

RISK MANAGEMENT

Managing Risk

► **Most of the time** we take risk as God-given. A project has its beta, and that's that. Its cash flow is exposed to changes in demand, raw material costs, technology, and a seemingly endless list of other uncertainties. There's nothing the manager can do about it.

That's not wholly true. The manager can avoid some risks. We have already come across one way to do so: firms use *real options* to provide flexibility. For example, a petrochemical plant that is designed to use either oil or natural gas as a feedstock reduces the risk of an unfavorable shift in the price of raw materials. As another example, think of a company that employs standard machine tools rather than custom machinery and thereby lowers the cost of bailing out if its products do not sell. In other words, the standard machinery provides the firm with a valuable abandonment option.

We covered real options in Chapter 22. This chapter explains how companies also use financial contracts to protect against various hazards. We discuss the pros and cons of corporate insurance policies that protect against specific risks, such as fire, floods, or environmental damage. We describe forward and futures contracts, which can be used to lock in the future price of commodities such as oil, copper, or soybeans. *Financial* forward and futures contracts allow the firm to lock in the prices of financial assets such as interest rates or foreign exchange rates. We also describe swaps, which are packages of forward contracts.

Most of this chapter describes how financial contracts may be used to reduce business risks. But why bother? Why should *shareholders* care whether the company's future profits are linked to future changes in interest rates, exchange rates, or commodity prices? We start the chapter with that question.

26-1 Why Manage Risk?

Financial transactions undertaken *solely* to reduce risk do not add value in perfect markets. Why not? There are two basic reasons.

- *Reason 1: Hedging is a zero-sum game.* A corporation that insures or hedges a risk does not eliminate it. It simply passes the risk to someone else. For example, suppose that a heating-oil distributor contracts with a refiner to buy all of next winter's heating-oil deliveries at a fixed price. This contract is a *zero-sum game*, because the refiner loses what the distributor gains, and vice versa.¹ If next winter's price of heating oil turns

¹ In game theory, "zero-sum" means that the payoffs to all players add up to zero, so that one player can win only at the others' expense.

out to be unusually high, the distributor wins from having locked in a below-market price, but the refiner is forced to sell below the market. Conversely, if the price of heating oil is unusually *low*, the refiner wins, because the distributor is forced to buy at the high fixed price. Of course, neither party knows next winter's price at the time that the deal is struck, but they consider the range of possible prices, and in an efficient market they negotiate terms that are fair (zero-NPV) on both sides of the bargain.

- *Reason 2: Investors' do-it-yourself alternative.* Corporations cannot increase the value of their shares by undertaking transactions that investors can easily do on their own. When the shareholders in the heating-oil distributor made their investment, they were presumably aware of the risks of the business. If they did not want to be exposed to the ups and downs of energy prices, they could have protected themselves in several ways. Perhaps they bought shares in both the distributor and refiner, and do not care whether one wins next winter at the other's expense.

Of course, shareholders can adjust their exposure only when companies keep investors fully informed of the transactions that they have made. For example, when a group of European central banks announced in 1999 that they would limit their sales of gold, the gold price immediately shot up. Investors in gold-mining shares rubbed their hands at the prospect of rising profits. But when they discovered that some mining companies had protected themselves against price fluctuations and would *not* benefit from the price rise, the hand-rubbing by investors turned to hand-wringing.²

Some stockholders of these gold-mining companies wanted to make a bet on rising gold prices; others didn't. But all of them gave the same message to management. The first group said, "Don't hedge! I'm happy to bear the risk of fluctuating gold prices, because I think gold prices will increase." The second group said, "Don't hedge! I'd rather do it myself." We have seen this do-it-yourself principle before. Think of other ways that the firm could reduce risk. It could do so by diversifying, for example, by acquiring another firm in an unrelated industry. But we know that investors can diversify on their own, and so diversification by corporations is redundant.³

Corporations can also lessen risk by borrowing less. But we showed in Chapter 17 that just reducing financial leverage does not make shareholders any better or worse off, because they can instead reduce financial risk by borrowing less (or lending more) in their personal accounts. Modigliani and Miller (MM) proved that a corporation's debt policy is irrelevant in perfect financial markets. We could extend their proof to say that risk management is also irrelevant in perfect financial markets.

Of course, in Chapter 18 we decided that debt policy *is* relevant, not because MM were wrong, but because of other things, such as taxes, agency problems, and costs of financial distress. The same line of argument applies here. If risk management affects the value of the firm, it must be because of "other things," not because risk shifting is inherently valuable.

Let's review the reasons that risk-reducing transactions can make sense in practice.⁴

² The news was worst for the shareholders of Ashanti Goldfields, the huge Ghanaian mining company. Ashanti had gone to the opposite extreme and placed a bet that gold prices would fall. The 1999 price rise nearly drove Ashanti into bankruptcy.

³ See Section 7-5 and also our discussion of diversifying mergers in Chapter 31. Note that diversification reduces overall risk, but not necessarily market risk.

⁴ There may be other, special reasons not covered here. For example, governments are quick to tax profits, but may be slow to rebate taxes when there are losses. In the United States, losses can only be set against tax payments in the last two years. Any losses that cannot be offset in this way can be carried forward and used to shield future profits. Thus a firm with volatile income and more frequent losses has a higher effective tax rate. A firm can reduce the fluctuations in its income by hedging. For most firms this motive for risk reduction is not a big deal. See J. R. Graham and C. W. Smith, Jr., "Tax Incentives to Hedge," *Journal of Finance* 54 (December 1999), pp. 2241-2262.

Reducing the Risk of Cash Shortfalls or Financial Distress

Transactions that reduce risk make financial planning simpler and reduce the odds of an embarrassing cash shortfall. This shortfall might mean only an unexpected trip to the bank, but a financial manager's worst nightmare is landing in a financial pickle and having to pass up a valuable investment opportunity for lack of funds. In extreme cases an unhedged setback could trigger financial distress or even bankruptcy.

Banks and bondholders recognize these dangers. They try to keep track of the firm's risks, and before lending they may require the firm to carry insurance or to implement hedging programs. Risk management and conservative financing are therefore substitutes, not complements. Thus a firm might hedge part of its risk in order to operate safely at a higher debt ratio.

Smart financial managers make sure that cash (or ready financing) will be available if investment opportunities expand. That happy match of cash and investment opportunities does not necessarily require hedging, however. Let's contrast two examples.

Cirrus Oil produces from several oil fields and also invests to find and develop new fields. Should it lock in future revenues from its existing fields by hedging oil prices? Probably not, because its investment opportunities expand when oil prices rise and contract when they fall. Locking in oil prices could leave it with too much cash when oil prices fall and too little, relative to its investment opportunities, when prices rise.

Cumulus Pharmaceuticals sells worldwide and half of its revenues are received in foreign currencies. Most of its R&D is done in the United States. Should it hedge at least some of its foreign exchange exposure? Probably yes, because pharmaceutical R&D programs are very expensive, long-term investments. Cumulus can't turn its R&D program on or off depending on a particular year's earnings, so it may wish to stabilize cash flows by hedging against fluctuations in exchange rates.

Agency Costs May Be Mitigated by Risk Management

In some cases hedging can make it easier to monitor and motivate managers. Suppose your confectionery division delivers a 60% profit increase in a year when cocoa prices fall by 12%. Does the division manager deserve a stern lecture or a pat on the back? How much of the profit increase is due to good management and how much to lower cocoa prices? If the cocoa prices were hedged, it's probably good management. If they were not hedged, you will have to sort things out with hindsight, probably by asking, What would profits have been if cocoa prices had been hedged?

The fluctuations in cocoa prices are outside the manager's control. But she will surely worry about cocoa prices if her bottom line and bonus depend on them. Hedging prices ties her bonus more closely to risks that she can control and allows her to spend worrying time on these risks.

Hedging external risks that would affect individual managers does not necessarily mean that the *firm* ends up hedging. Some large firms allow their operating divisions to hedge away risks in an internal "market." The internal market operates with real (external) market prices, transferring risks from the division to the central treasurer's office. The treasurer then decides whether to hedge the firm's aggregate exposure.

This sort of internal market makes sense for two reasons. First, divisional risks may cancel out. For example, your refining division may benefit from an increase in heating-oil prices at the same time that your distribution division suffers. Second, because operating managers do not trade actual financial contracts, there is no danger that the managers will cause the firm to take speculative positions. For example, suppose that profits are down late in the year, and hope for end-year bonuses is fading. Could you be tempted to make up the shortfall with a quick score in the cocoa futures market? Well . . . not you, of course, but you can probably think of some acquaintances who would try just one speculative fling.

The dangers of permitting operating managers to make real speculative trades should be obvious. The manager of your confectionery division is an amateur in the cocoa futures market. If she were a skilled professional trader, she would probably not be running chocolate factories.⁵

Risk management requires some degree of centralization. These days many companies appoint a chief risk officer to develop a risk strategy for the company as a whole. The risk manager needs to come up with answers to the following questions:

1. *What are the major risks that the company is facing and what are the possible consequences?* Some risks are scarcely worth a thought, but there are others that might cause a serious setback or even bankrupt the company.
2. *Is the company being paid for taking these risks?* Managers are not paid to avoid all risks, but if they can reduce their exposure to risks for which there are no corresponding rewards, they can afford to place larger bets when the odds are stacked in their favor.
3. *How should risks be controlled?* Should the company reduce risk by building extra flexibility into its operations? Should it change its operating or financial leverage? Or should it insure or hedge against particular hazards?

The Evidence on Risk Management

Which firms use financial contracts to manage risk? Almost all do to some extent. For example, they may have contracts that fix prices of raw materials or output, at least for the near future. Most take out insurance policies against fire, accidents, and theft. In addition, as we shall see, managers employ a variety of specialized tools for hedging risk. These are known collectively as *derivatives*. A survey of the world's 500 largest companies found that most of them use derivatives to manage their risk.⁶ Eighty-five percent of the companies employ derivatives to control interest rate risk. Seventy-eight percent use them to manage currency risk, and 24% to manage commodity price risk.

Risk policies differ. For example, some natural resource companies work hard to hedge their exposure to price fluctuations; others shrug their shoulders and let prices wander as they may. Explaining why some hedge and others don't is not easy. Peter Tufano's study of the gold-mining industry suggests that managers' personal risk aversion may have something to do with it. Hedging of gold prices appears to be more common when top management has large personal shareholdings in the company. It is less common when top management holds lots of stock options. (Remember that the value of an option falls when the risk of the underlying security is reduced.) David Haushalter's study of oil and gas producers found the firms that hedged the most had high debt ratios, no debt ratings, and low dividend payouts. It seems that for these firms hedging programs were designed to improve the firms' access to debt finance and to reduce the likelihood of financial distress.⁷

26-2 Insurance

Most businesses buy insurance against a variety of hazards—the risk that their plants will be damaged by fire; that their ships, planes, or vehicles will be involved in accidents; that the firm will be held liable for environmental damage; and so on.

⁵ Amateur speculation is doubly dangerous when the manager's initial trades are losers. At that point the manager is already in deep trouble and has nothing more to lose by going for broke.

⁶ International Swap Dealers Association (ISDA), "2003 Derivatives Usage Survey," www.isda.org.

⁷ See P. Tufano, "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry," *Journal of Finance* 53 (June 1998), pp. 1014–1052; and G. D. Haushalter, "Financing Policy, Basis Risk and Corporate Hedging," *Journal of Finance* 55 (February 2000), pp. 107–152.

