has projected that fixed expenses and interest expenses can be reduced. The revised figures follow:

Power Software Company Forecasts

	Probability of Occurrence						
	1%	**6%**	**13%**	**60%**	**13%**	**6%**	**1%**
Sales	$800	$1,000	$1,400	$2,000	$2,600	$3,000	$3,200
Variable Expenses	480	600	840	1,200	1,560	1,800	1,92
Fixed Expenses	250	250	250	250	250	250	250
Interest Expense	40	40	40	40	40	40	40

Recalculate PSC's business and financial risks and compare these figures with those calculated in problems 7-16 and 7-17. The tax rate is 30 percent.

Answers to Self-Test

ST-1. $CV = \sigma \div \mu = \$400{,}000 \div \$5{,}000{,}000 = .08 = 8\%$

ST-2. $\mu = (.2 \times .4) + (.6 \times .10) + (.2 \times .20) = .108 = 10.8\%$

ST-3.
$$\sigma = ([.2 \times (.04 - .108)^2] + [.6 \times (.10 - .108)^2] + [.2 \times (.20 - .108)^2])^{.5}$$
$$= [(.2 \times .004624) + (.6 \times .000064) + (.2 \times .008464)]^{.5}$$
$$= .002656^{.5} = .0515 = 5.15\%$$

ST-4.
$$\sigma_p = [(.4^2 \times .08^2) + (.6^2 + .12^2) + (2 \times .4 \times .6 \times (-.2) \times .08 \times .12)]^{.5}$$
$$= [(.16 \times .0064) + (.36 \times .0144) + (-.0009216)]^{.5}$$
$$= .0052864^{.5} = .0727 = 7.27\%$$

ST-5. $.18 + (2 \times .03) = .24 = 24\%$

$.18 - (2 \times .03) = .12 = 12\%$

Therefore, we are 95% confident that the actual return will be between 12% and 24%.

ST-6. $k_s = .04 + (.06 \times 1.2) = .112 = 11.2\%$

ST-7. $k = .04 + (.06 \times .4) = .064 = 6.4\%$

ST-8. WT of Stock C must be .25 for the total of the weights to equal 1:

$$.14 = (.06 \times .25) + (.10 \times .5) + [E(R_C) \times .25]$$

$$.14 = .065 + [E(R_C) \times .25]$$

$$.075 = E(R_C) \times .25$$

$$E(R_C) = .30 = 30\%$$

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