When a firm takes out insurance, it is simply transferring the risk to the insurance company. Insurance companies have some advantages in bearing risk. First, they may have considerable experience in insuring similar risks, so they are well placed to estimate the probability of loss and price the risk accurately. Second, they may be skilled at providing advice on measures that the firm can take to reduce the risk, and they may offer lower premiums to firms that take this advice. Third, an insurance company can *pool* risks by holding a large, diversified portfolio of policies. The claims on any individual policy can be highly uncertain, yet the claims on a portfolio of policies may be very stable. Of course, insurance companies cannot diversify away market or macroeconomic risks; firms use insurance policies to reduce their specific risk, and they find other ways to avoid macro risks.

Insurance companies also suffer some *disadvantages* in bearing risk, and these are reflected in the prices they charge. Suppose your firm owns a \$1 billion offshore oil platform. A meteorologist has advised you that there is a 1-in-10,000 chance that in any year the platform will be destroyed as a result of a storm. Thus the *expected* loss from storm damage is \$1 billion/10,000 = \$100,000.

The risk of storm damage is almost certainly not a macroeconomic risk and can potentially be diversified away. So you might expect that an insurance company would be prepared to insure the platform against such destruction as long as the premium was sufficient to cover the expected loss. In other words, a fair premium for insuring the platform should be \$100,000 a year.⁸ Such a premium would make insurance a zero-NPV deal for your company. Unfortunately, no insurance company would offer a policy for only \$100,000. Why not?

- *Reason 1: Administrative costs.* An insurance company, like any other business, incurs a variety of costs in arranging the insurance and handling any claims. For example, disputes about the liability for environmental damage can eat up millions of dollars in legal fees. Insurance companies need to recognize these costs when they set their premiums.
- *Reason 2: Adverse selection.* Suppose that an insurer offers life insurance policies with “no medical exam needed, no questions asked.” There are no prizes for guessing who will be most tempted to buy this insurance. Our example is an extreme case of the problem of *adverse selection*. Unless the insurance company can distinguish between good and bad risks, the latter will always be most eager to take out insurance. Insurers increase premiums to compensate or require the owners to share any losses.
- *Reason 3: Moral hazard.* Two farmers met on the road to town. “George,” said one, “I was sorry to hear about your barn burning down.” “Shh,” replied the other, “that’s tomorrow night.” The story is an example of another problem for insurers, known as *moral hazard*. Once a risk has been insured, the owner may be less careful to take proper precautions against damage. Insurance companies are aware of this and factor it into their pricing.

The extreme forms of adverse selection and moral hazard (like the fire in the farmer’s barn) are rarely encountered in professional corporate finance. But these problems arise in more subtle ways. That oil platform may not be a “bad risk,” but the oil company knows more about the platform’s weaknesses than the insurance company does. The oil company will not purposely scuttle the platform, but once insured it could be tempted to save on maintenance or structural reinforcements. Thus, the insurance company may end up paying for engineering studies or for a program to monitor maintenance. All these costs are rolled into the insurance premium.

⁸ If the premium is paid at the beginning of the year and the claim is not settled until the end, then the zero-NPV premium equals the discounted value of the expected claim or $\$100,000/(1 + r)$.

When the costs of administration, adverse selection, and moral hazard are small, insurance may be close to a zero-NPV transaction. When they are large, insurance is a costly way to protect against risk.

Many insurance risks are *jump risks*; one day there is not a cloud on the horizon and the next day the hurricane hits. The risks can also be huge. For example, Hurricane Andrew, which devastated Florida, cost insurance companies \$17 billion; the attack on the World Trade Center on September 11, 2001, involved payments of about \$36 billion, while Hurricane Katrina cost insurers a record \$66 billion.

If the losses from such disasters can be spread more widely, the cost of insuring them should decline. Therefore, insurance companies have been looking for ways to share catastrophic risks with investors. One solution is for the companies to issue *catastrophe bonds* (or *Cat bonds*). If a catastrophe occurs, the payment on a Cat bond is reduced or eliminated.⁹ For example, in 2009 Chubb Corporation issued \$150 million worth of Cat bonds. The bonds cover Chubb against any losses in excess of \$850 million resulting from Florida hurricanes. For taking on this risk investors receive a tempting interest rate of 10.25% over LIBOR.

How BP Changed Its Insurance Strategy¹⁰

Major public companies typically buy insurance against large potential losses and self-insure against routine ones. The idea is that large losses can trigger financial distress. On the other hand, routine losses for a corporation are predictable, so there is little point paying premiums to an insurance company and receiving back a fairly constant proportion as claims.

BP has challenged this conventional wisdom. Like all oil companies, BP is exposed to a variety of potential losses. Some arise from routine events such as vehicle accidents and industrial injuries. At the other extreme, they may result from catastrophes such as a major oil spill or the loss of an offshore oil rig. In the past BP purchased considerable external insurance.¹¹ During the 1980s it paid out an average of \$115 million a year in insurance premiums and recovered \$25 million a year in claims.

BP then took a hard look at its insurance strategy. It decided to allow local managers to insure against routine risks, where insurance companies have an advantage in assessing and pricing risk and compete vigorously against one another. BP considered that the insurance companies could do these tasks more efficiently than its own managers. But BP decided not to insure against most losses over \$10 million. For these larger, more specialized risks BP felt that insurance companies had less ability to assess risk and were less well placed to advise on safety measures. As a result, BP concluded, insurance against large risks was not competitively priced.

How much extra risk did BP assume by its decision not to insure against major losses? BP estimated that large losses of above \$500 million could be expected to occur once in 30 years. But BP is a huge company with equity worth about \$150 billion. So even a \$500 million loss, which could throw most companies into bankruptcy, would translate after tax into a fall of less than 1% in the value of BP's equity. BP concluded that this was a risk worth taking. In other words, it concluded that for large, low-probability risks the stock market was a more efficient risk-absorber than the insurance industry.

⁹ For a discussion of Cat bonds and other techniques to spread insurance risk, see N. A. Doherty, "Financial Innovation in the Management of Catastrophe Risk," *Journal of Applied Corporate Finance* 10 (Fall 1997), pp. 84–95; and K. Froot, "The Market for Catastrophe Risk: A Clinical Examination," *Journal of Financial Economics* 60 (2001), pp. 529–571.

¹⁰ Our description of BP's insurance strategy draws heavily on N. A. Doherty and C. W. Smith, Jr., "Corporate Insurance Strategy: The Case of British Petroleum," *Journal of Applied Corporate Finance* 6 (Fall 1993), pp. 4–15.

¹¹ However, with one or two exceptions insurance has not been available for the very largest losses of \$500 million or more.

26-3 Reducing Risk with Options

Managers regularly buy options on currencies, interest rates, and commodities to limit downside risk. Consider, for example, the problem faced by the Mexican government. Forty percent of its revenue comes from Pemex, the state-owned oil company. So, if oil prices fall, the government may be compelled to reduce its planned spending. That is always an unwelcome outcome, but it was particularly so in 2008 when the country faced recession.

The Mexican government's solution was to establish a floor on the price at which it could sell 330 million barrels of oil, equivalent to the country's total expected net oil exports in 2009. To do this, the government bought *put* options that gave it the right to sell oil at an exercise price of \$70 per barrel. If oil prices rose above this figure, Mexico would reap the benefit. But if oil prices fell below \$70 a barrel, the payoff to the put options would exactly offset the revenue shortfall. Of course, you don't get something for nothing. The price that the government paid for insurance against a fall in the price of oil was the estimated \$1.5 billion cost of the put options.

Figure 26.1 illustrates the nature of Mexico's insurance strategy. Panel (a) shows the revenue derived from selling 330 million barrels of oil. If the price of oil falls, so do the government's revenues. But, as panel (b) illustrates, the payoff on the option to sell 330 million barrels rises as oil prices fall below \$70 a barrel. This payoff exactly offsets the decline in oil revenues. Panel (c) shows the government's total revenues after buying the put options. For prices below \$70 per barrel, revenues are fixed at $70 \times 330 = \$23,100$ million. But for every dollar that oil prices rise above \$70, revenues increase by \$330 million. The profile in panel (c) should be familiar to you as the protective put strategy that we encountered in Section 20-2.

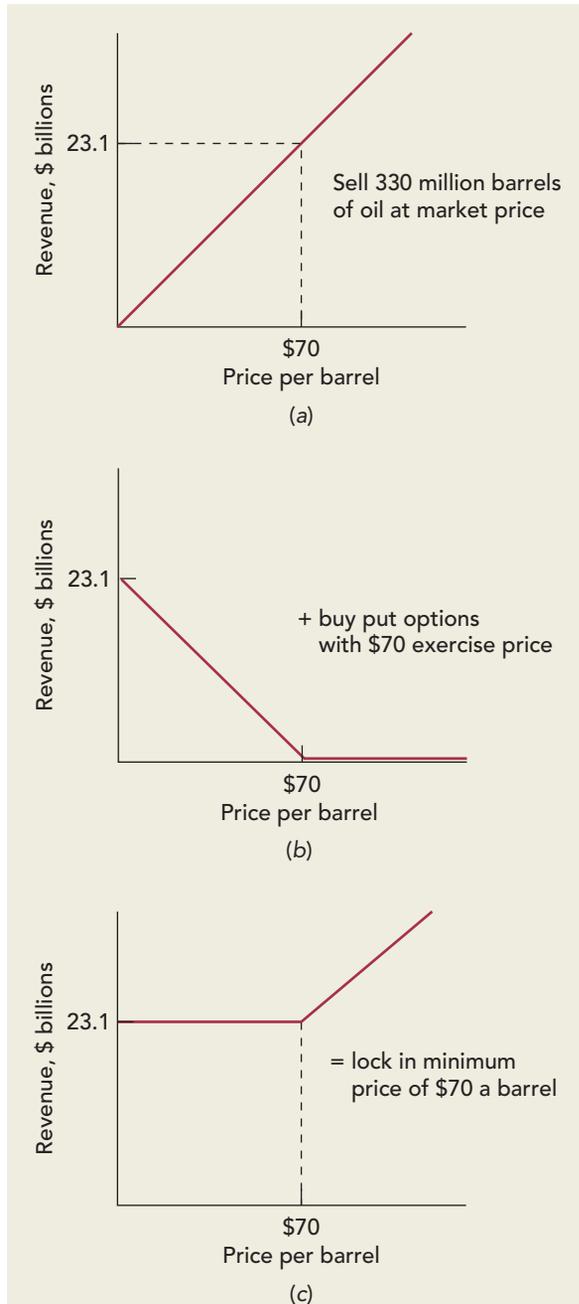


FIGURE 26.1

How put options protected Mexico against a fall in oil prices.

26-4 Forward and Futures Contracts

Hedging involves taking on one risk to offset another. It potentially removes all uncertainty, eliminating the chance of both happy and unhappy surprises. We explain shortly how to set up a hedge, but first we give some examples and describe some tools that are specially designed for hedging. These are forwards, futures, and swaps. Together with options, they are known as *derivative instruments* or *derivatives* because their value depends on the value of another asset.

A Simple Forward Contract

We start with an example of a simple **forward contract**. Arctic Fuels, the heating-oil distributor, plans to deliver one million gallons of heating oil to its retail customers next January. Arctic worries about high heating-oil prices next winter and wants to lock in the cost of buying its supply. Northern Refineries is in the opposite position. It will produce heating oil next winter, but doesn't know what the oil can be sold for. So the two firms strike a deal: Arctic Fuels agrees in September to buy one million gallons from Northern Refineries at \$1.60 per gallon, to be paid on delivery in January. Northern agrees to sell and deliver one million gallons to Arctic in January at \$1.60 per gallon.

Arctic and Northern are now the two *counterparties* in a forward contract. The **forward price** is \$1.60 per gallon. This price is fixed today, in September in our example, but payment and delivery occur later. (The price for immediate delivery is called the **spot price**.) Arctic, which has agreed to *buy* in January, has the *long* position in the contract. Northern Refineries, which has agreed to *sell* in January, has the *short* position. Both companies have eliminated a business risk: Arctic has locked in its costs, and Northern has locked in its revenues for one million gallons of output.

Do not confuse this forward contract with an option. Arctic does not have the option to buy. It has committed to buy, even if spot prices in January turn out much lower than \$1.60 per gallon. Northern does not have the option to sell. It cannot back away from the deal, even if spot prices for delivery in January turn out much higher than \$1.60 per gallon. Note, however, that both the distributor and refiner have to worry about *counterparty risk*, that is, the risk that the other party will not perform as promised.

We confess that our heating oil example glossed over several complications. For example, we assumed that the risk of both companies is reduced by locking in the price of heating oil. But suppose that the retail price of heating oil moves up and down with the wholesale price. In that case the heating-oil distributor is naturally hedged because costs and revenues move together. Locking in costs with a futures contract could actually make the distributor's profits *more* volatile. The nearby box illustrates that hedging decisions are not always straightforward.

Futures Exchanges

Our heating-oil distributor and refiner do not have to negotiate a one-off, bilateral contract. Each can go to an exchange where standardized forward contracts on heating oil are traded. The distributor would buy contracts and the refiner would sell.

Here we encounter some tricky vocabulary. When a standardized forward contract is traded on an exchange, it is called a **futures contract**—same contract, but a different label. The exchange is called a **futures exchange**. The distinction between “futures” and “forward” does not apply to the contract, but to how the contract is traded. We describe futures trading in a moment.

The Pros and Cons of Hedging Airline Fuel Costs

Jet fuel is a major cost of running an airline. For example, in 2008 purchases of kerosene accounted for about 20% of the operating costs of the German airline, Lufthansa. Jet fuel costs are notoriously volatile, rising by over 150% between January 2007 and May 2008, before falling by more than 70% over the following 12 months. Therefore, Lufthansa like many airlines uses a variety of market instruments, such as forward contracts and options, to hedge against unexpected fluctuations in fuel prices. In early 2009 it had hedged 63% of its fuel requirements for that year and 26% of its requirements for the following year.

Carter, Rogers, and Simkins, who conducted a study of hedging by U.S. airlines, concluded that investors placed a premium on airlines, such as Lufthansa, that hedged their fuel costs. The reason for this premium, they suggested, was that airlines may be led to cut back on profitable investments when fuel prices are high and operating cash flows values are low. An airline that is protected against rising fuel prices is better placed to take advantage of investment opportunities.

Hedging has its advantages for airlines, but there are also dangers. One problem is that if fuel prices fall, those airlines that have entered into contracts to cover their future fuel needs will suffer losses on

these contracts. If they bought the contracts on a futures exchange, they will need to put up cash as collateral to cover these losses. This was the case for many airlines when fuel prices plunged in the second half of 2008. Writing in *Aviation Week*, Adrian Schofield noted that at the end of 2008 Delta and United Airlines each had about \$1 billion in cash tied up as hedge collateral, while American had to put up \$575 million. These were large amounts of cash to find when the skies were far from friendly for U.S. airlines.

Schofield added an additional caution for would-be hedgers: “Competition among airlines paying lower jet-fuel prices should lead to lower fares. When that happens, lower fuel costs are offset by lower revenues, and losses on hedging contracts fall straight down to bottom-line income. Costs that are passed through to customers are naturally hedged.” Usually, only a portion of any increase in costs is passed through, so the natural hedge is partial. However, a firm needs to be careful when adding a financial hedge transaction to a natural hedge. It could overshoot and increase risk, not reduce it.

Sources: D. A. Carter, D. A. Rogers, and B. J. Simkins, “Hedging and Value in the U.S. Airline Industry,” *Journal of Applied Corporate Finance* 18 (Fall 2006), pp. 21–33; and A. Schofield, “High Anxiety,” *Aviation Week & Space Technology*, February 2, 2009, pp. 24–25.

Table 26.1 lists the most important commodity futures contracts and the exchanges on which they are traded.¹² Our refiner and distributor can trade heating oil futures on the New York Mercantile Exchange (NYMEX). A forest products company and a home-builder can trade lumber futures on the Chicago Mercantile Exchange (CME). A wheat farmer and a miller can trade wheat futures on the Chicago Board of Trade (CBOT) or on a smaller regional exchange.

¹² By the time you read this, the list of futures contracts will almost certainly be out of date, as thinly traded contracts are terminated and new contracts are introduced. The list of futures exchanges may also be out of date. There have been plenty of mergers in recent years. In July 2007 the CME and CBOT merged to form the CME Group. Also in 2007 the Intercontinental Exchange acquired the New York Board of Trade. In August 2008 the CME Group acquired NYMEX Holdings, which operates the NYMEX and COMEX exchanges.

Future	Exchange	Future	Exchange
Barley	WCE	Aluminum	LME
Corn	CBOT, MGEX	Copper	COMEX, LME
Oats	CBOT	Gold	COMEX
Wheat	CBOT, KC, MGEX	Lead	LME
		Nickel	LME
Soybeans	CBOT, MGEX	Silver	COMEX
Soybean meal	CBOT	Tin	LME
Soybean oil	CBOT	Zinc	LME
Live cattle	CME	Crude oil	ICE, NYMEX
Lean hogs	CME	Gas oil	ICE
		Heating oil	NYMEX
Cocoa	ICE, LIFFE	Natural gas	ICE, NYMEX
Coffee	ICE, LIFFE	Unleaded gasoline	NYMEX
Cotton	ICE		
Lumber	CME	Electricity	NYMEX
Orange juice	ICE	House prices	CME
Sugar	ICE, LIFFE	Weather	CME

TABLE 26.1 Some commodity futures and some of the exchanges on which they are traded.

Key to abbreviations:

CBOT	Chicago Board of Trade	LIFFE	Euronext LIFFE
CME	Chicago Mercantile Exchange	LME	London Metal Exchange
COMEX	Commodity Exchange Division of NYMEX	MGEX	Minneapolis Grain Exchange
ICE	Intercontinental Exchange	NYMEX	New York Mercantile Exchange
KC	Kansas City Board of Trade	WCE	Winnipeg Commodity Exchange

For many firms the wide fluctuations in interest rates and exchange rates have become at least as important a source of risk as changes in commodity prices. Financial futures are similar to commodity futures, but instead of placing an order to buy or sell a commodity at a future date, you place an order to buy or sell a financial asset at a future date. Table 26.2 lists some important financial futures. Like Table 26.1 it is far from complete. For example, you can also trade futures on the Thai stock market index, the Hungarian forint, Finnish government bonds, and many other financial assets.

Almost every day some new futures contract seems to be invented. At first there may be just a few private deals between a bank and its customers, but if the idea proves popular, one of the futures exchanges will try to muscle in on the business. For example, in the last few years the Chicago Mercantile Exchange has offered futures contracts on the weather in 18 U.S. cities and on house prices in 10 cities.

The Mechanics of Futures Trading

When you buy or sell a futures contract, the price is fixed today but payment is not made until later. You will, however, be asked to put up **margin** in the form of either cash or Treasury bills to demonstrate that you have the money to honor your side of the bargain. As long as you earn interest on the margined securities, there is no cost to you.

In addition, futures contracts are **marked to market**. This means that each day any profits or losses on the contract are calculated; you pay the exchange any losses and receive

Future	Exchange	Future	Exchange
U.S. Treasury bonds	CBOT	Euroyen deposits	CME, SGX, TFX
U.S. Treasury notes	CBOT		
German government bonds (bunds)	Eurex	S&P 500 Index	CME
Japanese government bonds (JGBs)	CME, SGX, TSE	French equity index (CAC)	LIFFE
British government bonds (gilts)	LIFFE	German equity index (DAX)	Eurex
U.S. Treasury bills	CME	Japanese equity index (Nikkei)	CME, OSE, SGX
Swaps	CBOT	U.K. equity index (FTSE)	LIFFE
Credit default swaps	CBOT	Chinese renminbi	CME
LIBOR	CME	Euro	CME
EURIBOR	LIFFE	Japanese yen	CME
Eurodollar deposits	CME		

TABLE 26.2 Some financial futures and some of the exchanges on which they are traded.

Key to abbreviations:

CBOT	Chicago Board of Trade	OSE	Osaka Securities Exchange
CME	Chicago Mercantile Exchange	SGX	Singapore Exchange
LIFFE	Euronext LIFFE	TFX	Tokyo Financial Futures Exchange
		TSE	Tokyo Stock Exchange

any profits. For example, suppose that in September Arctic Fuels buys one million gallons of January heating-oil futures contracts at a futures price of \$1.60 per gallon. The next day the price of the January contract increases to \$1.62 per gallon. Arctic now has a profit of $$.02 \times 1,000,000 = \$20,000$. The exchange's clearinghouse therefore pays \$20,000 into Arctic's margin account. If the price then drops back to \$1.61, Arctic's margin account pays \$10,000 back to the clearing house.

Of course Northern Refineries is in the opposite position. Suppose it sells one million gallons of January heating-oil futures contracts at a futures price of \$1.60 per gallon. If the price increases to \$1.62 cents per gallon, it loses $$.02 \times 1,000,000 = \$20,000$ and must pay this amount into the clearinghouse. Notice that neither the distributor nor the refiner has to worry about whether the other party will honor the other side of the bargain. The futures exchange guarantees the contracts and protects itself by settling up profits or losses each day. Futures trading eliminates counterparty risk.

Now consider what happens over the life of the futures contract. We're assuming that Arctic and Northern take offsetting long and short positions in the January contract (not directly with each other, but with the exchange). Suppose that a severe cold snap pushes the spot price of heating oil in January up to \$1.70 per gallon. Then the futures price at the end of the contract will also be \$1.70 per gallon.¹³ So Arctic gets a cumulative profit of $(1.70 - 1.60) \times 1,000,000 = \$100,000$. It can take delivery of one million gallons, paying \$1.70 per gallon, or \$1,700,000. Its *net* cost, counting the profits on the futures contract, is $\$1,700,000 - 100,000 = \$1,600,000$, or \$1.60 per gallon. Thus it has locked in the \$1.60 per gallon price quoted in September when it first bought the futures contract. You can easily check that Arctic's net cost always ends up at \$1.60 per gallon, regardless of the spot price and ending futures price in January.

¹³ Recall that the spot price is the price for immediate delivery. The futures contract also calls for immediate delivery when the contract ends in January. Therefore, the ending price of a futures or forward contract must converge to the spot price at the end of the contract.

Northern Refineries suffers a cumulative loss of \$100,000 if the January price is \$1.70. That's the bad news; the good news is that it can sell and deliver heating oil for \$1.70 per gallon. Its net revenues are $\$1,700,000 - 100,000 = \$1,600,000$, or \$1.60 per gallon, the futures price in September. Again, you can easily check that Northern's net selling price always ends up at \$1.60 per gallon.

Arctic does not have to take delivery directly from the futures exchange, and Northern Refineries does not have to deliver to the exchange. They will probably close out their futures positions just before the end of the contract, take their profits or losses, and buy or sell in the spot market.¹⁴

Taking delivery directly from an exchange can be costly and inconvenient. For example, the NYMEX heating-oil contract calls for delivery in New York Harbor. Arctic Fuels will be better off taking delivery from a local source such as Northern Refineries. Northern Refineries will likewise be better off delivering heating oil locally than shipping it to New York. Both parties can nevertheless use the NYMEX futures contract to hedge their risks.

The effectiveness of this hedge depends on the correlation between changes in heating-oil prices locally and in New York Harbor. Prices in both locations will be positively correlated because of a common dependence on world energy prices. But the correlation is not perfect. What if a local cold snap hits Arctic Fuels's customers but not New York? A long position in NYMEX futures won't hedge Arctic Fuels against the resulting increase in the local spot price. This is an example of **basis risk**. We return to the problems created by basis risk later in this chapter.

Trading and Pricing Financial Futures Contracts

Financial futures trade in the same way as commodity futures. Suppose your firm's pension fund manager thinks that the German stock market will outperform other European markets over the next six months. She forecasts a 10% six-month return. How can she place a bet? She can buy German stocks, of course. But she could also buy futures contracts on the DAX index of German stocks, which are traded on the Eurex exchange. Suppose she buys 10 six-month futures contracts at 4,000. Each contract pays off 25 times the level of the index, so she has a long position of $10 \times 25 \times 4,000 = \text{€}1,000,000$. This position is marked to market daily. If the DAX goes up, Eurex puts the profits into your fund's margin account; if the DAX falls, the margin account falls too. If your pension manager is right about the German market, and the DAX ends up at 4,400 after six months, then your fund's cumulative profit on the futures position is $10 \times (4,400 - 4,000) \times 25 = \text{€}100,000$.

If you want to buy a security, you have a choice. You can buy for immediate delivery at the spot price or you can "buy forward" by placing an order for future delivery at the futures price. You end up with the same security either way, but there are two differences. First, if you buy forward, you don't pay up front, and so you can earn interest on the purchase price. Second, you miss out on any interest or dividend that is paid in the meantime. This tells us the relationship between spot and futures prices:

$$F_t = S_0(1 + r_f - y)^t$$

where F_t is the futures price for a contract lasting t periods, S_0 is today's spot price, r_f is the risk-free interest rate, and y is the dividend yield or interest rate.¹⁵ The following example shows how and why this formula works.

¹⁴ Some financial futures contracts *prohibit* delivery. All positions are closed out at the spot price at contract maturity.

¹⁵ This formula is strictly true only for forward contracts that are not marked to market. Otherwise the value of the future depends on the path of interest rates over the life of the contract. In practice this qualification is usually not important, and the formula works for futures as well as forward contracts.

EXAMPLE 26.1 • Valuing Index Futures

Suppose the six-month DAX futures contract trades at 4,000 when the current (spot) DAX index is 3,980.10. The interest rate is 3% per year (about 1.5% over six months) and the dividend yield on the index is 2% (about 1% over six months). These numbers fit the formula because

$$F_t = 3,980.10 \times (1 + .015 - .01) = 4,000$$

but why are the numbers consistent?

Suppose you just buy the DAX index for 3,980.10 today. Then in six months you will own the index and also have dividends of $.01 \times 3,980.10 = 39.80$. But you decide to buy a futures contract for 4,000 instead, and you put €3,980.10 in the bank. After six months, the bank account has earned interest at 1.5%, so you have $3,980.10 \times 1.015 = €4,039.80$, enough to buy the index for 4,000 with €39.80 left over, just enough to cover the dividend you missed by buying futures rather than spot. You get what you pay for.¹⁶

Spot and Futures Prices—Commodities

The difference between buying *commodities* today and buying commodity futures is more complicated. First, because payment is again delayed, the buyer of the future earns interest on her money. Second, she does not need to store the commodities and, therefore, saves warehouse costs, wastage, and so on. On the other hand, the futures contract gives no *convenience yield*, which is the value of being able to get your hands on the real thing. The manager of a supermarket can't burn heating oil futures if there's a sudden cold snap, and he can't stock the shelves with orange juice futures if he runs out of inventory at 1 p.m. on a Saturday.

Let's express storage costs and convenience yield as fractions of the spot price. For commodities, the futures price for t periods ahead is¹⁷

$$F_t = S_0(1 + r_f + \text{storage costs} - \text{convenience yield})^t$$

It's interesting to compare this formula with the formula for a financial future. Convenience yield plays the same role as dividends or interest foregone (y) on securities. But financial assets cost nothing to store, and storage costs do not appear in the formula for financial futures.

Usually you can't observe storage cost or convenience yield, but you can infer the difference between them by comparing spot and futures prices. This difference—that is, convenience yield less storage cost—is called *net convenience yield* (net convenience yield = convenience yield – storage costs).

¹⁶ We can derive our formula as follows. Let S_6 be the value of the index after six months. Today S_6 is unknown. You can invest S_0 in the index today and get $S_6 + yS_0$ after six months. You can also buy the futures contract, put S_0 in the bank, and use your bank balance to pay the futures price F_6 in six months. In the latter strategy you get $S_6 - F_6 + S_0(1 + r_f)$ after six months. Since the investment is the same, and you get S_6 with either strategy, the payoffs must be the same:

$$\begin{aligned} S_6 + yS_0 &= S_6 - F_6 + S_0(1 + r_f) \\ F_6 &= S_0(1 + r_f - y) \end{aligned}$$

Here we assume that r_f and y are six-month rates. If they are monthly rates, the general formula is $F_t = S_0(1 + r_f - y)^t$, where t is the number of months. If they are annual rates, the formula is $F_t = S_0(1 + r_f - y)^{t/12}$.

¹⁷ This formula could overstate the futures price if no one is willing to hold the commodity, that is, if inventories fall to zero or some absolute minimum.

EXAMPLE 26.2 ● Calculating Net Convenience Yield

In January 2009, the spot price of crude oil was \$41.68 a barrel and the one-year futures price was \$58.73 per barrel. The interest rate was 0.44%. Thus

$$F_t = S_0(1 + r_f + \text{storage costs} - \text{convenience yield})$$

$$58.73 = 41.68(1.0044 - \text{net convenience yield})$$

So net convenience yield was negative, that is, net convenience yield = convenience yield – storage costs = $-.405$, or -40.5% over one year. Evidently the cost of holding of crude oil inventories was greater than the convenience yield provided by those inventories. Oil in 2009 was in ample supply and users had no worries that they would run short in the months ahead.

Figure 26.2 plots the annualized net convenience yield for crude oil since 1995. Notice how much the spread between the spot and futures price can bounce around. When there are shortages or fears of an interruption of supply, traders may be prepared to pay a hefty premium for the convenience of having inventories of crude oil rather than the promise of future delivery.

There is one further complication that we should note. There are some commodities that cannot be stored at all. You can't store electricity, for example. As a result, electricity supplied in, say, six-months' time is effectively a different commodity from electricity available now, and there is no simple link between today's price and that of a futures contract to buy or sell at the end of six months. Of course, generators and electricity users will have their own views of what the spot price is likely to be, and the futures price will reveal these views to some extent.¹⁸

More about Forward Contracts

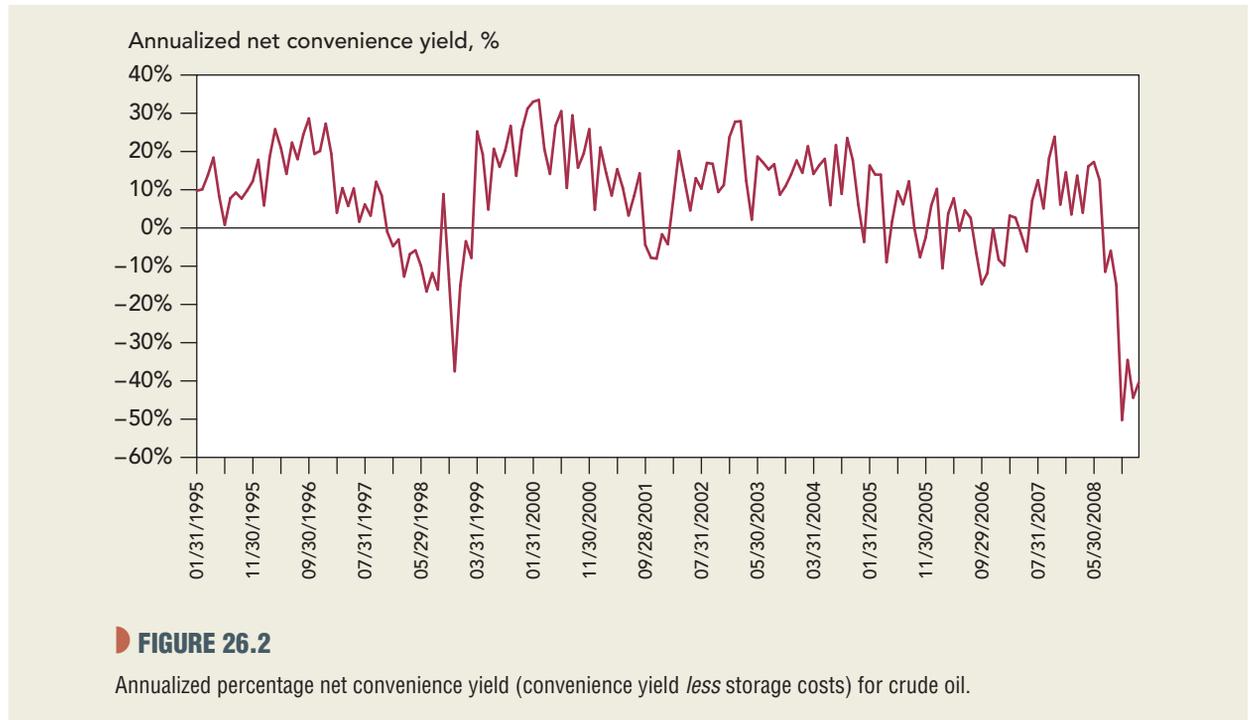
Each day billions of dollars of futures contracts are bought and sold. This liquidity is possible only because futures contracts are standardized and mature on a limited number of dates each year.

Fortunately there is usually more than one way to skin a financial cat. If the terms of futures contracts do not suit your particular needs, you may be able to buy or sell a tailor-made forward contract. The main forward market is in foreign currency. We discuss forward exchange rates in the next chapter.

It is also possible to enter into a forward interest rate contract. For example, suppose you know that at the end of three months you are going to need a six-month loan. If you are worried that interest rates will rise over the three-month period, you can lock in the interest rate on the loan by buying a *forward rate agreement (FRA)* from a bank.¹⁹ For example, the bank might sell you a 3-against-9 month (or 3×9) FRA at 7%. If at the end of three months

¹⁸ Critics and proponents of futures markets sometimes argue about whether the markets provide "price discovery." That is, they argue about whether futures prices reveal traders' forecasts of spot prices when the futures contract matures. If one of these fractious personalities comes your way, we suggest that you respond with a different question: Do futures prices reveal information about spot prices that is not already in *today's* spot price? Our formulas reveal the answer to this question. There is useful information in futures prices, but it is information about convenience yields and storage costs, or about dividend or interest payments in the case of financial futures. Futures prices reveal information about spot prices only when a commodity is not stored or cannot be stored. Then the link between spot and futures prices is broken, and futures prices can assist with price discovery.

¹⁹ Note that the party that profits from a rise in rates is described as the "buyer." In our example you would be said to "buy three against nine months" money, meaning that the forward rate agreement is for a six-month loan in three months' time.



the six-month interest rate is higher than 7%, then the bank will make up the difference;²⁰ if it is lower, then you must pay the bank the difference.²¹

Homemade Forward Rate Contracts

Suppose that you borrow \$90.91 for one year at 10% and lend \$90.91 for two years at 12%. These interest rates are for loans made today; therefore, they are spot interest rates.

The cash flows on your transactions are as follows:

	Year 0	Year 1	Year 2
Borrow for 1 year at 10%	+90.91	-100	
Lend for 2 years at 12%	-90.91		+114.04
Net cash flow	0	-100	+114.04

Notice that you do not have any net cash outflow today but you have contracted to pay out money in year 1. The interest rate on this forward commitment is 14.04%. To calculate this forward interest rate, we simply worked out the extra return for lending for two years rather than one:

$$\begin{aligned} \text{Forward interest rate} &= \frac{(1 + 2\text{-year spot rate})^2}{1 + 1\text{-year spot rate}} - 1 \\ &= \frac{(1.12)^2}{1.10} - 1 = .1404, \text{ or } 14.04\% \end{aligned}$$

²⁰ The interest rate is usually measured by LIBOR. LIBOR (London interbank offered rate) is the interest rate at which major international banks in London lend each other dollars (or euros, yen, etc.).

²¹ These payments would be made when the loan matures nine months from now.

In our example you manufactured a forward loan by borrowing short term and lending long. But you can also run the process in reverse. If you wish to fix today the rate at which you borrow next year, you borrow long and lend the money until you need it next year.

26-5 Swaps

Some company cash flows are fixed. Others vary with the level of interest rates, rates of exchange, prices of commodities, and so on. These characteristics may not always result in the desired risk profile. For example, a company that pays a fixed rate of interest on its debt might prefer to pay a floating rate, while another company that receives cash flows in euros might prefer to receive them in yen. Swaps allow them to change their risk in these ways.

The market for swaps is huge. In 2008 the total notional amount of swaps outstanding was over \$370 trillion. By far the major part of this figure consisted of interest rate swaps.²² We therefore show first how interest rate swaps work, and then describe a currency swap. We conclude with a brief look at total return swaps.

Interest Rate Swaps

Friendly Bancorp has made a five-year, \$50 million loan to fund part of the construction cost of a large cogeneration project. The loan carries a fixed interest rate of 8%. Annual interest payments are therefore \$4 million. Interest payments are made annually, and all the principal will be repaid at year 5.

Suppose that instead of receiving fixed interest payments of \$4 million a year, the bank would prefer to receive floating-rate payments. It can do so by swapping the \$4 million, five-year annuity (the fixed interest payments) into a five-year floating-rate annuity. We show first how Friendly Bancorp can make its own homemade swap. Then we describe a simpler procedure.

The bank (we assume) can borrow at a 6% fixed rate for five years.²³ Therefore, the \$4 million interest it receives can support a fixed-rate loan of $4/.06 = \$66.67$ million. The bank can now construct the homemade swap as follows: It borrows \$66.67 million at a fixed interest rate of 6% for five years and simultaneously lends the same amount at LIBOR. We assume that LIBOR is initially 5%.²⁴ LIBOR is a short-term interest rate, so future interest receipts will fluctuate as the bank's investment is rolled over.

The net cash flows to this strategy are shown in the top portion of Table 26.3. Notice that there is no net cash flow in year 0 and that in year 5 the principal amount of the short-term investment is used to pay off the \$66.67 million loan. What's left? A cash flow equal to the *difference* between the interest earned ($\text{LIBOR} \times 66.67$) and the \$4 million outlay on the fixed loan. The bank also has \$4 million per year coming in from the project financing, so it has transformed that fixed payment into a floating payment keyed to LIBOR.

Of course, there's an easier way to do this, shown in the bottom portion of Table 26.3. The bank can just enter into a five-year swap.²⁵ Naturally, Friendly Bancorp takes this easier route. Let's see what happens.

Friendly Bancorp calls a swap dealer, which is typically a large commercial or investment bank, and agrees to *swap* the payments on a \$66.67 million fixed-rate loan for the payments

²² Data on swaps are provided by the International Swaps and Derivatives Association (www.isda.org) and the Bank for International Settlements (www.bis.org).

²³ The spread between the bank's 6% borrowing rate and the 8% lending rate is the bank's profit on the project financing.

²⁴ Maybe the short-term interest rate is below the five-year interest rate because investors expect interest rates to rise.

²⁵ Both strategies are equivalent to a series of forward contracts on LIBOR. The forward prices are \$4 million each for $\text{LIBOR}_1 \times \$66.67$, $\text{LIBOR}_2 \times \$66.67$, and so on. Separately negotiated forward prices would not be \$4 million for any one year, but the PVs of the "annuities" of forward prices would be identical.

	Year					
	0	1	2	3	4	5
Homemade swap:						
1. Borrow \$66.67 at 6% fixed rate	+66.67	-4	-4	-4	-4	-(4 + 66.67)
2. Lend \$66.67 at LIBOR floating rate	-66.67	+ .05 × 66.67	+ LIBOR ₁ × 66.67	+ LIBOR ₂ × 66.67	+ LIBOR ₃ × 66.67	+ LIBOR ₄ × 66.67 + 66.67
Net cash flow	0	-4	-4	-4	-4	-4
		+ .05 × 66.67	+ LIBOR ₁ × 66.67	+ LIBOR ₂ × 66.67	+ LIBOR ₃ × 66.67	+ LIBOR ₄ × 66.67
Standard fixed-to-floating swap:						
Net cash flow	0	-4	-4	-4	-4	-4
		+ .05 × 66.67	+ LIBOR ₁ × 66.67	+ LIBOR ₂ × 66.67	+ LIBOR ₃ × 66.67	+ LIBOR ₄ × 66.67

TABLE 26.3 The top panel shows the cash flows in millions of dollars to a homemade fixed-to-floating interest rate swap. The bottom panel shows the cash flows to a standard swap transaction.

on an equivalent floating-rate loan. The swap is known as a fixed-to-floating interest rate swap and the \$66.67 million is termed the *notional principal* amount of the swap. Friendly Bancorp and the dealer are the counterparties to the swap.

The dealer is quoting a rate for five-year swaps of 6% against LIBOR.²⁶ This figure is sometimes quoted as a spread over the yield on U.S. Treasuries. For example, if the yield on five-year Treasury notes is 5.25%, the swap spread is .75%.

The first payment on the swap occurs at the end of year 1 and is based on the starting LIBOR rate of 5%.²⁷ The dealer (who pays floating) owes the bank 5% of \$66.67 million, while the bank (which pays fixed) owes the dealer \$4 million (6% of \$66.67 million). The bank therefore makes a net payment to the dealer of $4 - (.05 \times 66.67) = \$.67$ million:

Bank	←	.05 × \$66.67 = \$3.33	←	Counterparty
Bank	→	\$4	→	Counterparty
Bank	→	Net = \$.67	→	Counterparty

The second payment is based on LIBOR at year 1. Suppose it increases to 6%. Then the net payment is zero:

Bank	←	.06 × \$66.67 = \$4	←	Counterparty
Bank	→	\$4	→	Counterparty
Bank	→	Net = 0	→	Counterparty

The third payment depends on LIBOR at year 2, and so on.

Notice that, when the two counterparties entered into the swap, the deal was fairly valued. In other words, the net cash flows had zero present value. What happens to the value of the swap as time passes? That depends on long-term interest rates. For example, suppose that after two years interest rates are unchanged, so a 6% note issued by the bank would

²⁶ Notice that the swap rate always refers to the interest rate on the fixed leg of the swap. Rates are generally quoted against LIBOR, though dealers will also be prepared to quote rates against other short-term debt.

²⁷ More commonly, interest rate swaps are based on three-month LIBOR and involve quarterly cash payments.

continue to trade at its face value. In this case the swap still has zero value. (You can confirm this by checking that the NPV of a new three-year homemade swap is zero.) But if long rates increase over the two years to 7% (say), the value of a three-year note falls to

$$PV = \frac{4}{1.07} + \frac{4}{(1.07)^2} + \frac{4 + 66.67}{(1.07)^3} = \$64.92 \text{ million}$$

Now the fixed payments that the bank has agreed to make are less valuable and the swap is worth $66.67 - 64.92 = \$1.75$ million.

How do we know the swap is worth \$1.75 million? Consider the following strategy:

1. The bank can enter a new three-year swap deal in which it agrees to *pay* LIBOR on the same notional principal of \$66.67 million.
2. In return it receives fixed payments at the new 7% interest rate, that is, $.07 \times 66.67 = \$4.67$ per year.

The new swap cancels the cash flows of the old one, but it generates an extra \$.67 million for three years. This extra cash flow is worth

$$PV = \sum_{t=1}^3 \frac{.67}{(1.07)^t} = \$1.75 \text{ million}$$

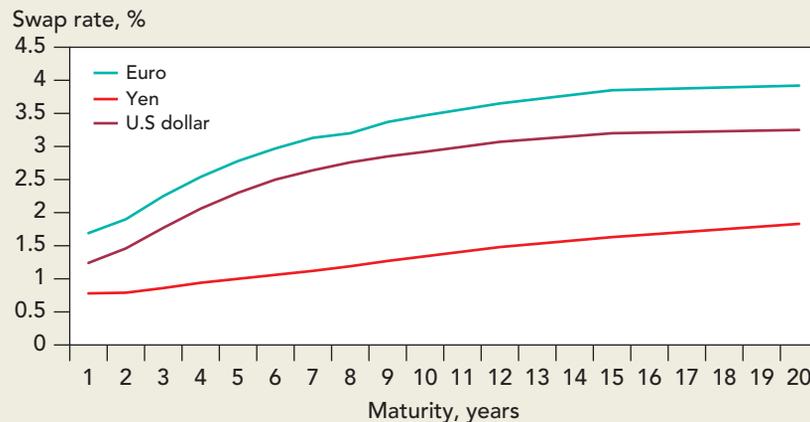
Remember, ordinary interest rate swaps have no initial cost or value ($NPV = 0$), but their value drifts away from zero as time passes and long-term interest rates change. One counterparty wins as the other loses.

In our example, the swap dealer loses from the rise in interest rates. Dealers will try to hedge the risk of interest rate movements by engaging in a series of futures or forward contracts or by entering into an offsetting swap with a third party. As long as Friendly Bancorp and the other counterparty honor their promises, the dealer is fully protected against risk. The recurring nightmare for swap managers is that one party will default, leaving the dealer with a large unmatched position. This is another example of counterparty risk.

The market for interest rate swaps is large and liquid. Consequently, financial analysts often look at swap rates when they want to know how interest rates vary with maturity. For example, Figure 26.3 shows swap curves in March 2009 for the U.S. dollar, the euro, and the yen. You can see that in each country long-term interest rates are much higher than short-term rates, though the level of swap rates varies from one country to another.

FIGURE 26.3

Swap curves for three currencies, March 2009.



Currency Swaps

We now look briefly at an example of a currency swap.

Suppose that the Possum Company needs 11 million euros to help finance its European operations. We assume that the euro interest rate is about 5%, whereas the dollar rate is about 6%. Since Possum is better known in the United States, the financial manager decides not to borrow euros directly. Instead, the company issues \$10 million of five-year 6% notes in the United States. Then it arranges with a counterparty to swap this dollar loan into euros. Under this arrangement the counterparty agrees to pay Possum sufficient dollars to service its dollar loan, and in exchange Possum agrees to make a series of annual payments in euros to the counterparty.

Here are Possum's cash flows (in millions):

	Year 0		Years 1–4		Year 5	
	Dollars	Euros	Dollars	Euros	Dollars	Euros
1. Issue dollar loan	+10		–.6		–10.6	
2. Swap dollars for euros	–10	+8	+.6	–.4	+10.6	–8.4
3. Net cash flow	0	+8	0	–.4	0	–8.4

Look first at the cash flows in year 0. Possum receives \$10 million from its issue of dollar notes, which it then pays over to the swap counterparty. In return the counterparty sends Possum a check for €8 million. (We assume that at current rates of exchange \$10 million is worth €8 million.)

Now move to years 1 through 4. Possum needs to pay interest of 6% on its debt issue, which works out at $.06 \times 10 = \$0.6$ million. The swap counterparty agrees to provide Possum each year with sufficient cash to pay this interest and in return Possum makes an annual payment to the counterparty of 5% of €8 million, or €0.4 million. Finally, in year 5 the swap counterparty pays Possum enough to make the final payment of interest and principal on its dollar notes (\$10.6 million), while Possum pays the counterparty €8.4 million.

The combined effect of Possum's two steps (line 3) is to convert a 6% dollar loan into a 5% euro loan. You can think of the cash flows for the swap (line 2) as a series of contracts to buy euros in years 1 through 5. In each of years 1 through 4 Possum agrees to purchase \$.6 million at a cost of .4 million euros; in year 5 it agrees to buy \$10.6 million at a cost of 8.4 million euros.²⁸

Total Return Swaps

While interest rate and currency swaps are the most popular type of contract, there is a wide variety of other possible swaps or related contracts. For example, in Chapter 23 we encountered credit default swaps that allow investors to insure themselves against the default on a corporate bond.

You can also enter into a *total return swap* where one party (party A) makes a series of agreed payments and the other (party B) pays the total return on a particular asset. This asset might be a common stock, a loan, a commodity, or a market index. For example, suppose that B owns \$10 million of IBM stock. It now enters into a two-year swap agreement to pay A each quarter the total return on this stock. In exchange A agrees to pay B interest of LIBOR + 1%. B is known as the *total return payer* and A is the *total return receiver*. Suppose LIBOR is 5%. Then A must pay B 6% of \$10 million, or about 1.5% a quarter. If IBM stock

²⁸ Usually in a currency swap the two parties make an initial payment to each other (i.e., Possum pays the bank \$10 million and receives €8 million). However, this is not necessary and Possum might prefer to buy the €8 million from another bank.

returns more than this, there will be a net payment from B to A; if the return is less than 1.5%, A must make a net payment to B. Although ownership of the IBM stock does not change hands, the effect of this total return swap is the same as if B had sold the asset to A and bought it back at an agreed future date.

26-6 How to Set Up a Hedge

To hedge risk the firm buys one asset and sells an offsetting amount of another asset. Suppose a farmer owns 100,000 bushels of wheat and sells 100,000 bushels of wheat futures. As long as the wheat that the farmer owns is identical to the wheat that he has promised to deliver, this strategy eliminates any uncertainty about his future income.

In practice the wheat that the farmer owns and the wheat that he sells in the futures markets are unlikely to be identical. For example, if he sells wheat futures on the Kansas City exchange, he agrees to deliver hard, red winter wheat in Kansas City in September. But perhaps he is growing northern spring wheat many miles from Kansas City; in this case the prices of the two wheats will not move exactly together.

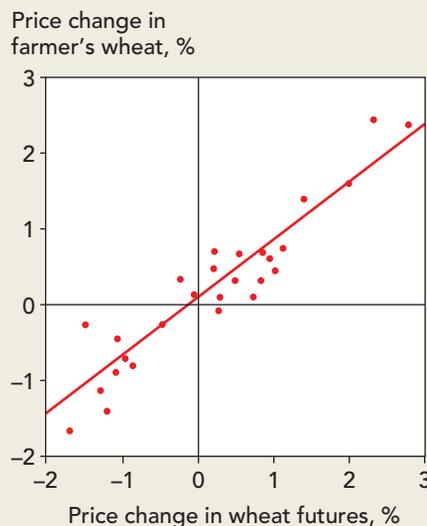
Figure 26.4 shows how changes in the prices of the two types of wheat may have been related in the past. Notice two things about this figure. First, the scatter of points suggests that the price changes are imperfectly related. If so, it is not possible to construct a hedge that eliminates all risk. Some basis risk will remain. Second, the slope of the fitted line shows that a 1% change in the price of Kansas wheat was on average associated with an .8% change in the price of the farmer's wheat. Because the price of the farmer's wheat is relatively insensitive to changes in Kansas prices, he needs to sell $.8 \times 100,000$ bushels of wheat futures to minimize risk.

Let us generalize. Suppose that you already own an asset, A (e.g., wheat), and that you wish to hedge against changes in the value of A by making an offsetting sale of another asset, B (e.g., wheat futures). Suppose also that percentage changes in the value of A are related in the following way to percentage changes in the value of B:

$$\text{Expected change in value of A} = a + \delta (\text{change in value of B})$$

FIGURE 26.4

Hypothetical plot of past changes in the price of the farmer's wheat against changes in the price of Kansas City wheat futures. A 1% change in the futures price implies, on average, an .8% change in the price of the farmer's wheat.



Delta (δ) measures the sensitivity of A to changes in the value of B. It is also equal to the *hedge ratio*—that is, the number of units of B that should be sold to hedge the purchase of A. You minimize risk if you offset your position in A by the sale of delta units of B.²⁹

The trick in setting up a hedge is to estimate the delta or hedge ratio. This often calls for a strong dose of judgment. For example, suppose that Antarctic Air would like to protect itself against a hike in oil prices. As the financial manager, you need to decide how much a rise in oil prices would affect firm value. Suppose the company spent \$200 million on fuel last year. Other things equal, a 10% increase in the price of oil will cost the company an extra $.1 \times 200 = \$20$ million. But perhaps you can partially offset the higher costs by higher ticket prices, in which case earnings will fall by *less* than \$20 million. Or perhaps an oil price rise will lead to a slowdown in business activity and therefore lower passenger numbers. In that case earnings will decline by *more* than \$20 million. Working out the likely effect on firm *value* is even more tricky, because that depends on whether the rise is likely to be permanent. Perhaps the price rise will induce an increase in production or encourage consumers to economize on energy usage.

Sometimes in such cases some history may help. For example, you could look at how firm value changed in the past as oil prices changed. In other cases it may be possible to call on a little theory to set up the hedge.

EXAMPLE 26.3 • Using Theory to Set Up the Hedge

Potterton Leasing has just purchased some equipment and arranged to rent it out for \$2 million a year over 20 years. At an interest rate of 10%, Potterton's rental income has a present value of \$17.0 million.³⁰

$$PV = \frac{2}{1.1} + \frac{2}{(1.1)^2} + \cdots + \frac{2}{(1.1)^{20}} = 17.0 \text{ million}$$

Potterton proposes to finance the deal by a \$17 million issue of 12-year bonds with a coupon of 10%. Think of its new asset (the stream of rental income) and the new liability (the issue of bonds) as a package. Does Potterton stand to gain or lose on this package if interest rates change?

To answer this question, think back to Chapter 3 where we introduced the concept of duration. Duration, you may remember, is the weighted-average time to each cash flow. It is important because it is directly related to volatility. If two assets have the same duration, their prices will be equally affected by a general change in interest rates. If we call the total value of Potterton's rental income V , then the duration of the rental income is calculated as follows:

$$\begin{aligned} \text{Duration} &= \frac{1}{V} \{ [PV(C_1) \times 1] + [PV(C_2) \times 2] + [PV(C_3) \times 3] + \cdots \} \\ &= \frac{1}{17.0} \left\{ \left[\frac{2}{1.10} \times 1 \right] + \left[\frac{2}{1.10^2} \times 2 \right] + \cdots + \left[\frac{2}{1.10^{20}} \times 20 \right] \right\} \\ &= 7.51 \text{ years} \end{aligned}$$

We can also calculate the duration of Potterton's bond in the same way. It turns out that it is 7.50 years, which is almost identical to the duration of the rental income. Therefore, the values of both the rental income and the bond are more or less equally affected

²⁹ Notice that A, the item that you wish to hedge, is the dependent variable. Delta measures the sensitivity of A to changes in B.

³⁰ We ignore taxes in this example.

by a change in interest rates. If rates rise, the present value of Potterton's rental income will decline, but the value of its debt obligation will also decline by the same amount. By equalizing the duration of the asset and that of the liability, Potterton has *immunized* itself against any change in interest rates. It looks as if Potterton's financial manager knows a thing or two about hedging.

The issue of a 12-year bond is not the only way for Potterton to hedge its income stream. For example, the company could issue a package of a 1-year bond and a 20-year bond that together had the same duration as the rental income. Again the values of the asset and the liability would be equally affected by a change in interest rates.

An important feature of these duration hedges is that they are dynamic. As interest rates change and time passes, the duration of Potterton's asset may no longer be the same as that of its liability. Thus to remain hedged against interest rate changes, Potterton must be prepared to keep adjusting the duration of its debt.

26-7 Is "Derivative" A Four-Letter Word?

A wheat farmer can sell wheat futures to reduce business risk. But if you were to copy the farmer and sell futures without an offsetting holding of wheat, you would increase risk, not reduce it. You would be *speculating*.

Speculators in search of large profits (and prepared to tolerate large losses) are attracted by the leverage that derivatives provide. By this we mean that it is not necessary to lay out much money up front and the profits or losses may be many times the initial outlay. "Speculation" has an ugly ring, but a successful derivatives market needs speculators who are prepared to take on risk and provide more cautious people such as farmers or millers with the protection they need. For example, if an excess of farmers wishes to sell wheat futures, the price of futures will be forced down until enough speculators are tempted to buy in the hope of a profit. If there is a surplus of millers wishing to buy wheat futures, the reverse will happen. The price of wheat futures will be forced *up* until speculators are drawn in to sell.

Speculation may be necessary to a thriving derivatives market, but it can get companies into serious trouble. The nearby Finance in Practice box describes how the German metals and oil trading company, Metallgesellschaft, took a \$1 billion bath on its positions in oil futures.³¹ Metallgesellschaft had plenty of company. The Japanese company, Showa Shell, reported a loss of \$1.5 billion on positions in foreign exchange futures. And in 1995 Baring Brothers, a blue-chip British merchant bank with a 200-year history, became insolvent. The reason: Nick Leeson, a trader in Baring's Singapore office, had placed very large bets on the Japanese stock market index that resulted in losses of \$1.4 billion.

These tales of woe have some cautionary messages for corporations. During the 1970s and 1980s many firms turned their treasury operations into profit centers and proudly announced their profits from trading in financial instruments. But it is not possible to make large profits in financial markets without also taking large risks, so these profits should have served as a warning rather than a matter for congratulation.

A Boeing 747 weighs 400 tons, flies at nearly 600 miles per hour, and is inherently very dangerous. But we don't ground 747s; we just take precautions to ensure that they are flown with

³¹ The Metallgesellschaft debacle makes fascinating reading. See, for example, F. Edwards, "The Collapse of Metallgesellschaft: Unhedgeable Risks, Poor Hedging Strategy, or Just Bad Luck?" *Journal of Future Markets* 15 (May 1995), pp. 211–264.

The Debacle at Metallgesellschaft

► In January 1994 the German industrial giant Metallgesellschaft shocked investors with news of huge losses in its U.S. oil subsidiary, MGRM. These losses, later estimated at over \$1 billion, brought the firm to the brink of bankruptcy and it was saved only by a \$1.9 billion rescue package from 120 banks.

The previous year MGRM had embarked on what looked like a sure-fire way to make money. It offered its customers forward contracts on deliveries of gasoline, heating oil, and diesel fuel for up to 10 years. These price guarantees proved extremely popular. By September 1993, MGRM had sold forward over 150 million barrels of oil at prices that were \$3 to \$5 a barrel over the prevailing spot prices.

As long as oil prices did not rise appreciably, MGRM stood to make a handsome profit from its forward sales, but if oil prices did return to their level of earlier years the result would be a calamitous loss. MGRM therefore sought to avoid such an outcome by buying energy futures. Unfortunately, the long-term futures contracts that were needed to offset MGRM's price guarantees did not exist. MGRM's solution was to enter into what is known as a "stack-and-roll" hedge. In other words, it bought a stack of short-dated futures contracts and, as these were about to expire, it rolled them over into a fresh stack of short-dated contracts.

MGRM was relaxed about the mismatch between the long-term maturity of its price guarantees and the much shorter maturity of its futures contracts. It could point to past history to justify its confidence, for in most years energy traders have placed a high value on owning the oil rather than having a promise of future delivery. In other words, the net convenience yield on oil has generally been positive. As long as that continued to be the case, then each time that MGRM rolled over its futures contracts, it would be selling its maturing contracts at a higher price than it would need to pay for the stack of new contracts. However, if the net convenience yield were to become

negative, the maturing futures contracts would sell for less than more distant ones. Unfortunately, this is what occurred in 1993. In that year there was a glut of oil, the storage tanks were full, and nobody was prepared to pay extra to get his hands on oil. The result was that MGRM was forced to pay a premium to roll over each stack of maturing contracts.

The fall in oil prices had another unfortunate consequence for MGRM. Futures contracts are marked to market. This means that the investor settles up the profits and losses on each contract as they arise. Therefore, as oil prices continued to fall in 1993, MGRM incurred losses on its purchases of oil futures. This resulted in huge margin calls.* The offsetting good news was that the fall in oil prices meant that its long-term forward contracts were looking increasingly profitable, but this profit was not money in the bank.

When Metallgesellschaft's board learned of these problems, it fired the chief executive and instructed the company to cease all hedging activities and to start negotiations with customers to cancel the long-term contracts. Almost immediately the fall in oil prices reversed. Within eight months the price had risen about 40%. If only MGRM had been able to hold on, it would have enjoyed a huge cash inflow.

Observers have continued to argue about the Metallgesellschaft debacle. Was the company's belief that the net convenience yield would remain positive a reasonable assumption or a gigantic speculation? How much did the company anticipate its cash needs and could it have financed them by borrowing on the strength of its long-term forward contracts? Did senior management mistake the margin calls for losses and just lose its nerve when it decided to liquidate the company's positions?

* In addition to buying futures contracts, MGRM also bought short-term over-the-counter forward contracts and commodity swaps. As these matured, MGRM had to make good the loss on them, even though it did not receive the gains on the price guarantees.

care. Similarly, it is foolish to suggest that firms should ban the use of derivatives, but it makes obvious sense to take precautions against their misuse. Here are two bits of horse sense:

- *Precaution 1: Don't be taken by surprise.* By this we mean that senior management needs to monitor regularly the value of the firm's derivatives positions and to know what bets the firm has placed. At its simplest, this might involve asking what would happen

if interest rates or exchange rates were to change by 1%. But large banks and consultants have also developed sophisticated models for measuring the risk of derivatives positions.

- *Precaution 2: Place bets only when you have some comparative advantage that ensures the odds are in your favor.* If a bank were to announce that it was drilling for oil or launching a new soap powder, you would rightly be suspicious about whether it had what it takes to succeed.

Imprudent speculation in derivatives is undoubtedly an issue of concern for the company's shareholders, but is it a matter for more general concern? Some people believe, like Warren Buffett, that derivatives are "financial weapons of mass destruction." They point to the huge volume of trading in derivatives and argue that speculative losses could lead to major defaults that might threaten the whole financial system. These worries have led to calls for increased regulation of derivatives markets.

Now, this is not the place for a discussion of regulation, but we should warn you about careless measures of the size of the derivatives markets and the possible losses. In mid-2008 the notional value of outstanding derivative contracts was about \$684 trillion.³² This is a very large sum, but it tells you *nothing* about the money that was being put at risk. For example, suppose that a bank enters into a \$10 million interest rate swap and the other party goes bankrupt the next day. How much has the bank lost? Nothing. It hasn't paid anything up front; the two parties simply promised to pay sums to each other in the future. Now the deal is off.

Suppose that the other party does not go bankrupt until a year after the bank entered into the swap. In the meantime interest rates have moved in the bank's favor, so it should be receiving more money from the swap than it is paying out. When the other side defaults on the deal, the bank loses the difference between the interest that it is due to receive and the interest that it should pay. But it doesn't lose \$10 million.³³

The only meaningful measure of the potential loss from default is the amount that it would cost firms showing a profit to replace their swap positions. This figure is only about 1% of the principal amount of swaps outstanding.

³² Bank of International Settlements, *Derivatives Statistics* (www.bis.org/statistics/derstats.htm).

³³ This does not mean that firms don't worry about the possibility of default, and there are a variety of ways that they try to protect themselves. In the case of swaps, firms are reluctant to deal with banks that do not have the highest credit rating.



SUMMARY

As a manager, you are paid to take risks, but you are not paid to take just any risks. Some risks are simply bad bets, and others could jeopardize the value of the firm. Hedging risks, when it is practical to do so, can make sense if it reduces the chance of cash shortfalls or financial distress. In some cases, hedging can also make it easier to monitor and motivate operating managers. Relieving managers of risk outside their control helps them concentrate on what can be controlled.

Most businesses insure against possible losses. Insurance companies specialize in assessing risks and can pool risks by holding a diversified portfolio of policies. Insurance works less well when policies are taken up by companies that are most at risk (*adverse selection*) or when the insured company is tempted to skip on maintenance or safety procedures (*moral hazard*).

Firms can also hedge with options and with forward and futures contracts. A forward contract is an advance order to buy or sell an asset. The forward price is fixed today, but payment is not made until the delivery date at the end of the contract. Forward contracts traded on organized futures exchanges are called futures contracts. Futures contracts are standardized and traded in

huge volumes. The futures markets allow firms to lock in future prices for dozens of different commodities, securities, and currencies.

Instead of buying or selling a standardized futures contract, you may be able to arrange a tailor-made forward contract with a bank. Firms can protect against changes in foreign exchange rates by buying or selling forward currency contracts. Forward rate agreements (FRAs) provide protection against changes in interest rates. You can also construct homemade forward contracts. For example, if you borrow for two years and at the same time lend for one year, you have effectively taken out a forward loan.

Firms also hedge with swap contracts. For example, a firm can make a deal to pay interest to a bank at a fixed long-term rate and receive interest from the bank at a floating short-term rate. The firm swaps a fixed for a floating rate. Such a swap could make sense if the firm has relatively easy access to short-term borrowing but dislikes the exposure to fluctuating short-term interest rates.

The theory of hedging is straightforward. You find two closely related assets. You then buy one and sell the other in proportions that minimize the risk of your net position. If the assets are *perfectly* correlated, you can make the net position risk-free. If they are less than perfectly correlated, you will have to absorb some basis risk.

The trick is to find the hedge ratio or delta—that is, the number of units of one asset that is needed to offset changes in the value of the other asset. Sometimes the best solution is to look at how the prices of the two assets have moved together in the past. For example, suppose you observe that a 1% change in the value of B has been accompanied on average by a 2% change in the value of A. Then delta equals 2.0; to hedge each dollar invested in A, you need to sell two dollars of B.

On other occasions theory can help to set up the hedge. For example, the effect of a change in interest rates on an asset's value depends on the asset's duration. If two assets have the same duration, they will be equally affected by fluctuations in interest rates.

Many of the hedges described in this chapter are static. Once you have set up the hedge, you can take a long vacation, confident that the firm is well protected. However, some hedges, such as those that match durations, are dynamic. As time passes and prices change, you need to rebalance your position to maintain the hedge.

Hedging and risk reduction sound as wholesome as mom's apple pie. But remember that hedging solely to reduce risk, with no other business purpose, cannot add value. It is a zero-sum game: risks aren't eliminated, just shifted to some counterparty. And remember that your shareholders can also hedge by adjusting the composition of their portfolios or by trading in futures or other derivatives. Investors won't reward the firm for doing something that they can do perfectly well for themselves.

Some companies have decided that speculation is much more fun than hedging. This view can lead to serious trouble. We do not believe that speculation makes sense for an industrial company, but we caution against the view that derivatives are a threat to the financial system.

Three general articles on corporate risk management are:

K. A. Froot, D. Scharfstein, and J. C. Stein, "A Framework for Risk Management," *Harvard Business Review* 72 (November–December 1994), pp. 59–71.

B. W. Nocco and R. M. Stulz, "Enterprise Risk Management: Theory and Practice," *Journal of Applied Corporate Finance* 18 (Fall 2006), pp. 8–20.

C. H. Smithson and B. Simkins, "Does Risk Management Add Value? A Survey of the Evidence," *Journal of Applied Corporate Finance* 17 (Summer 2005), pp. 8–17.

The Summer 2005 and Fall 2006 issues of the Journal of Applied Corporate Finance are devoted to risk management, and current news and developments are discussed in Risk magazine. You may also wish to refer to the following texts:



FURTHER READING

J. C. Hull, *Options, Futures, and other Derivatives*, 7th ed. (Englewood Cliffs, NJ: Prentice Hall, 2008).

C. H. Smithson, *Managing Financial Risk*, 3rd ed. (New York: McGraw-Hill, 1998).

R. M. Stulz, *Risk Management and Derivatives* (Cincinnati, OH: Thomson-Southwestern Publishing, 2003).

Schaefer's paper is a useful review of how duration measures are used to immunize fixed liabilities:

S. M. Schaefer, "Immunisation and Duration: A Review of Theory, Performance and Applications," *Midland Corporate Finance Journal* 3 (Autumn 1984), pp. 41–58.



Select problems are available in McGraw-Hill Connect. Please see the preface for more information.

PROBLEM SETS

BASIC

1. Vocabulary check. Define the following terms:
 - a. Spot price
 - b. Forward vs. futures contract
 - c. Long vs. short position
 - d. Basis risk
 - e. Mark to market
 - f. Net convenience yield
2. True or false?
 - a. Hedging transactions in an active futures market have zero or slightly negative NPVs.
 - b. When you buy a futures contract, you pay now for delivery at a future date.
 - c. The holder of a financial futures contract misses out on any dividend or interest payments made on the underlying security.
 - d. The holder of a commodities futures contract does not have to pay for storage costs, but foregoes convenience yield.
3. Yesterday you sold six-month futures on the German DAX stock market index at a price of 4,820. Today the DAX closed at 4,800 and DAX futures closed at 4,840. You get a call from your broker, who reminds you that your futures position is marked to market each day. Is she asking you to pay money, or is she about to offer to pay you?
4. Calculate the value of a six-month futures contract on a Treasury bond. You have the following information:
 - Six-month interest rate: 10% per year, or 4.9% for six months.
 - Spot price of bond: 95.
 - The bond pays an 8% coupon, 4% every six months.
5. "Northern Refineries does not avoid risk by selling oil futures. If prices stay above \$1.60 a gallon, then it will actually have lost by selling oil futures at that price." Is this a fair comment?
6. Calculate convenience yield for magnoosium scrap from the following information:
 - Spot price: \$2,550 per ton.
 - Futures price: \$2,408 for a one-year contract.
 - Interest rate: 12%.
 - Storage costs: \$100 per year.

7. Residents of the northeastern United States suffered record-setting low temperatures throughout November and December 2021. Spot prices of heating oil rose 25%, to over \$2 a gallon.
 - a. What effect did this have on the net convenience yield and on the relationship between futures and spot prices?
 - b. In late 2022 refiners and distributors were surprised by record-setting *high* temperatures. What was the effect on net convenience yield and spot and futures prices for heating oil?
8. After a record harvest, grain silos are full to the brim. Are storage costs likely to be high or low? What does this imply for the *net* convenience yield?
9. A year ago a bank entered into a \$50 million five-year interest rate swap. It agreed to pay company A each year a fixed rate of 6% and to receive in return LIBOR. When the bank entered into this swap, LIBOR was 5%, but now interest rates have risen, so on a four-year interest rate swap the bank could expect to pay 6½% and receive LIBOR.
 - a. Is the swap showing a profit or loss to the bank?
 - b. Suppose that at this point company A approaches the bank and asks to terminate the swap. If there are four annual payments still remaining, how much should the bank charge A to terminate?
10. What is basis risk? In which of the following cases would you expect basis risk to be most serious?
 - a. A broker owning a large block of Disney common stock hedges by selling index futures.
 - b. A Iowa corn farmer hedges the selling price of her crop by selling Chicago corn futures.
 - c. An importer must pay 900 million euros in six months. He hedges by buying euros forward.
11. You own a \$1 million portfolio of aerospace stocks with a beta of 1.2. You are very enthusiastic about aerospace but uncertain about the prospects for the overall stock market. Explain how you could hedge out your market exposure by selling the market short. How much would you sell? How in practice would you go about “selling the market”?
12.
 - a. Marshall Arts has just invested \$1 million in long-term Treasury bonds. Marshall is concerned about increasing volatility in interest rates. He decides to hedge using bond futures contracts. Should he buy or sell such contracts?
 - b. The treasurer of Zeta Corporation plans to issue bonds in three months. She is also concerned about interest rate volatility and wants to lock in the price at which her company could sell 5% coupon bonds. How would she use bond futures contracts to hedge?

INTERMEDIATE

13. Large businesses spend millions of dollars annually on insurance. Why? Should they insure against all risks or does insurance make more sense for some risks than others?
14. On some catastrophe bonds, payments are reduced if the claims against the issuer exceed a specified sum. In other cases payments are reduced only if claims against the entire industry exceed some sum. What are the advantages and disadvantages of the two structures? Which involves more basis risk? Which may create a problem of moral hazard?
15. List some of the commodity futures contracts that are traded on exchanges. Who do you think could usefully reduce risk by buying each of these contracts? Who do you think might wish to sell each contract?
16. Phoenix Motors wants to lock in the cost of 10,000 ounces of platinum to be used in next quarter’s production of catalytic converters. It buys three-month futures contracts for 10,000 ounces at a price of \$1,250 per ounce.
 - a. Suppose the spot price of platinum falls to \$1,100 in three months’ time. Does Phoenix have a profit or loss on the futures contract? Has it locked in the cost of purchasing the platinum it needs?
 - b. How do your answers change if the spot price of platinum increases to \$1,400 after three months?

Commodity	Spot Price	Futures Price	Comments
Magnosium	\$2,550 per ton	\$2,728.50 per ton	Monthly storage cost = monthly convenience yield
Frozen quiche	\$.50 per pound	\$.514 per pound	Six months' storage costs = \$.10 per pound; six months' convenience yield = \$.05 per pound.
Nevada Hydro 8s of 2002	77	78.39	4% semiannual coupon payment is due just before futures contract expires.
Costaguanan pulgas (currency)	9,300 pulgas = \$1	6,900 pulgas = \$1	Costaguanan interest rate is 95% per year.
Establishment Industries common stock	\$95	\$97.54	Establishment pays dividends of \$2 per quarter. Next dividend is paid two months from now.
Cheap white wine	\$12,500 per 10,000-gal. tank	\$14,200 per 10,000-gal. tank	Six months' convenience yield = \$250 per tank. Your company has surplus storage and can store 50,000 gallons at no cost.

TABLE 26.4 Spot and six-month futures prices for selected commodities and securities. See Problem 19.

17. In March 2009, nine-month futures on the Brazilian Ibovespa stock index traded at 44,439. Spot was 41,908. The interest rate was 11.25% and the dividend yield was about 3%. Were the futures fairly priced?
18. If you buy a nine-month T-bill future, you undertake to buy a three-month bill in nine months' time. Suppose that Treasury bills and notes currently offer the following yields:

Months to Maturity	Annual Yield
3	6%
6	6.5
9	7
12	8

What is the value of a nine-month bill future?

19. Table 26.4 contains spot and six-month futures prices for several commodities and financial instruments. There may be some money-making opportunities. See if you can find them, and explain how you would trade to take advantage of them. The interest rate is 14.5%, or 7% over the six-month life of the contracts.
20. The following table shows 2009 gold futures prices for varying contract lengths. Gold is predominantly an investment good, not an industrial commodity. Investors hold gold because it diversifies their portfolios and because they hope its price will rise. They do not hold it for its convenience yield.

Calculate the interest rate faced by traders in gold futures for each of the contract lengths shown below. The spot price is \$915.50 per ounce.

	Contract Length (months)		
	3	6	9
Futures price	\$917.90	\$920.85	\$923.30

21. In September 2014 swap dealers were quoting a rate for five-year euro interest-rate swaps of 4.5% against Euribor (the short-term interest rate for euro loans). Euribor at the time was

4.1%. Suppose that A arranges with a dealer to swap a €10 million five-year fixed-rate loan for an equivalent floating-rate loan in euros.

- What is the value of this swap at the time that it is entered into?
- Suppose that immediately after A has entered into the swap, the long-term interest rate rises by 1%. Who gains and who loses?
- What is now the value of the swap?

22. Securities A, B, and C have the following cash flows:

	Period 1	Period 2	Period 3
A	\$ 40	\$40	\$ 40
B	\$120	—	—
C	\$ 10	\$10	\$110

- Calculate their durations if the interest rate is 8%.
 - Suppose that you have an investment of \$10 million in A. What combination of B and C would immunize this investment against interest rate changes?
 - Now suppose that you have a \$10 million investment in B. How would you immunize?
23. What is meant by “delta” (δ) in the context of hedging? Give examples of how delta can be estimated or calculated.
24. A gold-mining firm is concerned about short-term volatility in its revenues. Gold currently sells for \$650 an ounce, but the price is extremely volatile and could fall as low as \$630 or rise as high as \$680 in the next month. The company will bring 1,000 ounces to the market next month.
- What will be total revenues if the firm remains unhedged for gold prices of \$600, \$630, and \$680 an ounce?
 - The futures price of gold for delivery one month ahead is \$660. What will be the firm’s total revenues at each gold price if the firm enters into a one-month futures contract to deliver 1,000 ounces of gold?
 - What will total revenues be if the firm buys a one-month put option to sell gold for \$650 an ounce? The put option costs \$45 per ounce.
25. Legs Diamond owns shares in a Vanguard Index 500 mutual fund worth \$1 million on July 15. (This is an index fund that tracks the Standard and Poor’s 500 Index.) He wants to cash in now, but his accountant advises him to wait six months so as to defer a large capital gains tax. Explain to Legs how he can use stock index futures to hedge out his exposure to market movements over the next six months. Could Legs “cash in” without actually selling his shares?
26. Price changes of two gold-mining stocks have shown strong positive correlation. Their historical relationship is

$$\text{Average percentage change in A} = .001 + .75 (\text{percentage change in B})$$

Changes in B explain 60% of the variation of the changes in A ($R^2 = .6$).

- Suppose you own \$100,000 of A. How much of B should you sell to minimize the risk of your net position?
- What is the hedge ratio?
- Here is the historical relationship between stock A and gold prices.

$$\text{Average percentage change in A} = -.002 + 1.2 (\text{percentage change in gold price})$$

If $R^2 = .5$, can you lower the risk of your net position by hedging with gold (or gold futures) rather than with stock B? Explain.

TABLE 26.5 Spot prices for selected commodities and financial assets. See Problem 29.

Asset	Spot Price	Comments
Magnosium	\$2,800 per ton	Net convenience yield = 4% per year
Oat bran	\$.44 per bushel	Net convenience yield = .5% per month
Biotech stock index	140.2	Dividend = 0
Allen Wrench Co. common stock	\$58.00	Cash dividend = \$2.4 per year
5-year Treasury note	108.93	8% coupon
Westonian ruple	3.1 ruples = \$1	12% interest rate in ruples

27. In Section 26-6, we stated that the duration of Potterton's lease equals the duration of its debt.
- Show that this is so.
 - Now suppose that the interest rate falls to 3%. Show how the value of the lease and the debt are now affected by a .5% rise or fall in the interest rate. What would Potterton need to do to reestablish the interest rate hedge?
28. Petrochemical Parfum (PP) is concerned about a possible increase in the price of heavy fuel oil, which is one of its major inputs. Show how PP can use either options or futures contracts to protect itself against a rise in the price of crude oil. Show how the payoffs in each case would vary if the oil price were \$70, \$80, or \$90 a barrel. What are the advantages and disadvantages for PP of using futures rather than options to reduce risk?
29. Consider the commodities and financial assets listed in Table 26.5. The risk-free interest rate is 6% a year, and the term structure is flat.
- Calculate the six-month futures price for each case.
 - Explain how a magnosium producer would use a futures market to lock in the selling price of a planned shipment of 1,000 tons of magnosium six months from now.
 - Suppose the producer takes the actions recommended in your answer to (b), but after one month magnosium prices have fallen to \$2,200. What happens? Will the producer have to undertake additional futures market trades to restore its hedged position?
 - Does the biotech index futures price provide useful information about the expected future performance of biotech stocks?
 - Suppose Allen Wrench stock falls suddenly by \$10 per share. Investors are confident that the cash dividend will not be reduced. What happens to the futures price?
 - Suppose interest rates suddenly fall to 4%. The term structure remains flat. What happens to the six-month futures price on the five-year Treasury note? What happens to a trader who shorted 100 notes at the futures price calculated in part (a)?
 - An importer must make a payment of one million ruples three months from now. Explain *two* strategies the importer could use to hedge against unfavorable shifts in the ruple-dollar exchange rate.
30. Is a total return swap on a bond the same as a credit default swap (see Section 23-1)? Why or why not?
31. "Speculators want futures contracts to be incorrectly priced; hedgers want them to be correctly priced." Why?
32. Your investment bank has an investment of \$100 million in the stock of the Swiss Roll Corporation and a short position in the stock of the Frankfurter Sausage Company. Here is the recent price history of the two stocks:

Percentage Price Change		
Month	Frankfurter Sausage	Swiss Roll
January	-10	-10
February	-10	-5
March	-10	0
April	+10	0
May	+10	+5
June	+10	+10

On the evidence of these six months, how large would your short position in Frankfurter Sausage need to be to hedge you as far as possible against movements in the price of Swiss Roll?

CHALLENGE

33. Phillip's Screwdriver Company has borrowed \$20 million from a bank at a floating interest rate of 2 percentage points above three-month Treasury bills, which now yield 5%. Assume that interest payments are made quarterly and that the entire principal of the loan is repaid after five years.

Phillip's wants to convert the bank loan to fixed-rate debt. It could have issued a fixed-rate five-year note at a yield to maturity of 9%. Such a note would now trade at par. The five-year Treasury note's yield to maturity is 7%.

- Is Phillip's stupid to want long-term debt at an interest rate of 9%? It is borrowing from the bank at 7%.
- Explain how the conversion could be carried out by an interest rate swap. What will be the initial terms of the swap? (Ignore transaction costs and the swap dealer's profit.)

One year from now short and medium-term Treasury yields *decrease* to 6%, so the term structure then is flat. (The changes actually occur in month 5.) Phillip's credit standing is unchanged; it can still borrow at 2 percentage points over Treasury rates.

- What net swap payment will Phillip's make or receive?
- Suppose that Phillip's now wants to cancel the swap. How much would it need to pay the swap dealer? Or would the dealer pay Phillip's? Explain.

- The Web sites of the major commodities exchanges provide futures prices. Calculate and plot (as in Figure 26.2) the *annualized* net convenience yield for a commodity of your choice. (*Note:* You may need to use the futures price of a contract that is about to mature as your estimate of the current spot price.)
- You can find swap rates for the U.S. dollar and the euro on www.ft.com. Plot the current swap curves as in Figure 26.3.
- You can find spot and futures prices for a variety of equity indexes on www.wsj.com. Pick one and check whether it is fairly priced. You will need to do some detective work to find the dividend yield on the index and the interest rate.



REAL-TIME DATA ANALYSIS